GÖSTA H. LILJEQUIST

HIGH LATITUDES

*A HISTORY OF
SWEDISH POLAR TRAVELS AND RESEARCH*

Gösta H. Liljequist at Maudheim, Antarctic.
Photo: Valter Schytt

Professor Gösta H. Liljequist, born 1914, has undertaken the comprehensive and demanding task of documenting the history of Swedish polar travels and research. His qualifications for this task are unique. No other Swede, now alive, has the extensive, firsthand experience of research work in the polar regions as professor Liljequist.

Gösta H. Liljequist, had a personal role in creating a considerable part of Swedish polar research. As a meteorologist, he participated in the Norwegian-British-Swedish Antarctic Expedition, 1949–1952, after which he carried out extensive and fundamental studies. During the *International Geophysical Year 1957–1958*, he was the leader of the Swedish-Finnish-Swiss expedition to Nord-austlandet, Svalbard. He later described this expedition in his popular book "*Arktisk utpost*" (1960). As a professor of meteorology at Uppsala University he has also written a number of important textbooks and manuals including *Meteorology* (1962) and *Climatology* (1970).

HIGH LATITUDES

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GÖSTA H. LILJEQUIST

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*A HISTORY OF
SWEDISH POLAR TRAVELS
AND RESEARCH*

In Memory of
Lennart Liljequist
1948–1987

THE SWEDISH POLAR RESEARCH SECRETARIAT
in collaboration with
STREIFFERT

We were fond together, because of the sweep of the open places, the taste
of wide winds, the sunlight and the hopes in which we worked...
We were wrought up with ideas inexpressible and vaporous, but to be fought for.

T.E. Lawrence

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FOREWORD

In 1927, I was then 13 years old, I read a short article dealing with Shackleton's south polar expedition of 1907–1909. A few days later, I found Shackleton's own narrative *The Heart of the Antarctic* in the library of my home town Kalmar. The work consists of two thick volumes, in which Shackleton and his companions describe the expedition and the sledging tours which they carried out, notably the expedition to the South Pole.

It is a wonderful piece of work in style, subject matter, illustrations, information and much more. This work was to influence my whole life and created a deep interest in the polar regions, which has remained with me ever since. My interest was awakened at a time when airplanes—and for a short time airships—were coming into the service of the polar explorer. For 20 years Sweden had not dispatched any major expeditions to the polar regions. However, in 1926, the Swedish meteorologist and oceanographer Finn Malmgren was invited to go with the Norwegians—and, in 1928, with the Italians—on flight expeditions. He had also gained practical and scientific experience on board the Norwegian polar ship *Maud* during her drift in the ice of the Polar Sea. It was the travels and scientific studies of Finn Malmgren that were to decide my future and choice of profession.

In 1938, I joined the Swedish Meteorological and Hydrological Institute in Stockholm, where I worked first as a hydrologist, later as a meteorologist and climatologist. The library of the Institute was extensive and I could devote myself to studying polar meteorology and oceanography and also polar history from a long series of the *Geographical Journal*. This was both a valuable and interesting period of my life.

I came to know Hans W:son Ahlmann, the glaciologist and the polar traveler and thanks to him, a decade later, I became a member of the Norwegian-British-Swedish Antarctic Expedition of 1949–1952. To a meteorologist the base Maudheim in Dronning Maud Land was a paradise for research work. In 1957–1958, I was leader of the Swedish-Finnish-Swiss expedition to Nordaustlandet, Svalbard, during the international Geophysical Year.

Several years later, in 1985, I attended a polar meeting in northern Sweden. Anders Karlqvist, head of the recently established *Swedish Polar Research Secretariat* was also present. We discussed Swedish expedition activities, which up till then had taken place in the Arctic. Expeditions to the Antarctic had been few; to be exact only two, 1901–1903 and 1949–1952, but highly successful.

At the time, Sweden was in the process of applying for membership in SCAR, Scientific Committee on Antarctic Research, for which purpose it was desirable to present an article or a small book on the two Antarctic expeditions and also a list of Sweden's most important Arctic expeditions. I consented to write part of this book entitled *Sweden and Antarctica*. Later, in the autumn of 1985, Anders Karlqvist discussed an Arctic counterpart, a book to be named *Sweden and the Arctic*. The difficulty here was that Arctic expeditions had been many, and to produce a book on this subject would involve a great deal of work. I agreed to write the book and began to collect references. It seemed desirable to include the two Antarctic expeditions in the new book. Thus both Arctic and Antarctic expeditions were to be documented for the period 1758–1966. The first date, corresponded with the visit of the first Swedish scientist to the Arctic, Anton Rolandson Martin, the latter date marked the time of the most recent major Swedish expedition that visited Spitsbergen. However, as time passed, this latter date was somewhat displaced.

An agreeable period followed; the literature was studied and copies were taken from books, scientific journals, etc. The University Library in Uppsala was of particular use during this time. Many books and articles were obtained from secondhand shops; I acquired

the habit of having repeated looks in their showwindows and bookshelves. The hunt for references was indeed an exciting and exhilarating pastime.

The time used for producing the raw manuscript was also a highly interesting period. Human relationships were often revealed from the literature; even trivial notes or events could elucidate the manners and character of the different individuals or reveal daily life of the expeditions, and the impression the polar landscape and nature made upon expedition members. The relationships between superiors and subordinates were also manifested in the literature. At an early date during the writing of the text I realized how valuable and elucidating such quotations would be, therefore they were quoted systematically in the text.

At the end of July 1990, the raw text was ready for typing. The Secretariat provided funds for this task, which was carried out by Dina Söderström. In the autumn of 1990, Göran Rudbäck at the Polar Research Secretariat initiated discussions on how to finance the production.

The President of the Polar Research Committee of the Royal Swedish Academy of Sciences, Professor Gunnar Hoppe, took on the task of applying for the necessary funds to print the book, under the title of *High Latitudes*. The following organisations have made very generous contributions to the publication of the book:

Knut and Alice Wallenberg Foundation

Swedish Natural Research Council

Swedish Council for Research in the Humanities and Social Sciences

King Gustaf VI Adolf Fund

Magnus Bergvall's Foundation

Illustrating the book was considered at an early stage. Photostat copies of photos, charts and diagrams were collected. Ann-Sofie Rickby, at the Secretariat, registered every item to make the extensive material easier to handle. Together, we made the decisions on which illustrations should definitely be included and these were photographed, when taken from earlier publications, books or journals. The photographic work was carried out by Mogens Didrichsen. Collecting and recasting pictures, writing and arranging captions was decidedly the most difficult task during the whole production process. I wish to convey my special thanks to all those who have contributed in different ways with photographic material.

Maps were also to be drawn. This was carried out by Kjerstin Andersson at the Geographical Department of Uppsala University. The English text was revised by Mr. Jon Van Leuven.

The staff of the Swedish Polar Research Secretariat have been most supportive, within their specialities, during my frequent visits to the Secretariat.

The most important contributions to transferring the book *High Latitudes* from the mental to the material world is ascribed to the following persons:

Anders Karlqvist, who started the process, Gunnar Hoppe, who solved the economical problems, Marika Lönnroth Carlsson who transformed the raw material into a printable manuscript and the publishing house, Streiffert Förlag, who are responsible for the technical production of *High Latitudes*.

To all persons mentioned in this foreword I herewith present my deepest gratitude.

Uppsala in June 1993

Gösta H. Liljequist

THE PIONEERS

1758–1863

1. THE FIRST SWEDISH SCIENTIST TO GO NORTH: ANTON ROLANDSON MARTIN (1729–1786)

Polar exploration goes back to the middle of the 16th century, when England and Holland attempted to find sea routes to the Far East north of the continents of Asia and North America, in order to avoid threats from Spain and Portugal on the southern routes around the tips of Africa and South America.

England and Holland never actually found the sea routes they were after, namely the North-East and the North-West Passages, but they gathered some knowledge of the arctic regions. These early voyages led among other things to the development of an intensive whaling industry in the seas off Svalbard and Greenland from the beginning of the 17th century onward, lasting for almost 300 years.

The quest for the North-East and the North-West Passages remained for more than 300 years the principal aim of polar exploration. Throughout this time England was the leading nation in the field, although competing with Holland during the first decades. Other nations came into the field later on, Sweden entering as late as 1755. Sweden embarked upon whaling in Spitsbergen waters on a very modest scale. Ships were sent north from both Göteborg and Stockholm, at a time when the whaling in those waters was declining.

Many of the pupils of the great Swedish naturalist Carl von Linné (1707–78) became well-known in natural science. Often they travelled to faraway lands in the pursuit of their studies.

Anton Rolandson Martin (1729–86) became a pupil of Linné in 1758. He was of Walloon descent, his grandfather having come to Sweden in the latter half of the 17th century, where he married.

Martin's studies were at first concerned with music and languages, but in 1750 botany became a main interest. He went to Uppsala in 1756, where he became acquainted with Linné. Two years later Linné proposed that he should set out on a voyage to the "North Pole" on board a ship of the Swedish whaling society in Göteborg, the Greenland Company.

This company had been founded in the middle of the 18th century, and in 1755 a ship was dispatched to the Arctic for the first time. It is characteristic of the time that a naturalist was invited by the Company to take part in a cruise.

It was one of the members of the Company, Pehr Samuel Bagge, who in this way initiated early Swedish

polar research, and it was through the assistance of Linné that Anton Rolandson Martin became the first Swedish polar scientist. Martin got a grant from the Royal Swedish Academy of Sciences, while the Company supplied free board and lodging on the ship. Martin's borrowed instruments were a thermometer, an azimuth compass and a quadrant. In addition, a member of the Royal Swedish Academy of Sciences supplied him with Bishop Erik Pontoppidan's work *The Natural History of Norway*, printed in 1752–54.

On April 17, 1758 the whaling ship *De Visser*, with a Dutch crew, set out from Göteborg on her arctic voyage. On the same day Martin began his meteorological observations, which were carried out three times daily at about 00.00h, 06.00h and 12.00h. He noted the temperature of the air, the wind direction, and the weather that had been prevailing or most characteristic during the day. His thermometer, which was freely suspended in the shade, had been carefully adjusted, and in the account of the voyage he proudly puts the question whether anybody had ever before tried to ascertain the character of the climate so far north by using an accurate thermometer.

After the cruise he supplied the Academy with his meteorological observations—printed in the *Journal* of the Royal Swedish Academy in the same year—and also with an account of his travels, which was not published until 1881, by the Swedish Society of Anthropology and Geography (SSAG) in its journal *Ymer*.

The travel account reveals Martin as a keen observer both of life at sea and of the natural surroundings. He supplied vivid descriptions of life on board, and of the whaling operations as far as he had the possibility to see them. But above all, he was a scientific observer, primarily in zoology and botany. He also supplied information on the history of Spitsbergen and on the whaling industry there. The voyage lasted from April 17 to July 29, and during this time only one visit was paid ashore: a few hours' stay on some islets off the western coast of Spitsbergen. The fjords and the coast were blocked by ice, which Martin found very frustrating.

On May 14 the first whales were noticed, 20 in number, and sloops were launched. Two whales came dangerously close to one of the boats. But the whales disappeared unhurt into the ice and none were caught. During the rest of the cruise, the outcome was the same—a disappointment, of course, or even a tragedy to the crew of the ship. But Martin had ample opportunities to observe animal life on the ice and in the open sea, to visit whaling ships of other nations, and to register the state of the ice, where the *De Visser* occasionally became "beset", a few times even for several days.

Anton Rolandson Martin (1729–1786). The first Swedish scientist to explore the north. (Royal Swedish Academy of Sciences.)

Cochlearia groenlandica, the small herb containing ascorbic acid, was chewed by the seafarers to avoid scurvy. This particular specimen, from Linné's herbarium now in the Swedish Museum of Natural History, was collected in 1758 by Martin during his voyage to the Arctic (right). Photo: Lars Falck.

The Arctic fulmar (*Fulmaris glacialis*). Martin was fascinated by its flight.

Photo: Lars Falck.

Not shown in digital edition

Early whaling in Spitsbergen. Detail from a painting by Cornelis de Man, Rijksmuseum, Amsterdam. Photo: Fred Goldberg.

He also visited other ships which had recently obtained a catch. He studied the whales from a zoological point of view, and in one ship he was presented with the eye of a whale to dissect. He observed seals, which were so alert that they could not be shot.

Already on the outward voyage, Martin had been fascinated by the gliding flight of the fulmar (*Fulmarus glacialis*), called Procellaria by him. Now in Spitsbergen waters he took the chance to observe the greediness of this bird, as well as its foolhardiness when gorging upon offal and garbage from the ship. After Martin's return home he wrote *Beskrifning på en Procellaria, som finnes vid Norr-polen* (Description of a Procellaria which is found at the North-Pole), a short article on the fulmar, which was printed in the Journal of the Royal Swedish Academy of Sciences in 1759.

Time passed, and still no catches—and, most deplorable to Martin, still no visits ashore, where he might have noticed something “remarkable”. He knew that there were vessels in the English harbour in Magdalenefjorden, but he could not persuade the ship's company to go there. On July 1, however, two sloops were rowed to some islets west of Spitsbergen near the Foreland. Only the hillocks were free of snow and full of brooding eider ducks; in the lower reaches, the men had to wade knee-deep in the snow. But they got what they had come for, a good catch of birds and eggs. The visit ashore lasted only a few hours; it started to blow, so they had to return aboard. Later they tried to fetch water for the ship, but the ice and a calm now prevented them from reaching shore. Nonetheless, they considered that they had enough drinking-water on board for the voyage home.

With every day the economic losses of the Company increased, and on July 4 the ship was steered south. The expedition had become an utter failure from an economic point of view. Everyone on board was discontented, especially the harpooners who would gain no profit at all from the voyage.

Before the expedition left Spitsbergen waters, at 76°N, Martin determined the water temperature at a depth of 8 fathoms (14 m) and found it to be +3°C. Besides, he took a water sample for determining the salinity at 18 fathoms (32 m). In the former case he used a bucket filled with sand into which the thermometer was thrust. By letting the bucket stay for six minutes at the depth chosen, he hoped to get a fairly correct reading. A water sample was obtained by lowering a corked empty jar to the depth chosen and uncorking it there.

On July 29, the ship reached Göteborg to find that almost a third of this beautiful town had been reduced to ashes by a conflagration.

Martin's later career was chequered. After return-

ing from the arctic voyage he wrote his travel account, edited his meteorological log and his notes on the northern fulmar, all of which he gave to the Royal Swedish Academy of Sciences. In 1759-60 he had an opportunity to visit Norway, but the account of this journey has been lost.

In 1761 he became a Bachelor of Medicine (B.M.) at Uppsala University, but soon afterwards he was attacked by gangrene in one leg, which had to be amputated. He gave up his medical studies and turned to chemistry. Living in great misery in Finland, he continued to send the Academy articles about diverse findings, and some of these contributions were printed. He was dependent on the grants he obtained from the Academy. His life turned into a series of sufferings and disappointments, and he considered that all his pains and labour in the service of science should have been worthy of a better fate. Martin died in 1786.

Martin's visit to the Arctic did not inspire other Swedish natural scientists to go north. Yet in remembrance of his visit to Spitsbergen, two geographical features received his name: *Kapp Martin*, north of the entrance to Bellsund, and *Martinbreen*, a glacier to the north of Van Keulenfjorden. Martinfjella to the east of Recherchefjorden are, however, not named after him.

2. SVEN LOVÉN'S TRAVELS IN NORWEGIAN FINNMARKA AND IN SPITSBERGEN 1836-1837

Seventy-nine years were to pass before a Swedish scientist next visited the Arctic. This expedition was undertaken in the summer of 1837 by a young zoologist of Lund University, *Sven Lovén* (1809-95). Martin's visit to the Arctic had been an isolated occurrence in time, and it had been planned by others: the Greenland Company in Göteborg, and Carl von Linné in Uppsala. Lovén's expedition to Spitsbergen was planned and executed by himself, a young zoologist who had no prior experience of polar travel, nor indeed any relations with people who did.

Lovén had begun his studies in natural science in 1824. It was a period when Lund University possessed several able naturalists. However, none of them had any previous polar connections when Lovén planned his expedition (compare p. 18).

Lovén had originally intended to devote himself to ornithology; but after a visit to Berlin in 1830-31, he changed his mind and turned to research on marine

invertebrates. This faunal group was almost unknown at the time, and Lovén was destined to gain world fame. His interest in ornithology was, however, to remain with him.

In June 1836, Lovén boarded the schooner *Johannes* in the Weser estuary. His destination was the town of Hammerfest in northernmost Norway, the province of Finnmark. He stayed in that region for a whole year, occupied with studies and collecting samples of the marine fauna. It was a well-spent interval. He got to know this distant corner of Europe towards the Arctic, and not only from a zoological point of view; he also became acquainted with its population and its way of life, trade and economy.

He travelled, by boat and by reindeer-drawn sledge, all over the region, from Vardö and Vadsö in the north-east to Lofoten and the Swedish Karesuando in the south. It is fair to recall that the region was extremely remote in those days.

In the late spring of 1837, he was busily engaged in Hammerfest preparing his Spitsbergen tour, which he paid for out of his own pocket. He hired the small schooner *Enigheten*, with a crew of six, including the skipper Andrew Michelsen.

The expedition left Hammerfest on June 19, 1837. Three days later Björnöya was sighted, but a landing was not attempted owing to banks of fog near the island. During June 24–30 the ship had to endure a gale followed by fog or headwinds. Ever since his departure from Hammerfest, Lovén had only managed to carry out *one* zoological dredging.

On July 7, Prins Karls Forland was sighted, a mountainous land covered in snow, and next day the pyramidal mountains of Daudmannen appeared out of the fog which covered the mainland. Auks and whales came close to the ship. All the miseries of the crossing to Spitsbergen were now forgotten, and Lovén was filled with hope and excitement over the scenery and the prospects of rich scientific harvests.

During July 10–18 the *Enigheten* was at anchor in Grönfjorden. Here Lovén alternated his scientific work with participation in the crew's walrus and reindeer hunting. He also got to know an arctic bird-cliff; his notes on the occasion are filled with youthful enthusiasm.

On July 18 the *Enigheten* steered north. Apparently the ship proceeded west of the Forland, as Lovén mentions that the depth did not allow any bottom dredgings. On the 23rd, Krossfjorden was reached, and the ship anchored on the west side of the fjord in a bay, called Ebeltoftthamna by later Swedish expeditions. Here were many relics of past hunting activity: numerous graves of Dutch whalers, a few Russian crosses, and a hut belonging to a Hammerfest hunter.

However, the dredgings gave no results; the bottom was extremely poor in life. Lovén therefore joined a boat trip to Kongsfjorden. He was landed on its southern side and walked eastwards along the shore, while the boat followed him at some distance. At the end of the fjord they visited the group of seven islets which are now called Lovénöyane. The scenery was enchanting, with the big calving glacier close at hand and the surrounding mountains. There were many eider-ducks on the islets. But the place was dangerous; the party was caught by the ice, and had to steer westward in a severe gale to the ship and safety.

On the same day they sailed south, but an easterly gale prevented her from entering Isfjorden and Bellsund. Lovén decided on July 3 to turn south for Björnöya "to get at least something done". Yet ice surrounded the island, so the ship proceeded to Norway, which was sighted on August 7. On November 8, 1837, he was back in Sweden.

Lovén was dissatisfied with his Spitsbergen expedition, which he had begun with such high expectations. His collections for Swedish museums, though, were rich and valuable. During his travels he had also carried out geological and geographical observations, but above all he had obtained a profound knowledge of the Arctic and of northern marine fauna. Many years later, these lessons allowed him to interpret finds of shells in subgeological banks in southern Sweden. This fauna indicated a once arctic climate here, apparently not so very long ago. He was also the first to discover animal fossils in Spitsbergen from the Carboniferous and the Jurassic periods, which contributed to knowledge of the climate of those epochs.

The expedition of 1837 was Lovén's first—and last—visit to the Arctic. Subsequently, however, he contributed to Swedish polar exploration by inspiring and encouraging young Swedish researchers. He contributed decisively to the launching, in 1858, of the long series of Swedish scientific polar expeditions. He has often been referred to as "the father of Swedish polar exploration", though this honour should in justice be paid to Otto Martin Torell.

Lovén was a versatile scientist. In his specialty, marine invertebrates, he was a pioneer with world renown. He also made valuable contributions to palaeobiology. He became head of the department of invertebrates at the Swedish Museum of Natural History in Stockholm, and he founded the Marine Biological station of Kristineberg under the auspices of the Royal Swedish Academy of Sciences. This station was to become a school and a "training ground" for Swedish marine biologists.

Personally Lovén was a man who did not like to talk or write about himself. As an individual he is therefore

Sven Lovén (1809–1895) (top left). (Royal Swedish Academy of Sciences.)

A simplified version of the Spitsbergen expeditions of the Norwegian, Baltazar Mathias Keilhau (1797–1858), in 1827 and of Sven Lovén in 1837, respectively (above).

Carl Jacob Sundevall (1801–1875), zoologist and member of the French Recherche expedition in 1838 (left). (Royal Swedish Academy of Sciences.)

Aurora borealis, as documented by the French draughtsman Bevalet at Bossekop in northern Norway during the winter of 1838–1839 (below). (Royal Swedish Academy of Sciences.)

not so well known, nor are the reasons for his actions. His travel account was never printed, and only short parts of it were published until his biographer Hjalmar Théel gave it a more full treatment in 1903. This account provides a vivid description of Lovén's visit to Spitsbergen and northern Norway, and also perhaps a better view of Lovén himself than any of his contemporaries could give.

Lovén's reticence is also deep with regard to the question why he, a young man in the south of Sweden, ever got the idea of undertaking adventurous travels in the far north. Théel left this issue open. But to the present author, the answer seems to be near at hand. In the years 1827–29, the Norwegian geologist Baltazar Mathias Keilhau (1797–1858) travelled in northernmost Norway and, in the summer of 1827, visited Spitsbergen together with the German burgo-master and industrialist Barto Löwenigh (1799–1853). In 1831 Keilhau published a charming little book which vividly described his travels in 1827 and 1828. It also contained much valuable information on the nature and the history of Spitsbergen. Was Lovén inspired to make his own northern expedition by reading this book?

There exist several close similarities between the two expeditions. However, Keilhau had no followers in Norway until 1888, and it remained with Sweden to initiate a truly scientific polar exploration.

It should be remarked in this connection that Carl Jacob Sundevall, a zoologist from Lund University, in 1838 took part in the French *Recherche* Expedition which, that same year, visited more or less the same regions as Keilhau and Lovén had travelled in. However, this was two years *after* Lovén had started his expedition.

3. THE FRENCH *LA RECHERCHE* EXPEDITION OF 1838–1840

Historical background. Expedition members.

The French scientific expedition of 1838–40 with the corvette *La Recherche* was in many respects a remarkable enterprise. Its interdisciplinary studies were carried out mainly in northernmost Norway and Sweden, but short visits were paid to Spitsbergen. The studies were not merely in natural history: humanistic research was also undertaken in ethnology, sociology and literature. Moreover, skilled artists helped to document the proceedings and to illustrate the scenery, landscape forms and scientific work.

The French fisheries near Iceland were the original cause of the dispatch of *La Recherche* to northern waters. In 1833 the French patrol ship *La Lilloise*, under de Blossville, penetrated the East Greenland ice pack after completing its mission at Iceland, to try and reach the Greenland coast. But the ship was never heard of again. Search expeditions were sent out during the three following summers in a desperate hope of finding the expedition—or remains of it. Nothing was seen that could elucidate the fate of *La Lilloise*. In 1835–36 the search was carried out with a corvette, *La Recherche*, which had been specially built for the purpose. With her went several scientists, and they made the voyage a scientific success, compensating for its humanitarian failure. Several of them were to take part in the *Recherche* expeditions of 1838–40, and one, the naval doctor Paul Gaimard (1796–1858), became the leader of the expeditions of 1836 and 1838–40.

Gaimard was the heart and soul of the *Recherche* expedition, and so was—at home in France—the King, Louis Philippe. As a noble in exile from revolutionary France, the latter had spent half of the year 1795 in Norway, also visiting Nordkapp. He was fascinated by the Norwegian landscapes and by the friendly manners of the people. For the rest of his life he maintained a great interest in the Nordic peoples and their culture. This explains his great concern with the *Recherche* expedition, and his invitation to scientists and other representatives from Scandinavia to join the expedition.

The Scandinavian members were:

SWEDISH MEMBERS

Carl Bertil Lilliehöök (1809–90), naval officer and physicist.

Per Adam Siljeström (1815–92), Ph.D., physicist.

Carl Jacob Sundevall (1801–75), Ph.D., zoologist.

Ulrik Vilhelm Gyldenstolpe (1808–63), army captain.

Lars Levi Læstadius (1800–61), vicar in Karesuando, expert on the flora of Lapland and on Lapp culture.

NORWEGIAN MEMBERS

C.P.B. Boeck (1798–1877), physician and zoologist.

E.G. Meyer (1800–78), army captain and staff officer.

C. Due (1805–93), naval lieutenant: hydrographic surveying and geomagnetic observations.

DANISH MEMBERS

J.M. Vahl (1796–1854), botanist.

H. Krøyer (1799–1871), zoologist.

Lilliehöök and Siljeström played an important role in the observational work of the expedition. Their names

are connected with several of its scientific publications. Sundevall's name is, however, not found in the official publications, which omitted zoology; the series was not completed. Læstadius served as guide and host to those expedition members who travelled overland to their respective homes; he also introduced the expedition members to the flora and culture of Lapland. Gyldenstolpe took some part in the observational work.

Among the French expedition members should be mentioned:

P. Gaimard (1796–1858), leader of the expedition, medical officer and natural scientist.

M. Fabvre, lieutenant, commander of *La Recherche*.

X. Marmier (1809–92), author, documenting the expedition.

V. Lottin, lieutenant, physicist.

A. Bravais (1811–63), naval officer, astronomer and physicist.

E. Robert, geologist and mineralogist.

R. Anglais, meteorologist.

Ch. F. Martins (b. 1806), medical officer, botanist and meteorologist.

A.E.F. Mayer (1805–90), seascape and landscape painter.

Bevalet, draughtsman.

These two artists as well as the literary member, Marmier, have left us excellent documentation of the expedition and its work.

THE EVENTS OF THE FIRST YEAR 1838–1839

The routes followed by the expedition are given in Fig. p. 20. As can be seen from the map, Hammerfest in northernmost Norway served as a centre for investigations of the northern lands and seas.

During the first two summers—1838 and 1839—a few weeks were spent at Spitsbergen, in the Bellsund region and in Magdalenefjorden respectively, to which regions the main observational activity in Spitsbergen was concentrated. At the end of this period, only a few of the scientific staff travelled home on *La Recherche*. Most of them returned overland, via Kautokeino and Karesuando. Much valuable information on the flora and culture of Finnmarka and Lapland was then supplied to the French members by the vicar in Karesuando, Sweden, L.L. Læstadius.

During the winter 1838–39, a scientific station was operated at Bossekop, situated at Altafjorden. Five men, among them two Swedish members, spent the season here occupied with geophysical observations.

The *Recherche* expedition of 1840 has not been documented, except in the form of charts and tables

giving the routes and the positions of the ship. During this summer the expedition seems to have had the character of an oceanographic cruise. It covered a wide area, from Iceland and the Faeroes in the west to the White Sea in the north-east.

There were no Swedish participants in the cruises of 1839 and 1840. We will therefore mainly limit ourselves to describing activities during the summer of 1838 and the overwintering at Bossekop in 1838–39.

The summer work in 1838 was delayed by a month and a half, because the ship had to be overhauled after a tropical voyage which immediately preceded its northern cruise. Not until July 13 did it reach Hammerfest, and only two days later the Spitsbergen cruise began.

On July 25 the *Recherche* anchored in Bellsund, to stay there until August 5. The Bellsund region was studied, and an observatory was set up in the southwestern part of Recherchefjorden, near the mountain named Observatoriefjellet (565 m a.s.l.). Observations in natural science were performed, but the visit was short. Gaimard was worried over the risk of being caught by the ice. He also had to consider the planned overland journey through Finnmarka, which must not be delayed too much to avoid the autumn's low temperature and unsettled weather.

A visit to Björnöya was given up, chiefly owing to ice. On August 12, *La Recherche* was back in Hammerfest; and on August 29 she left for France. Only three of the expedition members sailed on her, the rest intending to travel in a group or alone, and five men were to spend the winter at Altafjorden.

The geophysical observatory at Bossekop

Gaimard had originally wanted to locate his observatory at Hammerfest. But the Norwegian members, Due and Meyer, advised him to choose Bossekop at Altafjorden (lat. 70°N, long. 23°E), where the cloud conditions would better suit the aurora observations. This was a happy decision.

The five men overwintering at Bossekop were the French physicists Bravais and Lottin, the Swedish physicists Lilliehöök and Siljeström, and the French draughtsman Bevalet. After intensive work with mounting the instruments and constructing observation pavilions, the observations were started on September 6. The programme consisted of meteorological observations, geomagnetic measurements, and observations of the water-level of the sea.

Once the nights had become dark, *aurora* observations were added to the programme. Bevalet did fine work in his visual documentation of these bewitching light-phenomena. Attempts were also made to meas-

The routes of *La Recherche* in 1838–1840. The French King Louis Philippe had a great interest in Nordic people. Scientists from Scandinavia were therefore invited to join the expedition. (Nissen, Norsk Geografisk Tidsskrift 1940/41.)

The French corvette *La Recherche*.
(Nissen, Norsk Geografisk Tidsskrift 1940/41.)

ure the height of the aurora above the Earth's surface. For that purpose two stations are needed at some distance from each other. Lacking telephone, radio or photography, this was a delicate and somewhat unreliable procedure. Simultaneous sketches from the two stations were required, allowing determination of the aurora's position in relation to certain stars. A value of about 100 km was obtained, which roughly corresponds to later measurements. Bevalet's drawings of the aurora drew public attention to the aurora phenomenon itself. The meteorological observations were later taken over by the engineers at the adjacent copperworks of Kåfjord, and in this way a complete five-year series of observations could be secured.

In addition, temperature measurements were made in the free atmosphere—up to 450 m a.s.l.—with the help of fettered balloons. During the winter it was occasionally found to be warmer in the upper layers than near the surface, a most surprising result at that time.

Another important discovery was made by Bravais. Outside the expedition programme he had begun a study of previous shorelines on the mountain slopes. He found that these shorelines were situated at a higher level along the fjord than on the outskirts of the archipelago. This was amazing, as the respective shorelines were expected to occur at the *same* level—unless the land had become more uplifted inland than along the coast proper, as we now know to be the case. When the nights became light again in April, the observations at Bossekop were discontinued and the observers travelled homeward along different routes, except Bravais who stayed over the summer to complete his observations on the shorelines.

The activity at Bossekop made the place known internationally and directed the interest of the scientific world towards the phenomenon of the aurora borealis. Bossekop was often used in later years, especially for studies of the aurora. Norway employed it as an observatory-post during the First and Second Polar Years, 1882–83 and 1932–33. The two Norwegian scientists Kristian Birkeland (1867–1917) and Carl Störmer (1874–1957) took advantage of Bossekop for their epoch-making investigations of the aurora, the former around the turn of the century, the latter in 1910 and afterward.

Through Finnmarka and Lapland

As mentioned, groups of scientists travelled overland in the autumn of 1838 on the way to their respective homes. A few words may be said here concerning one of these groups. Its route passed through Finnmark and Lapland via Kautokeino and Karesuando, then southward through Sweden. The journey was vividly

described by Marmier, but no artist took part in the tour. Lars Levi Læstadius was the host in Karesuando, and Gaimard was interested to learn about his meteorological observations from this place, which were later included in the expedition reports. Gaimard was also impressed by Læstadius' knowledge of the Lapland flora and of the mythology of the Lapps.

THE EVENTS IN THE SUMMERS OF 1839 AND 1840

There were no Swedish members in the expeditions during the following two years. No overwintering was then attempted, but a visit to Spitsbergen occurred in 1839, this time to Magdalenefjorden at the north-west corner of the main island. Observations were carried out here for two weeks, July 31–August 13. A landing was also made on Björnöya.

As in the previous year, several expedition members travelled home overland via Karesuando, where Læstadius was the host of the parties. In regard to the activity in 1840, see p. 19.

A FEW COMMENTS

The French *Recherche* expedition of 1838–40 was a most remarkable scientific venture. Its programme was interdisciplinary and included humanistic as well as naturalistic studies. A notable feature was the opportunity offered to Scandinavian scientists for carrying out research on virgin soil.

However, the ambitions were too high in relation to the time allowed. Besides, the scientific work on board was hampered by lack of space, and the publication of the results had to be restricted. Nevertheless, the expedition's scientific results were substantial and important.

In many ways the *Recherche* expedition anticipated the later Polar Years or Geophysical Years. Its interdisciplinary aspects also heralded those of the Swedish polar expeditions which, from 1858, were organized and led by Otto Torell and Adolf Erik Nordenskiöld.

None of the Swedish and Norwegian expedition members visited the polar regions in the following years. However, some of them were to inspire others to go north. Most significantly, the zoologist Sundevall induced Otto Torell to give up a proposed medical career for studies and research in natural science—zoology and geology. This, in turn, led to Torell's foundation of systematic interdisciplinary polar exploration (compare p. 38).

4. OTTO TORELL (1828–1900)

A STUDENT OF THE ICE AGE AND AN INITIATOR OF SCIENTIFIC POLAR EXPLORATION

The very first Swedish contributions to arctic research had consisted of isolated ventures: they were not immediately followed by new expeditions aiming at a systematic study of the Arctic. Not until the end of the 1850s did such a development take place, and it was started primarily by one man, Otto Martin Torell (1828–1900).

Torell is rightly looked upon as “the father of Swedish polar exploration”. Even more, he is considered to be the initiator of *scientific* polar exploration. It will therefore be necessary to review his life and consider the factors and events which contributed to his scientific achievements, notably those in the polar regions—particularly since his plans did not have such an orientation from the outset.

Torell spent his early years at the coastal town of Varberg in southwestern Sweden. His father, a district medical officer specializing in eye surgery, died when the boy was very young, and his education was taken over by an uncle. Maturing quickly, he grew up with few relationships among people of his own age; and even later in life, he had no need of intercourse with others. Instead he devoted his time to studies and research, although he did not appear to be overly bookish or aloof from the world.

Otto Torell and the hypothesis of an Ice Age

Torell's interest in marine fauna had been awakened early. Already at the age of sixteen he entered Lund University. A deciding factor in Torell's studies was his acquaintance with Sven Lovén, from 1848 and onwards. Lovén directed his studies and introduced him to the marine fauna of the Swedish westcoast. When he studied the subfossil shells in banks in southern Sweden, he got to know an arctic marine fauna which had lived in the seas of Scandinavia. This indicated a cold climate in fairly recent ages, as Lovén had maintained (see p. 15).

The fact that the climate in southern Scandinavia had been arctic encouraged Torell to hypothesize an Ice Age, which was most unorthodox at that time. It did not, of course, mean that the land had been covered by a vast ice-sheet, far from any mountains. One had to learn the genesis of the loose earth-layers. This problem carried Torell further into the question of an Ice Age, and also led him to initiate scientific polar exploration. If large ice masses on land had once

existed in Europe, moraines and other glacial deposits must also exist in the lowlands, not only in and near the mountains where glaciers could easily form.

The idea of Scandinavian inland ice faced strong resistance from contemporary geographers and geologists. Theories of a mighty flow of boulders and pebbles, as the cause of striae and upper strata, still had many supporters. To explain erratic boulders, a “drift theory” was invoked: enormous blocks had been transported by icebergs over long distances across an ancient ocean and were deposited after the ice began to melt on the way.

Another theory envisaged a “fund” of snow and ice situated around the North Pole. It was characteristic that none of the scientists who advocated such theories had any deep knowledge of *existing* glaciers, inland ice, or glacial deposits and striae. Their hypotheses were not based upon field observations, but were simply desktop constructions.

Torell's ambition was to study the glaciers and inland-ice, and their deposits and striae in different geographical regions. This was made possible by the parental inheritance which he received in 1857 when his mother died. But already a year earlier he had been able to embark upon his studies of glacial geology, beginning with Switzerland and followed by Scandinavia, Iceland, Spitsbergen, and Greenland. These studies in regions of distinct character gave him a thorough knowledge of glacial phenomena. Not least, he could now recognize glacial deposits when they were found far away from any existing land ice and, therefore, must be relics from previous land ice.

Torell's field observations were to lay the foundation for a more realistic conception of the latest Pleistocene glaciation.

PREPARATORY EXPEDITIONS 1856–1859

In 1856–59 Torell carried out the following preparatory expeditions, partly for studying glacial geology and marine zoology, and partly in anticipation of his principal arctic venture, the large, interdisciplinary Spitsbergen expedition of 1861:

1856 A visit to Switzerland together with the geologist N.O. Gadde for studying glaciers and their deposits and other geological effects. Torell's loyal assistant Anders Jacobson (b. 1792) a fisherman from the Swedish west coast, accompanied him.

1857 A visit to Iceland—lasting about six months—for studying glaciers and glacial geology as well as marine zoology. Torell was accompanied by N.O. Gadde and the assistants Anders Jacobson and Cato.

1858 A reconnaissance along the west coast of Spits-

Otto Torell's preparatory expedition to Iceland in 1857. Glaciers, glacial geology and marine zoology were studied during the six-month visit. Routes and places of sojourn are schematic.

Otto Torell (1828-1900) initiated a systematic scientific polar research. (Nordenskiöld, A.E.: Den andra Dicksonska expeditionen till Grönland.)

Torell's preparatory Spitsbergen expedition in 1858. This was a mere reconnaissance tour along the west coast. Routes and places of sojourn are schematic.

bergen on board a small Norwegian fishing vessel, the *Frithjof* of Hammerfest.

Torell was accompanied by the Finland-Swedish mineralogist Adolf Erik Nordenskiöld (1832–1901), the young zoologist August Quennerstedt (1837–1926) from Lund, and Torell's assistant Anders Jacobson.

1859 A visit to western Greenland together with Anders Jacobson. They travelled by ship belonging to the Danish Trade, visited Upernavik (lat. 73°N) in the north, climbed the slopes of the inland ice and carried out zoological dredgings in the coastal waters.

Torell's preparatory expeditions, which he financed from his own pocket, gave him a deep knowledge of the glaciers, ice-caps and inland ice within climatically contrasting regions. As a result, Torell knew what he was talking about when he later embarked upon his studies of the latest Pleistocene glaciation in Europe, the Weichsel or Würm glaciation. He earned world fame in this discipline.

However, Torell's biographer, Leonard Holmström, notes his sketchy descriptions and his unwillingness to write about his undertakings. The list of his publications is strikingly meagre in terms of both titles and total pages. Torell's preparatory expeditions are therefore badly documented with regard to their events. The Iceland expedition was described in letters to Sven Lovén, who was thus able to give a fairly short summary of the investigations and the route followed. The Greenland visit is practically not documented at all, and from the Spitsbergen expedition of 1858 only brief notes were published by Nordenskiöld, Quennerstedt and Chydenius (see List of References, p. 585); Torell's own travel account was delivered to the Royal Swedish Academy of Sciences, but it was not printed. To the list above, a few comments should be added.

The *Iceland* expedition started at the north-eastern corner of the island and ended at the north coast to the west of Akureyri. Travelling was hard, and at times filled with great hardships, especially the passage with ten horses along the eastern and south-western margin of the vast ice-cap of Vatnajökull. And the two assistants, who carried out zoological dredgings along the coast in the north-east and near Reykjavik, had to battle with stormy weather.

THE SPITSBERGEN EXPEDITION OF 1858

The Spitsbergen expedition of 1858 was favoured by luck: the weather was fine, and ice was only met with north of Björnöya on the outward voyage. The expedition covered the Spitsbergen west coast from

Hornsund in the south to Klovningen in the north. Almost the whole of July was spent in the Bellsund area, where collections of plants and animals were gathered from land and sea. Plant fossils from the Tertiary were discovered, and from the Carboniferous period in almost vertical strata, as Nordenskiöld assessed. On the homeward passage a week was spent in Adventfjorden with new finds of Tertiary fossil plants. The plans included a visit to Tusenöyane in the south-east, but hard headwinds prevented the visit, and on August 28 they were back in Hammerfest.

To Nordenskiöld, Spitsbergen seemed an ideal land with easily accessible strata from different geological periods and with no high vegetation to hide the stratification. And, not least important, the fossils could be used for dating the strata and for determining the plant or animal life and the climatic conditions in bygone ages. All this was still almost unknown to science, and Nordenskiöld wanted to return.

To Torell the expedition was only part of his studies of glacial geology and the Ice-Age problem. He viewed it also as preparation for a new and greater arctic venture. For Quennerstedt, the Spitsbergen visit opened a gateway to an academic career at Lund University. A scientific arctic Eldorado had opened up to scientists.

5. TORELL'S SPITSBERGEN EXPEDITION OF 1861

Plans and preparations

Torell planned a new and larger Spitsbergen expedition for 1860. A contribution for it had been granted by the Swedish Parliament, though it was pointed out that further means had to be obtained from private sources.

However, it proved to be necessary to delay the departure of the expedition until 1861.

In 1860 Torell went to London to see Leopold McClintock and Sherard Osborne, two famous naval officers from the Franklin search expeditions, in order to discuss equipment and arctic travel technique. He discussed scientific matters with Sir Roderick Murchison, the geographer and geologist who was president of the Royal Geographical Society. In København (Copenhagen) he met the arctic travel expert Carl Petersen, who had been a member of three Franklin search expeditions, and who now consented to take part in Torell's expedition as arctic expert and adviser.

Torell even had time to visit glaciers in northern Scandinavia, and in the autumn he met Norwegian

Svalbard as it was known and delineated when the Swedish research in the area opened in the middle of the 19th century. The map is taken from Bellin: *Petit Atlas Maritime*, Paris 1764. This map is based on the chart of Giles and Rep from 1707–1720.

sealers to collect advice and fresh information.

During the expedition of 1858, Torell had noted how much time was wasted in fine-weather periods with no wind, when sailing vessels were used. In vain he had tried to obtain McClintock's ship the *Fox*, which had a "screw". He was forced to accept sailing vessels.

The Royal Swedish Academy of Sciences approved of his new plans for the expedition, which tended to grow as time passed. However, the government provided additional means and Crown Prince Oscar—later King Oscar II—contributed to make up for the deficiencies.

Torell's plans were in brief:

1. Interdisciplinary studies of Svalbard and the seas adjacent to it.
2. Reconnaissance for establishing a triangulation network for future measurement of an arc of meridian.
3. A sledge tour northward over the pack-ice of the Polar Sea, starting from Sjuöyane. The highest possible latitude was aimed at, as discoveries of new land might also result.

Among the scientific projects it is natural that Torell's studies of the land ice of Svalbard took high priority. But the zoological and botanical investigations were also expected to give valuable results, not least the dredgings in the sea. Moreover, the programme included geomagnetic, meteorological and oceanographic observations.

Reconnaissance to determine a triangular network for the measurement of an arc-of-meridian had been proposed already in 1826 by the prominent British geophysicist Edward Sabine (1788–1883), who in 1823 had joined an expedition with the British gunboat *Gripen* under Captain Douglas Clavering. During the expedition Sabine carried out pendulum observations in Norway, Spitsbergen and north-eastern Greenland, and also in lower latitudes. In Spitsbergen he had chosen his observatory on Indre Norsköya at the north-west corner of the main island, where markings of the place are still to be seen.

Sabine was aware of the favourable conditions in Spitsbergen for measuring an arc-of-meridian at a very high latitude, which was desired in order to estimate the Earth's ellipsoidal form by comparing the results with other observations obtained in lower latitudes. Sabine even offered himself to carry out a reconnaissance for the purpose, if the Admiralty placed a small ship at his disposal. But Sabine's scheme had no practical result—nor did a new proposal in 1843—until in 1860 Torell included the reconnaissance in his plans for his own expedition.

To facilitate the reconnaissance of the trigonometric chain stretching from Sjuöyane in the north via Hinlopenstretet to Sörkapp in the south, Torell needed two ships, one to be used for the northern part of the network and the other for the southern. Two small Norwegian sealers were hired, the brigantine *Aeolus* and the hunting yacht *Magdalena*.

Expedition members

Torell had managed to collect an impressive scientific staff. The members were assigned to the two ships as follows:

The brigantine *Aeolus*

Otto Martin Torell (1828–1900), Ph.D.; geology, glaciology and zoology; leader of the expedition.

Adolf Erik Nordenskiöld (1832–1901), Ph.D.; geology, astronomical determinations of position; second leader of the expedition.

Gustaf Bertil Lilliehöök (1836–99), lieutenant, commander of the *Aeolus*.

Anders Johan Malmgren (1834–97), from Finland; M.Sc.; zoology and botany.

Jakob Karl Emil Chydenius (1833–64), from Finland, M.Sc.; physicist, responsible for the reconnaissance of the triangulation network.

Carl Petersen, from Denmark, arctic expert and adviser to the expedition.

E. Breii, from Norway, mate, expert on ice navigation.

Anders Jacobson (b. 1792), fisherman, assistant in the zoological work.

The sailing yacht *Magdalena*

Johan Vilhelm Kuylenstierna (1822–81), captain in the merchant service, commander of the *Magdalena*.

Fritz Mack (1837–76), from Tromsø, Norway, mate, expert on ice navigation.

Christian Vilhelm Blomstrand (1826–97), Ph.D., chemistry and geology, scientific leader of the *Magdalena* group.

Nils Christofer Dunér (1834–1914), Ph.D. (1862), astronomer and physicist, responsible for the astronomical determinations of position and for the reconnaissance of the southern part of the triangulation network.

Axel Theodor Goës (1835–97), medical student (medical practitioner 1864), zoologist, botanist and doctor.

Fredrik (Frits) Adam Smitt (1839–1904), undergraduate (Ph.D. 1863), zoologist and botanist.

Gerhard Olof Justin von Yhlen (1819–1909), sportsman, zoologist and draughtsman.

The crews of the two ships were mainly Norwegian and mostly coming from Tromsø. The two mates

The *Aeolus* of the Torell expedition, 1861. This ship worked mainly in Hinlopenstretet and along the coastal areas of north-western Nordaustlandet. (Chydenius: Svenska expeditionen till Spetsbergen 1861.)

The *Magdalena* worked along the Spitsbergen north- and north-west coasts, 1861. (Chydenius: Svenska expeditionen till Spetsbergen 1861.)

Dirksodden with its Russian hut situated at the mouth of Wijdefjorden. The site was visited by the *Magdalena*, 9 July 1861. The artist of the expedition, Gerhard von Yhlen, was onboard this ship. (Chydenius: Svenska expeditionen till Spetsbergen 1861.)

were skippers of sealing vessels, experienced in ice navigation and well at home with the small ships generally used in Svalbard waters. The crew of the *Aeolus* numbered fifteen, that of the *Magdalena* eleven.

Delayed by the ice

An early start of the expedition was considered vital. Already on April 15 the members gathered at Tromsø, but unfortunately persistent northerly winds were blowing, and not until May 10 were the two ships able to leave Norway.

Björnöya was sighted on the 12th, but ice came drifting from the north-east, and any thought of a landing had to be given up. The scientific work had by then already started: the zoologists were taking samples of the marine fauna by dredging both along the surface and in deep layers. Spitsbergen—at Bellsund—was sighted on the morning of May 21. Later in the day they passed along Prins Karls Forland and the coast of Dei Sju Isfjella.

On the 22nd they passed north of Amsterdamöya. Until then, they had not met with any ice worth mentioning, but now they did. They were held up by the ice here at the north-western corner of Spitsbergen till June 1. Winter still gripped the land: temperatures stood at -2° to -5°C , fog alternated with hard winds or calms, the land was covered with snow and the ice barred the way.

The *Magdalena* group wanted to go south to start their scientific work, but the *Aeolus* group needed assistance from the *Magdalena* and her crew, not least for transporting the expedition's boats, ten in all. The two ships pushed their way eastward through the ice, and after it had drifted northward they managed to slip into open water in the mouth of Wijdefjorden. Behind Verlegenuken lay open water, but ice barred the way. In the evening, the south-south-easterly wind increased; in the night towards the 4th and during the 4th, a full gale was blowing and there was nothing to do except beat to windward.

The land consisted of low mountains and ridges of gravel and stones, originating from a time when the ice-sheet of the land had a greater extension. To Nordenskiöld the land gave an impression of desolation and cold beyond description. However, eleven years later he would have to spend a miserable year on this very coast, at Mosselbukta.

In the night towards June 6 the ice drifted northward, and in the morning the ships passed close to Verlegenuken, running into open water in the mouth of Hinlopenstretet. But ice came drifting from the south of the strait, and as a precaution the ships entered Sorgfjorden (Treurenberg Bay) in the night towards June 7. They anchored off Gravneset on the

western side together with four Norwegian sealing vessels. Near the anchorage 30 mounds of stones marked the last resting-places of Dutch whalers from the 18th century, as stated by a tablet.

Opposite Gravneset—on the eastern side of the fjord—the ship of Sir Edward Parry, the *Hecla*, had its anchorage in a small bay, Heclahamna, during the expedition in 1827, when Parry set a northerly record by dragging two flat-bottomed boats over the polar pack-ice. The party of 28 men were absent for 61 days from their ship and reached $82^{\circ}45'\text{N}$, which remained a record for almost half a century. Now Otto Torell intended to make a similar attempt, but he was to use a more northerly starting-point, namely Sjuöyane.

Near the *Hecla* anchorage, the Swedish Arc-of-Meridian expedition was to have its winter quarters in 1899–1900.

Naturally, the captivity in Sorgfjorden gave opportunities for scientific studies. But as the days passed on, the men became restless and pessimistic, and finally they realized that the planned march northward over the ice had to be given up. The summer melting of snow and ice had begun; it was getting too late in the season.

THE AEOLUS AND THE MAGDALENA PART

It was now possible to reach a clearer decision as to the operations of the two ships. These would now separate and work independently of each other. For both groups there remained a study of the land and sea in the regions chosen, besides carrying out the reconnaissance for a future arc measurement. The reconnaissance of the southern part of the triangulation network had been allotted to *Magdalena*, mainly in the Storfjorden area; attempts were also to be made to find out whether it would be possible to carry out a triangulation along the Spitsbergen west coast. The reconnaissance from Sjuöyane and further south along Hinlopenstretet was to be performed by the *Aeolus* group. It was further decided that the *Magdalena* would sail along the north and west coasts to reach Storfjorden, while *Aeolus* remained in the area of Hinlopenstretet and off the north-western part of Nordaustlandet. Much of the scientific work would be done during extensive excursions with boats.

Such excursions were destined to become a characteristic feature of the Swedish Spitsbergen summer expeditions in the future. In the days June 30–July 2 the two ships made unsuccessful attempts to leave Sorgfjorden, but they returned because of gales which raged over the strait, while there were only light winds in the fjord. They had already come to know this characteristic feature of Hinlopenstretet.

On July 3 the *Aeolus* stood out to sea on a northerly

course under reefed sails. But after a few hours she met with pack-ice at Langgrunnodden (Shoal Point) and was forced to tack southwards against the wind, until she found shelter in the mouth of Murchisonfjorden—which now received its name—and in the lee of a small island, later named Depotöya. Here she anchored in the early morning of July 5.

The two ships then separated, to work in different regions of Svalbard. The *Magdalena*, however, remained in Sorgfjorden for another few days after the *Aeolus* had left. Reconnaissances showed that there remained much ice to the west, and Norwegian sealers supplied the same bad news. But the time they had spent in Sorgfjorden was by no means wasted. When they arrived in the beginning of June, winter still prevailed, but on the 11th the first flowers had begun to appear. With the advent of July it had definitely grown warmer, and at times +11°C was reached: summer had arrived. The botanist rejoiced at the flowers which he was finally able to collect.

Blomstrand and Dunér made a trip to the glacier in the south of the fjord and found fossils of molluscs and mussels. Meteorological and magnetic observations were carried out on a routine basis.

Agreements had been reached with the *Aeolus* group: cairns should be built at some places with information on events and courses followed—and to be followed. If the ships did not come across each other, they were to meet in the middle of September at Kobbefjorden in the west of Dansköya.

On July 7 a sealer reported open water close along the shore westward. Accompanied by two sealers the *Magdalena* followed the open lane, a visit was paid to Verlegenuken for astronomical determinations of position, and then the *Magdalena* was taken through open ice into ice-free water in the mouth of Wijdefjorden. Their captivity was by no means over, but the *Magdalena* people were glad to be rid of Sorgfjorden, and at long last—on July 10—they were able to start their scientific studies in earnest.

THE AEOLUS GROUP: BOAT EXCURSIONS IN THE NORTH OF SVALBARD *Plans and equipment*

Let us now return to the *Aeolus*. Since July 5 she was riding at anchor at Depotöya, situated in the mouth of the fjord, which the expedition later named Murchisonfjorden. This fjord was more or less unknown at the time, and the next few days were therefore devoted to a study of it.

According to the old maps, the western part of Nordaustlandet was supposed to consist of two islands, which were formed by a waterway stretching from “present-day” Wahlenbergfjorden northward

via Murchisonfjorden. The northernmost of these two islands had the name Great Stone Island (present Storsteinhalvöya) and the other was called North-East Island.

On July 6-7 Nordenskiöld, Malmgren and Petersen visited some of the islands in the mouth of Murchisonfjorden, among them Nordre Russöya with its cross and remains of a Russian hut. While Nordenskiöld was occupied with his astronomical observations, Malmgren and Petersen climbed a mountain on the north side of the fjord (210 m a.s.l., as measured by the party)—probably Floraberget of present-day maps. The view from the top showed that there was no hope of penetrating northward with the ship.

After a short visit on board on the 7th Nordenskiöld and Malmgren returned to the northern shore of the fjord and followed it on the ice, which was in a very bad state. “Great Stone Island” consisted in its western part of low hills of limestone or similar fragments, but the land rose eastward, and at places it descended steeply into the fjord. They saw great numbers of gulls, among them Ivory Gulls (*Pagophila alba*, or *eburnea*), and Malmgren was happy enough to discover the breeding-place of the species, until then entirely unknown to science, but there was no time for a closer inspection. Instead they crossed the fjord—over the ice—and reached Kvalrosshalvöya, where they spent the night under a rising gale. In the evening of July 8 they were again at the ship.

They had carried out a relatively thorough survey of Murchisonfjorden, but they had not been able to settle the question as to any eventual connection with Wahlenbergfjorden to the south or with the Polar Sea to the north.

The time had now come for starting their scientific work more systematically. Participants in the different excursions were chosen and plans were outlined.

Two groups were to investigate the northern and western parts of Nordaustlandet, including Hinlopenstretet:

1. A geographical-geological group consisting of Torell, Nordenskiöld, Petersen and four men. The small English boat was to be used, and provisions for four weeks were to be brought.
2. A reconnaissance for a future arc measurement was to be carried out by Chydenius and four men, using the iron boat. Provisions for four weeks and a reserve of pemmican for two weeks were to be taken.
3. The expedition ship *Aeolus* was to move about—in a predetermined way—in the Hinlopen and off north-western Nordaustlandet. Small excursions were to be carried out by boat, notably under Malmgren for

The *Magdalena* visited the Magdalenefjorden in the north-west corner of Spitsbergen, 27–28 July 1861. This fjord is among the most beautiful in the whole of Spitsbergen. The artist Gerhard von Yhlen worked here from Gravneset, a cemetery from the Whaling Period in Spitsbergen. (Chydenius: Svenska expeditionen till Spetsbergen 1861.)

Boat excursions were a characteristic feature of the Swedish expeditions in Spitsbergen in the latter half of the 19th century. –Preparing for the night on the beach. (Fries & Nyström: Svenska polarexpeditionen 1868 med kronångarfartyget Sofia.)

The routes of the *Aeolus* and the *Magdalena* in 1861, starting from Sorgfjorden (filled circle) and ending up at the meeting-place at Dansköya in the north-west. Shaded surfaces indicate areas where the ships passage over several days.

biological purposes. One boat with four men was reserved for those investigations.

The use of boat excursions for scientific investigations was later adopted by many other Swedish expeditions in the Svalbard region during the latter half of the 19th century. It may therefore be of some interest to study the equipment and the procedures of the geographical-geological group.

The boats were used for both transport and lodging. For the latter purpose a ridge-roofed tent could be mounted over the boat in its entire length, giving practically 100% protection from draught and rain. In the bottom of the boat a waterproof tarpaulin was placed, on which the thick felt sleeping-bags were spread. Generally the boat, when used as a lodging, was drawn up on the beach or ice. The men travelled mainly at night and slept by day. For cooking they had a stove which was heated by using tallow, but it should be noted that the beaches generally were rich in driftwood suitable for open fires.

For food they had ample stores of pork and meat, which had been boiled and/or salted. They also had ample stores of rye bread and biscuits. Further provisions were butter, pemmican, bouillon cubes, dried potatoes, tea and sugar (mixed in adjusted portions), coffee (roasted and ground) and brown sugar. Last but not least, they had 19 bottles of snaps. Besides, hunting could—if time allowed—give them almost unlimited amounts of meat from reindeer, seals and walruses, polar bears, diverse birds, and so on.

As a rule their principal meal was taken in the morning, before they crept into their sleeping-bags. It consisted of soup from game shot while travelling in the preceding night; they preferred reindeer to sea-fowl. And naturally, the cooking took place in the open air over a fire of driftwood.

Their way of life during the excursions was more or less the same every day, except for some "happenings" now and again. But the scenery varied, of course, as did their collections and scientific results. Nordaustlandet was a little-known part of Svalbard.

For the benefit of the boat parties, a depot with provisions was established on Depotöya in Murchisonfjorden.

The first boat excursion of the geographical-geological group, July 10-23 1861

The geographical-geological party began its excursion on the evening of July 10. They passed Krossöya, topped by its Russian cross, and went ashore on the southern side of Murchisonfjorden. This stretch of coast was believed to constitute the northern shore of "North-East Island" of the old charts. From the hills

above they got a fine view over the fjord, but they saw no sound separating any "North-East Island" from the rest of Nordaustlandet. They found whale bones and shells fairly high a.s.l., which indicated that the land had been rising lately. The limestone deposits, however, gave a monotonous impression to both the geologist and the botanist.

They rowed south into Hinlopenstretet following the coast of Nordaustlandet and passed the mouth of Wahlenbergfjorden. They found that the "North-East Island" of the old maps was but a protruding part of Nordaustlandet, and the sound between the two was pure guesswork.

They managed to pass through a field of "rotten" ice and reached Fosteröyane in the night towards July 13. The islets were poor in life, but the views from the peaks were fascinating, with ice-covered lands all round and walruses roaring.

They left the islands on July 13 and rowed to the south side of Wahlenbergfjorden, which differed markedly from the drab country further north. The hillsides fell steeply into the sea from 450-600 m. The grey strata were horizontal and covered on top with a black hyperite bed. Landing at several places, they found that the sedimentary strata alternated between limestone, sandstone and quartzite. They also found fossils, which indicated an origin in the Permian period. At about latitude 79° 30' N they came to a place where the hyperite formation reached the shore in the form of a black cone, Svartberget, about 150 m high. It was later used as a trigonometric station. From its top they could see that ice blocked the southern entrance to Hinlopenstretet. They had therefore to give up the plan of rowing all the way round Nordaustlandet. Instead, they decided to row along the western shore of Hinlopenstretet, in order to find the *Aeolus* and then make a second attempt to push north towards Sjuöyane.

At midnight of July 13/14 they rowed south towards Wahlbergöya, the largest of Vaigattöyane. They ran into fog and were surrounded by a great number of walruses, which had been lying upon the ice floes. Some of these did not bother about the boat; others jumped into the water, but were not at all frightened. In fact they gathered near the boat, treading water in order to get a better view of the intruders. On the whole, a remarkable number of walruses was observed by the boat party.

On the 15th they visited the interior of Wahlenbergöya, which was made up of a hyperite plateau some 30 m high, from which a small cone rose to a height of 150 m. From its top they tried in vain to discover the sound which had been reported to exist between Storfjorden and Hinlopenstretet. In the eve-

ning they rowed to Angelinberget and found it rich in fossils. They saw a vast amount of walruses, and sometimes up to 50 animals gathered round the boat.

From Angelinberget they crossed Hinlopenstretet in order to look for the sound leading to Storfjorden. They reached the western shore of Hinlopenstretet below a magnificent mountain, Lovénberget, which fell steeply into the sea. On its top was a layer of hyperite, followed by layers of limestone and sandstone rich in fossils. In the evening of the 17th they rowed southward along the coast to find the reported sound—Heleysundet—but after some 15 km of rowing the passage was blocked by pack-ice, and they had to return. They obtained fine views over the glaciated coast and could make many valuable observations, not least on the plastic properties of glacier ice. They also noted good indications that the ice here had once reached higher on the land than now. The current was in their favour, and on the evening of the 18th they reached Kapp Fanshawe at the entrance to Lomfjorden.

On the way they had passed Alkefjellet, the most impressive bird cliff they had ever seen; after a gunshot the air was virtually darkened by birds. The cliff, some 900 m high, was disintegrated into octagonal and quadrangular pillars, some of which stood alone like capitals.

They were occupied with geological work in the area during the 19th, and then sailed to Depotöya in Murchisonfjorden, but the ship was not there. After placing their geological and zoological collections into a depot, they continued sailing and camped at Langgrunnodden on the evening of July 20. Here they found enormous amounts of “debris”: driftwood, pieces of pumice, cork, floats from the fishing grounds of Lofoten, and even a bean of the West Indian species *Entada gigalobium*, the latter indicating that the Gulf Stream reaches these northern regions. The driftwood was not restricted to the beach, but was also found at higher levels, though then in a state of disintegration.

They also encountered a cairn from the *Aeolus*, with a message stating that she had visited the place on the previous day and had now sailed to Brennevinsfjorden to the north-east.

On the 21st, the boat party sailed west of Lågöya. North of this island they met a sealing vessel, and were informed that the *Aeolus* had left for Hinlopenstretet. From the mast-head of the sealer, their binoculars could make out the Chydenius boat group at the ice edge in Brennevinsfjorden. The next thing to do was, however, to perform their toilet: they lit a sparkling fire on the Lågöya beach, spread a sail as protection from the wind, dried their wet clothes,

washed and shaved themselves, and had their hair cut.

On the 22nd they rowed to Brennevinsfjorden to meet the Chydenius group. They were informed that the ship was expected back from Hinlopenstretet at any time. They decided to await its arrival at the northern entrance to the fjord—beneath a precipitous mountain, Snötoppen, which in places fell straight down to the sea or was bordered by enormous collections of stone blocks from the mountain slopes. They camped south of the top at a place they called Depotodden, where the British university expedition under A.R. Glen was to be based in 1935–36. They climbed the mountain and got a magnificent view from its top: the whole north coast of Spitsbergen was seen to the west and south, and to the north extended the ice-covered Polar Sea. To the south and south-east the view was blocked by the ice-cap of Nordaustlandet.

On July 23 the *Aeolus* was observed lying at anchor at Lågöya, and in the evening they and the Chydenius group embarked on the ship.

The second boat excursion of the geographical and geological group, July 27–August 24, 1861

This excursion undertook research work along the north coast of Nordaustlandet, including adjacent islands. The party started from Brennevinsfjorden on July 27, only four days after their return on board the *Aeolus*.

There was still much ice to the north, but it proved possible to pass between the ice and the land. At night they camped on Nordkapp. The hard southerly winds of the previous days had cleared the waters to the north, but large ice fields still drifted about; so they were satisfied not to row further than Castrénöyane, with the aim of determining their longitude by the method of moon distances. To the east they could see Kapp Platen, and apparently some sailors building a cairn upon the promontory. This was, of course, an illusion caused by mirage effects.

The weather was excellent on the 29th, and they took the opportunity of rowing northward to reach Sjuöyane in spite of the ice fields. In the afternoon they landed at the south point of Parryöya. Nordenskiöld determined its position astronomically, while other parties made short excursions on the island. The flora and fauna were found to be poor, and the geology was similar to that of north-west Spitsbergen. On the following day Nordenskiöld made a tour along the shore under the steep cliffs, while another group visited the top of the cliff above him. Among other things, the “upper group” made a sport of rolling big stones over the cliff edge, under which Nordenskiöld was walking!

From the visit of the *Magdalena* to Kongsfjorden, 12 August 1861. In the background the mountains of Tre Kronor appear like pyramids. In front of the glacier some of Lovénöyane can be seen. (Chydenius: Svenska expeditionen till Spetsbergen 1861.)

The route followed during the geographical-geological boat excursion in July-August 1861. The scientific group consisted of Otto Torell, Adolf Erik Nordenskiöld and Carl Petersen, a Danish Arctic expert (above).

Walrus were common in Hinlopenstretet in 1861 (above). (Chydenius: Svenska expeditionen till Spetsbergen 1861.)

The geodetic chain in Spitsbergen proposed after the Swedish reconnaissance in 1861 and 1864 (left). (Royal Swedish Academy of Sciences.)

The fine weather now ended but, with difficulty, they managed to reach Martensöya, the most easterly of the Parryöyane. However, practically no observations were possible here until August 4, when the weather improved.

On the 5th they reached Phippsöya, its beaches covered with driftwood and relics from ships. They also found bones of whales high above the sea surface, indicating a considerable rise of the land.

It was then necessary to return to Nordaustlandet, as the matter of food might become critical if they were delayed by the ice. Until that point, they had not touched their four weeks' store of pemmican; but reindeer were no longer observed, nor auks, seals or walruses—only polar bears.

On the 7th they began their return journey. Pausing at Parryöya, they took the opportunity to study the ice from some mountain peaks. They noted a "street" of open water leading towards Nordaustlandet, and hoped to find an easy passage along it. But conditions were very hard until they approached an island which they later named Scoresbyöya; and from there it was possible to steer towards Castrénöyane, which they reached early next morning. A fire of driftwood on the beach helped them to dry their clothes, which had become wet from repeated cold baths during their passage through the ice.

There now seemed to be scant hope of proceeding eastward to any appreciable distance because of the ice, but they wanted to try. They had to land at a promontory—called Extremhuken since it had long been regarded as the most northerly point of Nordaustlandet. From its top they could definitely ascertain that "Great Stone Island" and its sound did not exist (see p. 29). They also got a view over the ice-cap and found it similar to the Greenland inland ice, though not so grand. In the night towards August 10 a southerly gale dissipated the ice, and on the 10th they sailed with good speed eastward. They made a landing on Sabineöyane, where Nordenskiöld—alone and unarmed—on the top of the island had a dangerous meeting with a polar bear. A direct hit with a stone made the bear change its intentions.

From Sabineöyane they rowed close to the coast of Nordaustlandet. Elsewhere the geological structure of the mainland had been made up by gneiss and granite, but these were now replaced by stratified rocks—although no fossils were found. The mountains were also shaped differently, and often gaudily coloured.

On the 11th they proceeded eastward under a good wind over an ice-free sea. They landed soon at a promontory (Kapp Lovén) and, to find out whether the fjord (Rijpfjorden) east of Kapp Lovén might offer

a connection with Wahlenbergfjorden, they climbed a mountain. The fjord was almost free of ice and ended in two arms far away into the mainland. They built a cairn on the mountain, containing information about their tour.

In the evening they landed on the stretch of coast which Parry had marked "Distant Highland" and which now bears the name Prins Oscars Land. They still found driftwood along the shores, but no longer any Norwegian debris. Vegetation and fauna were now poor.

On the 12th they marched overland to reach the top of a mountain, which they estimated to lie some 20 km away (probably Binneyfjellet). They were, however, prevented from reaching it by another fjord (Zorgdragerfjorden) running north-south.

Next day (August 13) they steered north and landed near Kapp Wrede. They climbed a mountain (Nordenskiöldvarden, 461 m a.s.l.) and from its top they had a wonderful view. In the distance to the north-east they discovered two small islands in the Polar Sea, Karl XII-öya and Drabanten. The sea was fairly free from ice, allowing them to continue their boat journey and reach Kapp Platen, the northernmost point of Nordaustlandet.

On the following day they rounded this north point of Prins Oscars Land and steered south-east into the next fjord to the east, Duvefjorden. However, they met with ice and had to turn back. From a mountain near Kapp Platen they saw that the ice was open near the cape, and to the east it seemed to be possible to row close to the land. Perhaps it would even be possible to row round Nordaustlandet to the meeting place in Lomfjorden. But on second thought, they considered the risks too great and decided to turn back.

Before commencing their return journey, they had a feast at Kapp Platen. It was served upon a flat piece of rock; a clean towel served as a tablecloth, flat chips of stone became plates, and sheath-knives were the cutlery. The menu included hazel-hens and a good old wine which had sailed round the world on board the Swedish frigate *Eugenie*. Glasses were clinked and speeches were delivered.

They started out on the morning of August 15 and reached Scoresbyöya that night. The weather deteriorated, bringing rain and fog. On August 17 they reached Depotodden and caught a sledge which they had brought along, as well as some pemmican. They entered Brennevinsfjorden expecting to find a sound leading into Murchisonfjorden. No such discovery was made, but they noticed that the Brennevinsfjorden would probably serve as a good winter harbour. On the 19th they rowed into Lady Franklin-fjorden and looked in vain for the sound.

On the 20th they reached Depotöya in Murchisonfjorden. They took away the stores which had been left there, and sailed under a good breeze for Lomfjorden to meet the *Aeolus*—which they did on the 24th, having first spent a few days in the interior of this fjord together with the Chydenius group.

*The boat excursion of Chydenius,
July 11–August 23, 1861*

While the ship stayed at Depotöya in Murchisonfjorden, Chydenius' boat party had been preparing their first excursion. They would try to reach the northern islands in order to start their reconnaissance from some of the Sjuöyane. Eventually they would also attempt to penetrate eastward.

The English iron boat was at their disposal; they had four weeks of provisions, and a reserve of pemmican for two weeks. On the 11th they sailed north under a fresh wind. As mentioned, the geographical and geological group had left on the previous day, and on the 12th the *Aeolus* left for Depotöya. The intention of the ship's party was to visit Sorgfjorden and look for messages from the *Magdalena*, then sail back to Langgrunnodden.

Malmgren and "the old man", Anders Jacobson, carried out dredgings. At Langgrunnodden in the limestone debris ashore, they found subfossil shells of *Mytilus edulus*, which does not live in Svalbard waters nowadays. The finds indicated a change towards a colder climate, and a rise of the land. They also located a depot from the Parry expedition of 1827 containing, among other things, tinned meat which was delicious to eat. The *Aeolus* stayed at Langgrunnodden till July 17, when the Chydenius group arrived.

Chydenius had wanted to visit the land near Langgrunnodden in order to investigate the ice conditions for planning the route. Their boat was heavily loaded and the freeboard was only about 30 cm. They met with ice and the passage became critical, so after a few days they decided to return to the ship, which had arrived after her visit to Sorgfjorden and now lay at Lågöya. They reached the *Aeolus* on July 17, and took time to reduce the weight of the equipment.

Their departure was delayed by fog and by fresh winds. They decided to go with the ship northward, and in the evening of July 18 they left her at latitude 80° 25'N. They were, however, much hampered by the ice and were forced to steer south-eastward towards the peninsula which lies south of Brennevinsfjorden, Botniahalvöya. Next day, the 19th, Chydenius climbed the mountain (358 m a.s.l.), which constitutes Kapp Hansteen (Hansteenfjellet). The top plateau was free from snow and it was possible to botanize, but fog surrounded the mountain, prevent-

ing observations in connection with the reconnaissance.

Next day the fog dispersed in the morning, and Chydenius climbed the mountain a second time. It now became clear to him how the triangulation points should be placed. He also got good measurements of angles for the reconnaissance and for the map. Besides, the geographical-geological group had arrived on their passage to the north and east. Eventual extra observations might be carried out by this group, while Chydenius turned his attention to more southerly parts of the trigonometric network.

The *Aeolus* had paid a visit to Depotöya on July 22, then sailed north again and anchored off Lågöya. There both boat groups embarked on the same day in order to make some preparations on board, before proceeding on their respective missions. Chydenius, who mainly intended to investigate the extension of the trigonometric network along Hinlopenstretet, was taken by the ship to Depotöya, where he made a reconnaissance tour by boat and on foot in the fjord's interior on July 30–31. He and Nilsson had climbed a mountain, Celsiusberget, which was chosen to be included in the trigonometric network. The top of the mountain consisted of a small plateau, free of snow and covered with big stones devoid of any vegetation. The view over the fjord and towards the ice-cap was stupendous. The cairn, which they had built on Kapp Hansteen, was plainly visible.

The reconnaissance was extended further eastward, in spite of deep snow, until they got a view over Lady Franklinfjorden and could follow the coast by eye almost to Langgrunnodden. It was now definitely clear that no sounds existed to either the north or south of Murchisonfjorden. They returned to the ship in the afternoon of July 31. Previously they had chosen Heklahuken at Sorgfjorden as a trigonometric station, and in the flat country near this mountain a base-line might be established.

On August 1 the *Aeolus* sailed south through Hinlopenstretet with the Chydenius group on board. The wind increased and a gale of northerly to north-westerly direction raged for a week—in combination with rain, snow, sleet and fog. The narrow Hinlopen was partly unknown in its southern part, so this was a most trying time to the ship's party. Moreover, they were threatened by the danger of colliding with pieces of glacier ice. In company with a sealer they entered Wahlenbergfjorden, where they found shelter as the gale still blew in the Hinlopen.

The wind calmed down on the 7th, and via Fosteröyane they reached Vaigattöyane the following day. The zoologist Malmgren and his assistant now had busy days; the marine fauna was rich, the islets

offered good opportunities for botanical studies, and the ship's captain sounded the depth of the waters. But the weather remained unsettled.

The Chydenius group left the ship on August 8 and steered towards Lovénberget on the western side of the sound. Chydenius managed to climb the steep slope of the mountain, but a dense fog gathered around the top, and he spent the time botanizing—mainly mosses and lichens. After seven hours he grew bored and went back to the boat. Next day he regained the top, but now clouds and fog concealed everything he wanted to see. After waiting 8 or 9 hours for an improvement in the weather, he returned to the boat.

This visit gave some indications on the weather conditions which could be encountered during future arc measurements in Spitsbergen. However, on August 14 Chydenius managed to perform the necessary observations.

The critical part of the trigonometric network was to be expected in the region between Storfjorden in the south and Hinlopenstretet in the north: would it be possible to find any suitable mountain tops there, as a link between the northern and the southern parts of the trigonometric network? The problems posed by this region included the feasibility of transport—to get from the Storfjorden region to Hinlopen, and to reach the inland mountains which might be chosen here.

A sound (Heleysundet) between Hinlopenstretet and Storfjorden had been reported by two Norwegian sealers, which had passed through it in the previous year. Both the Chydenius boat group and the geographical-geological boat group looked for the sound without finding it. On marches inland, Chydenius had noted a marked peak in the distance (among the Chydeniusfjella) which might be chosen for a trigonometric station, but of course nothing could be said as to its accessibility.

The two boat groups ended their excursions after completed missions on August 23, when after hard rowing in a strong headwind they reached the *Aeolus*, which awaited them at the entrance to Lomfjorden. The arc-of-meridian reconnaissance was now finished in the northern part of the trigonometric network. It was hoped that Dunér in the *Magdalena* had carried out the reconnaissance in the south. One question was, however, left unanswered: the connection overland between the two halves.

Autumn was now approaching. There was a risk that northerly gales might close the northern approach to Hinlopenstretet. Torell wanted to investigate the eastern side of Nordaustlandet, but time did not permit this; and in the evening of August 24 the *Aeolus* sailed north, passing Depotöya and Moffen

Island. No ice was observed, not even any iceblink near the horizon. Torell and the scientific members discussed a push northward—to perhaps 82° N—in order to find the southern limit of the pack-ice in the autumn.

However, the *Aeolus* was not a good sailer and might become beset in the ice, and Petersen objected strongly. Besides, the crew was homesick. If only Torell had possessed the power of steam rather than sails in his ship, the situation would have been quite different. Therefore the course was laid westwards, to spend time along the Spitsbergen west coast until the *Magdalena* turned up. The weather varied like the wind, and the result was that the cruise ended in Kobbekbukta at the western part of Dansköya, where the *Magdalena* appeared on September 9.

THE VOYAGE OF THE MAGDALENA

The scientific work accomplished by the *Magdalena* group will be dealt with more briefly. Its scientific staff consisted of five persons: Blomstrand (geology, scientific leader), Dunér (astronomer), Goës (doctor, zoologist and botanist), Smitt (zoologist and botanist) and von Yhlen (zoologist and draughtsman) (see p. 26). For their work, two boats were available—one with two men disposable to Blomstrand and Dunér, the other with three men to be used exclusively for zoological dredgings. Finally, a boat with a harpooner and three men was to be used for hunting.

The captivity of the *Magdalena* in Sorgfjorden came to an end on July 6, when a sealer reported that an open lane had formed along the land to the north. The *Magdalena* and two sealers put to sea and managed to pass Verlegenhukén—though in ice—and to run into Wijdefjorden, which was free of ice as far as the eye could reach to the south. But their captivity was far from over; ice lay packed against the western shore all the way up to Gråhukén and further northward, where it joined the polar pack. While the men rejoiced in having left Sorgfjorden at last, their new predicament was to last till July 19.

The ship tacked to and fro in the mouth of the fjord on the 9th, until the wind died down in the evening. Two boats were then sent out, to take two parties on an excursion to Dirksodden and its Russian hut on the eastern shore. The hut was found to be in good condition—an engraving gave the date 1839. There was some threat from ice drifting into the fjord mouth with the tide, a menace especially in calm weather or with strong winds, but the sand-reef of Dirksodden afforded protection.

Wijdefjorden is one of the most beautiful fjords of Spitsbergen. It is some 100 km long, and 10–15 km broad. The eastern side of the fjord (consisting of old

rocks) looks from a distance like a high smooth wall covered with ice or snow on top. The western side consists of Devonian sandstone and is sculpted in mountain ridges, peaks and deep valleys, with colours changing from brownish to green and red in the south.

Although the *Magdalena* had once again become captured by the ice, Wijdefjorden was most interesting from a scientific point of view and promised to supply much interesting work. The zoological dredgings went on, and the flora of land and sea yielded rich collections; the three glaciers, Dei Tri Isfjella, to the south of Dirksodden, were visited. The land on the eastern side of the fjord was rich hunting-ground, and the provisions of the *Magdalena* were now increased with reindeer meat, which was prepared by the cook in the most delicious style.

On July 12 Blomstrand and Dunér started a boat excursion to the southern part of the fjord. They followed the eastern shore until they reached "Midterhuken" (Petermannfjellet), which separates the two fjord arms of Wijdefjorden–Austfjorden and Vestfjorden. Here they steered towards the western shore, as they had discovered a Russian hut at a distance. The hut and its surroundings looked inviting. The rocks were red and green, and they expected to find luxuriant vegetation on the grassy plains nearby. The hut was similar to that at Dirksodden, but it was found to be situated on a dry sandy plain, locally covered with a crust of salt, and the vegetation was in reality outcrops of green rock. The little river and the fjord water were bright red due to mud coming from the red mountains.

While they were here, two boats arrived. These belonged to the two sealers which the *Magdalena* had earlier been in company with. One boat had entered the eastern fjord arm, Austfjorden, and reported that the fjord ended at a large glacier, later named Mittag-Lefflerbreen (see p. 342). The other boat had entered the western branch (Vestfjorden) but the inner part had not been seen. Therefore Blomstrand and Dunér decided to visit Vestfjorden.

As they entered the fjord, they were struck by the strange appearance of the landscape in the strong sunlight: the water was deep red, and the mountains around them changed from red to reddish brown. They sailed under a northerly breeze and discussed taking the captured *Magdalena* along this lane towards the west. But their boat was suddenly stopped by the soft red mud, and they had to stay there until the tide had raised the water level sufficiently. Meanwhile coffee was cooked over a fire in the bow of the boat.

They returned to a sandbank which they had passed earlier, and pitched their tent. Several reindeer were

grazing fearlessly near them, and in the fjord water swam a great number of white whales. Blomstrand made an arduous trek to the bottom of the fjord. It was very warm: +16°C was observed. Ultimately the time came to return to the *Magdalena*, which they reached in the night towards July 16.

On the 19th, when the ship's captivity ended, they had the good luck to find an open lane in the ice leading past Gråhuken (Grey Hook) and out into open water beyond. The ice, which had bothered them for six weeks, could be seen as a white strip on the northern horizon. They were now to experience the typical Spitsbergen summer weather—low visibilities alternating with extremely transparent air, and calms alternating with gales.

Geognostic, botanical and zoological studies were undertaken during boat excursions in the north-western corner of Spitsbergen. Dunér began his reconnaissance of an eventual triangulation network along the west coast, but the weather was not the best, and the topographical conditions did not seem suitable for the purpose.

Blomstrand, Dunér and Mack made a boat excursion from Norskøyane to Magdalenefjorden, which was chosen as a meeting place with the ship. On the way they visited the observation site on Indre Norsköya, which had been used by Phipps' expedition in 1773 and by Sabine in 1823. This site is generally referred to as *Sabine's observatory*, and was often used as a reference in connection with longitude determinations. Here they carried out observations for a few days. The two small islands of Fuglesangen and Klovningen (Cloven Cliff) were also visited, and the former was included in the reconnaissance of a western geodetic network.

After a visit to the ship because of unfavourable weather, the boat party steered south into Smeerenburgfjorden. By way of Sörgattet they reached Magdalenefjorden, one of the most beautiful fjords of Spitsbergen, with high mountains (gneiss and granite) and glaciers of different types. They found a fine harbour east of Gravneset, with its many graves of British sailors from the old Spitsbergen whaling period.

The *Magdalena* had meanwhile arrived and anchored in the mouth of the fjord. She stayed here for two days. The weather was excellent; the temperature was high, at +11°C by day and +5° at night.

Blomstrand, Dunér and Smitt climbed a mountain south of the fjord entrance. They were struck by the fact that the vegetation changed very little from the sea surface up to about 700 m. Almost all plants which did well near sea level did so at 600 m too. Large granite blocks and stones, which enclosed the moun-

tains along the shore, were wrapped in a luxuriant vegetation of mosses and lichens.

On July 29—in a calm—the *Magdalena* was towed out of the fjord. Well out at sea a fresh northerly breeze was blowing, and carried them southward along the coast of Dei Sju Isfjella. But soon the wind died again and the ship drifted around, pitching in a heavy swell from the west. Blomstrand, though, was able to pay a visit to the shore.

On the evening of July 31, they got a northerly breeze which brought them round Kapp Mitra, west of the entrance to Krossfjorden. A strong outgoing current forced them to anchor, and short excursions were undertaken by enthusiastic scientists, who had been kept inactive for three days. The flora was no more luxuriant here than at Sorgfjorden in the north, but they found the first fern (*Cystopteris fragilis*) which had ever been reported from Spitsbergen—two small specimens.

Next day, August 1, the *Magdalena* was towed into a little bay, which later Swedish expeditions called Ebeltoftthamna after their Norwegian representative in Tromsø, A.E. Ebeltofts (1820–81). Here the men anchored and, during the following week, undertook boat excursions and devoted themselves mainly to glaciological studies in the two innermost branches of the fjord. These excursions were somewhat adventurous because of the heavy winds coming from the interior of the fjord, and due to the great amounts of calved glacier ice which covered the sea surface.

On August 8 the *Magdalena* left Krossfjorden and steered into Kongsfjorden, although not directly owing to calms and currents. Next day she anchored behind a low sand-reef enclosing a lagoon, apparently the present Brandalspynten on the southern side of Kongsfjorden and a little to the north-west of present Ny-Ålesund. Blomstrand devoted himself to geological studies; among others, he investigated the almost vertical coal seams on the low land just to the east of the present Ny-Ålesund mine. In the sandstone he found fossils of leaves and other relics indicating previous forests of deciduous trees, mostly like maple-trees.

According to Scoresby, the Dutch whalers are reported to have collected coal at Kongsfjorden for their passages homeward, but Blomstrand found no indications of any old mines here. Probably the coal had been collected as loose pieces from the ground.

On the northern side of the fjord the limestone rocks were studied, notably on Blomstrandhalvöya. The crystalline limestone there resembled marble, with bluish grey and brick-red colours.

The scenery impressed the men of the *Magdalena*

with bold glaciers, extensive ice-fields beyond, and pyramidal mountains rising out of the ice. But the expedition was troubled by calms which hampered its mobility, so they were glad when they could sail southwards to Isfjorden, where Grönfjorden, Colesbukta and Adventfjorden were visited. Also here Blomstrand found coal seams and fossil leaves, like those at Kongsfjorden.

By now it was September, and autumn lay at hand. A hunter had observed that ice blocked the passage out of Isfjorden. The *Magdalena* was at Adventfjorden. Sealers dread the autumn ice and the risk of a forced wintering it may entail. There was a note of melancholy and pessimism among the crew of the *Magdalena*. But on September 6 the view from the slopes of a nearby mountain (apparently Nordenskiöldfjellet) indicated that the ice had dispersed. A break-out was successful, and in the morning of the 7th the *Magdalena* reached open water, and steered north to meet the *Aeolus* in Kobbekbukta.

On September 9 the two ships were reunited after ten weeks of separation, and on the 12th the homeward voyage began. The *Aeolus* reached Tromsø on September 23, and four days later the *Magdalena* arrived. The principal field investigations of the expedition had been brought to a close at Kobbekbukta. But on the passage to Norway, oceanographical observations were carried out when the weather permitted—including temperature measurements and samples of water, as well as of marine fauna from different depths. Especially valuable were the collections of fauna from depths down to 2500 m, a region almost unknown to science in those days.

A FEW COMMENTS

Torell's expedition of 1861 had been exceptionally successful, despite all the obstacles presented by ice and weather. It was the first interdisciplinary polar expedition carried out by competent professional scientists. There is no exaggeration in saying that this enterprise initiated scientific polar exploration, and that Torell is rightly looked upon, not only as the "father" of Swedish polar exploration, but as the founder of scientific polar exploration in general.

The map of northern Svalbard now became much more reliable than before, thanks to the basis supplied by 28 astronomical determinations of position. The geological collections were rich and provided an outline of the geological structure of northern Svalbard, including glacial geology.

The collections of plant fossils from the early Swedish polar expeditions were classified and described by a Swiss palaeobotanist, Oswald Heer (1809–83). In this way a knowledge of the palaeoclimate of

Svalbard was also obtained, as well as a dating of the strata. The zoological and botanical collections from both land and sea were rich, and it is noteworthy that deep-sea soundings were conducted down to 2500 m. A rich marine fauna was found to exist here. Running observations were carried out in meteorology, oceanography and geomagnetism.

The reconnaissance for an arc measurement could only be performed in the northern half of the projected trigonometric network. What remained were the southern half—in the Storfjorden area—and the definitive connection between the northern and the southern network. The *Magdalena* group had not been able to carry out this part of the expedition programme owing to calms and ice. It called for a new expedition.

The attempt to reach a high northerly latitude was a failure, but the dream of a northern record was to linger among Swedish polar travellers, notably with Torell and Nordenskiöld.

The Spitsbergen expedition of 1861 was Torell's last polar venture. The remaining reconnaissance for an arc measurement was carried out in the summer of 1864 by a small expedition sent out by the Swedish State (see Chap. 8.), but Torell was not invited to lead the expedition or even to take part in it. Instead Nordenskiöld and Chydenius were chosen for the purpose. After the death of Chydenius in 1864, N.C. Dunér was selected. Furthermore, with grants from another source, A.J. Malmgren, the zoologist of the previous expedition, could join the new expedition.

Torell was greatly offended by this treatment. The reconnaissance was after all his idea, and he had personally sacrificed considerable amounts of money for the planning. Torell and Nordenskiöld remained faithful friends thereafter, but Torell's disappointment lingered in his mind.

Meanwhile he had entered upon a university career, followed by a career in public service. In 1860 he became assistant lecturer in zoology and geology at Lund University, and in 1866 professor of the same disciplines—until in 1871 he was appointed head of the Geological Survey of Sweden, where he remained till 1897. His main interest was glacial geology, notably the conditions pertaining to the latest Ice Age, the Weichsel or the Würm. He still dreamt of new arctic ventures, and still considered a push north to a high latitude, preferably the North Pole; he also dreamt of investigating Novaya Zemlya, in connection with studies of deposits from the eastern part of the Scandinavian ice-sheet. Sometimes he felt unsettled. In the 1860s he seriously considered emigrating to England or America, and in several letters he complained about the fact that Professor C.J. Sundevall

(see p. 21) had persuaded him to give up his medical studies and become a scientist:

“Nobody has done more harm to me than Sundevall, when he pulled me away from a quiet and profitable career of surgery into the unrewarding one I have since been following.”

Torell had many deep interests and he was ambivalent in character. It fell upon A.E. Nordenskiöld to advance Swedish polar exploration along the lines which had originally been laid down by Otto Torell.

6. AUGUST QUENNERSTEDT'S ZOOLOGICAL STUDIES IN THE WEST ICE, MARCH–MAY 1863

The voyage of *August* Vilhelm Quennerstedt (1837–1926) to the Norwegian Sea, in the neighbourhood of the volcanic island of Jan Mayen, may be included among the pioneering Swedish travels to the Arctic. In many ways it resembled Anton Rolandson Martin's voyage to Spitsbergen waters in 1758 (see p. 13). Like Martin, Quennerstedt was prevented from setting foot on the land of his dreams, but instead he gained an inside knowledge of the seal hunting in the West Ice and of the fauna in the pack-ice.

Quennerstedt had been a member of Torell's Spitsbergen expedition of 1858 (see p. 24), becoming acquainted with animal life in the Arctic during the summer. Now he was going to study animals in the pack-ice far from land in the late winter and the spring. He had recently earned a Ph.D. in zoology, and he was to become professor of that subject at Lund University (1880–1902). Later in life he also wrote historical literature.

The Norwegian seal hunting in Svalbard waters mainly involved ships from northern Norway, while the hunting in the “West Ice”—primarily in Jan Mayen and East Greenland waters—was carried on from southern Norwegian ports such as Tönsberg, Drammen, and Kristiania (Oslo). In 1846 the first Norwegian hunting expedition, comprising three ships, was sent westward. It should be noted that the ships employed in the “West Ice” were considerably larger and stronger than those built for the Spitsbergen hunting.

The young of the Greenland seal (*Phoca groenlandica*) were hunted chiefly in the “West Ice”. The Green-

land seal is found in immense numbers upon the floes in the Jan Mayen ice during late winter and early spring. At the end of March or beginning of April, the females give birth to cubs, only one per female. In their first month of life, the cubs have a white woolly dress and avoid entering the sea water, so they become easy prey for hunters. They may also be hunted later in the season, but are then more difficult to approach.

At that time, the hunting generally ended in May and occurred principally in latitudes 72°–73° N, longitudes 0°–2° W, and within a promontory which is formed by the ice to the north-east of Jan Mayen. The hunting was pelagic in character, taking place at sea far from any land. The ships were thus naturally bigger than the modest Spitsbergen sealing vessels.

In 1863 Quennerstedt was invited as a passenger on a sealing expedition to the Jan Mayen hunting area. He boarded the brig *Jan Mayen* of Kristiania (Oslo), whose Captain was C. Castberg, at Fredriksværn near the fjord entrance to Larvik. He found an agreeable ship and received a very friendly welcome. The crew numbered 50 men; there were five hunting-boats on deck between the masts, and two along the sides of the ship.

On February 28 the *Jan Mayen* left Fredriksværn, and on March 11 she reached the outskirts of the ice. On the 16th, they met with heavy floes at about 73.0° N, 3.5° E. Two British ships were near. On March 28 they observed 23 ships from the crow's nest. A great part of the sealers were then close to the southern margin of the ice, where no seals had yet been seen.

Quennerstedt conducted observations of the ice conditions, studied the animal life, and preserved birds. He even found time to study and become fascinated by the mirages, which on some days were extensive and beautiful. Visits were paid to other vessels in the neighbourhood. Most British ships also hunted whales, generally west of Greenland, and were therefore not very interested in the seal hunting.

By April 21 the time for profitable hunting—that is, of the young seals—had run out. Until then, the *Jan Mayen* failed to secure any young seals. The hunting had proved a great disappointment, and this circumstance had deprived Quennerstedt of many important observations. Next day, though, they managed to get 80–90 young seals, and on April 29 more than 600, which might have been at least 1000 if the ice had not been so cumbersome. In Quennerstedt's words:

“The ship looked like a slaughter-house, and it demanded hardened nerves to look at this destruction, which had been brought upon defenceless animals.”

The island of Jan Mayen had, in the imagination of Quennerstedt, become a kind of dreamland. Before the voyage he had studied the literature dealing with the island and its history. There had been good hopes of attempting a landing, but the discouraging results of the hunting made such a landing less probable.

On May 2, at 71°32'N, 7°20'W, the island of Jan Mayen was sighted at a distance of 80–100 km. A mountain range loomed against the ice blink to the south-west, but it was so faint that Quennerstedt could not even make a picture of it on his drawing-paper. It was the northern part of the island, but Beerenberg, the high volcano, could not be discerned. There was uncertainty as to the possibility of forcing a path through the ice between the ship and the island. So, considering the outcome of the hunting, the ship changed her course and followed the ice edge eastward.

By May 14, a total of 1600 sealskins had been collected, and on the 15th they passed an area where thousands of seals could be seen. A dark streak along half the horizon, it was resolved through binoculars into a countless crowd of black dots—seals. However, the ice was rotten and the seals shy, so only 60 were obtained by the evening. In comparison, a total catch of 4000–5000 young seals was regarded as a fairly good haul among sealers.

On May 21, Quennerstedt noted in his diary that he found it remarkable that the migration of the snow bunting to East Greenland is so markedly spread out in time. Ever since the beginning of April, the melodious song of this little bird was heard on board during sunny days.

At the end of May they experienced fog for a number of days. Sometimes such conditions might last for weeks, and when the weather improved on May 29, a decision was taken to sail home if the fog returned. So it did—and this spoiled Quennerstedt's last chance of seeing Jan Mayen again. On that same evening the ship started back to Norway. Headwinds and calms characterized the voyage, and she did not reach Fredriksværn until June 16.

August Quennerstedt's voyage to the Jan Mayen hunting field in the West Ice 1863.

The crow's nest of a whaling ship. A constant lookout was necessary when sailing in unsurveyed waters (right). (Dunér & Malmgren & Nordenskiöld & Quennerstedt: Svenska expeditioner till Spetsbergen och Jan Mayen 1863 och 1864.)

Greenland seals with young in the West Ice, Jan Mayen in spring (below). (Dunér & Malmgren & Nordenskiöld & Quennerstedt: Svenska expeditioner till Spetsbergen och Jan Mayen 1863 och 1864.)

THE NORDENSKIÖLD
EPOCH

1864–1883

7. ADOLF ERIK NORDENSKIÖLD

BIOGRAPHICAL NOTES

Adolf Erik Nordenskiöld (1832–1901) had come to Sweden from Finland in 1857, at a time when Otto Torell had already embarked upon polar research. Henceforth Nordenskiöld was to remain in Sweden.

His family originated from the province of Uppland in central Sweden, where an ancestor, Johan Eriksson Nordberg (1660–1740), was born at Nordenåker in the parish of Tierp. In 1692 he was sent to Finland by the Swedish Count Fabian Wrede, in order to elucidate the unsatisfactory state of affairs at the latter's estates. This he did in a most commendable way. Nordberg remained in Finland, which was then a part of Sweden. He had three sons, who changed their name to Nordenberg. Two of these brothers became prominent as builders of fortifications and as scientists; in 1751 they were elevated to the nobility, and changed their surname to Nordenskiöld. Eventually many members of this prominent family came to serve in important civil as well as in military capacities in Sweden, Finland and Germany.

Nils Gustaf Nordenskiöld (1792–1866), Adolf Erik's father, was originally a lawyer. But his scientific interests gradually got the upper hand, especially mineralogy. Soon he was looked upon as a mineralogist and was appointed superintendent of the board of mines. A born collector, he travelled far and wide to enrich his collections of rock specimens. Adolf Erik grew up at the family estate Frugård near Helsingfors (Helsinki), where his father kept his mineral collection and scientific library. Adolf Erik took part in several of his father's expeditions, and was naturally encouraged to become a mineralogist and geologist. In 1857 he was awarded a doctor's degree.

The banquet after the conferment of doctorates was to change the destiny of Adolf Erik Nordenskiöld in a most unexpected way. There was tension in the country, not only between its citizens and the Russian authorities, but also within the population itself. Adolf Erik proposed a toast to the future of Finland, ending with a short and ardent speech. This soon came to the knowledge of the Russian governor, General Count F.W.R. Berg (1794–1874), who looked upon it almost as a case of high treason and lese-majesty. Nordenskiöld was given the means of conveying his excuses and pleading misunderstanding—otherwise he would have to leave Finland. He chose to leave, although Berg did not succeed in procuring a formal exile for him.

Nordenskiöld settled in Sweden, and already in the first summer, 1857, he acquainted himself with the country, its scientists and scientific institutions, notably Professor Carl Gustaf Mosander (1797–1858), head of the mineralogical department of the Swedish Museum of Natural History, and Professor Sven Lovén (1809–95), who had visited Spitsbergen in 1837 (see p. 16). Lovén arranged Nordenskiöld's participation in Torell's Spitsbergen expedition of 1858 (p. 22). This was followed by Torell's large Spitsbergen expedition of 1861, when Nordenskiöld served as second leader.

Professor Mosander died in the autumn of 1858, and Nordenskiöld was chosen as his successor. In 1861 he was made a member of the Royal Swedish Academy of Sciences. Thus, within a single year, Nordenskiöld's life had been launched on its definitive course—and he was then only 26.

In polar exploration Nordenskiöld's achievements are wide and remarkable, and he is reckoned among the greatest polar workers of all time. From 1864 until 1883 he dominated his country's contributions, and this period may justly be termed the *Nordenskiöld epoch in Swedish polar research*. He was the leader of eight expeditions to the Arctic during this time. Moreover, he visited Spitsbergen in 1858 and 1861 under Otto Torell.

Here is a short summary of the expeditions led by Nordenskiöld:

- 1864 Reconnaissance for an arc measurement in Spitsbergen (the southern part of the projected triangle network from Sjuöyane in the north to Sörkapp in the south) (p. 45).
- 1868 Penetration to a high latitude north of Spitsbergen with the steamer *Sofia*. Latitude 81° 42' N was attained, which was then a northerly record (p. 59).
- 1870 A small expedition to west Greenland; the inland ice was climbed and Nordenskiöld penetrated 50 km towards the interior (p. 65).
- 1872–1873 A large expedition wintering at Mosselbukta on the north coast of Spitsbergen; this was the first scientific expedition to winter in Spitsbergen. Attempts to sledge north over the pack-ice failed; instead the north coast of Nordaustlandet was explored. The homeward journey crossed the ice-caps of Nordaustlandet, which had never been attempted before. The expedition of 1872–73 suffered hardships due to severe weather and ice conditions (Chapt. 13).
- 1875 Reconnaissance to the Yenisey River with the small sealer *Pröven*, in order to examine a future sea route between the Atlantic and the Siberian rivers of Yenisey and Ob (p. 96).

Adolf Erik (A.E.) Nordenskiöld (1832–1901), famous for the North-East Passage, is considered among the greatest polar explorers of all time. Photo: Mannerheim Family Collection.

The Vega monument near the Swedish Museum of Natural History, in Stockholm (top right). Photo: Staffan Waerndt.

The schooner *Axel Thorsen* of the A.E. Nordenskiöld, Spitsbergen expedition of 1864. (Dunér & Malmgren & Nordenskiöld & Quennerstedt: Svenska expeditioner till Spetsbergen och Jan Mayen 1863 och 1864.)

The route of the *Axel Thorsen* in 1864. (Solid line = outward voyage; broken line = homeward voyage).

1876 Second voyage to the Yenisey, this time with the steamer *Ymer* carrying a cargo of manufactured goods (p. 107).

1878–1879 The *Vega*, a three-masted barque with a steam engine, traversed the entire length of the North-East Passage, but had to spend the winter in the ice near Bering Strait. Nordenskiöld was the leader of the expedition, and Louis Palander was commander of the ship (p. 118).

1883 An expedition to Greenland with the steamer *Sofia*. A trip was made on the inland ice, at the same place as in 1870, but the party reached further inland this time. Oceanographical, biological and geological research was carried out along the west coast; the present-day Angmagsalik on the east coast was reached (Chapt. 17).

Nordenskiöld embarked upon polar exploration at an age of 26 years, and was the foremost Swedish polar researcher from his 29th until his 51st year. He even contemplated a Swedish-Australian expedition to the Antarctic, under the leadership of his son Gustaf Nordenskiöld (1868–95). These plans were, however, given up because of Gustaf's illness and subsequent death, and also because of the Australians' inability to procure the necessary money.

* * *

Nordenskiöld was energetic and intelligent, he possessed an adventurous mind, and he was physically and mentally strong. A born leader of men, he was able to convey his enthusiasm to subordinates. But he could also behave very stubbornly. He had the power to inspire influential patrons for his expeditions, among them Oscar II (1829–1907, King from 1872) and Oscar Dickson (1823–97) (p. 63).

He was favoured by fortune at every turn, except in the decade preceding his death in 1901: his son Gustaf then died, to him the presumptive successor in Swedish polar research. Nordenskiöld was also at that time indirectly involved in two polar tragedies, namely the polar flight of S.A. Andrée and the Björling expedition of 1892 (see pp. 219, 248).

It is remarkable how often Nordenskiöld's plans and ventures arose at the most opportune moments for their realization—whether by accident or intent. He was the leader of expeditions to Svalbard and the Svalbard Seas, to Novaya Zemlya, to Siberia with the North-East Passage and to Greenland. The Canadian Arctic remained, while in the south beckoned the antarctic shores, inland ices and seas.

The last two decades of his life were largely devoted to studies of geographical history, including old maps, before 1600. He also maintained great interest in his

official duties at the mineralogical cabinet, and in the scientific activity which was continuing in the polar regions. He died on August 12, 1901, at his estate Dalbyö near the small town of Trosa south of Stockholm; he was buried in Västerljung.

8. THE VOYAGE OF THE SCHOONER *AXEL* *THORSEN* IN 1864

A RECONNAISSANCE FOR A FUTURE ARC MEASUREMENT

During Torell's Spitsbergen expedition it had been possible to reconnoitre the northern half of the proposed triangular network for a future arc measurement, from Sjuöyane in the north to Vaigattöyane in southern Hinlopenstretet at roughly latitude 79°N. The rest of the network—from 79°N to Sörkapp in the south—had not been investigated in 1861 owing to delays caused by ice and calms. A new expedition was therefore proposed by the Royal Swedish Academy of Sciences, and in 1863 money was obtained from the State.

Plans, participants, ship

Chydenius, who had carried out the reconnaissance in 1861, was to have the same duties on the new expedition, and A.E. Nordenskiöld was designated as leader. In addition, from a private donator, Count B. von Platen, means were obtained for attaching a zoologist to the expedition—A.J. Malmgren, a member of the team of 1861. Otto Torell was not offered the leadership of the expedition, a decision which he highly resented, as mentioned previously (p. 39).

A few weeks before the departure from Sweden, Chydenius died suddenly in Stockholm and was replaced by N. Dunér, who had worked in the same capacity on board the *Magdalena* during the voyage of 1861.

The new expedition was thus a small enterprise with only three scientific members:

Adolf Erik Nordenskiöld (1832–1901), Ph.D., professor; geologist; leader of the expedition.

Nils Christoffer Dunér (1839–1914), Ph.D., astronomer; responsible for the reconnaissance of the trigonometric network.

Anders Johan Malmgren (1834–97), from Finland, Ph.D., zoologist and botanist.

A rather unusual type of ship was hired at Tromsö for the purpose. Named *Axel Thorsen*, she and a sister-

ship had been constructed in 1810 to serve as gun-boats against British naval attacks along the Norwegian coast. After the war, they had been laid up for some 30 years, until in the early 1860s they were changed into sealers and sold. These ships were schooners of 25–30 tons, strongly built with modest bulk, and fast-sailing. The Norwegian crew of *Axel Thorsen* numbered 12 men, among them the skipper Hellstad. With four boats and expedition equipment, the space on board was extremely cramped, both below and on deck. The ship should have been provisioned for a year, in case of a forced wintering; but lacking sufficient space on board, only food for 5.5 months was taken, plus some Russian flour for the winter.

THE VOYAGE TO SPITSBERGEN AND A VISIT TO BjÖRNÖYA

The *Axel Thorsen* was towed from Tromsö to Karlsöy. Yet severe gales prevented a start for Spitsbergen, and not until June 15 was it possible to leave Norway and steer north.

On the 17th Björnöya was sighted. Attempts had been made by previous Swedish expeditions to land on the island—but either ice, bad visibility or gales had stopped them. This time, although conditions were favourable, the island was covered in snow which, of course, would make some investigations impossible. On the 18th a landing was, however, made with three boats at Sörhamnen, in the south-eastern part of the island. Nordenskiöld established himself as a photographer in the old Russian hut there. Excursions went some distance inland, and solar altitudes were measured.

On the 19th, an effort was made to row along the coast to the western side of the island, beneath the precipitous coastal cliffs and their millions of birds. However, due to a heavy swell and an increasing easterly wind, the party had to turn back to the ship. The *Axel Thorsen* resumed her planned route, south of the island and up along its western side, where a landing was made. Excursions were carried out a short distance inland, but not much of value could be done on the snow-covered plateau. A rough sketch of the island was produced, though, and this was to remain the most reliable map of Björnöya until 1898, when A.G. Nathorst's expedition visited the island. Björnöya will be treated in more detail later (see Chapt. 29).

The expedition left Björnöya on June 19, and the course was laid towards Storfjorden. Most optimistically they hoped to reach the fjord and begin the arc measurement reconnaissance already the next day. But they met with calms, fog and ice—often in concert—and in order to avoid being “beset” they steered

north-west. The ice became gradually more open as they proceeded north, and during a gale off Prins Karls Forland they were able to penetrate the ice and approach land. Ice blocked the entire south of Spitsbergen, and it proved necessary to await developments. In other words, they would have to give up Storfjorden and the reconnaissance, and concentrate on scientific research along the west coast.

IN ISFJORDEN: BOAT EXCURSIONS

They sailed southward in the open lane along the coast, but the lane closed south of the entrance to Isfjorden. Coming into Trygghamna on the northern side of the Isfjorden mouth, they anchored on June 25 to await improvements in the ice situation. Boat excursions were made in the same manner as on the previous expedition. On June 26 and 27 the weather was unsuitable with a northwesterly gale raging. The ice was collecting off the fjord entrance, hindering a southerly passage.

Nordenskiöld's boat excursion

to the Kapp Thorsen Peninsula, June 28–30, 1864
With Captain Hellstad and three men, a short excursion was carried out by Nordenskiöld for the purpose of collecting fossils on the “Middle Hook” of Isfjorden—the Kapp Thorsen peninsula. After a stay at Bohemanneset, which then received its name, they landed in the south-western part of the peninsula at the mouth of a little river, coming from a valley now called Sauriedalen (Nordenskiöld named it Rendalen). In the ravine of a brook in the mountain close to the landing-place, Nordenskiöld found many fossils from the Triassic period. These strata have a considerable extension horizontally both in the Isfjorden and in the Storfjorden region.

Near this locality Nordenskiöld found fossils of molluscs and fragments of bones of crocodile-like animals, some of them apparently about 120 cm long, indicating a warm climate during the Triassic. They also took time for reindeer hunting.

When the party returned to the ship on the 30th, those on board were so excited that they decided to conduct further excursions, preferably to the inner parts of Isfjorden. It was the best they could do in the given conditions.

Nordenskiöld's boat excursion on July 2–13, 1864

The participants in this excursion were Nordenskiöld, Malmgren, Hellstad and three men. Two boats left the ship on July 2 and approached the southern shore of Isfjorden on a south-easterly course. While one boat under Dunér ran into Colesbukta (see next page), the other under Nordenskiöld went north-

eastward along the shore to the mouth of Sassenfjorden.

During the passage along the mostly precipitous coast, the party landed at several places to collect plants or fossils, study the stratification, and shoot a reindeer or two. They spent the night in Adventfjorden and next day, the 3rd, they rowed into Sassenfjorden. Reaching a small black hillock resembling a hat, they named it "The Hyperite Hat" (its present name is simply Hatten). From here they measured the bearings to marked points in the landscape for the construction of the map.

Then they rowed northward to the Gåsöyane, which were found to be densely strewn with nests of eider ducks. On the 5th they rowed in open drift-ice to Gipshuken. The weather was excellent, and they were impressed by the view of the two mighty mountains, Gipshuken and Templet, both covered by diabase (hyperite) over gypsum strata. These strata were rich in fossils, so they stayed at Gipshuken for fossil hunting until the evening of July 6, when they attempted to make a rapid crossing of the mouth of Billefjorden.

This crossing might have led to a tragedy, as they were caught between an ice field drifting into the fjord and the stationary fast-ice in the fjord mouth. However, they were able to drag their boat up on the fast-ice before the two ice masses clashed. Disaster seemed imminent, since the boat had become surrounded by a field of loose ice, which was pressed together by the two ice masses. They camped on the northern shore of Billefjorden, and on July 9 a narrow channel opened along the coast—by which they reached Skansbukta and Kapp Thordsen, where intense work was begun (at 150–180 m) to collect saurian fossils. They managed to find two almost complete spines of saurians, with ribs attached.

This part of the coast was characterized by an almost flat plain, ending in a cliff 6–9 m high next to the fjord. The plain rose gradually inland, at first slowly: its flat surface was broken by ravines, which had been cut out by brooks or rivers in the layers of loose slaty bedrock. We shall deal later with this place and the expeditions related to it (Chapt. 12, 14, 36).

The provisions of the excursion party had by now run out, and the party had to rely on reindeer hunting. They were trapped by the ice, and not until July 12 did it open enough for them to try and proceed. Very soon, ice fields gathered between their boat and the open water off Adventfjorden; on the other hand, it was impossible to return to Kapp Thordsen. However, they managed to pass through the ice on a southerly course and reach Adventfjorden. Large crowds of white whales accompanied the boat, mak-

ing the passage a memorable event to all of the party. On the western side of Adventfjorden near its mouth (the present Hotellneset) there was a Russian hut in fairly good condition. Here they found three shipwrecked Norwegian hunters, and to the benefit of both parties they exchanged ammunition for bread.

They were informed that a ship with 4–5 "English lords" had anchored at Trygghamna, and that some of them were hunting reindeer on the eastern side of Adventfjorden. Moreover, they were told, Dunér had returned to Trygghamna. Next day, July 13, Nordenskiöld's party returned with the British to Trygghamna, but Dunér was not there. He had set out on a relief expedition to look for the Nordenskiöld party—an almost hopeless task as no messages had been left on the way, nor had their once planned route been followed because of the ice.

Dunér's boat excursion, July 2–9, 1864

Dunér's boat party, including the mate and two men from the ship, had separated from the Nordenskiöld group off Colesbukta on July 2 (see above). The party spent the night near the bottom of the bay, and next day, after making solar observations for position, they proceeded westward. Mapping the coast as they passed along it—a cliff some 9 m high—they passed into Grönfjorden. In the night towards July 4 they camped on the western shore.

The party visited an old Dutch burial-place and continued farther north. They spent the night towards July 5 a little to the west of the fjord mouth, near an old Russian hut. Hereabouts the legendary Russian trapper Ermi Staratschin (Starostin) had died of old age in 1826. He is said to have spent 30 winters in Spitsbergen, 15 of them in succession. (Compare Chapt. 9 p.56)

Ice blocked the way west, so Dunér returned to Colesbukta. From there he proceeded to Adventfjorden, met the three shipwrecked Norwegians and was told that Nordenskiöld's group had left for Sassenfjorden. Thus he, too, decided to leave too and head for Kapp Thordsen. This proved to be a somewhat troublesome passage through ice, pouring rain and dense fog. They rowed, using a compass for steering in the fog. A waterfall was heard, probably at Kapp Thordsen, and after various events they landed at Bohemanneset, reaching the ship in Trygghamna at midnight of July 8–9.

Nordenskiöld's party had not arrived and the delay caused worry, especially in view of the ice situation in the fjord. Therefore on July 12 Dunér launched a relief expedition by boat. He landed at Bohemanneset

and made solar observations for position. As it proved impossible to reach Kapp Thordsen because of the ice, he went on to Adventfjorden, where the three Norwegian trappers reported that the Nordenskiöld group, a few hours previously, had left for Trygghamna and the ship. Dunér's group turned back and reached the ship on July 14.

IN THE BELLSUND REGION

The ice conditions had now improved, so on July 17 the *Axel Thordsen* left the harbour and set out on her voyage to Storfjorden for the reconnaissance work to be done there.

However, off Bellsund they were attacked by a severe gale with rain, fog and heavy sea. They tried to beat to windward, but had to give up and find a harbour in Bellsund. On July 18 they anchored at Midterhuken a little to the south of the harbour, which is enclosed by some skerries. The harbour itself was full of ice.

The gale raged also on the 19th and 20th, but Nordenskiöld took the opportunity to photograph the glacier Fridtjovbreen, which now filled the entire Fridtjovhamna. He had visited Fridtjovhamna during Torell's expedition of 1858, when the glacier did not even reach the harbour. In the winter of 1860/61, the once small glacier had expanded across the moraines before it in the harbour's interior; it had then filled the entire harbour and even passed beyond. Nordenskiöld's short boat excursion met with diverse troubles—severe winds, pouring rain, and dangerous currents in the narrow fjord entrance.

The gale abated on the 21st and was followed by a calm. In order to make the best use of time, two boats were sent out on excursions, one to Van Keulenfjorden and the other to Van Mijenfjorden.

Dunér's boat excursion in Van Keulenfjorden, July 21–23, 1864

Dunér followed the southern shore of the fjord from Ahlstrandneset at the mouth to about Blautneset, where he crossed the fjord and turned west along the northern shore. The wind had increased and the passage back to ship was rapid. Some mapping, including solar observations for position, had been made from points on the southern shore.

Nordenskiöld's boat excursion to Van Mijenfjorden and the mouth of Bellsund, July 21–26, 1864

The main purpose of this excursion was mapping and, if possible, collecting plant fossils. During the 1858 expedition a few such fossils had been found at the foot of Kolfjellet on the northern shore of the fjord. They brought very few provisions, hoping to secure

enough from hunting and fishing.

Kolfjellet, however, proved a disappointment in terms of both fossils and hunting/fishing, so they continued towards the interior of the fjord. Off Sundevalltoppen they crossed the fjord, passing through rather dense drift ice. On July 23 they followed the southern shore and, passing the ship's anchorage, headed for the promontory on the south side of the entrance to Bellsund. They encountered a very heavy sea out in the fjord, with terrific breakers bordering the coast. The storm persisted on July 24–25, so the ship could not come to fetch them and their equipment, as had been agreed. But on the 26th, the wind abated so much that the boat party could cross the fjord to meet the ship, which still lay at her old anchor ground at Midterhuken.

RECONNAISSANCE IN STORFJORDEN

On July 27 the *Axel Thordsen* sailed southward in order to reach Storfjorden and start the reconnaissance work, for which purpose the expedition had been dispatched to the Arctic. It was now fairly late in the season, and the expedition's success would depend greatly on weather and ice conditions.

The winds proved to be variable. Visibility was low and, when it increased after two days of sailing, they had come only as far as Isöyane off the large Torellbreen. A mighty mountainous landscape was disclosed to them, marked chiefly by Hornsundstind (1431 m) to the south-east. In the calm weather the ship was towed to Dunöyane, where she anchored on July 30. That day Nordenskiöld and Dunér—each with one boat—rowed to Hornsund in order to map the fjord, one party rowing along the northern shore, the other along the southern.

However, they ran into a strong headwind and a very rough sea in the fjord—while at the ship's anchorage a calm still prevailed. They had to land on the northern shore of Hornsund, and on July 31 they were able to do the mapping from the northern shore, using only triangulation methods.

On August 3 the *Axel Thordsen* continued her voyage towards Storfjorden, meeting with considerable amounts of drift ice. On the 6th they at last managed to round Sörkapp, but the ice prevented a landing. So they proceeded along the east coast towards Kvalhovden (345 m), which could be seen to the north. But ice was encountered and the party got the impression that the whole of Storfjorden was packed with it.

Sailing now on a north-easterly course, they found open water off the southern part of Edgeöya (Stans Foreland). They headed for Kvalpynten (415 m. a.s.l. in its southern part; 461 m in its northern), a broad

Camping on the beach during a boat excursion (above). (Dunér & Malmgren & Nordenskiöld & Quennerstedt: Svenska expeditioner till Spetsbergen och Jan Mayen 1863 och 1864.)

A.E. Nordenskiöld's boat excursions in Isfjorden in 1864 with start and destination in Trygghamna.

Borgmesterporten in the south of Russehamna, Björnöya. Borgmester is the Norwegian name for the glaucous gull (*Larus glaucus*). Compare photo p. 286 (right). (Dunér & Malmgren & Nordenskiöld & Quennerstedt: Svenska expeditioner till Spetsbergen och Jan Mayen 1863 och 1864.)

and flat mountain mass marking the south-western cape of Edgeöya. Here they anchored on August 9 near a small diabase promontory to the north-west of the mountain. The harbour was a small bay, protected in all directions. North of the harbour lay ruins of Russian huts, relics of one of the largest Russian colonies in Svalbard, visited by Keilhau in 1827.

The expedition had at long last reached the goal of its ambitions. But the season was far advanced, and only three weeks remained for the reconnaissance, or less if ice and weather conditions were not perfect. And there was always the risk of a forced wintering with insufficient provisions.

After a climb, which in places was hazardous, they reached the summit of the mountain (461 m), which almost imperceptibly rose above a stone desert devoid of vegetation. From here they had no view towards the south, so they marched across the plateau to its southern edge. Then a wide view of mountain and sea opened before them: to the east lay Tjuvfjorden (Deevie Bay), and to the south-east they could count 28 islets in the Tusenöyane archipelago. Hopen Island was not seen, but the entire west coast of Storfjorden stretched in the sunlight. Many of the peaks were similar in height, but it was possible to recognize the mountains near Kvalhovden and Agardhbukta, most prominent being the lofty Hornsundstind (1 431 m).

However, from this point of observation, the eastern side of Storfjorden was not visible. Consequently they returned to the flat hillock in the northern part of the plateau (461 m). After taking some bearings they returned to the ship.

From the top of Kvalpyntfjellet they had observed that Kvalhovden could not be reached by the ship because of ice. They sailed instead to Agardhbukta. This bay had a bad reputation among Spitsbergen sealers: the anchorage is bad, there are sunken rocks, and great caution has to be exercised on the approach.

The ship anchored there in the night towards August 12. The shore was a sheer precipice verging upon a flat plateau, which looked like a market-place, paved and cleaned. They had to row some distance along the shore to find a place where they could pull the boat out of the water and start climbing the slope.

After measuring solar altitudes, they climbed the mountain Agardhfjellet (638 m) in the forenoon of the 12th. They took a number of bearings and returned to the ship, which immediately weighed anchor and was towed out to sea. Ice was drifting into the bay, and there was no wind until they got farther from the coast.

In the afternoon of August 13 they reached Kapp Lee. Here in the north-western corner of Edgeöya,

they anchored in a little bay to the south-west of the mountain Leehovden (325 m). There were ruins of some Russian huts, and on the mountain plateau a Russian cross served as a sea-mark.

The climb up the slope to the mountain plateau was easy. Freemansundet between Edgeöya and Barentsöya lay beneath them. The eastern side of Storfjorden could also be seen; it was free of glaciers, except one to the north. Otherwise the coast consisted of a mountain wall or of grassy slopes, which were fine reindeer-grounds. They reached the harbour about midnight, and after a few measurements of solar altitudes they sailed northward—much to the discontent of the crew, who craved a rest.

They hoped to reach the north-west point of Barentsöya, Mistakodden, in the morning. But owing to ice and fog, they had to anchor halfway in a little harbour, protected by two small diabase islands to the south and the mainland (Barentsöya) to the east. To the north a spit protruded from Barentsöya, and beyond the spit lay the only glacier on the eastern side of Storfjorden.

On August 15 and 16 a severe northerly gale drifted the ice out of the northern part of Storfjorden, and the outlook for reaching the northern end of the fjord suddenly seemed bright. On the 16th they continued the voyage northward under an east-north-easterly wind. They were nearly running aground, but on August 18 they anchored near the low Mistakaodden, the north-western point of Barentsöya. They climbed an adjacent mountain (176 m) in order to measure angles, both for the construction of the map and for the reconnaissance. Several reindeer could be seen, yet they were difficult to approach in the flat countryside.

Next day they climbed the highest point of the foreland (205 m) and found that the bottom of Storfjorden was only a few tens of kilometres away. They built a big cairn to be used as an aiming point for their measurements from the triangle points they were to visit. After taking the necessary bearings, they started the descent to the ship. This proved to be harder than expected, for which reason the cape was given the name of Mistakaodden. They had also trouble in identifying some faraway mountain peaks, as the extremely clear air made them underestimate the distance. Thus a new series of bearings had to be taken before they left.

On the 18th the ship was suddenly attacked by a severe gale and came close to foundering. But a calm followed; and next day they left Mistakodden in order to look for a suitable harbour in the northernmost part of Storfjorden. The calm was aggravated by fog, and they drifted with the current among open drift-

ice, unable to reach the harbour selected. They sent out a boat to shoot seals and walruses, yet the fog made the animals too wary, and the boat crew had to concentrate upon the object of the excursion—finding a harbour for the ship. Finally they reached such a place at the foot of Edlundfjellet, protected from wind and sea by an island to the east, a spit of land to the west, the mainland to the north and extensive ground-ice to the south. The ship was towed into the harbour and anchored.

Next day, August 20, they started to climb the mountain along the glacier to its east, but violent winds forced them back to the ship. Conditions improved on the following day, and they ascended rather easily to the diabase plateau at the top (440 m). To the north-west stretched the inland ice, and from its surface separate mountains protruded. There was also a chain of high mountains, among them the peak which Chydenius in 1861 had recommended as a triangulation point.

To the south, Storfjorden extended from Kvalhovden and Kvalpynten in the south, and in the north they could see the innermost parts of the fjord. To get a better view of the mountains on the inland ice, they marched out on the ice, which here was at a level with the top of Edlundfjellet. The ice was flat and covered with frozen snow, quite comfortable to walk upon. It appeared that the mountains to the north-west would be easy to reach, should a trigonometrical station be chosen in this region.

The descent was more rapid than the ascent, though not entirely safe. A boat had meanwhile been equipped on board the ship for an excursion lasting a few days. On the same day, August 21, they rowed eastwards to the little sound, Heleysundet, which connects Storfjorden with the wide Olga Stretet to the east. The distance was relatively short, but troublesome on account of drift ice. They camped in a small lowland area between Heleysundet and the glacier which surrounds Kvitberget (492 m).

The climb of Kvitberget occurred next day, while the ship's crew hunted reindeer on the north side of the sound. It turned out to be an easy ascent on the slightly sloping ice-field, but it was tiresome owing to the structure of the snow-field, an ice crust covering loose snow.

After several hours of climbing, they reached the top of the mountain, a small plateau covered by ankle-deep snow resting upon glacier ice.

The view from the top was grand. To the east, at a distance of roughly 200 km, they observed a rather high land with two rounded peaks rising above the others. Citing Nordenskiöld and Dunér:

"It was the most westerly part of a vast, still almost unknown arctic continent, which—though discovered as early as 1707 by Commander Giles—had remained forgotten and omitted on the newest charts. Between this land and Spitsbergen the sea was covered by large, unbroken ice-fields, between which no ship could have advanced."

However, this was not part of the land given as "Giles Land". It belonged to the group of islands, Kong Karls Land, which had been reported by Norwegian sealers at approximately 79°N, 28°E, a few years before Nordenskiöld's observation. These islands had probably first been seen by the English whaler Thomas Edge in 1617, but this discovery had been forgotten (see pp. 85 and 269). Giles Land is the island which nowadays is called Kvitöya.

The view from Kvitberget embraced a good deal of the region that was relevant for an arc measurement. The western and northern coasts of Storfjorden were visible from Kvalhovden in the south to the bottom of Storfjorden in the north. Below Kvitberget extended the enigmatic sound, Heleysundet, which a few years earlier had been sailed through by Norwegian sealers. This discovery had, though, been made already in 1617 by William Heley from Holland.

To the north-east they saw the mountains of Nordaustlandet, as well as the islands and mountains in and at Hinlopenstretet. West and north-west the ice-sheet of Spitsbergen extended, with nunataks and mountain ranges protruding above the ice. As usual they took a number of theodolite measurements, but no tripod had been brought along, so they pressed the theodolite into a heap of snow which they had stamped down with their feet.

The descent towards the coast was rapid, although again tiring because of the snow's structure. They returned to the boat at 22.00h on August 22, and found to their annoyance that a polar bear had raided the camp while they were away on the mountain.

Their investigation of the practicability of an arc measurement in Spitsbergen was now completed. The expedition had carried out its task successfully in spite of winds and ice, which had opposed it for all but the last three weeks.

One problem had, however, been left more or less open: the connection between the northern and the southern triangulation networks. This connection would pass over the ice-sheet with its nunataks and mountain ranges, and its feasibility had only been roughly estimated.

*A POLAR RECORD—EXCHANGED FOR
A RELIEF VOYAGE*

The question now was: what should be done before steering south and homeward? They might sail east to map "Giles Land"—that is, Kong Karls Land. Or they might try to reach a high northerly latitude, and determine the position of the edge of the polar pack-ice in the first half of September. For the latter purpose, two routes were possible: through Heleysundet and north through Hinlopenstretet, or doubling Sörkapp and proceeding north along the Spitsbergen west coast.

Considering the risks of being "beset" in the ice, followed by a forced wintering with scanty stores, only the last alternative could be contemplated. So in the morning of August 25, the *Axel Thorsen* weighed anchor and steered south, rounded Sörkapp and started up the west coast.

On the 30th, however, near Prins Karls Forland, a boat flying a large flag approached. It was crammed with men, and another six boats were on the way. They carried a total of 37 men from three Norwegian

sealers, which had foundered in the pack-ice north of Svalbard. One of these ships was the *Aeolus* of Torell's expedition in 1861. Her captain was now the well-known sealer Sivert Tobiesen from Tromsø (compare p. 288). The boats arrived between August 30 and September 4; ten men could be taken to Norway on board two small sealers. The remaining 27 men were brought on board the *Axel Thorsen*, where space now became utterly cramped.

As a result, the northern trip had to be abandoned. Instead the ship was taken to Tromsø, where she arrived on September 14.

* * *

The expedition of 1864 was extremely successful. What it set out to do had been done—both the reconnaissance for an arc measurement and the research in geography, geology, zoology and botany. This was Nordenskiöld's first expedition as a leader, and years later (according to A.G. Nathorst) he used to say that the expedition of 1864 had been the most agreeable of all his polar travels.

Boat excursions of A.E. Nordenskiöld and Nils Dunér in the Bellsund area in 1864, with start and destination at Midterhuken (marked with a circle) (above).

View eastwards from Kvitberget, August 22, 1864. In the background Kong Karls Land, which Nordenskiöld believed to be the Giles Land of the old charts. This view fascinated the young A.G. Nathorst (below). (Dunér & Malmgren & Nordenskiöld & Quennerstedt: Svenska expeditioner till Spetsbergen och Jan Mayen 1863 och 1864.)

9. THE SPITSBERGEN EXPEDITION OF 1868: A RECORD 81°42'N

Planning, economy, participants

The Swedish arctic expeditions after 1858 made several attempts at attaining high northerly latitudes. Torell had planned in 1861 to push northward over the pack-ice using dog sledges, but did not do so because of adverse weather and ice conditions (see pp. 24, 36, 38). Towards the end of the summer of 1861, Torell contemplated a push northward with the expedition ship *Aeolus*; this time he was foiled by the late season and opposition from the ship's company. In 1864, after reconnoitring for an arc measurement, A.E. Nordenskiöld proceeded north with his ship *Axel Thorsen* in order to carry out a similar scheme, but now the rescue of shipwrecked Norwegian sealers prevented a realization of the plan (p. 52).

Thus, both Torell and Nordenskiöld had been interested in reaching farther north, though the scientific character of their expeditions was not allowed to suffer from such a record-hunt. After 1864 there seemed to be little hope of obtaining financial help from the State for new arctic ventures. The previous Swedish expeditions of 1858–64 had carried out excellent scientific work in the Svalbard region, but further research was still necessary on land and in the surrounding seas.

To these scientific projects might be added a push northward in the expedition ship. In the early attempts, sailing vessels from Tromsø had been used, but after 1864 Nordenskiöld aimed at using a steamship specially built for action in ice. He would then become independent of wind and, in many situations, also of ice obstructions.

Nordenskiöld won support for his next expedition from the city of Göteborg, where the county governor, Count A. Ehrensvärd, quickly succeeded in awakening the enthusiasm of influential men of finance to make the venture a reality. Among them was Oscar Dickson, later to become the patron of Nordenskiöld's many arctic expeditions (p. 63). The crown prince, subsequently King Oscar II, now also began his generous aid to Swedish polar expeditions.

With the economy of the expedition secured, Nordenskiöld turned to government authorities for practical help. Private sources in Göteborg had provided about 40% more than he had requested, and what he wanted as a ship was a strong propeller steamer. The Swedish Postal Administration was using two steamers in the Baltic for the winter traffic: the *Polhem* (built in 1858) for the postal service be-

tween Gotland and the Swedish mainland, and the *Sofia* (built in 1864) for the traffic between southern Sweden and Germany. Nordenskiöld applied to the Government for one of the two "winter steamers", and the *Sofia* was placed at his disposal for the summer season of 1868. She was a luxurious vessel, judged by the polar standard of the time. Her length was 41 m, beam 7 m and draught 3.2 m, and the engine gave about 60 hp. Besides, she was a brigantine and a fairly good sailer. The sea-ice of the Baltic could hardly be compared with that of the Polar Sea. Nordenskiöld seems to have underrated this difference.

Captain Fredrik Wilhelm von Otter was appointed commander of the *Sofia*, Lieutenant Louis Palander became second-in-command and Dr. Carl Nyström the doctor. The rest of the ship's company was supplied by volunteers from the Navy, chosen by Captain von Otter. Equipment and provisions were obtained from Navy stores, and modifications of the ship were carried out by the naval authorities.

The financial status of the expedition had thus developed quite positively. According to the original plan only three scientists were to be taken, but the number could now be increased markedly, to the benefit of the enterprise.

The ultimate list was as follows:

THE CREW OF THE *SOFLA*

Captain Fredrik Wilhelm von Otter (1833–1910), commander of the ship.

Lieutenant Adolf Arnold *Louis* Palander (1842–1920), second-in-command.

Carl Ludvig Hippolyt Nyström (1839–1913), Ph.D. (1863), M.B., ship's doctor.

In addition, the crew included 20 men, among them 6 Norwegian sealers.

Captain von Otter was a daring seaman and a highly qualified naval officer. He was to rise in the ranks to become an admiral, a minister of naval affairs and later prime minister. Lieutenant Palander would also meet with success, becoming an admiral and minister of naval affairs, but he is best known as the captain of the *Vega* during her passage in 1878–80 along the North-East Passage and round Eurasia.

SCIENTIFIC MEMBERS

Adolf Erik Nordenskiöld (1832–1901), Ph.D., professor, geologist, in charge of astronomical observations for position, leader of the expedition.

August Emil Algot Holmgren (1829–88), zoologist (entomologist).

Anders Johan Malmgren (1834–97), Finlander, Ph.D., zoologist and botanist.

Fredrik (Frits) Adam Smitt (1839–1904), zoologist. Sven Berggren (1837–1917), Ph.D., botanist.

Theodor (*Thore*) Magnus Fries (1832–1913), Ph.D., botanist.

Karl Selim Lemström (1838–1904), Finnish, M.Sc., physicist.

Ernst *Gustaf* Reinhold Nauckhoff (1847–1919), geologist and mineralogist.

Assistant to the zoologists was A. Svensson, a taxidermist.

The most conspicuous project would of course be the push northward. Here Nordenskiöld built mostly upon the experience of British expeditions and Norwegian sealers—and, of course, upon his own experience. The advance would be made in the autumn (late September and early October), when the ice-melt had reached a maximum and it was about to start freezing up. The southern limit of the polar pack would then be expected to have attained its most northerly position of the year, unless winds and currents had upset the distribution of the ice. This part of the cruise would offer good opportunities for studying the flora and fauna in the deep sea while measuring the depth.

The main scientific work, however, would be carried out during the summer.

The following studies were planned:

1. A study of the flora and fauna of Björnöya, which at the time was almost unknown.
2. A close study of the strata at Björnöya, Isfjorden and Kongsfjorden which contain plant fossils.
3. A search for post-Miocene strata in the peninsula between Bellsund and Isfjorden, which is present-day Nordenskiöld Land.
4. A thorough investigation of the saurian strata at Kapp Thorsen.
5. Investigation of fragments from whale skeletons along the shores of Spitsbergen; investigation of the marine flora of algae, which was imperfectly known at the time; further studies of the fauna of sea and land; dredgings in the deep sea; geomagnetic and meteorological observations; astronomical and geodetic determinations of position.

The chances were assessed as fair for undertaking cruises to north-eastern Greenland, or to “Giles Land”—Kong Karls Land, as it was later called (compare p. 51). In the middle of November the expedition was estimated to be back in Norway, assuming that it had not been forced to winter in the ice. For that contingency, fourteen months of provisions were brought.

A preliminary timetable and itinerary for the summer's work was drawn up:

Tromsö–Björnöya–Isfjorden: 3–4 weeks.

Kongsfjorden: a visit to the “coal harbour”; collection

of coal and plant fossils.

Kobbekbukta, Dansköya: to await a suitable date for proceeding northward at the end of September or beginning of October.

A VISIT TO BJÖRNÖYA, JULY 22–27, 1868

On June 29th the *Sofia* left Karlskrona and began her voyage north, passing by Göteborg where the scientific members with equipment boarded the ship. Tromsö was visited from July 16–20, and on July 22 the precipitous rocks and grey hills of Björnöya were dimly seen among banks of fog. In the same evening enthusiastic scientists left the ship in two boats, with provisions for a week's stay ashore; at the same time the *Sofia* started a cruise round the island.

It should be noted that very few scientific expeditions at the time had visited Björnöya. Knowledge of the natural features had been gained mainly from studies by the Norwegian geologist B.M. Keilhau on August 20–23, 1827 (see pp. 18 and 284). Many expeditions on their way to Spitsbergen had passed near the island, but the majority had been unable to either see or reach it, let alone land there. This had been due to the scarcity of harbours as well as to the unsettled weather and the ice.

The two boats landed at Sörhamna in the south-east of the island, and this place was made a base for excursions and for the routine observations in meteorology and geomagnetism. As usual on the Swedish expeditions, boat-tents were used for lodging. The geomagnetic observations were carried out in a separate tent.

They found the island extremely dreary: a flat plateau 60–90 m a.s.l., except in the south. There were no glaciers, the colour of the land was grey, and the vegetation was poor. To cite Keilhau:

“The earth crust lies uncovered close to utter nakedness with stones and more stones.”

The island was, however, fabulously rich in birds.

The weather during their stay was bad, and the scientific work was greatly impeded except among the geologists. Much of the island was found to consist of strata of limestone rich in fossils of mussel-shells and corals, hinting at a once near-tropical ocean. Coal had been discovered on the island already in the beginning of the 17th century. The expedition was able with the help of plant fossils to date this coal, namely to the Carboniferous period. Previous Swedish expeditions had dated much of the Spitsbergen coal as originating from the Tertiary period.

The biologists carried out botanical and zoological studies during excursions northward to Nordhamna.

Captain Fredrik Wilhelm von Otter (1833–1910), the commander of the *Sofia* in 1868. Photo: Svenskt Porträttarkiv, Nationalmuseum.

The *Sofia* at her most northerly position 81°42'N, on 19 September 1868 (below). (Fries & Nyström: Svenska polarexpeditionen 1868 med kronångarfartyget *Sofia*.)

The route of the *Sofia* in 1868, excluding the visit to Isfjorden. Former northern records were set by the British whaling Captain William Scoresby in 1806 and by Captain Edward Parry of the British Navy in 1827 (see p. 62).

A look into Longyeardalen from Adventfjorden. The "capital" of Svalbard, Longyearbyen, was later to be founded here. (Fries & Nyström: Svenska polarexpeditionen 1868 med kronångarfartyget *Sofia*.)

The expedition's map of Björnöya was not to be any improvement on previous maps; rather the opposite, perhaps due to the weather. On July 27 the land parties—with collections and equipment—were fetched by the *Sofia*. She then set course for Spitsbergen, at the southern point where no scientist—except Keilhau—had ever landed. But ice prevented them from reaching the shore, and the passage was also blocked towards the east. Thus they were forced to begin investigations along the west coast of Spitsbergen, which were included in the expedition programme.

IN ISFJORDEN, JULY 31–AUGUST 13, 1868

On July 31 the ship anchored in Grönfjorden (Green Harbour) at the entrance to Isfjorden. In this region the Russian hunters once had a favourite ground. The “Nestor” among them, Emil Starostin, who died in 1826, had spent 32 winters in Spitsbergen, 15 of them in succession (see p. 47). His hut still stood on a promontory to the west of the fjord entrance.

The ship stayed for three days here, and the zoologists and botanists were especially busy. Two boats were used for dredgings. Some scientists hurried to the shore for collecting plants, insects and fossils. One boat party left for the western shore of Grönfjorden to hunt and reconnoitre.

On August 2 the *Sofia* left for Adventfjorden farther east. The stay there is described by the expedition members as belonging to the most agreeable memories from the whole cruise. On a couple of days the temperature was +7°C. The physicist carried out geomagnetic observations near the Russian hut on Hotellneset (as it is called today), and excursions were made in the surroundings. A small valley running towards the west pleased the scientists. This was Longyeardalen, where the mining “city” of Longyearbyen is now situated.

A collection was made here which bore out the reports by hunters that salmon existed in Spitsbergen waters. These reports had been considered as “tall tales” until, in 1861, a poor specimen was secured in Wijdefjorden by the Torell expedition. Now, however, four good specimens were obtained, one of them three feet long.

The *Sofia* remained at Adventfjorden until August 11. But before then, Nordenskiöld had launched a boat excursion which will be summarized below.

*Boat excursion to the northern part of Isfjorden,
August 6–11, 1868*

The participants were Nordenskiöld, Palander, Malmgren and four men. As agreed, the ship and the boat party were to meet at Kapp Thordsen on August 11. The boat party left Adventfjorden in the evening

of August 6, and at midnight Kapp Thordsen was reached. The party stayed here until the 8th, occupied with studies in natural history and with reindeer hunting.

The region was notably excellent for geological investigations, on the Saurie Mountain at about 300 m a.s.l. and on the steep banks of a river. In the strata near sea level, the river banks showed alluvial formations. Peat bogs, up to 3.6 m thick, had deposited at a time when coniferous and deciduous forests did not thrive here. They contained northerly types of plants, as well as shells of *Mytilus edulis* and *Cyprina islandica*, which no longer live in Spitsbergen but are found in northernmost Norway. This hints at a climate less dominated by ice than today.

However, the main purpose of the boat excursion was to collect fossils of saurians from the Triassic period, which were first discovered here by Nordenskiöld in 1864. Fossils containing parts of spinal columns and ribs were gathered, but no skulls—although two skulls had been found in 1864.

On the 9th, the party proceeded to Nordfjorden and made astronomical determinations of position on the promontory separating its two branches, which were now named the Ekman- and Dicksonfjorden. Under a fresh breeze the boat penetrated to the bottom of Ekmanfjorden, the western branch. The men enjoyed the sight of the two mighty mountains of Capitulum and Colosseum, which resembled colossal ruins and were now named accordingly.

Next day they studied the eastern branch, Dicksonfjorden. It was found to penetrate farther north and inland than they had expected. So the party were forced to turn back already somewhat north of Kapp Smith, as they had to reach Kapp Thordsen on the 11th to meet the *Sofia*.

On the 12th, the ship left Kapp Thordsen for Colesbukta, to fetch a boat party which had gone there in order to obtain an undamaged skeleton of a “white whale” (*Delphinapterus leucas*) from Norwegian hunters. This had, however, been a journey without success; the skeleton was indeed damaged.

*IN THE NORTH-WEST OF SPITSBERGEN,
AUGUST 13–30, 1868*

It was now time to go north. Next day, August 13, the ship steamed out of Isfjorden and proceeded northward along the western coast of Prins Karls Forland, with the object of carrying out deep-sea soundings and mapping. The mapping could not be done owing to unsuitable weather—but the soundings gave both the depths and samples of the bottom material, including the bottom fauna. A short visit was paid to Fuglehuken, the north point of the Forland, with

graves and ruins of oil-cookeries from the whaling period in Spitsbergen. They also found a luxuriant vegetation of lichens here. On August 16 they entered Kongsfjorden and anchored near its bottom.

Before going north, a boat party had left the *Sofia* in order to pass up through Forlandsundet, the sound between Prins Karls Forland and the Spitsbergen mainland. This party (Nordenskiöld, Palander, Berggren and four men) reached the ship at Kongsfjorden on the 17th, having met with fogs, gales, rain and cold, which prevented them from doing any useful work. It was a most displeased group which boarded the *Sofia*.

The ship stayed in Kongsfjorden till August 19. The reports are filled with enthusiastic descriptions of the scenery of ice and mountains, the rumbling sounds from calving glaciers, the crackle from small pieces of glacier ice in the water, the rocky coast with its caves, arches and isolated blocks, mountains of sandstone horizontally striped like the pyramids of Egypt, and so on. The scientists added to their collections of plants, marine animals and Miocene fossils. And the crew of the ship increased the stores of fuel with about two cubic metres of the finest Spitsbergen coal.

The next station was Kobbekbukta in the western part of Dansköya, at the north-western corner of Spitsbergen. Among sealers this bay is known as a good harbour. It is protected from most winds, it is ice-free during a good part of the year, and fresh water can be obtained from a small lake.

A meeting had been prearranged with a Norwegian sealing vessel, the *Severine*, which was to carry coal from Tromsö to the *Sofia*. But on arrival in Kobbekbukta they found no ship—nor any coal on the beach and no letters at the “post office”, a stone cairn on a small islet.

The *Sofia* went off to the remains of the old whaling base, Smeerenburg, of the Dutch on Amsterdamöya some distance to the east. No coal was found here either, but next day, August 20, the supply ship arrived. The *Sofia* stayed until August 23, and the glaciers on the eastern side of Smeerenburgfjorden were visited, as well as Smeerenburg with its remains from the Dutch whaling period in the 17th and 18th centuries.

There had developed conflicting interests on board as to the scientific work which should be carried out during the remaining period in the Spitsbergen area. The time had now come when the *Sofia* was to be taken on cruises mainly towards the west and the north. Most of the scientific members were not interested in this part of the expedition programme; they wanted to do their studies on land, not in the open sea or in the pack-ice.

An agreement was reached: most of the scientists were to remain at Kobbekbukta while the ship was on her mission. This was estimated to last eight days. Should the ship not appear according to plan, they were to remain at Kobbekbukta until September 23 at the latest, and then return with the “collier” *Severine*, which was expected from Tromsö. The *Sofia* would in that case very probably have become “beset” in the ice, or perhaps even crushed by it.

The scientific members were distributed in the following way between the ship and the camp:

ON BOARD THE *SOFLA*

Nordenskiöld, geologist and leader

Malmgren, zoologist and botanist

Smitt, zoologist

Nyström, doctor

IN THE KOBBEKBUKTA CAMP

Lemström, physicist

Holmgren, entomologist

Nauckhoff, mineralogist

Berggren, botanist

Fries, botanist

Svensson, assistant

On August 23 the “camp party” was landed, and shortly afterward the *Sofia* put out to sea and proceeded west. Those on land were eager to pursue their respective main interests: Lemström wanted to carry out geomagnetic observations, and Nauckhoff a study of the archæan rocks in the region. The two botanists looked forward to examining vegetation among the same archæan rocks; until then, they had only been able to study the flora in limestone and schist regions.

The party pitched their tarpaulin tent on a low sandy hillock. Next day they pitched a tent for the geomagnetic observations, and the scientific work began. Hourly geomagnetic and tidal observations were to be made, with all scientists sharing in this effort. Short excursions in the surroundings would also be undertaken.

The weather-gods, however, were not in their favour. They experienced cold, snow and a frozen ground; fierce winds blew from between N and NE, at times reaching full gale force. The excursions became most arduous or useless. Mosses and lichens were covered by a crust of ice; the insects disappeared, and the geomagnetic observations were partly ruined because the tent was blown over or the instrument position was upset. All small brooks became frozen to the bottom, and water had to be carried from distant sources.

Still, a certain amount of scientific information was gained. Several plants, previously unknown from Spitsbergen, were collected; insects were gathered

and their way of life was studied; and usable geomagnetic observations were secured. The tarpaulin tent was too dark for work, but the botanists could use a boat-tent, where those working at night also found a place of refuge.

The land party welcomed the return of the *Sofia* in the night towards August 30.

*THE FIRST CRUISE IN THE ICE,
AUGUST 23–SEPTEMBER 11, 1868*

According to the plan, the *Sofia* was to proceed west and try to reach the Greenland coast. Deep-sea soundings were to be taken on the way, including studies of the marine fauna. Naturally, the cruise would also provide information on the ice conditions.

After leaving Kobbekbukta on the afternoon of August 23, the ship made good speed. There was practically no wind and no ice, until the 25th when she was stopped by ice near longitude 0°. The course then changed to near north, and was followed until latitude 81°N. During the next days, they sailed eastward along the ice edge—with more or less open water on the starboard side—and reached 81°09'N.

On August 27 they sighted Sjuöyane, which were unattainable owing to ice, as was Brennevinsfjorden to the south-east. Instead they entered Liefdefjorden in northern Spitsbergen. The weather had been fine, with air temperatures between -1° and -6°C. They had met with repeated and sudden variations of the water temperature as they passed into and out of flows of Gulf Stream water.

Deep-sea soundings had generally been carried out twice a day, at depths between 695 and 3900 m. With the help of ice anchors, the ship was moored to a large floe during the soundings. The sounding apparatus was lowered into the water, and a bottom sample was taken. Once on board, it was given to the zoologists, who took care of its live contents. New species (crustaceans and others) were found chiefly at depths near 1600 m, but even at the greatest depths a rich fauna was discovered. The most abundant animal life was noticed in the immediate neighbourhood of the ice.

The ship entered Liefdefjorden on August 28, and very soon the zoologists were busy with their harvests from the dredging-boats. Near the anchorage of the *Sofia*, excursions were made across the slightly undulating lowland of Reinsdyrflå, apparently in its south-eastern corner near present-day Worsleyneset. The reports speak of islets rich in terns, and of plains coloured brownish-green. They enjoyed the views over the wide moor with its hillocks, depressions and fairly deep ravines. The vegetation was rather rich. Flocks of geese assembled on the plains, about to migrate southward. A Russian cross, animal bones,

and even human skulls indicated previous hunting activity.

On August 29 the *Sofia* left for Kobbekbukta to fetch the group of scientists left there. Six men stayed behind at Liefdefjorden–Nordenskiöld, Malmgren, Nyström and three of the ship's crew. Liefdefjorden had not been studied previously by any scientists, and it was considered vital to make the most of the time by carrying out a boat excursion in the region.

On that first day, the boat party rowed westward along the southern shore of Reinsdyrflå. Next day, the 30th, they crossed the fjord and reached Roosneset. Here in the characteristic red schist, earlier Swedish expeditions had looked in vain for fossils. Now they found plenty of shells and fish-scales, which made a dating of the strata possible, namely to the Devonian formation. Nordenskiöld was more than satisfied!

From Roosneset they crossed Woodfjorden and followed its eastern shore northward, camping for the night in a small bay. On September 1 they continued along the shore and camped at a small islet near Gråhøken. Next morning they were roused by two sailors from the *Sofia* and were soon on board again.

They proceeded into Woodfjorden and anchored in Love Harbour at about noon. The dredging-boats obtained rich harvests, and the two botanists roamed the land, returning heavily laden. The vegetation was definitely richer than in the granite regions; it reminded them of the flora at Isfjorden. A longer stay was indeed desirable, but autumn had arrived and they needed to hurry. September 2–4 was spent here, and the excursions during these days were to remain in their memories: a clear blue sky, mountains, glaciers and a glassy sea—though now and again they were surrounded by fog banks.

On September 4 the ship weighed anchor and left for Brennevinsfjorden in the north-western part of Nordaustlandet. The fjord was filled with ice, but Depotødden at the northern entrance could now be reached. In 1861 a depot had been established there, including a small iron-boat and ten boxes of pemmican. These stores were now well worth having, in case of a forced wintering.

Some indecision prevailed as to the next step in the expedition plans:

1. They might pass Sjuöyane, proceed eastward and round the north-eastern corner of Nordaustlandet to investigate its east coast. They might even proceed further east to unknown regions—Franz Josef Land was not yet discovered.
2. They might study the southern part of Hinlopenstretet and, with luck, reach the land which had been observed from Kvitberget in 1864 by Norden-

skiöld and Dunér (see p. 51). However, to avoid any unfair competition with the German expedition under Carl Koldewey, they could only choose the first option.

They left Depotodden in the evening of September 5 and sailed north through ice, which gradually grew denser. Anchoring at the Nordkapp of Nordaustlandet, they stayed there until the 8th. From the hills they saw ice to the east and north otherwise open water towards the horizon, beyond an ice band near the land.

Thanks to fresh south-east winds, the ice opened and the *Sofia* managed to reach Sjuöyane on the 8th. The islands were enclosed in a girdle of ice, but a visit to Parryöya was possible by walking over the ice. Snow and ice covered most of this island, and only the depressions on the mountain slopes were green. The fauna too was poor. The visit was interrupted by a signal from the ship: ice was approaching and the ship had to steam south into open water.

In the night towards September 9, the *Sofia* passed through northern Hinlopenstretet, and early in the morning she anchored in Lomfjorden a little to the south of Valhallfonna. The temperature was around 0°C, and heavy showers of snow prevented the zoologists and botanists from enjoying their excursions ashore. The ship therefore soon continued her voyage southward, and on September 10 she was off Lovénberget, now appearing in a winter dress of snow. In spite of this, rather fine limestone fossils could be collected.

It was, however, time to turn back. The stores of coal on board were nearly used up, and the coal depot at Smeerenburg had to be reached as soon as possible. Furthermore, they did not want to interfere with the work of the German expedition further to the south. It was also time to "get rid of" those expedition members whose scientific interests did not agree with what would be needed during the projected voyage northward. To let them draw upon the store of provisions was not good economy.

Expedition members go home

On the 11th, the *Sofia* chose the shortest route to Smeerenburg. The "collier" *Severine* had already arrived with coal, mail and potatoes. She was now to receive those expedition members who were no longer required on board the *Sofia*.

For five days (September 12-16) nothing could be done except to pack scientific equipment and collections. The weather was characterized by biting winds, fogs, low clouds and snow or sleet.

Finally, the expedition members were distributed on the two ships as follows:

THE SEVERINE

Fries
Holmgren
Malmgren
Nauckhoff
Smitt
Svensson
four Norwegian
seal hunters

THE SOFIA

Nordenskiöld
Berggren
Lemström
Nyström
two Norwegian
seal hunters

Altogether there were now 22 men on board the *Sofia*. On September 16, she towed the *Severine* to Kobbekbukta, and in the evening the two ships parted. The *Sofia* embarked upon her perilous voyage northward and the *Severine*—as it turned out—upon an almost equally hazardous journey home.

The voyage of the *Severine* may be summarized first. She bounced over the waves like a nutshell, and in the crowded spaces below deck, remains of rotten fish emanated vapours of poisonous hydrogen sulphide.

The ship was also plagued by bad weather, and by the skipper's unclear idea of his location. When at last on the 23rd, rocky islands had appeared fading into blue on the horizon, the crew wondered whether they were east or west of Nordkapp, or perhaps approaching the Shetland Islands. Eventually they noticed a lighthouse, realized that they were well south of Tromsø, and had to beat against a wind which became a gale. On the 24th, land was seen again and they found that they were now off the Malangen, the southern approach to Tromsø. The wind abated, and soon they were faced with a calm. Not until September 26 did the ship reach Tromsø, after ten days at sea.

THE SECOND CRUISE IN THE ICE, SEPTEMBER 16-25, 1868

A northern extreme for the Sofia

When the *Sofia* began her most spectacular cruise on September 16, the land gave a highly wintry impression: snow covered even the plains, and new ice was forming. The wind was fresh and the ship used her sails. Sjuöyane were the nearest destination, and these islands had been chosen as a base of operations.

On September 18 she entered the ice, and steam was raised as an emergency measure. Sjuöyane were surrounded by ice, but to the north lay open water. In the morning of September 18 they reached latitude 81°32'N, and open water still extended northward. The northern record of the British whaling captain William Scoresby from May 25, 1806, had been 81°30'N. Hence there was an atmosphere of optimism on board.

That afternoon, they moved the ship to an ice floe,

in order to carry out a deep-sea sounding to the bottom at 2300 m.

The ice was now becoming denser; during the following night, they passed through ice of variable structure and strength. At 08h on the morning of September 19, they reached their northernmost position: latitude $81^{\circ}42'N$, longitude $17^{\circ}30'E$. Dead reckoning had given $81^{\circ}39'N$, but was corrected by a solar altitude. There were no lanes in the ice opening northward, nor any dark water-sky in the clouds in the same direction.

By contrast, Scoresby had used a sailing vessel to set his record of 1806 in the same area. Captain Edward Parry of the British Navy had managed to reach an utmost northerly position of $82^{\circ}45'N$ on July 22, 1827, starting from Sorgfjorden in the north-east of Spitsbergen. Yet this position was attained by dragging small flat-bottomed boats over the ice fields.

A Swedish counter-sign was now fired from the *Sofia*, and the national flag fluttered from her masts. The physicist carried out geomagnetic observations on the ice, water samples were taken, and the "Bulldog" apparatus collected a bottom sample from 2440 m. Finally it was time to return.

The ice was most open towards the west, so a westerly course was set. But the current carried them south, and once again they became enclosed by ice, which called for pushing and zigzag courses. On September 20, Spitsbergen was sighted and they steered westward. The ice had become harder and thicker, and mirages made it appear more awesome than it really was. They observed driftwood, and a glass ball—a float of a type used by Norwegian fishermen. The ice, together with the darkness, rendered navigation hazardous, but the fauna was rich and several birds were seen. The deep-sea soundings steadily increased the zoological collections.

They steered along the ice edge for some days. As had been the case in August, the direction of the ice edge became more southerly as they moved west. On September 23, at lat. $78^{\circ}26'N$, long. $2^{\circ}17'W$, they decided to go back. The weather was fine, and the ship was moored to an ice floe, from whose centre the crew collected fresh water. The physicist carried out his observations, others skated, and a few even went skiing.

The fauna was unexpectedly abundant, and deep-sea sounding proved to be extremely interesting. From 4700 m came a bottom sample which consisted almost entirely of brown and white foraminifera. The zoologists were surprised at finding such rich animal life at so great a depth.

It was impossible to penetrate farther west or north. Ice stretched as far as the eye could tell; conditions had

been about the same in August, and were unlikely to change much in October. Previous expeditions had encountered similar conditions—despite the fact that the *Sofia* operated in the autumn when the ice had shrunk to a minimum by melting, before the winter freezing commenced.

At first the ship had to force her way eastward until she reached open water. On the 24th a deep-sea sounding was carried out, attaining 2 500 m. Spitsbergen was sighted on the 25th, and the *Sofia* anchored in Sörgattet to the south of Dansköya.

THE THIRD CRUISE IN THE ICE, SEPTEMBER 29–OCTOBER 4, 1868

A narrow escape

The group stayed at Sörgattet for four days (September 25–29), while overhauling their personal equipment and the ship's engine. Observation-tents were pitched on the shore, and watch duties at the instruments were organized. Excursions in the surroundings were not popular now; it meant plodding through deep snow. But the twilight colours were beautiful, and northern lights had begun to appear, creating much work for the physicist.

Leaving her anchorage on September 29, the *Sofia* first stopped at Kobbekukta and left news from the expedition in the "letter-box". Next she called at Smeerenburg, where driftwood and the remaining store of coal in the depot were loaded. The cold season was approaching; in the cabins on board, the temperature was $+4^{\circ}C$, and darkness was gathering over sea and land.

They now planned to take the ship as far north as possible. Perhaps they would find new land north of Spitsbergen, which could serve as a base. If these plans failed, they might try to reach Sjuöyane and advance from there towards the north or the east—to "Giles Land". They might spend the winter at Sjuöyane and, in February, start marching north over the pack-ice. With provisions for 60 days, they might get as far as latitude $84^{\circ}N$. Conceivably they would even march eastward in the spring, to "Giles Land".

Evidently the men gave free rein to their imagination. But they had underrated the difficulties. The cold had now made the ice as hard as stone, and collisions with it were dangerous to the ship. New ice cemented the floes together; darkness limited the effective time of travel and work, and hindered an assessment of the ice situation. But most formidable of all were winds of gale force in the outskirts of the ice fields, where the ice blocks and small floes were tossed against each other by the waves—or against any ship that might fall into their power.

The group saw no need to fear an overwintering.

The provisions were rich, and they were provided with antiscorbutics. Besides, they had brought along warm clothes, furs and reindeer skins; and the ship was supposed to be well insulated. Nonetheless, she had only been tested in the ice of the Baltic.

They lacked draught-animals and clothes appropriate for sledging. Much would have to be improvised. In addition, no one on board possessed any previous experience of polar winter conditions and winter travel, or of the potential perils that lurked in the outskirts of the polar pack-ice. Figuratively speaking, the men of the *Sofia* were stumbling with blind eyes into deadly dangers.

On October 1, the ship steered out of Smeerenburg's fjord and started upon her third cruise northward. The temperature was -7°C and a strong wind was blowing from the northeast. The men soon realized that there would be little chance of getting far north this time. Conditions had changed markedly to their disadvantage.

In the following night, they reached the ice at latitude $80^{\circ}14'\text{N}$, and moored to an ice floe. Next day they passed mostly northward through drift-ice, whose floes were largely joined by newly formed ice. The ship repeatedly suffered hard bumps against the ice. Already on October 2, it was apparent that the ice became thicker towards the north. Soon the new ice attained a thickness of several inches, and the ship, even given full power, could not advance with greater speed than 2 knots. It was necessary to try coming out of the ice by steering south.

A fight for life

On October 3, the *Sofia* reached open water and passed along the ice edge towards about north-east. Ice was again sighted ahead in the afternoon, and the ship was laid hove-to overnight, awaiting dawn. At 03.00h on October 4, her position was nearly 81°N . A south-east wind was rising, and the sea with it. Her sails reefed and fire under her boiler, she advanced through the ice that came drifting before the wind.

At 08.30h she had to pass through a rather dense band of ice. A strong gale was blowing, and the ship was tossed between the ice blocks. Then she was hurled against a large block to leeward. A leak arose in the starboard coal box aft. The hatch of the box was stopped up as carefully as possible to confine the water to the box.

It seemed that land would be reached without further trouble. One hour later, however, it was reported that water was flowing onto the double flooring—and that the engine pump was fully engaged in pumping away water which had entered the engine room from the coal box. It would be necessary to

empty the ship with buckets, and soon water began to come up into the ash-ovens, so the buckets had to be used even there.

All men, crew and scientists alike, worked hard for 11 hours. The temperature was -6°C ; they were soaking wet and took no food. A hundred buckets travelled along the chain of hands every fifteen minutes. The ship was fighting for her life. Under both sail and steam, she hurried towards Smeerenburg. Boats would have had little chance in such weather—and even if the men had been able to reach land under these circumstances, it is doubtful whether they would have survived.

Towards noon the Spitsbergen mountains were sighted. The leaks had now been located, but now even the cabins were inundated with water. In the lee of land it became possible to heel over the ship and stop the water flowing to the double flooring. Soon before 18.00h on October 4, the *Sofia* anchored at Amsterdamöya. The heeling of the ship could now be increased by hoisting several boats to the ship's side and filling them with water.

It had been a narrow escape. Next day, despite their aching muscles and stiff limbs, the men had to take care of the ship, their equipment and clothes, and tidy up.

Homeward bound

The ship was taken to Kongsfjorden to be overhauled in a sheltered harbour. She was heeled on the shore of an islet with the help of the tide in order to expose the leak. They spent seven days here, and melted snow to get fresh water for the voyage home; the physicist carried out observations in his tent. But it was not worthwhile to make any excursions. By the evening of October 10, the essential repairs were completed and it was time to haul the *Sofia* into the water as soon as possible.

Next day was a Sunday and they rested, but on October 12 the homeward voyage started. The intention was to make an attempt to reach "Giles Land" (Kong Karls Land). Yet near Tusenöyane they met with strong winds and dared not strain the crippled ship. It was now found that the *Sofia* also had two broken ribs.

At Björnöya they discovered a bank with depths of 30–70 m, extending some 60 nautical miles north-east from the island. Dredgings here gave fine results but a north-east wind, increasing to a full gale or worse, created a terrifying sea on the banks.

The ship lay hove-to from October 16–18 with Björnöya rather close to leeward—a most unpleasant situation. Moreover, the ship was becoming iced; in the double flooring and in the wardroom, water

splashed to and fro; it was cold, and the stove gave no heat.

Björnöya was sighted on the 17th. Next day they were still hove-to, when those below deck noted that the engine was being started. Soon the ship's rough behaviour changed into a smooth swaying motion, and she began to scud with the wind and waves. The course was set for Tromsö, which was reached on October 20.

The *Sofia* finally reached Karlskrona on October 26, 1868, having completed a voyage rich in scientific results as well as in adventures and dangers. As things had turned out, Nordenskiöld now gave up all plans of reaching a high northerly latitude by means of a ship. Instead he decided to travel over the pack-ice before summer began—in late winter and spring. He had not abandoned his dreams of approaching the top of the world.

Thus, fate had brought Nordenskiöld very close to ending his career as a polar explorer, and Swedish polar research itself to being discontinued for several years in future.

EXPERIENCES AND RESULTS

While planning the expedition of 1868, Nordenskiöld had studied reports from expeditions that, during the previous 100 years, penetrated northward with ships in the Spitsbergen area. These attempts at reaching a high northerly latitude were all made in the summer, when the ice was not yet melted to a maximum. They had got only as far north as about 80,5°N, except for the latitudes 81°30'N and 81°06'N reached, respectively, by Scoresby in 1806 and Parry in 1827¹.

The philosophy behind the cruises of the *Sofia* in the autumn of 1868 had been to take advantage of the maximum melting, which should have occurred in the autumn before the winter freeze-up began. However, the northernmost position of the *Sofia* did not differ markedly from those of her predecessors—81°42'N as compared with 80,5°–81,5°N—though it marked a northerly record at the time. Nor did the ice edge seem to be very different in its general direction: from near Sjuöyane it stretched W–WSW and became southerly to the west of Spitsbergen.

At the time there existed two opposite ideas as to the extension of the pack-ice in the Polar Sea:

1. *The Polar Sea was entirely filled with ice*, except for lanes or local areas with open water.

2. *There existed an open Polar Sea*. This idea was advocated by the famous German geographer August

Petermann (1822–78), who even considered that it should be as easy to sail from Spitsbergen to the North Pole as from Tromsö to Spitsbergen! Later, though, he renounced this optimistic view.

The first theory was supported by experience from the cruises of the *Sofia* as well as from previous expeditions. A further conclusion was that it would not be worthwhile to strive for a high northerly latitude in the autumn by using a ship. The risks were too great in this season. Much would also depend upon the currents and the wind prevailing at the time. Nordenskiöld was to gain further practical experience on that point during his next Spitsbergen expedition in 1872–73.

During the cruises of the *Sofia*, much new information was acquired from the deep-sea soundings. They indicated that the Polar Sea was a deep ocean, and that its marine fauna was very rich down to the greatest depths attained: 2440 m at the northernmost point, 81°42'N, and 4720 m west of Spitsbergen at 78°25'N, 2°17'W. It should be pointed out, however, that measurements of great depths at the time generally suffered from the difficulty of knowing exactly *when* the lead reached the bottom.

Much geological work had also been carried out by the expedition. In part it supplemented previous work done by the Swedish expeditions. Of special interest were the finds of fossils for dating different strata. Most significant in this connection was that, in 1868, Nordenskiöld managed to find fossils from the Devonian period in the red schist of Roosneset at Liefdefjorden.

Here it is worth emphasizing the important contributions of the Swedish expeditions.

The first finds in Svalbard of fossils from different geological periods are attributed to the following Swedish scientists:

FOSSILS FROM	FIRST FOUND BY
The Devonian	Nordenskiöld 1868
The Triassic	Blomstrand 1861
The Triassic (saurian fossils)	Nordenskiöld 1864
The Jurassic	Lovén 1837
Post-Tertiary Mytilus strata	Torell, Malmgren, Blomstrand 1861

Also notable among the scientific work during the expedition of 1868 were the preliminary surveys of the northern part of Isfjorden, of Liefdefjorden and of Woodfjorden—and the astronomical determinations of position in different parts of Svalbard. The two botanists made a careful and ambitious study of the Spitsbergen phanerogamous and cryptogamous flora. Nor should we forget the geomagnetic and meteorological observations.

¹ Parry's northerly record of 1827, lat. 82°45'N, was attained by using boats dragged over the pack-ice in the summer (see map p. 55).

10. THE GREENLAND EXPEDITION OF 1870

Original plans

After the Swedish Spitsbergen expedition of 1868, Nordenskiöld was still adamant in wanting to repeat his quest for a high northerly latitude. But he was sure that the push northward should be done with sledges over the pack-ice, from a base situated as far north as possible—preferably Sjuöyane in northernmost Svalbard. Such a journey would have to be undertaken before the beginning of the summer melt, requiring the expedition to spend the winter at its base.

From the arctic literature, Nordenskiöld had become convinced that there were only two regions from which to start such a journey: northern Svalbard, or through the Smith Sound fairways in northwestern Greenland. An expedition to the latter region would demand far more money than could be expected from Swedish sources. An expedition to northern Svalbard, on the other hand, would involve many advantages. Not least, the previous scientific research in this region, which had proved so interesting and promising, could be supplemented systematically.

Then there was the question of transport over the ice. Here the Swedes lacked practical experience. Torell had discussed the use of dogs as draught-animals with British and Danish polar travellers, but otherwise nobody in Sweden possessed direct knowledge of dog-driving.

A visit to Greenland was necessary, both for learning the art and for arranging an eventual purchase of the animals as well as their transportation to Sweden.

This called for a small expedition to Greenland, with Nordenskiöld as the sole member. Yet on second thought, he found that much could be gained by making the visit a scientific expedition, with a small group of competent researchers.

Nordenskiöld's sponsor, Oscar Dickson (1823–97), gave his consent to such a change in the plans of the enterprise, which now developed into the *Greenland expedition of 1870*.

DICKSON'S LEGACY

Oscar Dickson is the most important benefactor in the history of Swedish polar research. It was thanks to him—or, rather, to the mutual influence between him and Nordenskiöld—that the remarkable activities of his countrymen in the Arctic became possible.

Dickson had already contributed to the expedition of 1868, together with several other wealthy men in Göteborg. But from then on, he became the principal patron of Nordenskiöld's expeditions. In a few cases he shared the sponsorship with others, notably King Oscar II and Alfred Nobel (1833–96).

Oscar Dickson was born in Göteborg in 1823. He was the son of a Scottish businessman, James Jamesson Dickson, who had emigrated to Sweden early in life. Oscar took a position in the family wood-export firm, and much of his time was spent in Norrland (northern Sweden), where the family owned large forests and sawmills. Thus arose his great interest in nature, natural history and hunting. From 1855 he lived in Göteborg, and he died in 1897 on his estate, Almnäs, located at Lake Vättern in southern Sweden. His importance to Swedish polar research is clear from the list below.

EXPEDITIONS SPONSORED BY OSCAR DICKSON

<i>Expedition</i>	<i>Leader</i>	<i>Remarks</i>
Spitsbergen, 1868	A.E. Nordenskiöld	Dickson with other sponsors in Göteborg
Greenland, 1870	A.E. Nordenskiöld	Dickson sole sponsor
Spitsbergen, 1872–73	A.E. Nordenskiöld	Dickson paid part of the costs
To the Yenisey, 1875	A.E. Nordenskiöld	Dickson sole sponsor
To the Yenisey, 1876	A.E. Nordenskiöld	Dickson and Sibiryakov sponsors
<i>Vega</i> expedition, 1878–80	A.E. Nordenskiöld	Dickson, King Oscar II and Sibiryakov shared the costs
Greenland, 1883	A.E. Nordenskiöld	Dickson sole sponsor
Spitsbergen, 1890	G. Nordenskiöld	Dickson principal sponsor
Attempts to reach the North Pole by balloon, in 1896 and 1897	S.A. Andrée	Principal costs shared by Dickson and Alfred Nobel
Spitsbergen, 1896	G. De Geer	Dickson sponsor, with others
Svalbard, 1898	A.G. Nathorst	Dickson sponsor, with others

It should be added that the Swedish Government contributed to several of these ventures with equipment, personnel, transport and so on.

Dickson also supported expeditions to other parts of the globe. He sponsored a planned Swedish-Australian Antarctic expedition which, however, had to be given up (see p. 199). He assisted, too, the publication of the scientific results of the *Vega* expedition. Finally, of course, Dickson was not left without his share of various rewards from the expeditions.

The expedition's members and plans

With Dickson's consent, Nordenskiöld's visit to Greenland thus developed into a study tour concentrating on geography, geology, zoology and botany. Participants were:

Adolf Erik Nordenskiöld (1832–1901), Ph.D., leader of the expedition, geologist and geographer, responsible for astronomical determinations of position.

Sven Berggren (1837–1917), Ph.D., botanist.

Per Erik Valdemar Öberg (1842–1934), Ph.D. (1872), zoologist and geologist.

Carl Fredrik *Theodor* Nordström (1843–1920), Ph.D., geologist.

The Greenland Trade (Den Grönländske Handel), of København, was then engaged in shipping between Denmark and Greenland with its own vessels. These afforded a cheap but slow passage to Greenland, lasting 5–8 weeks, starting from København in April–June and leaving Greenland in September. Some ships left Greenland already in July and were able to make two passages.

The expedition planned to land at Godhavn, situated on the south coast of the large island of Disko. The Greenland Trade assisted the expedition in many ways, not least by paving the ground for the investigations in Greenland.

Transport and scientific work during the stay in Greenland were to be conducted partly with two whale-boats, manned by Greenlanders. According to the original plans, which on the whole were realized, the expedition intended to work in two fairly separate groups:

- (a) Nordenskiöld and Nordström would make an excursion on the inland ice, starting from the bottom of Auleitsivik Fjord to the south of Egedesminde. Afterwards the group would carry out geological studies and collect plant fossils along the Vaigat, Disko Bugt and Umanak Fjord.
- (b) Öberg and Berggren would conduct studies of the flora and fauna along Disko Bugt.

Arrival and preparations

The expedition left København for Greenland on May 15, 1870, on board the brig *Hvalfisken* and arrived in Godhavn on July 2. They soon learned that it would be impossible to obtain any Greenlanders from Godhavn for the two whale-boats. The Greenlanders preferred to stay at their summer hunting and fishing sites, together with their families, and were unwilling to give up this agreeable life. After a week of negotiations, the expedition was transported by the "Trade" to the colony of Egedesminde where fewer difficulties were expected. This proved to be true.

In just a few hours, the expedition was supplied with two whale-boats and their crews, and could start the scientific work almost at once. The original plans were now changed, partly because Nordström had caught a lingering cold during the passage to Greenland. His place in the excursion on the inland ice had to be taken by Berggren, the botanist. It was also decided that Öberg was to carry out dredgings from one of the whale-boats of the expedition, and do other zoological work as well, in the neighbourhood of Egedesminde, while the inland-ice party was away.

Nordenskiöld, Berggren and Nordström left Egedesminde in one whale-boat on July 12, steering south until they reached the narrow Auleitsivik Fjord. They followed it to the bottom of its northerly branch, arriving on July 17. The inland ice ended there in the form of a protruding glacier with a vertical edge. The starting point for the march on the ice was chosen just to the north of this glacier, where they consequently pitched their camp.

The land was like the Scandinavian peninsula and Finland: it consisted of stratified crystalline rocks with dikes of granite. It had once been covered by the inland ice or by glaciers. Boulders were lying on the land and strewn across the rounded hills; the rock faces were polished and contained glacial striae; the fjords were deep and had probably been dug out by glaciers. The interior of Greenland was unknown. The Greenlanders feared the inland ice, and Europeans had only set foot on its marginal zone (see below).

In his report on the expedition Nordenskiöld wrote:

"There are many reasons which seem to indicate that the inland ice only constitutes a *frame* of ice along the coast, surrounding ice-free land in the interior, which to the south perhaps even may be wooded and might become of no little economic importance to the rest of Greenland."

The following attempts to penetrate towards the interior of the inland ice had been made before Nordenskiöld's visit in 1870:

1. In 1729 the Danish governor Major Claus Enevold Paars, with soldiers, climbed the nearest slope of the inland ice to the east of Godthaab, intending to cross Greenland and reach the Austerbygd of the old Norse population, then still supposed to exist in east Greenland (cf. p. 167).
2. In September 1751, Lars Dalager, a Danish tradesman who had spent many years in Greenland, penetrated at latitude 62°31'N two geographical miles (8 nautical miles) inland from the edge of the inland ice. He was accompanied by five Greenlanders. The attempt had to be given up, because their footwear became quite worn out during the march.
3. In July 1867 the English mountaineer Edward Whymper with Dr. Robert Brown, three Danes and a Greenlanders—attempled to travel inland with dogs and sledges, but reached only a fraction of a geographical mile from the ice edge. The area chosen was situated a short distance to the north of Jakobshavns ice-fjord.

*The ice-march of Nordenskiöld
and Berggren, July 19–26, 1870*

The inland-ice party consisted of Nordenskiöld himself, Berggren and two Greenlanders. To begin with, they were accompanied by a group which was to assist them in the difficult terrain.

The start took place on July 19. The party was rowed to a small bay, from where they continued on foot. The land was hilly, and further inland it was bordered by an ice wall—the edge of the inland ice, vertical in some places and bulging at others. Close to the edge, the ice was covered with a layer of earth and stones.

The party found a cleft where it was possible to climb the slope with the equipment. Some ways beyond the top of the cleft, they separated from the assisting group and continued their march, but stopped very soon for the night. They had one sledge loaded with equipment and provisions for 30 days.

The ice was smooth but there were many deep crevasses, running at a right angle to the ice edge. In order to avoid these, they laid their course southward and came out of the crevassed area. But now they ran into an area with a very uneven surface, characterized by pyramids and ridges of ice, which were higher than 12 m and sloped at 25–30°. It was extremely difficult to handle a heavily loaded sledge in such terrain.

Next day, July 20, they decided to leave the sledge and much of the equipment and provisions, and carry the rest on their backs. In the following days they would have no tent—only two sleeping-bags (for four men) and a tarpaulin to lie upon. But the weather

remained fine, often with no clouds in the sky by day. The air temperature was near 0°C close to the surface, but +7°–+8°C somewhat higher up, and “in the sun” the thermometer often read +25°–+30°C. After sunset the nights were cold and the pools on the ice froze over. Therefore, rests were short in the night and somewhat longer in the daytime.

Except near the ice edge, no stones lay on the ice surface. Instead there were cylindrical hollows, 30–60 cm deep and with diameters of 5–50 cm or more. The hollows were so close together that it was generally impossible to find enough place for setting one’s feet. In the bottom of the hollows was a layer of a grey powder, a few mm thick. In the microscope most of this powder was found to consist of white, transparent, angular grains. There were also fragments of plants, yellow particles and black grains. Nordenskiöld suggested the name *kryokonit* (ice dust) for the principal component.

Even in this desert of snow, Berggren was able to devote himself to his specific science, botany. He discovered, both on the ice surface and in the hollows, a brown multicellular alga. One species of alga occurred in such great amounts that the ice surface took on a strange colour. Two other species were restricted to the fine sand which rested upon the ice as a thin coating, or as more or less dense layers in the bottom of the hollows. The first-mentioned species of alga did not need such a substrate. It was built up from 2–16 cells (diameter 0.02 mm, length 0.02–0.04 mm) forming a thread without forks.

The course of events during the ice-march is suitably summarized from day to day:

July 21, noon-position: lat. 68°21'N, long. 36 longitudeminutes, corresponding to 24.7 km east of the base camp (the starting point). Altitude (above sea level): 415 m. The two Greenlanders now wanted to return. They were given sufficient food for reaching the base camp, even if the depot on the way were not found. Then Nordenskiöld and Berggren continued their march inland. They now met with bowl-shaped depressions, filled with water, as well as deep and broad crevasses. Their progress was slow.

July 22, noon-position: lat. 68°22'N, long. 56 longitude minutes to the east of the base camp (38 km). Altitude almost 600 m.

They had not seen any animals during their march, except two ravens which flew overhead when they separated from the Greenlanders. However, they had seen droppings from ptarmigans at several places. When holding the ear close to the ice, a strange roaring sound was heard from the watercourses in the ice. Sometimes they heard sounds like gunfire, testifying to the formation of crevasses within the ice.

H. Rink's map of a part of north-western Greenland, used by Nordenskiöld on the expedition of 1870. The ice-march of 1870 is marked near the lower right corner of the map. ("Noursoak-halfö" = Nuqssuaq Peninsula). See also Chapter 17. (Nordenskiöld, A.E.: Redogörelse för en expedition till Grönland 1870.)

They also came upon a pillar of fog that protruded from a "bottomless" abyss, into which a glacier river plunged.

July 23. They had a halt at 68°22'N and 76 longitude minutes to the east of the base camp (52 km). The altitude was 565 m, somewhat lower than previously. The rise of the surface towards the inland was noticeable here.

Their food supply had now been reduced so much that it was time to think of the return march. An ice-hill could be seen to the east. They wanted to reach it in the hope of getting a better view of the surrounding country. They left provisions and sleeping-bags and, hoping to remember the place, set out on a forced march towards the ice-hill, which was found to be larger and more distant than they had estimated. They got a fine view from its summit: the ice was seen to rise inland without any protruding nunataks. The horizon to the east, north and south was unbroken like that of the ocean. It was not worthwhile to push further eastward.

At their *turning-point* they were about 83 longitude minutes (57 km) to the east of the base camp, or about 50 km from the edge of the inland ice, at an altitude of 650 m above sea level. They nearly missed their depot on the way back, as there were few characteristic landmarks in the terrain. But they found it and, by forced marches, were able to reach their base camp on July 26.

From the return march, some events may be noted. Near the turning-point they met with a stream, which

was impossible to pass. The march was therefore intercepted, though they had not passed this water-course on the march inland. The conclusion was evident: the river must flow into an opening in the ice and could be avoided. Next they observed an intermittent jet of water, mixed with air—like a geyser—near a river which rushed into an opening in the ice.

To avoid the rough and dangerous area of the inland ice, which they had passed during the first days of their march, they changed their course towards the northwest in order to come down upon the ice-free land, situated between Disko Bugt and the inland ice. The ice was rather smooth and it was easy to get down. But the land was hilly and there were many rivers coming from the inland ice. One river was uncrossable, so they had to climb the ice again to circumvent it.

To Nordenskiöld the march through the ice-free land was full of interest. It was a country which the ice had left not very long ago, and it had the appearance of woodless gneiss regions in Sweden and Finland. Everywhere stood rounded gneiss hillocks full of erratic boulders, many occupying highly "adventurous" positions of equilibrium. The land also contained low valleys with small mountain lakes and striated rock surfaces, but there were also real moraines, which seem to characterize ordinary glaciers rather than the inland ice proper. We cite Nordenskiöld:

"The geologists are mistaken when they are of the opinion that the glaciers of Switzerland offer a model on a small scale of the inland ice of

NORDENSKIÖLD'S AND BERGGREN'S MARCH ON THE INLAND ICE IN 1870

July 17	The expedition reached the camp site at Auleitsivik Fjord.
" 18	Preparations for the ice-march.
" 19	March overland to the edge of the inland ice and up its marginal slope.
" 20	Nordenskiöld and Berggren left the sledge and much of their equipment, and continued the march with loads on their backs.

See further the Table below.

In the night of July 25/26 the party returned to Auleitsivik Fjord.

The march was carried out in an easterly direction. From the longitude differences, corresponding distances in km from the camp site at Auleitsivik Fjord were derived, using Nordenskiöld's astronomical determinations of latitude and longitude.

	Latitude	Longitude	Longitude difference from Auleitsivik Fjord	Distance in km, corresponding to long. diff.	Height m above sea level
Camp site at Auleitsivik Fjord	68°20.8'N	51°06.3'W	0	0	ca 0
July 21 Noon	68°21'N	50°30'W	36'	25	415
" 22 "	68°22'N	50°10'W	56'	38	ca 600
" 23 "	68°22'N	49°50'W	76'	52	565
" 23 Turningpoint	68°22'N	49°43'W	83'	57	650

Astronomical determination of position by measuring the solar altitude with a prismatic circle and a mercury horizon. From drawing by Theodor Nordström (1843–1920), geologist and member of Nordenskiöld's expedition to Greenland 1870 (left). (Nordenskiöld, A.E.: Den andra Dicksonska expeditionen till Grönland 1883.)

After completing a tour on the inland-ice, scientists and Eskimos with wives and kayak-men took a short cut to reach Disko Bugt. From a drawing by Theodor Nordström (right). (Nordenskiöld, A.E.: Den andra Dicksonska expeditionen till Grönland 1883.)

Erratic block in the once ice-covered land near the present ice-edge. (Nordenskiöld, A.E.: Den andra Dicksonska expeditionen till Grönland 1883.)

Greenland, or of the inland ice which once covered Scandinavia. The glacier proper or the advancing glacier compares with the inland ice as does a swift river or a brook with a large and calm lake."

When they approached the base camp, they found that the inner part of the fjord, Tessiursarsoak, was almost filled with ice. Their first impression was that they had a branch of the inland ice in front of them. The glacier near the base camp had calved during their absence, and the Greenlanders at the camp were still frightened. They dreaded being kept prisoners by the ice, and they feared the surges which the calving had given rise to.

Geological and zoological/botanical investigations

The continuation of their journey had previously been arranged with the Danish inspector of North Greenland. He was going to make an official visit to Upernavik in his sloop, and had promised the expedition that he would tow its two whaleboats part of the way.

Furthermore, several kayak-men were to arrive with the object of helping the expedition to haul one of the whaleboats across the isthmus, which separated the fjord from Disko Bugt. In this way a long detour was avoided, not to mention that they could avoid the threats from glacier-ice and tidal currents during the passage through Auleitsivikfjorden.

Öberg had completed his studies of the marine fauna in the Egedesminde region, and now he joined the rest of the expedition. Its members were taken to Christianshaab in the western part of Disko Bugt, and from there to Leer Bugt, where an excursion was made to Jakobshavn's Isström and the old deserted village of Kaja. The expedition's further studies called for two independent groups: a geological group with Nordenskiöld and Nordström, and a zoological/botanical group with Berggren and Öberg.

The geologists wanted to visit as many stations as possible, but their stays would be restricted to a few hours. The zoological and botanical investigations, on the other hand, required longer stays of a few days. This was in part dictated by the preservation of the collections.

The regions which were studied by the two groups can be seen from the map (Fig. 66). The geologists worked along the coasts of the Nugssuaq Peninsula and along the north-east coast of Disko Island, while the biologists worked in the eastern parts of the Vaigat and Disko Bugt. The geologists were looking for plant fossils covering the long span of time from the Cretaceous period to the Miocene in the Tertiary

period—the former period characterized by woods of ferns, the latter by woods of beech and plane.

The geologists left Leer Bugt on August 1 and were towed by the inspector's sloops across Disko Bugt. They finished their boat journey at Kome on the north coast of Nugssuaq (Noursoak) Peninsula on August 23, from where they were transported to Godhavn on board a ship of the Greenland Trade. They arrived here on August 30.

The weather had been in their favour. They had one rainy night; otherwise the sky was clear and a fair wind filled their sails most of the time, making it possible to take optimal advantage of time. Their collections of fossils were obtained from over 20 stations and originated from five different geological horizons. As had been the case with previous Swedish polar expeditions, the material of fossils was handed over to Professor Oswald Heer of Zürich for study and description.

The biological group spent August 1–13 at Claushavn north of Leer Bugt, preserving their collections. Of course, time was also devoted to collecting rich new material. They then travelled north, entering some fjords on the way, and ended up at Ritenbenk. There, on August 28, they boarded a ship of the Greenland Trade and were transported to Godhavn, arriving on the 28th.

The Uvifak iron boulders

Already upon the expedition's arrival at Godhavn in July, Nordenskiöld had promised a reward to Greenlanders in the area, if they could provide information on pieces of "meteoric" iron in the neighbourhood. Among many of Nordenskiöld's interests was the study of meteors. At some places in Greenland finds of blocks or pieces of iron, possibly of meteoric origin, had been reported. After the return to Godhavn of the two groups of the expedition at the end of August, a Greenlander reported that he had found iron boulders below a mountain called Uvifak, 10 nautical miles to the west of Godhavn.

With two boats the expedition now left Godhavn and went westwards. The place was found. It was open to winds and waves, but the weather was fine, and it was possible to land close to the largest of the iron boulders, which rested among blocks of gneiss and granite at the foot of an enormous talus slope of basalt. Above this slope towered an almost vertical rock face, built up from horizontal basaltic strata (see Fig. 71).

The iron blocks had been found, but to take the largest ones away demanded a new expedition. And it was now time to return home. A kayak messenger had informed Nordenskiöld of the outbreak of the Franco-Prussian war, which made him hasten to Egedesminde

in order to catch the first available ship for Denmark. The other three expedition members had to remain at Godhavn for some time, taking care of their collections. Nordenskiöld landed at Helsingör, Denmark, on November 2, and the rest of the expedition landed in Göteborg on November 17.

It had been a successful venture, rich in results despite its few members. The weather had been excellent for their purpose. The geological results and collections were abundant, and could be looked upon as valuable supplements to the Swedish geological investigations in the Svalbard region. The same may be said about the zoological and botanical studies. A trip had been made on the inland ice to about 50 km from its edge, and knowledge had been gained about the conditions prevailing in its marginal zone at the height of summer. The strong melting of the snow and ice rendered the ice-march difficult and dangerous. Previous ice-marches had penetrated only a few km from the ice-edge.

Some 20 astronomical determinations of latitude and longitude had been made, thanks to the fine weather. And finally a great number of small iron boulders and some large blocks had been found at Uvifak to the west of Godhavn, which called for a new expedition as soon as possible.

In a newspaper article written by Nordenskiöld 31 years after the expedition, the following enthusiastic words are found:

"The costs of the Greenland expedition of 1870 amounted to 6000 Sw.Cr. It is unsurpassed in its wealth of results."

Nordenskiöld had originally planned an expedition to study dogs for sledging on his next Spitsbergen expedition, and to make arrangements for their transfer to Sweden. But the dogs were apparently soon forgotten, and Nordenskiöld later preferred to use reindeer instead.

11. THE GREENLAND EXPEDITION OF 1871

A MISSION FOR FETCHING IRON BOULDERS

Nordenskiöld managed to bring about a new Greenland expedition in 1871, the main object now being to transport the Uvifak iron boulders to Europe. The Swedish government placed two naval ships at his disposal, the gunboat *Ingegerd* and the cargo-brig *Gladan*. Nordenskiöld did not take part in the voyage. It was a naval expedition under the leadership of the commander of the *Ingegerd*, Captain Fredrik Wilhelm von Otter, previously commander of the *Sofia* during the Spitsbergen expedition of 1868 (see p. 53). However, a staff of five scientists was included.

Among the members were the following:

SHIP'S OFFICERS

Captain Fredrik Wilhelm von Otter (1833–1910), commander of the *Ingegerd* and of the expedition.
Lieutenant Eric Brusewitz (1844–1919), second-in-command of the *Ingegerd*.

Captain *Gerhard* Philip von Krusenstjerna (1840–1907), commander of the *Gladan*.

Sublieutenant Ernst *Herman* von Holten (b.1843), second-in-command of the *Gladan*.

SCIENTIFIC STAFF

Ernst *Gustaf* Reinhold Nauckhoff (1847–1919), Ph.D. (1872), geologist.

Theodor (*Thore*) Magnus Fries (1832–1913), Ph.D., botanist.

Johan Harald *Josua* Lindahl (1844–1912), Ph.D. (1874), marine zoologist.

Knud Johannes Vogelius Steenstrup (1842–1913), Danish geologist, a man of distinction in the Danish investigations of Greenland; he had at the time spent 11 summers and two winters there.

The Greenland expedition of 1871 has not been well documented. From scattered sources we obtain the following summary.

The two ships left Karlskrona, Sweden, on May 1 and reached Godhavn on June 16. Their first days in Greenland were devoted to reconnaissances. The *Ingegerd* went westward to Uvifak to find out the bottom conditions near the iron boulders. As mentioned, the coast was open and was considered by the Greenlanders as almost unapproachable—even in the summer—owing to strong breakers along the coast.

Meanwhile, von Holten and the crew of *Gladan* explored the coast near Godhavn in order to find a place suitable for mounting a crane. This was to be used for taking the three largest boulders aboard, if no suitable place could be found near Uvifak—which

Intermittent fountain on the Greenland inland ice, about 45 km from the coast (top right). (Nordenskiöld, A.E.: Den andra Dicksonska expeditionen till Grönland 1883.)

Nordenskiöld and Berggren marching through the marginal zone of the Greenland inland ice, about 50 km from the coast, July 1870 (top left). (Nordenskiöld, A.E.: Den andra Dicksonska expeditionen till Grönland 1883.)

The largest iron boulder - referred to as boulder I - is now placed outside the Swedish Museum of Natural History in Stockholm. The iron boulders are now considered to be of telluric origin (left). (Nordenskiöld, A.E.: Den andra Dicksonska expeditionen till Grönland 1883.)

Iron boulders which Nordenskiöld believed to be of meteoric origin, were found at Uvifak (Ovifak) west of Godhavn on the beach below an enormous talus slope. Above towered an almost vertical cliff-face of basalt strata. The marked ravine in the talus slope leads down to the iron boulders at the water's edge (above). (Nordenskiöld, A.E.: Studier och forskningar...)

proved not to be the case. Therefore the boulders had to be taken aboard the *Gladan* near Godhavn.

The boulders were too large for weighing, so their weights had to be estimated from their dimensions and density.

The estimates of Nordenskiöld and Nathorst for the three largest boulders were:

	I	II	III
Nordenskiöld	21 000 kg	8 500 kg	3 800 kg
Nathorst	25 000 kg	6 500 kg	4 090 kg

Each boulder was loaded at Uvifak on a raft built up from cisterns, and was then towed to the *Gladan* near Godhavn and taken aboard. These operations were carried out during June 19–29 in the very best of weather conditions, and without any injury to the men or damage inflicted on the equipment and ships.

With the boulders well on board the *Gladan*, Steenstrup left the expedition, and its next stage could begin. This part of the expedition has not, to the author's knowledge, been documented properly; but von Otter mentioned the following plans in his report of July 5.

The two ships were to leave Godhavn in the night towards July 6. The *Ingegerd*, with one boat and crew from the *Gladan*, would investigate Mellem Fjord and Nord Fjord in the western part of Disko Island. These fjords had not yet been studied at the time. The *Ingegerd* was to proceed down the Vaigat, north of Disko Island, to meet the *Gladan* at the colony of Ritenberk on the 19th. With the boat and its crew transferred to the *Gladan*, the *Ingegerd* was to depart for Umanak Fjord, where scientific work and soundings were to be carried out. Then the ship would proceed northward as far as the ice would permit, whereupon the eastern edge of the pack-ice was to be followed southwards. The ships were to meet at the colony of Holsteinborg on July 29 before starting the voyage home.

Captain von Otter was an intrepid naval officer, and on the homeward voyage he seized the opportunity of making a fast passage—in 12 days—across the Atlantic from St. Johns to Plymouth. The *Ingegerd* reached Karlskrona on October 23, and the *Gladan* five days later.

The Uvifak iron

The three iron boulders, and a number of smaller pieces of iron, reached Sweden safely. The largest boulder (I) was later set up in the entrance hall to the building of the Royal Swedish Academy of Sciences in Stockholm. Later the Academy moved to new premises in the northern outskirts of Stockholm, and the boulder

was transferred there in 1916 to be set up outside the Swedish Museum of Natural History—where it can still be seen.

Boulder II was handed over to the University of København and placed in the open air. Boulder III was given to Nordenskiöld personally, but was donated by him to the University of Helsinki and was also set up outdoors.

The boulders were scrutinized carefully in the following years. Their chemical components, apart from iron, were determined and a debate arose as to whether the blocks were of meteoric or telluric origin. Nordenskiöld was definite on the former alternative. His successor as head of the mineralogical department of the Swedish Museum of Natural History, Hjalmar Sjögren (1856–1922), gave a summarizing report in 1916 on the Uvifak iron boulders, from which we cite:

“With the finding of the Uvifak iron in 1870, which soon resulted in the discovery of other basaltic irons in Greenland, this controversial question is once and for all laid to rest. Any doubt as to the existence of telluric iron can no longer be upheld. The Uvifak iron was not the only block to be recognized as telluric; several older finds of iron, which had previously been looked upon with suspicion, were also identified as telluric. The similarities between these rocks containing iron and meteorites gave rise to interesting comparisons. The theoretically important question as to the existence of an inner *unoxidized* nucleus of the Earth acquired a new aspect after direct evidence had been obtained that such incompletely oxidized rocks did occur. The large blocks of Uvifak iron, which have no counterparts as unoxidized masses of iron of eruptive origin, gain in this way a far greater *geological* importance than if they had been meteorites. And as a remarkable irony of fate, attention should be brought to the fact that the discoverer of the Uvifak iron, A.E. Nordenskiöld, who until the very end championed the *meteoric* origin of this iron, has thereby done more than any other researcher to demonstrate *telluric* iron—an example among many others of the fact that scientific discoveries and objective observations will always have a lasting value even if the ideas concerning their interpretation are at first imperfect or erroneous.”

12. THE “COLONY” ON KAPP THORSDEN, SPITSBERGEN

THE GEOLOGICAL SPITSBERGEN EXPEDITION OF WILANDER AND NATHORST IN 1870

During the Spitsbergen expedition of 1864, Nordenskiöld had found strata of phosphorite at Kapp Thorsden. It was assumed to be possible to obtain fertilizers from these strata, which in fact are very old layers of guano.

In 1870 a number of businessmen paid for an expedition to look into the matter. It was a small venture, consisting of two young men:

Hjalmar Mathias Wilander (1844–1891), Master of Engineering, geologist.

Alfred Gabriel Nathorst (1850–1921), undergraduate (Ph.D. 1874), geologist and botanist.

The object of the mission was to make a technical study of these phosphate strata in order to find out whether they could be worked with advantage. Outside the practical programme of the expedition, the present and fossil flora of the region were to be studied.

With this expedition Nathorst, 20 years old, entered the field of polar research. He was later to take over the role of Nordenskiöld as grand old man of Swedish polar research. He was also destined to become an expert in paleobotany and, so to speak, a successor of Oswald Heer at Zürich in dealing with future Swedish collections of plant fossils.

No full travel account of the expedition was published. A very rough outline of it was given in a letter from Nathorst to Nordenskiöld, and published by the latter in a footnote to his report on the Spitsbergen expedition of 1872–73. In his own later publications, Nathorst occasionally devoted a few words to events during the expedition of 1870. From these sources we can summarize the venture as follows.

The expedition had hired the sloop *Lydianna* of Tromsø for the summer. Her skipper was Nils Johnsen. She left Tromsø on July 4, and a short visit was paid to Björnøya on July 12. During a walk along the north-eastern corner of the island, Nathorst found glacial striae, which seemed to indicate a glacial drift coming from the east or the north-east. The striae therefore had probably not been created by local glaciers or ice-caps and—if Nathorst’s interpretation of the striae was correct—Björnøya must have been covered by a vast ice-sheet, perhaps extending between Norway and Spitsbergen.

Nathorst considered it highly desirable to obtain further data to check his hypothesis. His observations were in many ways to influence his activity during the next 28 years.

In the night towards July 17, the *Lydianna* entered Bellsund in Spitsbergen and remained there, because of headwinds, until the 22nd. Then she sailed to Kapp Starostin, a short distance west of Grönfjorden at the mouth of Isfjorden.

On July 24–25 the ship stayed at Kapp Thorsden. An investigation of the region had just begun when the wind suddenly increased to full gale—an onshore wind besides—and forced the ship to be taken to Adventfjorden on a windward sailing. Not until August 5 was it possible to return to Kapp Thorsden, where the geologists now pitched a camp and carried out the investigations of the phosphorite strata. On August 17 they were fetched by the *Lydianna*.

The activity which followed next may be sketched briefly. On August 23, plant fossils from the Carboniferous period were discovered at Gipshuken. They visited Grönfjorden, and Colesbukta where, on August 29, the first find in Spitsbergen of dwarf birch (*Betula nana*) was made by Nathorst.

The expedition then left Spitsbergen, and on September 8 Tromsø was reached.

The “Colony” on Kapp Thorsden is established —and given up

The report presented to the group of businessmen was apparently in favour of extracting fertilizers at Kapp Thorsden. Already in 1872 the next phase commenced. On February 9, articles of association were laid down for AB Isfjorden. This company was to establish a “colony” at Kapp Thorsden and to collect the phosphorite for fertilizers. Among the shareholders were Oscar Dickson and Nordenskiöld.

In the spring of the same year, two ships, the *Fiskeren* and the *Mimer*, left Norway with the prospective “colonists” and their belongings, as well as building material and provisions.

Per Öberg (1842–1934), a member of Nordenskiöld’s Greenland expedition of 1870, accompanied the “colonists” to Kapp Thorsden. He now served as geologist and chemist to the enterprise.

At Kapp Thorsden the mouth of a small brook was chosen as a landing place, and 700 m inland the men of the expedition started to build the dwelling-house for the members of the “Colony”. Between the house and the landing place, a décauville trolley line was laid out. AB Isfjorden was not destined to prosper, though. Already in the same autumn it was found necessary to leave the installations at Kapp Thorsden and go home.

Alfred Gabriel Nathorst (1850–1921), 21 years old. In the previous year he had started his successful Arctic career. (Swedish Museum of Natural History.)

The route of the sloop *Lydianna* of Tromsø in 1870, with the Wilander-Nathorst expedition onboard.

In 1957—during the International Geophysical Year—a Norwegian-Swedish group visited the old station at Kapp Thorsen in order to carry out comparative geomagnetic measurements. The main building “Svenskehuset” was then in fairly good condition.

Photo: Anders Häggblom.

It was, no doubt, thanks to Per Öberg that the operation was stopped before suffering further losses. Öberg was a capable man in several respects, and in the present situation he kept both his feet on the ground. He had realized that profitable extraction could never occur at Kapp Thordsen: the shipping conditions on the unsheltered shore were too difficult, besides the fact that the nearby waters were full of shoals. Moreover, other phosphates had appeared on the market and could not be competed with.

Left behind at Kapp Thordsen were the following: a well-built house and building material for a second house, the décauville line with its trolleys, coal, paraffin oil, a considerable amount of provisions consisting of 20–30 sacks of flour, peas and grains, several barrels of preserved potatoes and meat, condensed milk, meat extract, dried vegetables, and other items.

AB Isfjorden later sold the station to Nordenskiöld and Oscar Dickson. Subsequently it came into the possession of Jernkontoret in Stockholm (the Iron Office). Among Norwegian sealers and hunters, the house was referred to as *Svenskehuset* (the Swedish House). The house still stands, and has passed through periods of decay, robberies, tragedies, restoration and scientific activity. Since 1980, it is classified as historic remains of Svalbard and has been carefully restored under the auspices of Norsk Polarinstitut (the Norwegian Polar Research Institute) Oslo.

“SVENSKEHUSET” ON KAPP THORSEN: A SUMMARY

The most noteworthy events connected with the Swedish house on Kapp Thorsen are:

- 1872–73 The tragic death of 17 shipwrecked Norwegian sealers (see Chapt. 14).
- 1882–83 The Swedish scientific station during the First Polar Year 1882–83 was located here (see Chapt. 18).
- 1888 Four shipwrecked Norwegian sealers found temporary shelter in the house, but then went missing (see pp. 203–204).
- 1890 A Swedish expedition under Gustaf Nordenskiöld, the son of A.E. Nordenskiöld, arranged test-mining in the coprolite (phosphorite) strata.
- 1933, 1957 During the Second Polar Year (1932–33) and the International Geophysical Year (1957–58), geomagnetic observations were temporarily carried out at the site of the geomagnetic observatory of 1882–83.
- 1982 The building was restored by Norsk Polarinstitut and classified as historical remains of Svalbard.

Finally it should be mentioned that the “Colony” on

Kapp Thorsen gave rise to the international discussions on the sovereignty of Spitsbergen (Svalbard); see pp. 398–399.

13. THE FIRST WINTERING IN SVALBARD BY A SCIENTIFIC EXPEDITION

THE SPITSBERGEN EXPEDITION OF 1872–1873 *Plans, equipment, and personnel*

Ever since the return of the Spitsbergen expedition of 1868, Nordenskiöld had envisioned a fresh attempt to reach a high northerly latitude, now using sledges for transport over the pack-ice. As we have seen, the object of the Greenland expedition of 1870 was to learn the art of dog sledging from Danes and Greenlanders. But Nordenskiöld had finally decided to use reindeer as draught-animals instead of dogs. In addition to an infectious disease among the dogs in Greenland, the relationship between weight transported to food consumed was in favour of reindeer. However, the availability of food in the field—meat and reindeer-moss respectively—during a sledge journey was not mentioned.

A questionnaire was sent to individuals in Lapland who were accustomed to using reindeer for transport. Nordenskiöld chose reindeer. Moreover, he studied the arctic literature for information on the routes of approach for reaching a high northerly latitude. Only two such routes seemed advantageous: through the sounds between Greenland and Ellesmere Island, and a route starting from northern Svalbard, preferably from Sjuöyane.

The former approach would need an expedition with great economic resources, compared to one that began from Svalbard. In any case a wintering expedition was required, as the sledge tour would have to be undertaken between late winter or early spring and the snow melt in late June. It would be the first wintering of a scientific expedition in the Svalbard area, and of any Swedish polar expedition. And not least, the observations in meteorology and geomagnetism besides the studies within botany and zoology would be of utmost interest and value during a wintering.

The reindeer, 40 in number, were bought at Kautokeino in northernmost Norway. Their provisions, amounting to 3 000 sacks of reindeer-moss, were obtained from both Norway and Sweden.

A grant was obtained from the Swedish Government, and a donation from Oscar Dickson. The

The cargo-brig *Gladan* of the Swedish Navy should have returned home when unloaded—but she was imprisoned in the ice at Mosselbukta together with the freighter *Onkel Adam* (right). (A.E. Nordenskiöld's Photographic Collection, Royal Swedish Academy of Sciences.)

According to plan the steamer *Polhem* was determined to winter in Spitsbergen 1872–1873. This was to be the first wintering in Svalbard by a scientific expedition (below). (A.E. Nordenskiöld's Photographic Collection, Royal Swedish Academy of Sciences.)

The crew of the brig *Gladan*, 1872.

(A.E. Nordenskiöld's Photographic Collection, Royal Swedish Academy of Sciences.)

Government placed two ships at Nordenskiöld's disposal, the mail-steamer *Polhem* and the cargo-brig *Gladan* of the Swedish Navy. The *Polhem*, built in 1858, was designed for winter traffic in the Baltic (Västervik–Visby), and was thus a relatively strong ship at the time. The *Polhem* was to winter in Svalbard, but the *Gladan* was to return at the end of the summer. The *Gladan* had been used by the Greenland expedition of 1871 (see Chapt. 11).

The expedition's equipment was bulky: a dwelling-house, three observatories, coal for the engine of the *Polhem* and for heating the ship and dwelling-house, provisions, the reindeer and their food, as well as other pieces of expedition equipment. It became necessary to hire a third ship at the last moment, the steamer *Onkel Adam* of Göteborg. This ship, too, was to return home at the end of the summer.

THE PLANS OF THE EXPEDITION WERE:

1. Wintering in a spacious house on some of the Sjuöyane, eventually on the Spitsbergen north coast. Observations were to be carried out in meteorology, geomagnetism, aurora and astronomical refraction. Pendulum observations were to be made, and during the whole stay dredgings were to be conducted for collecting zoological and botanical material.
2. During a sledge journey in spring, a group would push north to as high a latitude as possible.
3. In the summers of 1872 and 1873 geological and biological studies were to be made along the coasts of Spitsbergen. Also deep-sea soundings in the seas surrounding Spitsbergen were to be carried out.

Altogether 66 people, including the ships' personnel, went north with the expedition—28 of them on board the *Polhem*, and 25 on the *Gladan*. They were distributed upon the three ships as follows:

THE MAIL-STEAMER *POLHEM*

Adolf Arnold Louis Palander (1842–1920), lieutenant, commander of the *Polhem*.

Axel Wilhelm Envall (1844–1912), medical officer, photographer to the expedition.

Eugenio Parent (1845–85), lieutenant in the Italian Navy, second-in-command.

Sixteen non-commissioned officers and men from the Swedish Navy.

SCIENTIFIC STAFF

Adolf Erik Nordenskiöld (1832–1901), Ph.D., professor; geologist, responsible for astronomical observations of position, leader of the expedition.

Frans Reinhold Kjellman (1846–1907), Ph.D., botanist.

Anders Gustaf August Wijkander (1849–1913), Ph.D., astronomer and physicist.

There were also a taxidermist named Sandberg, four Lapps, and a Norwegian seal-hunter.

THE CARGO-BRIG *GLADAN*

Gerhard Philip von Krusenstjerna (1840–1907), lieutenant, commander of the *Gladan*.

Ernst Herman von Holten (b. 1843), lieutenant, second-in-command.

Twenty-three non-commissioned officers and men.

S/S ONKEL ADAM

Börje Leonard Eugen Clase (1839–1885), captain in the merchant marine, commander of the *Onkel Adam*.

Thirteen others, including the female cook, Amanda Wennberg, and a taxidermist, Malmberg, from the Museum of Göteborg.

In comparison it should be noted that the expedition had only three scientists—Nordenskiöld, Kjellman and Wijkander. Originally Nordenskiöld intended to launch the expedition in 1871, but the Greenland mission of the same year delayed the start one year.

The search for winter quarters

On July 4, 1872, the *Polhem* and the *Gladan* left Göteborg. The latter ship sailed directly to Spitsbergen, while the former called at Tromsø on July 13 to load equipment. On the 21st, Nordenskiöld embarked and the *Polhem* left for Spitsbergen.

An effort to land at Björnöya failed because of strong winds, a rough sea and fog. The island was not even seen. An attempt to map the Sörkapp region of Spitsbergen also failed, as dense fog came drifting.

On July 27 the two ships met in Adventfjorden, in the south of Isfjorden. Here the *Polhem* ran aground, which led to a great amount of unloading before she got afloat again. Thereafter, the loading and stowing were somewhat disorderly.

On the 29th a boat excursion was made to Dicksonfjorden and Kapp Thordsen, where the building work at the "Colony" was going on (see pp. 73–75). The *Polhem* then visited Adventfjorden, Colesbukta and Grönfjorden. Nordenskiöld collected plant fossils from the Cretaceous and the Tertiary periods at habitats to the west of Grönfjorden.

The two ships left Isfjorden on August 4. The *Polhem*—with steam power—passed through Forlandundet, while the sailing vessel *Gladan* preferred the open sea to the west of Forlandet.

The *Polhem* reached Norsköyane at the north-west corner of Spitsbergen. She anchored to the south of Indre Norsköya in the waters called Fair Haven. This place was close to Sabine's observation site of 1823, where he had made careful astronomical determinations of latitude and longitude. The place had been

The leaders of the Spitsbergen expedition 1872–1873 in front of Festningen at the mouth of Isfjorden. From left to right: Gerhard von Krusenstjerna, A.E. Nordenskiöld and Louis Palander, commander of the *Polhem*. (A.E. Nordenskiöld's Photographic Collection, Royal Swedish Academy of Sciences.)

The Lapps march out in April 1873 to carry out biological dredgings. With them is the reindeer "Christian" the only draught-animal, which remained after the heavy gale in September 1872. (A.E. Nordenskiöld's Photographic Collection, Royal Swedish Academy of Sciences.)

Frans Kjellman (1846–1907), botanist, was responsible for the biological studies. He also wrote the book about the 1872–1873 Spitsbergen expedition. (Royal Swedish Academy of Sciences.)

marked with a ring of stones, and was later referred to as Sabine's observatory. Wijkander seized the opportunity to check the chronometers of the expedition here.

Next day the *Gladan* arrived. The *Polhem* towed her, with a course set for Parryöya among the Sjuöyane. But soon they met with ice and had to moor within it.

During this stop Nordenskiöld found that the snow-cover on the ice contained black dust particles. According to later chemical analysis, they turned out to contain metallic iron, phosphorus, cobalt and probably also nickel-like the "kryokonit" which Nordenskiöld had collected on the Greenland inland ice in 1870 (see p. 66). He thought that the dust particles were of cosmic origin and had come down to earth with precipitation.

The ice lingered, and conditions were expected to improve at any moment, so time had to be spent waiting in Liefdefjorden and at the north-west corner of Spitsbergen. The geology of the area was studied; dredgings were carried out. Envall photographed the glaciers in the neighbourhood. The microscopic algae in both red and green snow were collected, and geomagnetic observations were carried out. But the men always had to be ready to break up instantly.

The expedition's third ship, the *Onkel Adam*, had left Göteborg on July 20. At Tromsø she loaded a cargo of coal, reindeer, reindeer-moss, boxes, packages, pigs, hens and a house. On August 13 she arrived in Fair Haven, and now the whole flotilla was assembled here.

Yet it was late in the season, and they had still not found any place for wintering, let alone established their winter quarters.

The steamer *Mimer* of the "Colony" had gone to Tromsø and loaded cargo for the expedition, such as coal, to take it to Isfjorden. The *Onkel Adam* was therefore dispatched to Isfjorden, and her present cargo—including the reindeer—was transferred to Indre Norsköya.

Nordenskiöld wanted to stay and await the return of the *Onkel Adam*, but the commanders of the *Polhem* and the *Gladan* were extremely anxious to find a place for wintering. This gave rise to some friction on board. However, a few men remained behind at Norsköyane to await the arrival of the *Onkel Adam*.

At last on September 1, the two ships managed to go east. But the ice blocked the way to Sjuöyane, nor could Murchisonfjorden or Sorgfjorden be reached. Mosselbukta at the entrance to Wijdefjorden, though, was accessible.

The bay was open to the west, but a few skerries would act as a breakwater and give shelter to the ship, the *Polhem*, which was to stay over the winter.

Establishing winter quarters in Mosselbukta

It was now September 5. The summer was gone, no stores had yet been landed, and the dwelling-house still had to be set up. But the weather was fine.

A suitable place for the winter quarters was found on an islet, connected to the mainland by a bar of stones, all part of the "breakwater" previously mentioned. The landing of equipment could then commence.

The house had a very strong construction. It was about 15 m long, 11.5 m wide, and 2.7 m high at the roof ridge. Both floor and walls consisted of five layers. In the floor, these were respectively boards, gravel, boards, gravel, and boards.

A plan of the house, and the allocation of the different rooms among the expedition members, are shown on p. 181. It should be remembered that only the *Polhem* was to stay at these quarters during the winter; the other two ships were to return home after unloading. The house was designed to accommodate the scientific staff as well as the *Polhem* crew.

On September 6 the *Onkel Adam* arrived, heavily loaded and more like Noah's Ark than ever. The future looked bright: the store of provisions of the *Polhem*, for the wintering party, was estimated to last 18 months for 22 persons, in excess of what would be needed. Moreover, for safety's sake, Captain Clase of the *Onkel Adam* had purchased provisions for his ship during the visit to the "Colony". With 3/4 rations, this supply would last 10 months for the crew of the *Onkel Adam* alone. However, it consisted only of salted food.

The roof framework was mounted atop the dwelling-house on the 10th. The three observation pavilions had already been raised, one for geomagnetism and meteorology, two for astronomy. Each was pre-painted with special colours for separating the building materials.

The reindeer, which had arrived with the *Onkel Adam*, were transferred to the southern side of Mosselbukta, where they could graze. They were not tethered, but they were guarded by the Lapps who pitched a tent at the place.

At long last the expedition had completed its winter quarters. On the other hand, its position (79°53'N, 16°04'E) was not so northerly as had been hoped for, considering the planned sledge journey over the pack-ice.

On September 15, a dinner of thanks and farewell was held on board the *Polhem*: next day the *Gladan* and the *Onkel Adam* were to leave for home. It was autumn, but not extremely late, as sealers often remained here well into October. Nonetheless, it was soon found to be exactly one day too late.

In the aft-saloon of *Polhem*, while waiting for the ice conditions to improve, August 1972. From right to left: A.E. Nordenskiöld; Gerhard von Krusenstjerna, the commander of the *Gladan*; Frans Kjellman, botanist; and August Wijkander, astronomer.

(A.E. Nordenskiöld's Photographic Collection, Royal Swedish Academy of Sciences.)

Mosselbukta on the north coast of Spitsbergen, air photograph from NW. Photo: Norsk Polarinstitutt, Oslo.

The base Polhem in Mosselbukta, April 1873. The house, which was designed to accommodate the scientific staff and the *Polhem* crew, proved to be commodious and well planned. The people in the house enjoyed the best of conditions. (A.E. Nordenskiöld's Photographic Collection, Royal Swedish Academy of Sciences.)

Captured on the north coast of Spitsbergen

Early in the morning of the 16th, a severe gale started to blow, followed by an invasion of cold air masses, snow and a fall in temperature to -21°C . The ships could not put to sea. Wind and rough waves came right into the bay, and threatened to drive the ships ashore. The sea calmed down in the afternoon, but ice came drifting with the wind. Soon the whole of Mosselbukta was filled with ice, and the ships had become enclosed in it. The cold weather seemed to have come to stay; on September 30 the temperature was as low as -27.5°C . The broken ice between the floes froze into a continuous mass.

The *Gladan* and the *Onkel Adam* would have to be prepared to spend the winter in Spitsbergen, lacking suitable equipment and sufficient stores of provisions. It should be noted that the *Onkel Adam* had finished unloading on the afternoon of the 14th. Captain Clase had then asked for permission to leave, but was informed by Nordenskiöld that he had to stay until the morning of the 16th: "the wintering party must be given time for writing letters home". Captain Clase was very angry, and thenceforth an antagonism existed between him and the *Polhem* party, especially between him and Nordenskiöld.

The cold-air invasion on the 16th had further consequences. On the 17th, the Lapps reported that the reindeer had run away towards the south, away from the biting wind. The Lapps had been in their tent drinking coffee at the time. Only one reindeer returned later, but patrols were sent out to look for the others. They were, however, never seen again. *The expedition had thus lost its draught-animals for the northern sledge tour.*

But the real catastrophe lay in the fact that the stores of provisions were now insufficient. The *Polhem* had enough for 21-22 men during 16 months, but the stores of the *Gladan* would last only until December. The *Onkel Adam* was better off, though, thanks to the provisions which Captain Clase had bought from the "Colony". With some help from the *Polhem*, the supplies would last till April. On 2/3 rations, the total stores were estimated to hold out until August or September.

On September 30 the dwelling-house was ready for occupation, and the little island on which it stood was named *Polhem*, like the ship. The occupation would take place next day, but before then a number of black dots were observed on the ice off the bay. These appeared to be a party coming from Norwegian sealers, which had been captured in the ice: four ships at Gråhukken and two at Velkomstpynten, amounting to 58 men.

They had provisions only for a few months, and

their situation was critical. Now they had come to ask whether the expedition was willing to help them. The answer was that they were welcome to receive food and lodging after December 1. At the same time, they were informed of the "Colony" at Kapp Thordsen and the rich stores of provisions which had been deposited there.

The relations between Captain Clase and "Mr. Science" now reached a low-level mark. The *Polhem* members of the expedition seem to have regarded the people of the two cargo-ships as a burden which jeopardized their programme.

Clase demanded that the food rations on board the *Onkel Adam* should be the same as for the rest of the expedition. Here Palander declared that he would have nothing to do with the *Onkel Adam*, but Clase considered that those who had prevented him from leaving on September 14 should see to it that his people were no worse off than the rest of the expedition.

However, Clase's relations with the people of the *Gladan* improved to become most friendly during the course of the winter—but the rift between the two freighters and the land party increased.

Preparations for the winter: reduced food rations

A severe winter was expected, but it emerged that mild periods were rather common in this season. As for strong winds, it even seemed that the *Gladan* and the *Onkel Adam* might be able to escape from their prison and start the voyage home. But there was always something that prevented them: unfavourable winds, ice, darkness.

The house proved to be commodious and well-planned. In the ships, special arrangements had to be made to meet the special conditions in the winter. Part of their holds became rooms for habitation and handicraft, the bunks were covered with reindeer skins, and the decks were provided with superstructures—in the *Gladan* made from sails, in the *Onkel Adam* from snow.

The *Polhem* people, now living in the house, enjoyed the best of conditions. This was evident from the group's state of health. They also led a more diverse life than did the inhabitants of the two freighters.

It was important to establish a fixed routine for the *Polhem* people. Those who took part in the scientific observations had to differ in this respect from the personnel with practical duties. Observations were carried out by day and night, whereas the practical tasks were generally concentrated in daytime. Thus, Nordenskiöld and Palander presented a list to regulate the latter duties:

06.20h	The lamps are lighted.
06.30h	The men are roused, all hands wash, dress and make their beds; the rooms are aired and tidied up, etc.
07.50h	Inspection.
08.00h	Prayers, then gymnastics and breakfast.
09.00–11.30h	Work or instruction.
12.00h	Dinner.
13.00h	Work or instruction.
13.30h	Weighing out provisions.
15.00h	Coffee.
17.30h	Cease work or instruction, etc.
19.30h	Supper.
21.15h	Turn-in.
21.30h	The lamps are put out, except in the common work-room; fire inspection.

The meteorological and geomagnetic observations were shared among Envall, Kjellman, Nordenskiöld, Palander, Parent, Wijkander and two men of the crew. The day consisted of four 6-hour watches, starting at 08.00h in the morning. Observations took place every hour, except on the 1st and 15th days of each month, when they were made every five minutes.

Due regard was paid to the distribution of the rooms amongst the wardroom personnel, when the observation watches were set up. Here the rooms were shared by pairs of men: Nordenskiöld and Palander, Envall and Wijkander, Kjellman and Parent.

The scientific work included other observations which, however, were not conducted on such a routine basis. These concerned astronomy and refraction, the tides, pendulum motion, the aurora, atmospheric electricity, and temperatures of the land and sea.

There were also zoological investigations by dredging under the ice and, at the same time, algological studies. Dredgings were carried out from October 23 to April 24, covering the whole dark period and part of the light season.

Life at the Polhem base was dictated by the clock to a very high degree. But there was time for relaxation as well. A good library was much appreciated, and opportunities existed for pursuing various hobbies. Promenades and excursions provided fresh air and exercise. This outdoor life was, so to speak, part of the medical treatment against scurvy, which so suddenly had become a potential danger to the expedition. Vitamin C was unknown at the time, but many anti-scorbutics were familiar, such as lime juice and cloudberry jam or porridge. Exercise and work in the fresh air were also considered a means of avoiding this dreaded complaint.

Conditions in the *Gladan* and the *Onkel Adam* were different from those at the Polhem station. The daily life on board the two cargo-ships was more dull, and lacked the fixed routine that characterized the land station. Besides, the equipment of the *Gladan* and the *Onkel Adam* was not so good, especially in terms of clothing.

Nothing was heard from the Norwegian sealers who had been frozen in at Gråhuken and Velkomstpynten. When the days passed without any news from them, Palander and five men set out on a sledge tour to Gråhuken on October 22. The sealers were found in good health, but Palander was informed that their food would last only until the middle of November at the most. They asked for permission to come to Mosselbukta already on November 10, and it was granted. They also told Palander that 17 men from the captured ships had left in two boats on October 7, to find refuge in the "Colony" at Kapp Thordsen.

After Palander's return to Mosselbukta, preparations began for receiving the sealers. The ship *Polhem* was to be their home. The problem was, however, the food. It had already become a worry. As originally planned, the provisions of the *Polhem* were adapted for 21–22 men during 16 months. With the *Gladan* and the *Onkel Adam* frozen in at Mosselbukta, the number of persons had increased to 66, and 2/3 rations would be necessary. Now, with the addition of the remaining sealers, the expedition would have to feed another 41 men, making a total of 107. Probably it would be necessary to go on *half* rations or less. Would this result in a catastrophe with all or almost all perishing from malnutrition or scurvy towards the end of the winter?

The polar night and its perils

But no sealers arrived, and nothing more was heard from them. Probably they had managed to sail home to Norway. At Mosselbukta the truth would be known next summer.

After September, the temperature remained low at first. But during the winter, until February, mild air masses repeatedly invaded from the south. Temperatures rose above the freezing point, resulting in ice breakage.

The ice was broken at repeated intervals in Wijdefjorden, but it continued to block Mosselbukta. In December there were also darkness and fog, which prevented the two freighters from leaving.

On October 21 the polar night began. From now on, the sun was to remain under the horizon day and night until February 20. There would be twilight in daytime for altogether two months, but darkness for two months around midwinter. Of course, visibility

When ice-conditions permitted, biological dredgings were carried out from the ice, otherwise they were made from a boat.
(Kjellman, F.R.: Svenska Polar-expeditionen 1872-1873.)

The severe gale in September 1872 together with low temperatures and heavy ice, imprisoned the three ships in Mosselbukta. The food rations had to be held low, with scurvy as a result. The picture depicts boatswain Svan of the *Gladan* being taken to his last resting-place, in a wild gale, a few days before Christmas. (Kjellman, F.R.: Svenska Polar-expeditionen 1872-1873.)

would be helped by the moon as well as by the aurora and the snow-covered ground.

At the beginning of the winter, the state of health had not been satisfactory aboard the *Gladan*. On December 8 the doctor reported the first case of scurvy, though nobody was then alarmed, as the man in question only ate salted food; his rations had therefore been small. The patient regained health after having started to eat the food which was served on board. The doctor advised everyone to be observant of symptoms, and to exercise in the fresh air.

Yet on December 20 the first death occurred. It was a young sailor of the *Gladan*, boatswain Svan, who had suffered from a combination of a lung-disease and scurvy. It was near Christmas, and it was deemed desirable to bury him before the Christmas celebrations and their preparations started. But on the day determined for his burial, a severe gale was raging with heavy snowfall and drifting snow. The grave had been dug up on the mainland and the funeral service was held on board his ship. A large procession with men in front holding lamps then began moving towards the interior of the bay. This ceremony was not without risks, given the darkness and low visibility. It surpassed in wild ghastliness anything that the participants had ever experienced. Remarkably, though, Nordenskiöld said nothing about the death or the funeral in his report on the expedition.

Next day, the 21st, the ice in Mosselbukta was broken by a north-westerly gale. The break-up passed off better than Captain Clase of the *Onkel Adam* had expected, but the propeller of his ship became somewhat damaged. Nordenskiöld tried to make Clase put to sea, and "threatened by all means possible", but it was impossible to leave because of the darkness and the pack-ice.

Christmas Eve was celebrated traditionally, and the food was rich. But outside there raged a severe gale with drifting snow and a temperature of -24°C .

On December 20 Captain Clase wrote:

"We are, thank God, hale and hearty on board, and in the *Gladan* and the *Polhem* they are feeling better now; it would be a great mercy if we all could be in good health, and the doctor really deserves it, as he is tireless in his efficacy to avert ill health and take care of those who are ill. Mr. Science and Lieutenant Palander are now very polite and friendly, though I believe that they wish me further."

After New Year they were almost sure that the "real" winter had begun, but on January 10 the ice in the bay was broken by prolonged southerly winds, and after

the 16th the temperature rose above freezing, reaching a maximum of $+3.6^{\circ}\text{C}$.

The *Gladan* and the *Onkel Adam* were cleared for the home voyage—and the *Polhem* for a push northwards. But the south and south-east winds were too strong for the ships to stand out to sea. Finally the departure had been fixed at January 29, and the men who were to go with the three ships were on board, but the departure was postponed continuously because of the wind.

On the 30th the wind increased still more. Both the *Gladan* and the *Polhem* went adrift. The *Polhem* tried in vain to assist the *Gladan*, which was drifting towards the shore, but was prevented from being blown on shore by a band of broken ice. Bumping against the bottom, she lost both her rudder and her loose keel. At last the *Polhem* managed to tow the *Gladan* into the lee of the Polhem islet. Yet now the *Polhem* ran aground and lay bumping against the rocky bottom. However, it was low-water level at the time and, after unloading some cargo, she escaped when the water level started to rise again.

The severe gale continued during the night and the following day. In the forenoon the situation became critical again, the three ships having come adrift in the merciless wind, which had veered to north-west. Broken-up ice was drifting into the bay, and the rough sea came to an end. The ships were now surrounded by a thick layer of sludge and were able to stand up to the severe gale. Next day, February 1, it was possible to walk upon the sludge, which had frozen. At some places it had attained a thickness of about 1 m.

The danger had been very great—not only to the ships but to the whole expedition. A shipwreck need not necessarily have meant losses of human life, but certainly a loss of provisions, which in turn might have led to death from scurvy of many or even all men in the expedition.

From February 10 through April, severe cold prevailed almost constantly, with a lowest temperature of -38°C . Mosselbukta became completely covered by ice, and was to remain so until the end of June.

The light returns. Scurvy

The return of the sun towards the end of the winter eased the minds of the men. Already on January 12 a faint dawn could be seen near the southern horizon at noon.

The darkness at this time felt oppressive, and they were tired of the lamplight all day long. The sunlight revealed in a marked way the influence which the polar night had exercised upon them. They were sallow and listless; they had lost weight and their faces were covered in wild beards. Thanks to the mild

weather and the twilight at the beginning of February, many in the expedition could go out for long walks in the surroundings. For an interval Mosselbukta was once again freed from ice, and the ships prepared to leave. But on February 9 the cold weather returned to stay, and again neither the *Gladan* nor the *Onkel Adam* had been able to leave.

During the winter, the animal life on land had been practically absent. Only one fox and two polar bears had been observed, one of which was shot. No sea-birds were seen, except an auk on December 23. But after the return of the light they began to show up: on March 4, black guillemots and fulmars were sighted. On March 30, all these types were seen in great numbers in the open water off Mosselbukta. On April 4, little auks and snow buntings were noted.

On the mountain slopes to the south of Mosselbukta, there had been ptarmigans throughout the winter, but it had not been possible to shoot any birds during the dark season—even after February 5 in periods with moonlight. Chances improved only when the twilight had become sufficiently strong.

Dredgings were carried out almost every day during the winter. These zoological and algological dredgings were mostly done by the Lapps. If there was open water in the neighbourhood, they preferred to perform their dredgings there, rather than cutting a hole in the ice. No seals were observed in the dark season, although there was much open water. Not until the beginning of March were they seen lying upon the ice, indicating that they moved towards more southerly regions during the dark period.

True, life seemed to have returned once the sun had appeared again. But scurvy had not loosened its threat. On March 3, three people were affected by the dreaded disease. Around the turn of April into May, the northern sledging party started its long journey. The most depressing and miserable time of the entire expedition then began at the winter quarters. The ice in the bay remained unbroken, and the weather was characterized by dense low clouds, if not also by a cold and thick fog. Heavy snow fell, generally at temperatures between -5° and -10°C .

The store of provisions had become seriously reduced, and one of the antiscorbutics, lemon juice, was used up. There prevailed a great and general loss of strength among the men. A medical examination of the crew in the *Onkel Adam* showed that all, except one man, were affected by scurvy. Some of the men were severely afflicted and had to be moved ashore to the expedition house. On board the *Gladan*, too, the state of health was far from satisfactory, and among the Polhem people new symptoms had begun to develop.

Every day patients from the ships came to see the doctor in the base house. Some came on crutches, others supported themselves on sticks.

Altogether there were 28 cases of scurvy—12 from the *Onkel Adam*, 10 from the *Gladan* and 6 from the *Polhem*. Dr. Envall reported that a good remedy in the treatment was obtained from cloudberry (the best), lingonberry, horseradish, pickles and condensed milk. No one died from the disease; help from the outside world was obtained before the threat became serious. Among other things, they obtained invaluable additions to the provisions from Mr. Leigh Smith, the British polar traveller. The longest time of treatment was 132 days, the shortest 14 days.

THE LONG SLEDGE TOUR, APRIL 24—JUNE 29, 1873

Preparations and plans

Preparation for the sledge journeys, which were to be carried out in spring and early summer, began in the latter half of February. Two long sledge journeys were contemplated.

The most important tour would go northward over the pack-ice. Before it was to start, a trip eastwards should have been carried out—an attempt to reach Kong Karls Land, or “Giles Land”, which Norden-skiöld and Dunér had seen from Kvitbeget in 1864 (see pp. 51–269). The time of departure was fixed for the eastern trip as March 15, and the sledges were packed in time for the start. But the departure was delayed for several days because of heavy snowfall. When the weather improved, they found travelling impossible due to the thick and loose snow, which now covered the land. And if they waited for the snow conditions to improve, it would be too late to start the northern journey. The eastern sledge trip had to be given up.

On the whole, there had been many setbacks in connection with the preparations of the northern sledge tour. The position of the winter quarters was unfavourable, the loss of the reindeer in September had been a catastrophe, and the low rations of food in the winter had affected the men. The physical fitness of the prospective sledgers was not ideal.

According to the plans, the route would lead from Mosselbukta via Sorgfjorden, then pass across Hinlopenstretet to Langgrunnodden and from there to Sjuöyane, where they had originally intended to locate their winter quarters. From Sjuöyane the “real” journey northward was to start.

The push northward would be undertaken by one main party, which was to be supported by two relief parties. Of the latter, one would accompany the main group to Sjuöyane, where they would establish a

depot with provisions intended for the homeward journey of the main group. The other relief party would proceed northward with the main group for part of the way, hand over some of their provisions, and turn back.

The relief party which would return at Sjuöyane was taken from the crew of the *Gladan*. The other relief party consisted of people from the *Polhem*: three Lapps, two Norwegians and a "volunteer" (the mate Christiansson of the *Onkel Adam*). Nordenskiöld and Palander were included in the main group.

Start of the sledge tour. Adversities

The tour began on April 24, its route passing overland to the mouth of Sorgfjorden. The parties were helped by all healthy men of the expedition, which was necessary as their three sledges were loaded, in addition to sledging equipment, with one boat per sledge. This caused, however, too much strain upon the sledges, and two of them had to be taken back to Mosselbukta for repair.

Palander and one group returned, while Nordenskiöld and the remaining men continued across Hinlopenstretet, which was frozen.

The weather was fine, but soon they became enclosed by frost fog. Consequently, it was difficult to avoid the irregularities of the ice surface. The ice crystals of the frost fog gave rise to glorious halo phenomena. Full of enthusiasm, Nordenskiöld gives a description of these.

The reduced visibility was the cause of the second death of the expedition. Near Langgrunnodden a party had been sent to the shore to collect driftwood for cooking. "Through misunderstood zeal" one of the sailors went off alone towards the shore in order to help the others. He never returned, and in spite of an intense search for him during several days he was never found. The drifting snow covered all footmarks. Furthermore, the men were at the time attacked by snow-blindness.

Because of the delay, Nordenskiöld had to send six men back to Verlegenhukén on May 2, to meet Palander and his men. As a result, these men could not go north and assist Nordenskiöld as had been planned—the ice had broken up.

It should be noted that Nordenskiöld, on his journey to Nordaustlandet, brought with him the sole remaining reindeer "just for study". He concluded that his sledging party, with 40 reindeer available, would have come far to the north, even considering the severe ice conditions north of Nordaustlandet.

On May 5, at the time fixed, Palander arrived at Verlegenhukén. Here, a few days previously, a lane of open water had formed, and in only 18 hours Palander

was able to cross Hinlopenstretet and reach Langgrunnodden, where Nordenskiöld and four men were waiting.

The largest relief party was not coming, so the number of days during which the main party could be away had therefore been reduced.

On the way at last. Routines

The two sledging parties started from Langgrunnodden on May 6. A fresh wind was blowing, and they were able to use sledge-sails all the way to the south point of Lågöya (Low Island). The first long sledging tour in Swedish polar history had now commenced, and it may be of some interest to study its equipment and routines.

The sledgers were the main group and one relief party. The main group consisted of Nordenskiöld, Palander and 9 men. The relief party, made up of 6 men, was to accompany the main group to Sjuöyane and support the latter on the way, and establish a depot on one of Sjuöyane. The main group carried with them a boat, a tent and provisions for 50 days. Their equipment was loaded on two sledges, which now "behaved" well.

Two hours before they were to start, the cook was roused. This service was taken in turns among the men, and the cook's first duty in the morning—or in the evening as they often travelled at night—was to make coffee. Fuel for the cooking was either tallow or driftwood. Frequently the cooking took place inside the tent, and this practice soon gave the sledgers' skin a blackish tone.

The coffee was served in tins, which were used both as coffee-cups and as soup tureens. After the coffee there followed about 0.21 kg of pemmican, heated in a frying-pan. Besides, each man received 0.11 kg bread and 0.08 kg butter.

Next came the break-up of the camp and departure. There were 5 hours of march, with 15 minutes' break every 1.5 hours, before the halt for the midday meal. This consisted of 0.11 kg bread, a piece of bacon and 1.5 cl snaps.

After the midday halt, they marched for another 5 hours, then pitched camp. This time the cook served 0.21 kg pemmican, now boiled to become a strong and most popular soup. Also served were 0.11 kg bread, 1.5 cl snaps and finally coffee or tea.

In the reports from the expedition, no description is given of the tents which were used, except a note that the people lay "densely packed in a thin tent of cotton cloth". Anyhow, after the meal they inflated their rubber mattresses and crawled into their pesks¹. A common grey felt blanket was spread over them, and soon all slept deeply.

Change of plans: eastward instead of northward

Having started from Langgrunnodden on May 6, they reached the south point of Lågöya in the evening. The events of the next ten days will now be summarized.

May 7–9: After marching for a few hours on the 7th, they had to pitch camp as the wind increased, followed by heavy snowfall with drifting snow and reduced visibility. The temperature was -19°C . They could not resume their journey until the 10th. For three days they were forced to remain in the tent, lying densely packed like sardines, while the drifting snow found its way into the tent through all small openings. Rime formed on the canvas inside, and any rash movement produced a shower of snow over them.

May 10–17: Breaking camp in glorious weather, they passed close to Kapp Hansteen, steered into Brennevsfjorden and crossed the neck of land at the bottom of its northern branch, finally reaching Extremhuken and Castrénöyane on the 12th. Up to Kapp Hansteen the going had been good, and the ice had been smooth and fine. But from now on they met with very rough ice, piled up by the strong northerly to north-westerly winds that had prevailed.

One of the Lapps had become snow-blind and was left on one of the Castrénöyane. The others proceeded to Parryöya, one of the Sjuöyane, about 19 km north-east. The going was slow over the piled-up ice, and they needed three days to reach the island. The relief party was then sent back, and the main group continued the march. From the top of Phippsöya, on May 17, they got a view of the ice conditions—a chaotic expanse of piled-up ice. If they had wintered on Parryöya, they would have had time to reconnoitre a suitable way through the chaos—but there was no time for that now.

It was necessary to change the plans fundamentally. Instead of marching north, Nordenskiöld decided to go east and pass round Nordaustlandet, whose eastern parts were unknown or badly known. It would be possible to study the geological conditions of the area, and to make important contributions to the map of Nordaustlandet. They might also get to know the ice-cap of Nordaustlandet. Nordenskiöld estimated that 20–30 days would be needed for the tour, but it turned out that this route was more difficult than anticipated; the march was to last 40 days.

May 18–31: They resumed their march on the 18th. For easier travel, they left the boat and other articles of equipment on the island Phippsöya. The course was set eastward. The ice was good to begin with, but soon they met with piled-up blocks, loosely stacked

upon each other to form pyramids or walls, some reaching a height of 9 m.

Their progress was utterly sluggish, and was made harder by the frost fog, which enveloped them and forced them to push onward haphazardly. They observed many polar bears and there were footprints everywhere, which gave the men a good indication of where the going would be best.

East of Kapp Platen the ice was good, but now their journey was slowed down by scientific work: geological investigations, mapping and astronomical determinations of position. They were beyond the “extreme east” of the expedition of 1861, and the area through which they travelled was virtually unknown. The weather was now fine and warm; the snow-melt had begun. The mountains were beautiful and on their precipitous slopes many sea-birds were breeding. The men shot reindeer, and these were already fat.

The eastward journey showed that Nordaustlandet reached farther to the east than most maps indicated, as had already been pointed out by the British traveller Leigh Smith. They were now able to confirm this statement, and at the same time to supply a reliable map of the north coast of Nordaustlandet, including the regions east of the turning-point during the expedition of 1861.

On May 31, Nordenskiöld and Palander climbed Raschöya (von Otter-öya), 100 m high at long. 26°E , one of the most easterly of the small islands near the north-east corner of Nordaustlandet. They observed a wide expanse of open water off the eastern and north-eastern part of Nordaustlandet, so they had to give up the plan of following the east coast on the sea ice. No longer having a boat, they dared not take the risk of following a vertical barrier-coast. They gazed out over the ice towards the north-east, hoping to sight the enigmatic Giles Land—which had been discovered by the Dutchman Giles in 1707, and was later rediscovered and named Kvitöya.

Homeward across the ice-cap of Nordaustlandet

To avoid going back the same way as they had come, they would have to travel across the ice-cap of Nordaustlandet, which had never been done before. They decided to follow a southerly course that would bring them to Kapp Mohn, or eventually Torellneset, in the south of Nordaustlandet via the ice-cap.

June 1–16: They started the ascent of the ice-cap along a rather gentle slope. From the top of Raschöya the surface of the ice-cap had appeared smooth. After only a few hundred metres they reached a crevasse, but were able to pass it easily over a snow-bridge. A few kilometres further along, one of the sailors suddenly disappeared into a crevasse, yet remained hang-

¹⁾ A kind of overcoat of reindeer skin used by Lapps.

The long sledge-tour of A. E. Nordenskiöld and Palander, April 24–June 29, 1873. The tour did not go north—as planned—but along the north coast of Nordaustlandet and then over the ice-caps back to the base. (Nordenskiöld, A.E.: Den andra Dicksonska expeditionen till Grönland 1883.)

In 1924, the British Oxford expedition under George Binney had travelled over the ice-caps of Nordaustlandet meeting with crevasses and low visibility—like Nordenskiöld—in the same area to the east of Wahlenbergfjorden. Ahlmann in 1931, on the other hand, had the good luck to get a fine view over the same area: "a mighty amphitheatre of ice and snow". (Geographical Journal, July 1925.)

ing in his harness. Consequently all harnesses were checked, and thenceforth the man leading the "caravan" tested the carrying capacity of the ice with a boat-hook.

They were to encounter a great number of crevasses. Nordenskiöld speaks with appreciation of the men's almost cheerful way of meeting this menace, previously unknown to them. In spite of all caution, they often trod through with one foot, or fell through to the hip.

The weather was fine during the first day of their ice-march, but they were to experience the typical weather of the ice-sheets on Nordaustlandet. At first, the ice-cap extended west and south without a break from any mountain ridge or nunatak. By degrees it rose towards a plain of ice and snow at 600-900 m a.s.l..

Each puff of wind created a flow of fine snow dust along the snow surface, which had become polished by the wind and the drifting snow, giving the impression of a floor of white marble.

At their halts, they dug a pit to serve as a shelter for the cooking. This also gave Nordenskiöld opportunities for studying the structure of the snow in the upper layers of the ice-cap. He found that the snow passed into ice at a depth of 1.2-1.8 m:

"First there appeared a layer with large and well-developed ice crystals, followed below by a granular mass of ice and at last by hard glacier ice."

This should be compared with the observations of Valter Schytt (see p. 554).

During practically the whole of their ice-march, on June 1-15, either drifting snow or frost fog reduced the visibility and prevented them from seeing the nearest surroundings. With strong headwind and dense drifting snow, they were forced to spend several days packed in their thin cotton tent, utterly inactive, while the snow dust gently sifted down into the tent.

The ice was initially smooth, after they had overcome the crevasses in the marginal zone. Thus the reduced visibility did not trouble them very much, as they could always use the compass for finding the course. But it would get worse.

The air temperature on the ice-cap was, at a height of 500 m a.s.l., generally 5-7°C lower than at Mosselbukta, and melting of the snow did not occur. Nordenskiöld noted the appearance and the structure of the snow. He mentioned supercooled droplets, as well as deposits and coatings of ice caused by these. He also compared the new conditions with his experiences from his march on the Greenland inland ice in 1870, when the snow- and ice-melt had been consid-

erable in the marginal zone and had obstructed the march. One advantage, though, was the fact that the crevasses in Greenland had been open, not treacherously hidden below the snow as they were here in Nordaustlandet in June.

Nor did he observe here any small pits and holes filled with water and at the bottom containing the enigmatic "ice dust", which had been so characteristic of the marginal zone of the inland ice in Greenland at the height of summer. Also absent in Nordaustlandet were the microscopic algae on the ice, which Dr. Berggren had brought home from the Greenland inland ice. However, this latter circumstance might have been due to differences in the time of year.

Nordenskiöld's description of the sledge tour on the ice-cap is difficult to follow. Some of the report gives an impression of having been written from memory, and more or less without the help of diary notes. This is to be regretted, because the most interesting part of the sledge journey is therefore pretty conjectural.

Nordenskiöld's account of the latter part of the ice-march will be followed to begin with. But we shall add comments from reports of later ice marches, namely George Binney's and Hans W:son Ahlmann's journeys in 1924 and 1931 respectively (p. 90).

When the Nordenskiöld party was approaching Kapp Mohn—according to dead reckoning—they entered on June 10 an area which was traversed by "canals". These were elongated depressions in the ice, about 12 m deep and 9-30 m broad, with fairly vertical sides. They would have been a serious obstacle, were they not filled with snow in places, where it was rather easy to pass. The "canals" were often parallel to each other at a mutual distance of about 90 m.

The passage across a "canal" involved a certain risk, because of the crevasses along its sides. Near-accidents did occur. Often a "canal" was used as protection against the wind by pitching camp on its bottom. There also existed a kind of relatively short canal whose short sides, too, were vertical and sharply marked. The sailors in the sledging group used to refer to this kind as "docks".

Nordenskiöld carefully considered the problem of the genesis of the "canals" and "docks". But the snow, which covered the ice-sheet, prevented him from getting a clear understanding of the phenomenon. He thought that these features might be a type of faults. In any case, the "docks" were not river valleys, like those which he had observed on the Greenland inland ice in 1870.

Besides, the description of the sledge journey makes it difficult or impossible to determine exactly where these formations occurred. Were they observed after

the change of course—from about SSE to about W—or both before and after it (see the map, p. 88)? Nordenskiöld also mentions this change of course without giving the date when it was made. One might suggest, from a table of temperatures and altitudes, that the date was June 11. Nordenskiöld writes on this occasion:

“From the place upon the inland ice where we turned off towards the west, we could see clearly, when the fog lifted for a few moments, that the ice-sheet further to the south had been subjected to more considerable disturbances than those which existed at the places where we were passing along. From our turning-point towards the west, which was situated at an altitude of 407 m, the inland ice descended slowly to an icy plain at a much lower level, from the south side of which it rose rapidly in steep terraces. In field-glasses it was possible to distinguish huge angular blocks of ice, scattered about the ice plain at the foot of the terraced ledges, from which they had tumbled down. It is possible that the altitude a.s.l. of the ice-plain was inconsiderable, and that here in front of us we had an ice-covered arm of the sea leading to the east coast of Nordaustlandet.”

It was this rough terrain which made them decide to give up the plan of marching towards Kapp Mohn, from there along the southern coast of Nordaustlandet to Torellneset, and then home to Mosselbukta via Ny Friesland. Instead the course was changed westward towards Wahlenbergfjorden.

COMPARISON WITH OTHER EXPEDITIONS

In 1924 an Oxford University expedition under George Binney worked in Nordaustlandet. Sledge journeys were made. Of these the sledge tour, led by Binney himself, is of greatest interest in the present case. During August 5–15, the sledgers passed from Isispynten on the east coast (lat. 79°42'N, long. 26°40'E) to the bottom of Wahlenbergfjorden, though somewhat more to the south than Nordenskiöld's route.

Unfortunately Binney passed the “interesting” area in conditions with visibility reduced by fog and snow-fall. However, his party met an area of “chasms” 10–30 m wide and 12 m deep, with masses of congealed snow and open crevasses at the bottom. These chasms might correspond to Nordenskiöld's “ice-canals”. Moreover, when Binney's sledging party was transported by their ship, the *Polar Björn*, to Isispynten along the barrier coast, they observed that the inlet or low-lying valley, which had been marked by

Nordenskiöld at the south-eastern corner of Nordaustlandet, did not exist.

In the summer of 1931, the Swedish-Norwegian expedition under Hans W:son Ahlmann worked in north-western Svalbard. A sledge journey under Ahlmann was conducted over the ice-caps of Nordaustlandet, initially passing on top of Sörfonna to the south of the routes of Nordenskiöld and Binney.

Ahlmann was, however, favoured by luck: the typical fog of the ice-caps of Nordaustlandet lifted for a short while, when the party was on the ice-cap to the south of the bottom of Wahlenbergfjorden. Ahlmann writes:

“But then the fog begins to lift, the ceiling of the clouds rises, and for a while I can look across a magnificent depression lying in the extension of Wahlenbergfjorden. Like a giant amphitheatre, with a circumference of some 60 km, it extended in front of us. In the form of tremendous frozen waterfalls the inland ice flowed down from all directions towards the opening in the west. No wonder that both Nordenskiöld and one of the parties of the Oxford expedition had met with their greatest hardships just there. None of them had had the good luck to look out from the rim of this ‘kettle’ before they came down into it, and because of this they were barred from obtaining a general view of the conditions.”

Apparently A. E. Nordenskiöld had passed along the northern slope of the amphitheatre, Etongropa (Eton-depression) as it is now called. The view he had obtained on June 11 from a height of 407 m a.s.l., which he had interpreted as an “inlet of the sea” and had placed on the map in the south-eastern corner of Nordaustlandet, must have been Etongropa. Nordenskiöld's party must have believed that they were further to the south and east than they really were.

It is remarkable that Nordenskiöld gave such a “diffuse” report of his march on the ice-caps, especially concerning the navigation. From Nordenskiöld's map with its winding route in the area in question, one can gather that he and his party were travelling through rough country.

As to the latter part of the journey on the ice-caps, he mentions only that the ice sloped gently down towards Wahlenbergfjorden, where they arrived on June 16.

Arrival in Mosselbukta. Homeward ho!

Their subsequent journey offered no shortage of dangers. The sea-ice on the fjord was in a state of

decomposition; openings and channels were met with, especially near the shore. When they approached the mouth of the fjord, they had to travel on the ice-cap, here called Vestfonna. Thus they reached Murchisonfjorden and Langgrunnodden at midnight of June 23/24.

On their outward tour they had laid up a boat there, and Palander with three men could now use it for crossing Hinlopenstretet and reaching Mosselbukta, while Nordenskiöld and six men waited to be picked up in a larger boat. However, before then they were visited by a sealing vessel and taken to Mosselbukta. On June 29 the entire expedition was assembled at Mosselbukta.

There was an atmosphere of breaking-up at the base. A channel had been sawn in the ice between the ships and the open water, and in the afternoon the *Gladan* and the *Onkel Adam* were taken into the open sea off Mosselbukta. In the evening of the 29th, the *Onkel Adam* started her voyage home, taking six shipwrecked sealers as passengers; and next morning the *Gladan* was towed out to sea by the *Polhem*.

The *Polhem* was to remain in Spitsbergen during the summer. Among her plans was a voyage north of Spitsbergen for making dredgings. Wijkander, the physicist, wanted to stay at the base as long as possible in order to obtain more complete series of meteorological and geomagnetic observations. Packing of equipment also had to be done.

The *Polhem* started her cruise on July 1 with the following tasks on her programme:

1. To bury two Norwegian sealers who had succumbed at Gråhukken during the winter.

2. To carry out dredgings north of Spitsbergen.
3. To land a group under Nordenskiöld at the mouth of Isfjorden for geological investigations.

After completing her mission the *Polhem* sailed north for Mosselbukta, where she arrived on July 17. With help from the crew of a Norwegian sealing vessel, the equipment was taken aboard in one day. Next morning the station was closed, and on July 20 the *Polhem* was back in Isfjorden, where Nordenskiöld's group was taken aboard. The expedition then remained in Isfjorden until the 28th. "Svenskehuset" at Kapp Thorsden was visited, and geological research was carried out at Kapp Boheman.

The voyage home passed by Bellsund, where six shipwrecked Norwegian sealers were taken aboard. Nordenskiöld also visited Kapp Lyell at the mouth of the fjord. The place is described by him in the most enthusiastic wording:

"...it is perhaps the richest habitat of plants from the Miocene epoch...a colossal herbarium, where every leaf indicates that the glacial period now prevailing in the high North only belongs to the latest geological periods, and that one now must go to lands far to the south in order to find a counterpart to the wonderful vegetation which once prevailed in these regions."

The expedition reached Tromsø on August 6, and—delayed by engine troubles—Göteborg on August 29. Here and later at Karlskrona, the expedition was dissolved.

ANNUAL MEAN TEMPERATURE: -8.9°C .
TEMPERATURE ($^{\circ}\text{C}$) AT MOSSELBUKTA, LAT. $79^{\circ}53'\text{N}$, LONG. $16^{\circ}04'\text{E}$ (MAINLY FROM 1872–73)

	Jan.	Feb.	March	April	May	June ¹
Mean temp.	-9.9	-22.7	-17.6	-18.1	-8.3	+1.1
Max. temp.	+3.6	+1.6	-0.4	+0.2	+3.6	+9.4
Min. temp.	-32.4	-38.2	-38.0	-32.6	-19.4	-3.9
	July	Aug. ²	Sept. ³	Oct.	Nov.	Dec.
Mean temp.	+4.6	+2.9	-3.9	-12.7	-8.1	-14.4
Max. temp.	+12.8	+9.0	+6.1	-0.6	+2.6	-3.4
Min. temp.	± 0.0	-2.6	-19.0	-27.2	-19.4	-26.6

Max. and Min. give the highest and lowest temperatures of each month respectively. The months July–September contain either no observations from 1872–73 or only observations during parts of those months. A. Wijkander has here used observations from previous expeditions, and from the ship *Polhem*, to make up for missing data:

¹ July: all observations are from Parry's expedition of 1827 (Sorgfjorden).

² August: Parry 1827 and the *Polhem* 1872 (11.8–31.8).

³ September: the *Sofia* 1868 and the *Polhem* 1872 (base and ship).

A FEW COMMENTS

The Spitsbergen expedition of 1872–73 had been haunted by adversities and difficulties. It had become much more expensive than expected, among other things due to the forced wintering of the two cargo-ships, the *Gladan* and the *Onkel Adam*.

With insufficient stores of provisions the expedition had, though, pulled through the wintering comparatively well in spite of the many cases of scurvy. Of the two deaths which did occur, one was due to a combination of a lung-disease and scurvy, and the second to an accident.

It was the first wintering of a scientific expedition in Spitsbergen. Almost complete annual observation series were now obtained in meteorology, geomagnetism and marine biology. The record march northward over the pack-ice, which had been planned, could not be undertaken because of the piled-up ice near Sjuöyane. The north coast of Nordaustlandet was instead investigated geologically and mapped, as were—though more superficially—the ice-caps of Nordaustlandet.

The configuration of Svalbard upon the map showed, after the expedition, in its essential features a rather close agreement with reality. Practical experiences from the expedition of 1872–73 were to be of great value in the planning of later Swedish polar expeditions. Nordenskiöld was displeased, but Oscar Dickson paid the overdraft.

This was Nordenskiöld's last visit to Spitsbergen. Next his interest turned to the arctic regions in the east and in Greenland.

14. SHIPWRECKED IN SPITSBERGEN

THE FATE OF NORWEGIAN SEALERS IN 1872–1873

On September 16, 1872, six Norwegian sealing vessels were caught by the ice off the north coast of Spitsbergen. At the same time the Swedish Spitsbergen expedition of 1872–73 was caught in Mosselbukta, not very far from the sealers. Four of the sealers were beset at Gråhuken—the yachts *Ellida*, *Dragedukken*, *Svanen* and *Helene*—and two at Velkomstpynten, the sloops *Jakobine* and *Pepita*.

Their crews totalled 58 men. The provisions on board these vessels were not sufficient for a forced wintering. An appeal for help was made to the Nordenskiöld expedition in Mosselbukta. It was agreed that they were to settle with the expedition after December 1. For various reasons none of the Norwe-

gians came to Mosselbukta, nor were they heard from during the winter.

Not until the following summer was their fate revealed to the Swedish expedition:

1. On October 7, two boats with 17 men had left the two sealing vessels at Velkomstpynten, in order to find a refuge in "Svenskehuset" at Kapp Thorsden in Isfjorden.
2. On November 4 the sea was almost ice-free at Velkomstpynten, but not at Gråhuken, and all but two of the remaining Norwegians went aboard the two sloops *Jakobine* and *Pepita*, which weighed anchor and left for Norway. An attempt to reach Kapp Thorsden to fetch the 17 men there failed, owing to a strong easterly gale in the mouth of Isfjorden. Both ships and the 39 men on board reached Norway in safety after a very hard passage.
3. The skipper of the *Ellida* and his cook had preferred to remain at Gråhuken in order to guard their ship and its catch. They both died of scurvy during the winter. They had then lived most of the time ashore in a hut made up of two boats placed on edge and covered with sails.

The fate of the Kapp Thorsden group of 17 men is known in detail thanks to the journal, which was kept almost to the end. Their voyage from the north coast of Spitsbergen had passed off without any notable incidents. During the first two days after leaving Velkomstpynten on October 7, the men had been obliged to drag their two boats over the ice to reach open water. They passed Norsköyane and Kobbukbukta, sailed through Forlandssundet and reached Kapp Thorsden on October 14.

The men settled down in the newly built house, "Svenskehuset". They were certain that they would spend the winter here in the very best of circumstances. Eventually they might soon be taken away by a ship and carried to Norway. A journal was kept daily, and on October 16 they started weather observations, including temperature, wind direction and a general description of the weather. The observations were made five times daily, at 04.00h, 08.00h, 12.00h, 16.00h and 20.00h.

They found ample stores of provisions, clothes, fuel, tools and so on. Here was everything that would be needed during a wintering. The polar night was near. During the first few weeks they managed to shoot two polar bears and a few reindeer, but very soon they found that hunting was impossible in the darkness.

On December 2 the first case of illness appeared, but did not worry them; it was not even mentioned in their journal to begin with. However, no recovery

took place, and on December 19 there was another man in the sickbed. On Christmas Eve almost everyone felt somewhat ill, and on January 3 a third man had to seek out the sickbed. The two men who had become ill first died on January 19, and were buried near the brook ravine to the east of the house. Then one man after the other had to take to bed and die. On April 19 the last entry was made in the journal. If the deaths had been accounted for correctly, three men would then have been alive. The meteorological observations went on until March 13, though with some reduction, but thereafter only the temperature was given once a day, at 08.00h, up to April 16. After this date no observations were made.

The two sloops, *Jakobine* and *Pepita*, brought news to Norway of the adversities which had been met with on the north coast of Spitsbergen. However, no one at home was overly worried: the two men at Gråhuken were staying near the large Swedish expedition, while the seventeen men who went to Kapp Thordsen had a commodious house and ample stores of provisions at their disposal.

In spite of these facts, three ships attempted to relieve the men during the winter, but with no success. The ships had to break their voyages before reaching their destination; either the weather was too stormy or the ice obstructed the passage, or the sea was rough and caused severe icing of the ship.

In the early summer of 1873, the sealer *Ellida* called at Kapp Thordsen. The whole tragedy was then disclosed. With the ship went the well-known sealing-captain Fritz Mack from Tromsø. His detailed report on the disaster was printed in the "Tromsø Stiftstidende". The crew of the *Ellida* cleared up the disorder that prevailed, and collected the fifteen corpses into a mass grave near the house.

Mack's criticism of what had happened is severe:

"I got the impression that these men had not understood how to lead a way of life that was necessary here. No one who has wintered in the Arctic has had so many facilities at his disposal as these men had: there were necessities of life in abundance, a sufficient supply of fuel, tools of different kinds, a carpenter's bench, etc. We tried to find some piece of work which had been done by them. The only things we found were the hull of a small boat, a desk and a few rough-hewn pieces of wood. This demonstrates clearly that they had surrendered to drowsiness and had imagined that the great amounts of provisions at their disposal would exempt them from scurvy. Instead of using two rooms for sleeping, all seventeen of them had crowded into one room. The kitchen was large and commodious, and they should have used it for their meals too, but they do not seem to have been thinking of anything but eating and sleeping. The carpenter's bench, which they should have used diligently, had been placed outside the house."

In a different part of his report Mack writes:

"As ill luck would have it, these people did not understand how to use the articles of food which would have been most appropriate to them."

On June 6, 1873, the Swedish expedition in Mosselbukta was paid a visit by a sealing vessel, and was informed of what had happened to the frozen-in sealers, namely the evacuations of the ships and the deaths at Gråhuken. But the fate of the 17 men who had gone to Kapp Thordsen was unknown to those on board the visiting ship, and was not disclosed until later in the summer.

MEAN TEMPERATURES (°C) OBSERVED IN 1872-1873 BY SHIPWRECKED NORWEGIAN SEALERS AT
KAPP THORSEN, SPITSBERGEN

	1872			1873	
Oct.	Nov.	Dec.	Jan.	Feb.	March
(-9.5°)	-7.3°	-14.0°	-9.8°	-19.0°	-14.3°

Compare with observations from Mosselbukta (p.91).

15. THE YENISEY RIVER AND THE KARA SEA

Historical background

After the Svalbard expedition of 1872–73, Norden-skiöld's interests became focused upon the Siberian Arctic, at first the regions to the west of the Yenisey River and its estuary. Now his ambitions were not only scientific, but also practical and economic: he wanted to study the seaways from the Atlantic to the giant rivers and fairways of the Yenisey and the Ob. By knowing these routes from geographical, meteorological, climatological and hydrographical points of view, the planning and execution of future freight voyages would become easier and safer.

The Siberian coast was not unknown territory, since both Russian and other expeditions had navigated or travelled over land or ice along almost its entire length. Nordenskiöld turned to the literature dealing with these classical voyages and journeys. Here we shall briefly survey the history of voyages and discoveries in the western Siberian Arctic until 1875, when Nordenskiöld started his research in this area.

The earliest voyages and land tours were carried out by Russians. They were traders or hunters who, in the 16th century or earlier, travelled eastward from the White Sea and the river Pechora, passed through the sounds south of Novaya Zemlya, and entered the Kara Sea. By river or by portages overland they reached the Ob estuary, the river Taz and the settlement of Mangazeya. Eventually they could proceed still farther east, to the Yenisey or perhaps even further. Unfortunately, these early travels were not properly documented. In 1620 they were prohibited by the Tsar.

In north-western Europe, interest had been directed towards the Far East during the 16th century. This was at a time when the two seafaring nations of Spain and Portugal took advantage of their discoveries of the sea routes to the Far East and its riches. England and Holland were beginning to develop into maritime powers, but being inferior to the Spaniards and the Portuguese they were prevented from using the seaways south of the large continents. It became necessary to find and investigate new routes north of these continents.

The *Company of Merchant Adventurers* in England received its charter in 1505. Not very long afterward, under its auspices, the English began voyages of exploration towards the north-west and north-east. The discovery and investigation of the North-West and North-East Passages became principal aims in the field of polar exploration which was now created.

Another sea route which was contemplated in those days went north, where a more or less open Polar Sea was expected.

The main English voyages during the previous, as well as the following, years were documented by Richard Hakluyt (1553–1616). He was indefatigable in collecting material on English voyages, including those to the Arctic. He published reports on the many maritime enterprises that were undertaken. His great work was the *Principal Navigations*, published in 1598–1604 in three folio volumes. After Hakluyt's death, his unpublished material was used by Samuel Purchas to produce *Hakluytus Posthumus*, or *Purchas his Pilgrims*. This work too is of great value.

The first expedition towards the north-east with an ambition of reaching the Far East left England with three ships in 1553, led by Sir Hugh Willoughby. With two of his ships he reached the Goose Coast in south-west Novaya Zemlya. Then he sailed to the Murman Coast to winter, but here he and all his men perished. The third ship, commanded by Richard Chancellor, had sailed to the White Sea, where Chancellor obtained supplies from Arkhangelsk—or rather from Kholmogori, some way upstream along the Dvina. He also obtained information on the country, which induced him to travel to Moscow. As a result of this journey, trade was established between England and Russia—and the *Merchant Adventurers* obtained a new charter in 1553 to be incorporated in the old charter.

Sir Hugh Willoughby had been the first to search for a North-East Passage. Three years later Stephen Burrough reached the southern entrance to the Kara Sea, but was prevented by ice from entering the sea. Most important, from a historical point of view, were his reports on previous and recent Russian activity in those regions. Some of these activities now became documented for the western world through the English.

Later on the Dutch became interested in the North-East Passage, while the English, after their failures to find a north-eastern route to China, turned their attention westward for some time. The most remarkable attempts of the Dutch to find a sea-route in the north-east were three expeditions, which were carried out in 1594, 1595 and 1596–97. Willem Barents (c.1550–97) took part in these voyages as chief pilot and navigator; he inspired them so greatly that they are generally referred to under his name. All three expeditions were directed towards the north of Novaya Zemlya, to be used as a starting-point. The main voyage was the last one, which will therefore be described below.

The expedition of 1596–97 consisted of two ships

Remains from Barents' winter quarters were found in 1871 by the Norwegian sealing Captain Elling Carlsen (1819–1900). (Nordenskiöld, A.E.: Vegas färd kring Asien och Europa...)

The zoologist Hjalmar Théel (1848–1937). He was a member of the Yenisey expeditions of 1875 and 1876. (Royal Swedish Academy of Sciences.)

Willem Barents' expedition of 1596–1597. The expedition wintered in northeastern Novaya Zemlya, where a hut was built. The homeward voyage in 1597 went along the west coast of Novaya Zemlya and then further westwards. (Fröhlén et al.: Upptäcktsresor och Äventyrsfärder, 1922.)

The Norwegian sealer *Prüven* of Tromsö was used for the Yenisey expedition in 1875. (Nordenskiöld, A.E.: Vegas färd kring Asien och Europa...)

commanded by J. van Heemskerk and J.C. Rijp, and Barents was on board Heemskerk's ship. The ships left Amsterdam on May 10, 1596, and reached Björnöya on June 9. This island was now discovered and named—Beeren Eiland. They steered north on June 13 and, sailing west of Spitsbergen, discovered the north-western part of this island on June 19. It too was given its name, although believed to be a part of Greenland. The ships then sailed back along the Spitsbergen west coast, regaining Björnöya on July 1.

Severe disagreement had prevailed between Rijp and Barents. The former wanted to go north and take advantage of the open water which was supposed to exist there, while the latter demanded a north-easterly course in order to round the north point of Novaya Zemlya, a region well known to Barents since the two previous summers. Rijp separated from Heemskerk and Barents, and proceeded to eastern Spitsbergen. Barents headed for Novaya Zemlya, which was sighted at 73°20' N on July 17.

The ice caused trouble during the passage north along the west coast of Novaya Zemlya. Finally on August 19 Barents passed the island's north point, the Longed-for-Headland, where the coast turned south-east. The ice conditions, instead of improving as Barents had hoped, became still worse. On September 5 the ship became enclosed by the ice at a place which they later called Winter or Ice Haven, as they were doomed to spend the coming winter here.

This was in fact the first truly arctic wintering of a polar expedition. Experience was lacking, and the cold was especially dreaded—not to mention the curse of scurvy. It is remarkable, though, how well the crew of seventeen Dutchmen came through the winter in spite of some deaths. Their ship had been damaged by ice pressure, so they built a house on the shore from drift-timber and from timber taken off the ship.

On June 24, 1597, the Dutch expedition left Ice Haven in two undecked boats. They followed the west coast of Novaya Zemlya to the Kara Gate (Karskiye Vorota) in the south, then headed west and passed the mouth of the River Pechora. At last, on September 12, they reached Kola in the west after a boat tour of 2.5 months. On November 11 the expedition was back in Amsterdam. Of the original crew of 17 there remained 12, the rest having succumbed to hardships and scurvy. Barents himself and one of the sailors had died only five days after leaving Ice Haven.

The expeditions of Barents are well documented, notably the third one, by Gerrit de Veer, who had served as mate during these enterprises. The narrative of the voyage of 1596–97, illustrated with wood-engravings, has become a polar classic. It gives a simple yet vivid description of how a very early expe-

dition experienced the polar night, the cold, the ice and a shipwreck in the Arctic.

Of special interest in this context is a visit which was paid to Ice Haven on September 7, 1871, by a Norwegian sealing vessel from Tromsø commanded by Elling Carlsen (1819–1900). The place had not been visited since the Dutch left in 1597. By chance the Norwegians found the remains of the hut of Barents, including many relics from the expedition. These were later deposited in the model room of the Naval Department at The Hague.

The Great Northern Expedition of the Russians in 1734–43, which supplied so much information on the Siberian Arctic coastline, will be treated shortly in Chapt. 16.

The Russian expeditions, which in the 19th century visited—or tried to visit—the Kara Sea, encountered severe ice conditions that stopped their progress. This region acquired a reputation of being a veritable “ice cellar”. However, from 1869 and onwards Norwegian sealers, notably Elling Carlsen (1819–1900) and Edv. E. Johannesen (1844–1901), penetrated into the Kara Sea and found that these waters could very well be navigated, at least in the latter half of the summer.

Such was the situation in 1873 when Nordenskiöld set his sights on the Kara Sea and the estuaries of the giant rivers Ob and Yenisey. Particularly interesting were his ideas about how the ice conditions were affected by the warm water from these rivers, especially in the latter half of the summer.

THE VOYAGE OF THE *PRÖVEN* IN 1875

Planning and preparations

After his return from the expedition of 1872–73, Nordenskiöld wanted a change of scientific activity. The polar lands to the east attracted him. Novaya Zemlya and the surrounding seas were, at best, poorly known to science. It was therefore natural to extend the Swedish expedition activity to these less familiar regions. The reports from Norwegian sealers, who had hunted seals in the Kara Sea since 1869, indicated that the ice conditions in this inland sea were by no means as bad as rumour implied. A practical aim also lay near at hand: to reconnoitre a usable sea route between the Atlantic and the estuaries of the Yenisey and Ob.

The plan called for an expedition with a small Norwegian sealing vessel, which would leave Tromsø at the beginning of June 1875.

The stages in the work of the expedition were outlined as follows:

1. Geological, botanical, zoological and ethnographical research in the south of Novaya Zemlya.

Exterior and interior of Barents' hut "Ice Haven" on the northeast coast of Novay Zemlya, 1596–1597. (Nordenskiöld, A.E.: *Vegas färd kring Asien och Europa...*)

2. A northward push along the west coast of Novaya Zemlya until its north point was reached, and from there a thrust towards unknown regions in the north-east, as well as south-east to the mouths of the Yenisey and the Ob. Of geological interest in the latter regions would be possible finds of mammoth.
3. If ice conditions proved favourable, the intention would be to travel with a North-Land boat up one of the big rivers and return overland to Sweden.
4. The ship would return to Tromsø via Matochkin Shar or the Kara Gate; it was estimated to be back in Tromsø at the end of September or the beginning of October.

The expedition was financed by Oscar Dickson. Its scientific staff consisted of five persons:

Adolf Erik Nordenskiöld (1832–1901), Ph.D., professor, geologist, responsible for astronomical determinations of position, leader of the expedition.

Frans Reinhold Kjellman (1846–1907), Ph.D., botanist.

Axel Nikolaus Lundström (1847–1905), Ph.D., botanist.

Johan Hjalmar Théel (1848–1937), Ph.D., zoologist.

Anton Julius Stuxberg (1849–1902), Ph.D., zoologist.

Nordenskiöld had managed to acquire a highly competent scientific staff. As expedition ship he hired the little 43-ton yacht *Pröven* of Tromsø. Including her skipper Isak Isaksen, the crew counted 12 men, all having previous arctic experience.

The scientific programme was dominated by the biological sciences, but the equipment also contained instruments or tools for meteorological observations, astronomical determinations of position, topographical and hydrographical measurements and geological investigations. The little ship had to accommodate 17 persons during the expedition, so that extra cabin facilities had to be created on board. Space for three more cabins was found in her hold, both fore and aft. In this way the hold itself shrank, and great problems arose when the cargo was stowed in, especially as Oscar Dickson had insisted that provisions for 14 months should be taken. The deck was cluttered with five boats. As predetermined, the ship was to be ready for sea on June 1, but belated equipment necessitated a restowing of all equipment, which meant additional delay.

Novaya Zemlya

The *Pröven* could not leave Tromsø until June 8. She was towed north for some distance, and headwinds

then caused further delay. Not until June 14 was the ship able to stand out to sea. Nordkapp, the northernmost point of Europe, was passed on June 17, and the course was set eastward, the aim being to reach Novaya Zemlya at Goose Land (Poluoostrov Gusinaya Zemlya) in the southwest of the south island.

When weather and speed permitted, Kjellman studied the flora and fauna in the surface layers, while Théel and Stuxberg collected animals from the bottom of the sea by using a deep-sea sounding apparatus, dredges or other suitable means. There exist practically no whales near Novaya Zemlya, which hints at differences in lower animal life between the western seas—Baffin Bay and the seas of Svalbard and East Greenland—and the Barents Sea.

On June 21 the first drift-ice was met with, but the ship came through easily, and next day Novaya Zemlya was sighted. The wind was very light, and dredging was carried out at a depth of 90 m. The animal life was rich, with lots of starfish and sea-urchin.

The skipper felt at home on the west coast of Novaya Zemlya; he had made six voyages to these regions. According to him, there usually stretches an open lead along the coast from Matochkin Shar to Ostrov Vaygach in April–June, but further north the ice generally comes closer to the land. South of Goose Land the waters are usually filled with ice until mid-July. At the end of August, the sea is generally ice-free off the west coast of southern Novaya Zemlya. The ice in the Kara Sea does not *drift* away; it disappears by melting, and in the beginning of September this sea tends to be largely ice-free.

On June 22 they anchored in a bay on the northern side of Goose Land, so called because it is a favourite haunt of geese, as well as of swans. It is a low land, with a precipice 3–5 m high facing the sea. Cottages belonging to Russian hunters were visited here. Many insects and spiders were observed, a fauna which was very little known at the time. A short excursion was made on the land; then the ship weighed anchor and sailed north. Dredgings gave a rich yield, but only of sea-urchins. The animals seemed to cluster in colonies, which were rich in individuals. The water temperature was determined with the help of reversing thermometers.

During July 2–6 they stayed at Guba Bezymyannaya (at lat. 73°N). Here it was noticed that the rivers widened near their mouths to form a kind of shallow bays, where a boat could not float. Driftwood was plentiful. They continued on their northerly course on July 6, reached Matochkin Shar the same day, and anchored close to the northern shore of the sound.

The southern part of the South Island is, like Ostrov Vaygach, made up of a smooth plain dotted

with small lakes. But farther north the land becomes hilly, and near Matochkin Shar the mountains reach 900–1200 m a.s.l.. Local glaciers exist here. Farther south there are no glaciers, yet indications of previous glaciers exist (glacial striae and polished rock-faces), which show that the region was once glaciated. From Matochkin Shar the glaciation increases towards the north to form a continuous ice-sheet.

They stayed in Matochkin Shar during July 6–13 and anchored at several places. The western entrance of the sound was free of ice, but masses of ice drifted with the strong currents in the sound, and the ship was exposed to danger. There were also violent gusts of wind in the narrow sound. Dense ice prevented them from sailing either into the Kara Sea or north along the western coast. There remained the two gates to the south of Novaya Zemlya. However, if they had stayed for another few days, the way east would have been open and had enabled them to reach Dickson Harbour a fortnight earlier than they ultimately did, according to information from a sealer later on.

Scientific work was, of course, carried out in the sound: boat excursions were made, and plants were collected. On land it was a bit too early in the season and the vegetation was little advanced, but algae were rich on the rocks along the shore. The insect fauna was unexpectedly abundant. Mapping and astronomical determinations of position were also carried out. But the country's geology offered little of interest.

On July 13 they proceeded southwards, ran into a severe south-westerly gale and had to lie hove-to off the sound. The gale changed into a calm, and they lay drifting near the shore until they could anchor in a bay, called Skodde Bay by the sealers. The rocks of the coast consisted of a black limestone with striae and marine fossils—although the latter, originating from the Permo-Carboniferous periods, were few and far between. They also gathered a very rich collection of magnificent Jurassic fossils contained within concretion balls, which were found on the beach, having been washed off the overlying rocks.

During July 16–21 they visited Goose Land. Marine fossils from the Permo-Carboniferous were found at Northern Goose Cape, and at Southern Goose Cape they found fossils from the Jurassic period. They obtained rich botanical and zoological collections, and Kjellman's dredgings yielded several species of algae that were new for the region.

On July 21, they anchored at the northern entrance to Kostin Shar (at 71,5° N). Instead of a smooth plain covered with mosses and dotted with small lakes, they found a countryside of small hillocks and valleys. The vegetation was rich in the valleys, with bushes growing upright (*Salix glauca*). The Russians carry on a

profitable salmon-fishing in the region's river mouths.

They sailed through Kostin Shar on July 24 and reached the Kara Gate next day. But in the following night they were hit by a severe northerly gale and had to lie hove-to at times. The gate was blocked by ice which had drifted south along the east coast of Novaya Zemlya. Consequently they sailed farther south to Yugorskiy Shar, but were forced to anchor off Mys Grebeni, the south-western point of Ostrov Vaygach, the gale having increased to partly hurricane force. They stayed here during July 27–29, but could not get ashore as it was impossible to lower a boat. However, the zoologists dredged from the ship, thanks to a special arrangement with a float, and took great harvests.

On the 30th it was possible to visit Ostrov Vaygach. They found layers of limestone rich in Silurian fossils: brachiopods, cephalopods, trilobites, entomostracans and corals. The zoologists captured live specimens of *Mytilus edulis*, the full-grown animals being obtained with the scraper, while the young ones were fastened to the algae.

Here they met Samoyeds for the first time—two men and a boy.

Across the Kara Sea

During the severe gale, much ice had been drifting out of the Kara Gate and Yugorskiy Shar. It was probable that practically all ice in the Kara Sea was blocking the two sounds, and that the sea could not be entered. Nordenskiöld was impatient at a delay, so they weighed anchor on July 31 in order to sail into Yugorskiy Shar. But now they were becalmed, and the strong tidal current forced them to anchor off the Samoyed village. From there, on August 1, Nordenskiöld rowed with Lundström and Stuxberg to the northern shore, to make botanical and zoological studies and to carry out astronomical determinations of position. They were fetched on the 2nd, whereupon the ship sailed or drifted with the current through the sound—and into the Kara Sea, which was reached on the 3rd.

The sea was free of ice, as far as they could see from the crow's nest; but in directions towards the Kara Gate, heavy ice fields were observed. They continued the voyage in good hope, but the wind was light, lending opportunities for studies in natural history and for hydrographic measurements. The depth was sounded at least once on every watch, and a couple of measurements of solar altitudes were made for determining the route. Dredgings were carried out several times each day, water temperatures were measured at different depths, and water samples were taken.

According to their data, the Kara Sea was deepest

along the east coast of Novaya Zemlya. The eastern part of the Kara Sea was found to be rather shallow, with almost uniform depth. The sea off the west coast of Poluostrov Yamal (Yamal Peninsula) was especially shallow, and great care had to be taken when approaching the land, where breakers also endanger a landing in boats; thus sealers avoid landing here. The bottom of the Kara Sea consisted of fine sand and clay, except near Novaya Zemlya.

The temperature of the surface layer is highly variable in the east. In calm summer weather, the warm water from the Yenisey and the Ob can spread on the surface. With no ice a temperature of $+11^{\circ}$ or more is then observed while, only a few metres below, temperature and salinity remain practically constant: the temperature at -1° to -2°C and the salinity about the same as off the Norwegian coast. There is a marked boundary between the two layers of water in such situations, but it will be whirled up in conditions with a strong wind. The salinity of the upper layer is so low in fine weather that the water can be used for drinking.

In zoological respects, the Kara Sea was practically unknown before the expedition of 1875. The marine flora and fauna were considered extremely poor, but the dredgings of the expedition showed that such was not the case. The bottom of sand and clay was inhabited by many marine animals. Although their species were outnumbered by those in warmer waters—or, indeed, Spitsbergen waters—their numbers of individuals might well rank the Kara Sea among the most favoured oceans in the world.

Most of the animal forms in the Kara Sea live throughout the year in the salty, cold layers below the brackish and warm surface layer. The latter is, in fact, a deadly “poison” to the animals which are taken from the bottom only a few metres below. It should be noted that sea urchins were rare, whereas the high animal forms were about the same as in other parts of the Arctic. Whales were rare, but seals and walrus were common in the drift-ice. The walrus was especially found in great numbers on a “walrus bank” at about latitude 72°N , off the west coast of Yamal. Dredgings, which were carried out here, indicated that this favourite haunt of the walrus might be ascribed to a richness in large molluscs.

Botanically, the Kara Sea was found to be a real desert during the voyage to the Yenisey estuary. Not a single well-rooted alga was caught by the scraper, and on the western coast of Yamal—where a landing was made—no algae were found washed up on the beach. The causes may have been the brackish water and the unfavourable character of the bottom. The conditions were quite different along the

east coast of Novaya Zemlya (see p. 102).

The east coast of the Kara Sea, namely the Yamal coast, was sighted on August 6. Next day the position of the ship was $72^{\circ}17'\text{N}$, $68^{\circ}20'\text{E}$. They were near the “walrus bank”. There was no ice but, in spite of that, many walrus were seen swimming in the water.

A landing was made on the Yamal coast by Nordenskiöld, Lundström and Stuxberg, on a small point of land which projected from the coastline. The beach was flat and very low, but some 50 m inland a precipitous embankment rose 6–30 m. Beyond it extended a slightly undulating plain. It was covered with vegetation, monotonous but still much more luxuriant than that of Novaya Zemlya and Ostrov Vaygach:

1. The greatest variety of species was found next to the coast, among others a luxuriant grass vegetation.
2. The dry inland plain, the Yamal Tundra proper, was decidedly poorer in species. Here the ground was covered with a carpet of vegetation, which consisted of short and dry specimens.
3. In the valleys and depressions created by water-courses, the vegetation presented a fresh verdure and several interesting forms.

On Yamal the botanists collected 53 species of vascular plants. With a few exceptions these species also occur on Ostrov Vaygach, where the flora is much richer. Fourteen species of lichen were found, and on the beach a sticky foam, mixed with sand, was rich in diatoms.

The country was monotonous: there was no rock, just sand or clay mixed with sand. No stones, even pea-sized, were observed in spite of eager search. And off the coast, the scraper never caught any stones. This may prove that the shore-ice from the Ob and Yenisey never drifts into this part of the Kara Sea. Nor did the layers of sand contain any subfossil shells—as do the layers of sand on the Yenisey Tundra—or any Noah’s wood, that is, very old wood buried in the layers of sand.

No inhabitants were seen, but they saw traces of bare feet, reindeer, dogs, sledges. They found a place of sacrifice upon the embankment, with a stack of 45 bear-skulls. Astronomical observations for position were carried out. In the evening they left the place, went aboard and proceeded north along the coast, passing much ground-ice that rested on the bottom at depths of 9–16 m. During the night they passed five Samoyed tents and grazing reindeer. The land became gradually quite flat and low, and the sea more shallow.

Nordenskiöld wanted to land on Ostrov Belyy, situated off the northern extremity of Yamal, but the

ice-free sea made him change his mind and proceed upon a north-easterly course, in order to find out how far away the open water extended. On August 12, having reached 75°40'N, 78°40'E, they were stopped by a vast field of continuous, though rotten, ice which stretched in an east-west direction. The ice was not very thick and after 3–4 weeks it would probably be possible to sail here.

*Dickson Harbour. Planning a boat tour
on the Yenisey 1875*

The course was now set for the mouth of the Yenisey. They sailed in almost open water; the depth was 36 m and the bottom was as smooth as the surface of the sea in a calm. On August 13 they were attacked by a severe gale for a few hours and had to lie hove-to. But it soon calmed down and they could pursue the voyage, continuously sounding the depth and dredging as they went along.

On August 15 land was sighted, and in late evening they anchored in the midst of a great many islets. A polar bear was shot, “an old land king, who had become too lazy for hunting and therefore had to be content with grass fodder”, as the sealers said. The bear’s stomach and intestinal canal were found to contain nothing but grass, which confirms similar observations from the Spitsbergen expedition of 1864.

The harbour where the *Pröven* lay at anchor was given the name Dickson Harbour. Nordenskiöld writes:

“Thope that this harbour—now so desolate—within a short time will, at least for a part of the year, become a meeting-place for numerous ships, which effectuate the traffic not only between Europe and the river basins of the Ob–Yenisey but also between Europe and Northern China.”

As will be mentioned later (p. 150), Dickson Harbour—or simply Dickson—was later to become a central station on the Northern Sea Route of Russia.

According to the original plans, the *Pröven* should now be sent back to Norway, with some members of the scientific staff. Nordenskiöld and the rest of the scientists, with some of the ship’s crew, were to row and/or sail a North-Land boat up the river Yenisey or perhaps the Ob, until one of the great connecting links of communication was reached. The *Pröven* had reached the estuary of Yenisey a fortnight earlier than expected, so it would be possible to carry out botanical as well as zoological studies during the boat journey up the river. Nordenskiöld therefore asked Lundström and Stuxberg to come with him. As soon as they had anchored, preparations for the boat tour were started.

The North-Land boat, the *Anna*, was furnished with provisions and other articles of equipment for six men over four weeks. During their first days in Dickson Harbour, there prevailed such heavy winds, as well as rain and thunderstorms, that neither the *Anna* nor the *Pröven* could leave. Not until the night towards August 19 did the wind abate enough, whereupon the boat expedition left before noon.

The expedition was now divided into the *Pröven* group and the boat group:

PRÖVEN	BOAT GROUP
Kjellman,	Nordenskiöld,
botanist, leader	geologist, leader
Théel, zoologist	Lundström, botanist
Isaksen, commander	Stuxberg, zoologist
of the <i>Pröven</i> ,	three men from the
and eight men	ship’s crew:
	Nils Andersen,
	Reinert Johansen,
	Johan Pedersen

*The Pröven homeward bound,
August 19–October 3, 1875*

On August 17 and in the night towards the 18th, a severe north-easterly gale raged. They feared that the *Pröven* might become caught in the harbour by the ice.

It had been decided that the two expedition groups were to leave the harbour on the 19th, but on that day ice fields appeared off the harbour. However, the ice did not come closer; instead it moved slowly westwards. It was still blowing, but at 11 o’clock the boat group started south under a reefed sail.

The departure of the *Pröven* was delayed, as the wind was unsuitable, but the conditions improved and at 17.00h even she was able to leave Dickson Harbour. The plan was to visit the winter quarters, Ice Haven, of Willem Barents from 1596–97, and then round the northern extremity of Novaya Zemlya (compare pp. 96 and 97).

At 22h they met with drift-ice. It was very open to begin with, but grew denser during the night. The ice was, however, fairly rotten and could be passed through. Beyond it opened an ice-free sea with a marked swell.

On the 21st, a severe gale between north and north by west started to blow, accompanied by a very rough sea. The situation became critical, as it was necessary to sail in order to avoid being drifted into the Ob estuary, or onto the isthmus between the Ob and the Yenisey.

The sails were strongly reefed, and on board they feared that the leeway would be so great that the ship might come close upon Ostrov Belyy. It was impossi-

ble to steer higher than west. Even far out to sea the depth was only a few metres (cf p. 100 and 123), resulting in heavy breakers in situations with strong wind. The *Pröven* worked hard in the powerful waves.

However, Ostrov Belyy was not sighted. Before midnight the wind decreased, and the weather became fine with a light north-north-westerly breeze. The depth increased gradually as the ship approached Novaya Zemlya, from about 27 m to 220 m.

In spite of the north wind, it appeared that the ship had been set 1° northward and 2° (longitude-degrees) westward by the current. Despite the northerly wind, too, the current was rapid and directed northward out of the Ob-Yenisey estuaries.

On August 23, at 75°22'N, 66°30'E, when they were near Novaya Zemlya, they met with ice. It was dense to the north, but between west and north-west only a few pieces of ice were seen. They sailed north-west along the ice edge, and found it not advisable to push north through the ice. They gave up the plan of rounding the northern end of Novaya Zemlya. Instead they steered south, intending to pass through Matochkin Shar and emerge into the Barents Sea.

Later they were informed by sealers that the ice, which had blocked their way, was just a fairly narrow band which they could have passed—and that there had been open water to the north, and at the north point of Novaya Zemlya.

On the 24th they were becalmed, with fog and a heavy south-westerly swell. This weather persisted for five days. The sails were rarely filled by the wind, and the rolling of the ship was dreadful. Now and again they glimpsed land: a smooth high plateau, covered by an ice-sheet with outlets through five large glaciers reaching the sea.

During these five days off the east coast of the North Island of Novaya Zemlya, they were mainly occupied with zoological investigations; they dredged repeatedly. The depth varied between 50 and 270 m, and they got good harvests of low marine animals. The Kara Sea had a reputation of being very poor in low animal forms. That this was the case along the route of their eastward passage, further to the south, they had confirmed (cf. p.100). They now found that the north-western part of the Kara Sea possessed a richness in invertebrates which surpasses that of the sea to the west of Novaya Zemlya; it can be compared with that known from other parts of the Arctic.

In the evening of August 28 the weather changed. It cleared up, and a fresh north-easterly breeze started to blow. They made good headway southward along the land, which soon became characterized by deep valleys opening seaward. Very little ice and snow were seen.

On August 29 they passed, at lat. 74°30'N, a rather deep fjord surrounded by high mountains, with a glacier at its bottom. This was the last glacier they observed on the east coast. The fjord was called Pröven Bay. In the evening they anchored at 74°10'N in a bay which they named Udde Bay because of the great number of tongues of land which were found there. The land was utterly desolate, its vegetation poor and partly destroyed by the frost. Of the algae which were collected, one third was common to the Sea of Okhotsk and the European Arctic. But at that time, it had not yet been shown whether algae occurred to the east of the Kara Sea.

Next day they left Udde Bay and continued the voyage southward, but the favourable winds were now replaced by calms alternating with light headwinds. They were near the land, which was characterized by deep indentations. They measured the depth and the water temperature at different depths; water samples were taken. Dredging gave rich harvests of marine animals. When the depth was 89 m, they were some 20 km from the coast. They were slowly carried south in a calm, surrounded by fog.

In the night towards September 4 they sailed into Matochkin Shar. The sky was sparkling with a brilliant aurora, the first one observed during the expedition. On the 10th they reached the western entrance to the sound. The passage through the sound had been delayed by strong winds, calms and disadvantageous currents. The tidal current changed direction every six hours, but the east-going current was much stronger than the west-going, and the wind direction was mainly northwesterly.

Autumn had come to Matochkin Shar; the mountains were shrouded in snow and the lowland, too, had acquired a whitish tone. The land vegetation was affected by the frost, and migratory birds were collecting on the eve of their departure. The zoological and algological collections were increased further—now with fruit, seed and germ from phanerogamous plants for the purposes of experimental cultivation.

On September 11 the *Pröven* left Matochkin Shar and stood out to sea. She had a very rough passage to Norway. The wind was between south-south-west and north-west all the way, and one severe gale followed another, with unceasing showers of rain or snow and a furious sea.

On September 20 Nordkin, east of Nordkapp, was sighted, and next day in a terrible blizzard with breakers they managed to anchor in Magerö Sound. The *Pröven* was weather worn and her crew exhausted from the exertions they had been subjected to. She entered the harbour of Hammerfest on the 26th, and finally reached Tromsö on October 3.

The western part of the North-East Passage, with approaches. (Armstrong, T.: The Northern Sea Route, 1952.)

Dogs were often used for dragging boats upstream along the Yenisey River (below). (Nordenskiöld, A.E.: Vegas färd kring Asien och Europa...)

The voyages of the *Pröven* and the *Ymer* in 1875 and 1876, respectively. Simplified map from Nordenskiöld's reports (below). (Solid lines = routes of the *Pröven*. Broken lines = routes of the *Ymer*.)

*ALONG THE YENISEY BY BOAT AND STEAMER,
AUGUST 19–NOVEMBER 30, 1875*

*A boat tour in the estuary and the lower reaches
of the Yenisey, August 19–31*

The boat group consisted of six persons, three from the scientific staff and three from the ship's crew: Nordenskiöld, Lundström, Stuxberg and Andersen, Johansen, Pedersen respectively. They brought bread, coffee, sugar and butter for six weeks, besides tinned food and salted meat for three weeks. They also brought a tent, sleeping-bags, some clothes and instruments.

The boat, the *Anna*, was heavily loaded—she was almost without a freeboard—and would have been unable to endure a heavy sea.

The group left Dickson Harbour at 11 o'clock on August 19, and proceeded southwards along the shore under a reefed sail. A rather strong offshore wind was blowing, and the sea was therefore fairly smooth where they sailed.

They travelled without any long halts for 42 hours, until they reached Mys Shaytanskoy in the night towards August 21. They were then soaking wet and dead tired from prolonged watching: they had only landed at two places on the way, near Jefremov Kamen and at Krestovskoy. There had been no extra space in their boat.

They noticed that the vegetation differed from that of Novaya Zemlya; large bushes and dwarf birch were missing.

They had rested briefly at Krestovskoy, a deserted simovie (winter huts for travellers) consisting of three houses with flat turfed roofs. The interiors of the houses constituted a real maze of rooms.

The eastern shore of the Yenisey is generally clear of shoals, and the depths some way out from the shore are 10–15 m, at some places even 21 m. The water temperature at Krestovskoy was measured at +11°C, and so the temperature remained during practically the whole boat tour.

At about 73°N—at Jefremov kamen—the eastern shore had consisted of a precipitous cliff of sand 10–30 m high. Beyond it stretched the tundra, an endless, slightly undulating plain, filled with marshy swamps and small shallow pools of water. The tundra here was covered with sparse vegetation, whose flowering season was now over.

At Mys Shaytanskoy (at about 72° 05'N), the place of their first night-rest, they observed great masses of ripe cloudberry, as well as lingonberry and bog bilberry. This was also the northernmost area where they found dwarf birch (*Betula nana*).

From Mys Shaytanskoy, they sailed to Sopochnaya korga. The wind was strong, and a shoal, the extent of

which they could not see in the twilight, made them stop earlier than planned.

Sopochnaya korga is a low spit of land that protrudes into the river. They found the place very ugly. A good part of the isthmus was covered by a "brush-wood" of drift-timber: large logs were piled upon each other in a jumble, making it very difficult and dangerous to pass. The logs near the shore were fresh and usable, but those farther from shore exhibited all stages of disintegration.

Until now the western shore of the Yenisey had not been visible. But now it was possible to distinguish a sand ridge, which protrudes into the river at Sverevo and marks the southern end of the Yenisey estuary. They were detained for two days at Sopochnaya korga. Leaving in the evening of August 23, they headed for Golchika on the eastern shore, where there was an occupied simovie, but they could not see the house in the twilight of the night.

The course was therefore set for Sverevo on the western bank, which had another occupied simovie, yet this hut was not seen either. So they sailed back across the river to find a place fit for landing on the eastern shore. The situation became critical, as the wind was fresh, and they happened to steer into the midst of an area of roaring breakers. There was nothing to do but steer straight through the breakers. Luck was with them, and they found a good landing-place near a small tributary—at Mesenkin.

Here they stayed on August 24–26. During an excursion they found two Russian workmen from the simovie of Golchika who were picking cloudberry on the swamps. One of the men, Feodor, was asked to act as guide during their passage to Dudino, the outpost of civilization. Their two days at Mesenkin were occupied with excursions and studies, while Feodor was away asking his chief for permission to leave.

Nordenskiöld was interested in locating remains of mammoths. These had previously been reported from the lower Yenisey. He was informed that fragments of bones could be found near their camping-place; later he was told that pieces of skins, and large pieces of bones, were to be found at the outlet of the river Mesenkin, where they were washed out from the sand cliff during spring flood. But when Nordenskiöld heard this, he was already on his way to Dudino to catch the steamer, which was to carry the expedition upriver and home. Everybody had told them that they must hurry as much as possible, if they were to be in time for the departure of the latest steamer of the year. In vain they kept a look-out on the shore-terraces of the tundra for possible remains of mammoth. At certain places, such remains were said to be found in great numbers.

The eastern shore of the Yenisey offers rich opportunities for studies of the structure of the strata of earth which form the bed of the tundra. With few exceptions, these are maritime formations, consisting of an upper layer of clay and a lower layer of sand mixed with clay. No erratics of a size found in Scandinavia were seen. This seems to indicate that northern Siberia has lacked glaciers. Shells, which were found in the layers, indicated a climate similar to that of the present.

Early in the morning of August 26 Feodor, the guide of the expedition, arrived. They left Mesenkin and steered in glorious weather towards Mys Gostinoy. The water temperature in the surface layer was $+11^{\circ}\text{C}$, but during the previous days it had varied between $+3.6^{\circ}$ and $+6.2^{\circ}$. This is evidence that a cold bottom current can penetrate upriver a rather long distance and, in conditions with strong wind, can lower the surface temperature by mixing.

The bush vegetation on the shore of a tributary they passed was luxuriant. They observed arctic raspberry (*Rubus arcticus*) and angelica, about 2 m in height.

After losing their way now and again in a twilight with fog, they landed at last in the night towards August 27—at a low isthmus by the mouth of the Jakovieva River, where they had to spend the night because of a dense fog. It was a place practically devoid of vegetation or driftwood.

Next day, August 27, they reached the northernmost of the islands in the labyrinth which occupies the Yenisey between 69.5° and 70.3°N . On the 28th, they rowed among a great many islands, which generally face the river with a precipitous cliff. The night was spent among the Nikandrovski Islands close to an occupied fishing hamlet, where people were seining.

They continued their forced rowing on August 29 and passed Sopochnoy, Mys Muksinskoy. Finally, on the 31st, they reached the long-anticipated steamship *Alexander* at Saostrovskoy in the neighbourhood of Dudinka.

They were now crossing the forest limit. To cite Nordenskiöld:

“We saw here on the western bank the first traces of a forest, larches 3–6 m high, broken by strong winds and half-faded, like a thin beard-stubble, which stuck out from the high river bank. These trees represented, in this region, the last outposts towards the north of the world’s largest forest, announcing that we had now left the region of the tundra and had entered the forest region...

Many people think of the tundra as a wasteland, where only here and there snow-free spots

can be seen, covered with a sparse vegetation of moss. It would not be out of place to recall that such is not the case. The vegetation, especially on the islets which become submerged during the spring-flood, was characterized by a luxuriance to which I have seldom seen any counterpart; and already here the fertility of the soil, the unmeasurable extent of the meadow-land and abundance of grass, gave rise to exclamations of envy and surprise from one of our sealers, a middle-aged Finn, who was the owner of some little patch of ground in northern Norway. It was envy at the wonderful land which The Lord had given to ‘that Russian,’ and surprise at the fact that no cattle were grazing in the meadow-land and that no scythe was cutting the grass.”

*By steamer along the Yenisey,
August 31–September 30, 1875*

In 1875 three paddle-steamers took care of the shipping upon the Yenisey in summertime. They were neither passenger ships nor freighters, but simply movable shops. The *Alexander*, by which the expedition now was to travel, had her fore saloon arranged as a shop. The saloon aft served as office and storage space, and as a writing-room and bedroom to the “master”—the shopkeeper, who was first in command on board, though he did not concern himself with the navigation of the ship.

The “master” was not pleased to see the expedition, and it seemed doubtful if he would be willing to accept its members as passengers. But he changed his mind when told who they were, and became most obliging to them. A small cabin on deck, used as a storeroom, was cleared out and offered to the expedition’s scientific staff, while the three men of the *Pröven* had to find places elsewhere, for example in the engine room. Later a larger storeroom was offered to the expedition, with space enough for all. The group’s boat, the *Anna*, was towed beside the steamer and two lodjas were towed behind the ship.

When under way, one man was constantly in the bow checking the depth with a long pole. To avoid the strong current in the deepest furrow of the river, the steamer stayed near the shore. On the whole stretch to Yeniseysk, about 1500 km from Dudino, there was not a single jetty. Consequently the steamer, as well as the lodjas, brought along several small boats and barges for communication with the shore.

All steamers on the river were fired with wood, which was collected on the shore. The progress was slow with several stops, in addition to those caused by business, grounding and the current.

The many stops were appreciated by the scientists

of the expedition, giving them opportunities to extend their studies as far south as 60°N. Lundström, the botanist, was well acquainted with the flora and its geographical distribution in Scandinavia.

He now had the privilege of investigating the flora along the Yenisey and its estuary, ranging from 73°N to 60°N, and to make comparisons with the flora of Scandinavia. A rich botanical material was collected. Even a preliminary comparison showed that the northern limit of several species of plants extended farther north in Siberia than in Scandinavia. This proves that the harder winters in Siberia do not have a decisive detrimental effect upon the summer plants.

The *Alexander* weighed anchor as soon as Norden-skiöld and his men had come aboard at Saostrovskoy on August 31. The ship steamed to the church village of Dudino, situated at the outlet of the tributary Dudinka. The village, containing only a few houses, was inhabited by a tradesman named Sotnikoff, two clergymen, a "policeman", a few exiles, some workmen and natives ("Asians"). The expedition members were met with great friendliness from all, and one of the clergymen held a special thanksgiving service for them on board the steamer.

On September 4 the *Alexander* left Dudino and steamed upriver in excellent weather. South of Dudino the landscape began changing its character. After some 20 or 30 km the coniferous forest became lofty, though the position was still north of the Arctic Circle. On most maps at the time, the forest limit was drawn along the considerable bend of the Yenisey to the north-west of Dudino, nearly at 70°N.

When going south, it is here that one first finds conifers in great numbers, although seldom more than 6 m high. The trees cover the hills with a sparse vegetation, which lacks the luxuriant touch that characterizes the brushwoods of willow and alder further to the north.

Until September 7 they landed on the high eastern shore, or on islands in the river. But on this day, they visited the western shore for the first time. It consisted mostly of low stretches of land, which generally became submerged in the spring. Now they were covered with splendid grassy spaces that gave the impression of parks. By contrast, the virgin forest reached right down to the eastern shore.

In the northern provinces the simovies were covered with flat turfed roofs. Yet farther south, the houses had broken roofs and their gables were decorated, facing the village road.

On September 12 they visited a simovie, called Selivaninskoy, which was exclusively inhabited by Copts. This special sect consisted of self-mutilators, of a kind that necessitated a continuous addition of

new proselytes from the outside world to keep the community alive. Later the same day they arrived at the Troytskoy Monastir, not far from Turuchansk. The monastery had once been rich and famous, but now it was only occupied by a single monk, the prior himself, a friendly old man.

Thanks to the steamer's slow progress, the expedition could establish good contacts with the population. Besides settled Russians, there were natives who stayed over the summer for fishing, either for themselves or hired by Russians. They owned a great many dogs, which were used for diverse transport during the winter and for towing boats upriver in the summer.

The weather had been fine and warm since they left Dudinskoy, but in the night towards September 20 the temperature fell below freezing. During the following nights there was generally frost, though in daytime the temperature still remained high. The frost gradually lowered the benefits which were derived from scientific excursions near the stops of the *Alexander*.

On September 20, they anchored at the mouth of one of the largest tributaries that the Yenisey receives from the east, Podkamennaya Tunguska. They took the opportunity to measure the depth in a section across the Yenisey, which was 1 km broad here. They measured 7 m near the western shore; then the depth decreased to 4.5 m, and somewhat closer to the eastern shore it increased to 12.5 m. They carried out measurements at other places along the river as well. These confirm the assertions of the pilots that even deep-draught ships can navigate the river all the way up to Yeniseysk.

The *Alexander* arrived in Yeniseysk on September 30 or October 1. Her owner, Mr. Balandin, declined to accept any fare. From there, the journey home went overland—except on the very last stage. On November 30¹ the boat group arrived in Stockholm.

A FEW COMMENTS

The voyage of the *Pröven* aroused hopes and expectations that the sea route between the Atlantic and the Yenisey River would be usable in future.

Enthusiasm was great in Siberia, where the bad connections with the outside world constituted a hindrance to the development of the country in both cultural and economic terms. Nordenskiöld and his companions met with much appreciation and goodwill during their journey home through the Russian Empire. But there were also many who argued that the single voyage of the *Pröven* might have been just

¹ Nordenskiöld gives September 31.

a piece of luck, which in no way represented average conditions.

The scientific results from the expedition of 1875 were of great value. The geography, botany and zoology of the Kara Sea region had been elucidated. The prevailing ideas of the Kara Sea as a mere "ice cellar" and biological desert were proved wrong or were modified. The tour up the Yenisey River had yielded results in phytogeography and zoogeography, not least of value to discussions about cultivation in the region.

But had the voyage of the *Pröven* been mere luck? Would it be possible to repeat it every, or almost every, year? These doubts called for a second voyage to the Yenisey. The scientific results were also in need of supplementation.

A SEA ROUTE BETWEEN THE ATLANTIC AND THE YENISEY.

THE VOYAGE OF THE *YMER* IN 1876 *Historical background and planning of the expedition*

Many critical persons refused to accept the voyage of the *Pröven* as a proof that the sea route from the Atlantic to the Yenisey could be used commercially. They considered that the voyage had been favoured by exceptionally good ice conditions in August 1875. These might have been brought about by sheer "chance."

In vain Nordenskiöld tried to convince his adversaries by explaining that the melting of the ice in the Kara Sea was caused by the relatively warm water spreading from the Yenisey and the Ob rivers. He also pointed to the voyages which had been made by Norwegian sealers in the Kara Sea since 1869, by John Palliser in 1869, by Joseph Wiggins in 1874, and by Nordenskiöld himself in 1875.

The warm river-water in the summer must have cleared the waters of ice in the latter part of the summer. If Ostrov Belyy, off the northern tip of Yamal, could be reached, the passage would also be open in the estuaries of the Yenisey and the Ob. Nordenskiöld now wanted to show the practicability of the Ob-Yenisey route by starting a new expedition to the region. Besides, it was necessary to obtain a better knowledge of the waters, the ice and the weather conditions in the area.

The investigations which had begun during the *Pröven* expedition should be continued.

This also applied to the scientific studies in the Yenisey valley, which had been carried out by the boat group in 1875. Important scientific work had previously been done here by the Finlander Castrén and the Russians Middendorff and Schmidt, but much

remained to be learned. The investigations in 1875 had provided basic data for an estimate of the suitability of the land for cultivation. These studies had taken place at the end of the summer and in the autumn. A study of the fauna and flora in spring, early summer and high summer was now found necessary.

The new expedition was to consist of two groups like the expedition of 1875, one group travelling by steamer from northern Norway to the Yenisey, the other going *down* the Yenisey by boat and river steamer. Symbolically the steamer, which would come from Norway, was to carry a cargo of Swedish industrial products to be sold in Siberia.

The expedition was financed by Oscar Dickson (1823-97) and Alexander Sibiryakov (1849-1933), the latter a rich Russian industrialist and owner of mines in Siberia.

A steamship, the *Ymer* of Göteborg, was hired for the transport from Scandinavia to the Yenisey and back. The river group was to travel overland and by river to Krasnoyarsk. From there, the group would start their tour down the Yenisey to meet the ship's group near the mouth of the river.

The Yenisey expedition of 1876 consisted of the following members:

THE *YMER* GROUP

SCIENTIFIC STAFF

Adolf Erik Nordenskiöld (1832-1901), Ph.D., professor, geologist, responsible for astronomical determinations of position, leader of the expedition.

Frans Reinhold Kjellman (1846-1907), Ph.D., botanist, to be landed at Mäsöy in northernmost Norway.

Anton Julius Stuxberg (1849-1902), Ph.D., zoologist.

CREW OF THE STEAMSHIP *YMER*

Nils Ericson, sea captain, commander of S/S *Ymer*.
Two mates, 11 men.

RIVER GROUP

Johan Hjalmar Théel (1848-1937), Ph.D., zoologist, leader of the river group.

Mårten Magnus Wilhelm Brenner (1843-1930), Finlander, botanist.

Hampus Wilhelm Arnell (1848-1932), Ph.D., botanist.

John Reinhold Sahlberg (1845-1920), M.Sc., Finlander, zoologist (entomologist).

Arvid Filip Trybom (1850-1913), B.Sc, zoologist.

Thus again, for his second Yenisey expedition, Nordenskiöld managed to acquire a highly competent scientific staff. The freighter *Ymer* which he now hired was a strong ship, built of oak in 1870. She measured 400 tons and her steam engine developed

45 hp. Her average speed with a full load, but without sails, was 6.5 knots.

On the Yenisey, the river group would hire local boats and rely on local transport facilities. The *Ymer*, when leaving Tromsø, carried provisions for 14 months and coal for 40 days. The plans of the two expeditions were as follows.

The *Ymer* would sail into the Kara Sea at the turn of July into August, when the waters were expected to be more or less free of ice. After a few days the ship was expected to reach Mesenkin near the mouth of the Yenisey, where a meeting with the expedition's river group had been arranged.

With the river group on board, the ship might proceed upriver to Dudino, where the cargo would be unloaded.

Before the end of August, the *Ymer* was to return along the same route as on her outward passage, bringing the river group. Possibly a trip would be made towards the north-east, to study the ice conditions between Cape Chelyuskin and the Yenisey estuary. The ship would be back in Norway in the latter half of September.

From Tromsø to the Yenisey estuary

The *Ymer* left Tromsø on July 25 with her three scientists: Nordenskiöld, Kjellman and Stuxberg. A route inside the skerries was followed to Mäsöy, an island near Nordkapp. Kjellman was landed here. Until the return of the *Ymer* from the Yenisey, he intended to study the marine algae in the region, supplementing his similar investigations at Spitsbergen in 1872–73 and at Novaya Zemlya in 1875.

The ship continued towards Novaya Zemlya, where a mountain at 73°N, Pervoussmotrennaya Gora, was chosen as a landmark. It is 600–900 m high and is seen from far away.

The wind was in their favour, there was no ice, and the mountain was sighted already three days after they had passed Nordkin. They now met with fog which, however, dispersed so much on July 30 that they could enter Matochkin Shar, the narrow sound between the north and south islands of Novaya Zemlya. Near the western mouth of the sound, two Russian ships were occupied with catches of white whales, reindeer and salmon; the latter generally occurs in great numbers in the river mouths of Novaya Zemlya.

The *Ymer* proceeded through the sound and anchored near its eastern mouth in a sheltered bay, Byelusha Guba. Geological excursions and dredgings were carried out here.

On July 31 the ship stood out upon an ice-free Kara Sea; her course was easterly. An "ice blink", was, however, observed ahead near the horizon. A few

hours later they met with very open ice, increasing gradually in density towards the east. They tried to circumvent the ice band by going south, but again they encountered impassable ice, so they turned back to Matochkin Shar and awaited changes for the better. They anchored near the southern shore not far from a decayed Russian hut, at a place where the Russian charts indicated "Rossmyslov's winter station 1768–69."

The sea was rich in diverse animals, but the land was bare and poor. The mountains were probably low Silurian black shale. Nordenskiöld looked in vain for fossils. The shale was pierced at several places by veins of quartz containing numerous crystal druses. Their brilliant contents may have caused the report of the unfortunate Chirakin, a member of the above-mentioned expedition, that he had here found a boulder studded with gorgeous and precious stones—a report for which, after his death, he was severely criticized by his chief Rossmyslov, who had later searched in vain for such a treasure.

This part of Novaya Zemlya is of great interest. Not less than seven distinctly marked shorelines can be seen. They are situated at different heights above each other, and indicate that the land during the latest geological epoch has risen by at least 150 m in relation to the sea surface, probably during postglacial times.

On August 5 the *Ymer* once again steamed into the Kara Sea. There was no hope of finding open water to the east, as no westerly or southerly winds had been blowing during the previous days. But there was open water along the eastern coast of the South Island, so they decided to go south along the Novaya Zemlya coast. The ice was much disintegrated.

In fine weather the *Ymer* proceeded southward, and already next day she was off Proliv Karskiye Vorota (Kara Gate). A new attempt was made here to go east, but once again they were obstructed by ice in combination with fog. Several times they lay still, an obvious advantage to the zoological and hydrographical investigations.

When the fog lifted somewhat, they steamed along the ice edge, which gradually turned towards the east, and on August 10 they sighted Cape Byelushi on the west coast of Yamal (at lat. 70°04'N). The ice was rotten and had, to begin with, little effect upon their progress, but at places there stretched bands of dense ice from the coast. These were an impediment, especially when combined with fog. For 24 hours the *Ymer* was caught between floes of old ice. Once free, she was still on the south side of the band of ice. But on August 12 the ice scattered, so the ship was able to round Ostrov Belyy and cross the estuaries of the Ob and Yenisey.

Land was sighted on August 15, earlier than estimated, and it soon appeared that this was not the eastern shore of the Yenisey estuary. They had instead discovered a hitherto unknown island, which was called Sibiryakov's Island. Low and flat, it was not seen even from a rather short distance—which explains why it had not been reported previously, as from the eastern shore of the estuary. The waters round the island are deep and clear of shoals. The *Ymer* followed its south-western shore and thus detected its insular character.

A fruitless wait: August 16–September 1, 1876

The *Ymer* steamed into the estuary and, in the forenoon of August 16, reached the area between Sverevo and Sopochnaya korga, where the river mouth contracts to less than 20 km in breadth. They anchored at neighbouring Golchika, which was then the northernmost occupied simovie on the eastern shore. The shop assistant came aboard and informed the expedition that three river-steamers had visited Polchika and exchanged wares and stores. He mentioned that "some foreign gentlemen" had been to Yeniseysk, from where they intended to travel to the mouth of the Yenisey.

The *Ymer* went on to Mesenkin, not far away. This place had been chosen for meeting the river group under Théel. In the plans of the expedition, it was assumed that Théel should try to reach Mesenkin early enough to carry out excavations for mammoth remains (compare p. 104). Another reason for the choice was that the river group was supposed to measure the depths in the river farther south, so as to find a safe route for the *Ymer*.

At Mesenkin the *Ymer* people met Feodor, the pilot of the *Pröven* in the previous year, but the river group had not arrived and nobody had heard from it.

With due regard to the ice conditions in the Kara Sea, the *Ymer* could linger in the river for some time before returning home. Nordenskiöld therefore decided to proceed towards Dudina, in spite of the fact that a competent pilot was missing for the passage through the islands between lat. 69°N and 71°N. Feodor, who was on board the ship—but not in the capacity of a pilot—was unable to understand why the *Ymer*, with a draught of 3.5 m, needed waters deeper than those used by the smaller river craft.

While at Mesenkin, they visited the locality where hides of mammoth had been found. No complete hide was discovered, but at the shore they excavated a few pieces of hide, both large and small. The "natives" gave them another few pieces, and some parts of a skeleton.

The *Ymer* weighed anchor on August 17 and pro-

ceeded south. At first nothing unusual happened, but near Yakovieva the depths began to decrease; until then they had measured 9–21 m. In hopes of finding a deep channel, the ship was steered in all directions on the widened river to the north of the Nikandroff Islands. All in vain, though; soon a fog rendered navigation in the shallow waters difficult. The *Ymer* ran aground several times, but could be warped off without any damage, thanks to the soft bottom. Due to increasing wind, she turned back to deeper waters and anchored at Mesenkin again.

In his report on the expedition, Nordenskiöld mentions that even deep-draught vessels could proceed beyond Dudino—but not until the river had become sounded. Without previous soundings it would not be advisable to repeat the procedures of the *Ymer*, especially if lacking enough coal to permit extra tours on the river.

Nordenskiöld now decided to wait for the river group at the place previously agreed upon, Mesenkin, and to spend the time unloading and storing the cargo. Next year it might be carried south on board a river-steamer. The simovie Korepovskoy was well suited for the purpose: the wares would be in the care of a reliable person, and there were dwelling-houses and storehouses which, if necessary, could be used in the present case. Nordenskiöld negotiated with Mr. Sotnikoff's shop assistant, and on the 20th the *Ymer* moved to Korepovskoy. Next day the unloading of the cargo started.

Nordenskiöld was acquainted with the shop assistant since the previous year; but by the following night the latter had apparently changed his mind, for fear that he would have to remain at Korepovskoy throughout the winter to guard the stores. Anyway, he left the ship without further notice. Nordenskiöld, who believed that Feodor would be willing to take care of the stores, still determined to land the wares at Korepovskoy.

The unloading was finished on the 23rd, and on the 25th the *Ymer* was ready for sea.

First, however, the ship was taken to Mesenkin to find out whether the river group had arrived there. Then Nordenskiöld decided to make another effort to steam upriver to meet the river group. He had noticed that the river was deepest near the shores. With this knowledge he would try to reach Dudino or at least Saostrovskoy. But the *Ymer* ran aground. The season was late and the store of coal was running low. No more attempts to go south could now be made. The ship was anchored between Orlovskoy and Gostinoy, and the following days were devoted to studies of the geology of the tundra. A rich collection of subfossil shells was obtained here.

On the eastern side of the Yenisey, the tundra has the character of a slightly undulating plain; it drops down towards the river, forming a precipitous cliff 15–30 m high. We quote Nordenskiöld:

“Inland there are no hills or mountains, but the plain is criss-crossed by deep river valleys, which give beautiful cross-sections of the earth layers. The tundra was once lying below the sea surface, as is apparent from a great number of marine shells which are found in the layers. A considerable rise of the land must have taken place during the very latest geological span of time. All the shells, which are embedded in the tundra sand, belong to now existing forms—most of the species recur in the Kara Sea, in postglacial banks of shells in southern Sweden and Norway, and in the crag-formations in England. The tundra was thus formed during a period with a climate similar to the present. To the geologist it is hard to understand why, in these very layers of sand, there are remains of mammoths and rhinoceroses—forms of animals which thrive in tropical or subtropical climates. It is remarkable that one finds skeletons here as well as meat, hides and entrails of animals which have been dead for many hundred thousands of years.”

The collections of the expedition were enriched with patches of hide from mammoth, fragments of bone, musk-ox crania, and subfossil shells.

During the stay of the *Ymer* in the Yenisey River, dense fog with rain often prevailed. But otherwise the weather was warm and summer-like, the highest temperature observed being +20.4°C.

The ground was free of snow, and the tundra valleys were adorned with a many-coloured carpet of flowers.

The temperature of the river water was practically always +12° to +13°C at the surface, and was as high as +11.1°C even at a depth of about 20 m.

It had been agreed with Théel and the river group that they should under no conditions linger so long in the north that they risked missing the last river-steamer of the season. It was not thought probable that Théel would continue beyond Saostrovskoy (69.7°N), if he had no chance of reaching Mesenkin before September 1.

Nordenskiöld considered it needless to remain with the *Ymer* in the region after the end of August.

September 1 was chosen as the date of departure, and a message was sent to Saostrovskoy about the presence of the *Ymer* and when she would leave for home.

The return voyage of the Ymer:

September 1–22, 1876

On September 1, the ship was taken through the deep and broad sound between Sibiryakov's Island and the eastern Yenisey shore. The next destination was Dickson Harbour, where ballast and driftwood were to be loaded. But on the 2nd, the weather was so favourable that Nordenskiöld decided to continue the voyage immediately. The course was set for Cape Middendorff in the north of Novaya Zemlya.

The Kara Sea was free of ice, but near the east coast of Novaya Zemlya, at about 75.5°N, the ship met with a dense band of disintegrated ice which extended along the coast towards Matochkin Shar. The ship followed the ice edge towards the south, until at 74°40'N the edge became westerly, making it possible to head directly for Matochkin Shar; a smooth swell indicated ice free waters. Had the expedition followed a course westward from Ostrov Belyy, they would probably not have met with any ice at all.

The ice conditions thus presented no hindrance, but the fog did. However, it presented good opportunities to Stuxberg, the zoologist, to dredge and swab in the deep channel along the east coast of Novaya Zemlya. The animal life in the Kara Sea had been unknown, though considered very poor, until the summer of 1875. Many of the species occur locally in large quantities; others are found whenever a dredging is carried out, but in much lesser amounts. The brackish water from the large rivers does not affect the composition of the bottom fauna, as it forms only in the surface layers.

They arrived at Matochkin Shar on the evening of September 7 and stayed until the 13th, intending to fill the coal-boxes and to load fresh water and ballast. Unfortunately, they ran aground and had to throw part of the ballast overboard in order to come off the shoal.

During the passage to Norway they enjoyed glorious weather. Early on September 18 they anchored at Hammerfest, and four days later Tromsø was reached.

Nordenskiöld took advantage of the stay at Tromsø to collect information on ice conditions in the Arctic, especially in the Kara Sea. To judge from the hunting cruises carried out by Norwegian sealers in the Kara Sea, from Palliser's and Wiggins' voyages and from Nordenskiöld's own travels with the *Pröven* and the *Ymer*, the conclusion might be drawn that the route between the Atlantic Ocean and the Ob–Yenisey, for a few weeks in the latter part of the summer, would involve no greater hazards and difficulties than along any other routes on the globe which are *not* infested by ice.

A voyage along the North-East Passage was already

occupying Nordenskiöld's thoughts. What he had seen during his two summer cruises in the Kara Sea seemed to favour a successful realization of the classic dream of a shortcut to the Far East.

INVESTIGATIONS BY THE RIVER GROUP

By boat down the Yenisey:

June 16–July 28, 1876

The expedition had planned a tour by boat or steamer down the Yenisey from Krasnoyarsk in the south—at about lat. 56°N—to the river mouth, at almost 72°N. The river group was to meet the *Ymer* at the river mouth and to go back with her to Norway.

This group consisted of scientists in the biological disciplines. They wanted to obtain a sample of the flora and fauna along the Yenisey valley in the height of summer. As it turned out, the two expedition groups never met, and the members of the river group had to go back the same way as they had come. In this way the fauna and flora could also be studied at the end of the summer and the beginning of the autumn.

The group's members were three zoologists (Théel, Sahlberg, Trybom) and two botanists (Brenner, Arnell). Sahlberg would go with the group until the Yenisey was reached, and would then work independently.

They left Stockholm on April 29, 1876. The journey went first by railway to Nishny-Novgorod (after 1932 called Gorkin). Then they travelled by river-steamer along the Volga and Kama to Perm. Next came a ride by tarantass, the robust Siberian type of horse-drawn coach, across the Ural Mountains to Tyumen. They proceeded on river-steamers along the rivers of Tura, Tobol, Irtysh and Ob to Tomsk and, finally, by tarantass to Krasnoyarsk, where they arrived on June 8. This occurred some 25 years before the Trans-Siberian Railway was built.

From Krasnoyarsk on the Yenisey, the group began to pursue investigations. Here they would also start the planning of their transports along the river. The scientific outcome of their studies would depend upon how well this planning was done. It was also important to conduct studies on the southerly part of the river. Although summer had barely arrived, the region's vegetation made an overwhelming impression. The botanists, in particular, eagerly fell to examining this luxuriant plant life.

On June 16 they left Krasnoyarsk in two small boats, one for themselves and the other for their equipment. The boats were tied alongside with ropes and, in order to make the arrangement more robust, one boat was fastened to a frame of logs.

The current in the river was rather strong between Krasnoyarsk and Yeniseysk, and it was not necessary

to use the oars. With the water providing power, the crew of the craft—two oarsmen and a “coxswain”—had little to do. They could not make any long stops on the way, being anxious to reach Yeniseysk as early as possible. But they had to cook their tea-water on the shore, and thus found time enough for interesting studies.

On June 18 they reached the mouth of the Angara River, from where the Yenisey takes on more immense dimensions. Towards midnight the white tower of Yeniseysk was seen, and very soon the river group had finished this first stage of their long tour. In 2.5 days they had travelled almost 500 km with the help of the river alone.

The scientists stayed at Yeniseysk for a week, June 19–25. They were much occupied with various preparations, but also made excursions in the surroundings. The governor-general of East Siberia, Baron Friedrich, had sent Mr. P.G. Rshevin from Irkutsk to accompany and assist the group. In addition, a Cossack was ordered to accompany them.

They bought a large boat having a superstructure or cabin, in which there was room enough for sleeping and for working with the collections. In the bow of the boat was a fire-place, where their meals could be prepared. Mr. Rshevin bought a similar, though somewhat smaller boat for himself.

“Post stations” had been established along the river as far north as Tolstonos at lat. 70.2°N, for the purpose of conveying travellers. It was considered that it would be cheaper, and would allow better contact with the population, than hiring a crew for the whole summer. The scientists were also told that they could find people at Dudinskoy or Tolstonos who were willing to convey them farther north.

The group left Yeniseysk on June 25. Soon afterwards, a plague of mosquitoes began to appear. The mosquitoes occurred in enormous masses, and it was impossible to stay long in the open air without using a horse-hair mask. The heat, too, was almost unbearable, and the scientific work suddenly became toilsome. The high temperature remained practically unchanged until the expedition reached Turuchansk at 66°N, where on July 14–17 a maximum was reached, +40°C “in the sun”. The vegetation was luxuriant here, and in the deciduous forests one felt as if wandering in a hothouse. It was fertilized by the river at times of flooding.

Between Osinova and Podkamennaya Tunguska, the river forms rapids and falls. It is squeezed between high granite mountains, making the current fairly strong. Boats have few problems in midsummer, but work hard during the autumn to zigzag between the hidden and visible rocks.

Four paddle-steamers operated along the river; all of them were intended to have barges in tow. Such steamers, which are fitted up as shops, usually leave Yeniseysk in late May and return for winter quarters in late September or early October. During this time the two large steamers made two trips, and the two smaller ones a single trip.

There are also smaller vessels on the river. A special type of craft is a five-sided "box" or barge, built of huge logs in regions upstream, which are rich in corn. With 25–30 men on board it is steered downstream. At the destination such a "box" is used for firewood or building timber. Many of the Yenisey's tributaries are also navigable.

On July 13, the group arrived at Monastirskaya, by the mouth of the Lower Tunguska. Here awaited the famous monastery, Troitskoy Monastir, in an imposing position near the village (cf. p. 106). Two monks resided with its old prior.

At Turuchansk the expedition's boat had to be repaired because of a leak, so bad that the boat was difficult to keep free from water. It was now found that the boat was thoroughly rotten and quite useless. The village authorities supplied a new boat of similar type as a loan.

Turuchansk is situated at the tributary Turuchan. It seemed to be a fairly large settlement, decayed and surrounded by swamps and stagnant water. A small church and a slightly leaning tower, standing by itself, were the only buildings of interest. But a post office, shops and taverns were to be found. The expedition was received with great kindness by the inhabitants.

They were ready to leave Turuchansk on July 16, but the wind was so strong that they anchored very soon. In spite of the current—which was in their favour—the boats could not be forced to move forward against sea and wind. Instead they took opportunities to investigate the shore, which was exposed to the annual flooding of the river. The vegetation was grand, though monotonous.

On July 19 they passed the mouth of the Kureyka river with a good harbour. Graphite is mined 100–200 km up the Kureyka, and is freighted downstream to the harbour. South of the river mouth—between Angutskoy and Goroshinskoy—they first saw herds of tame reindeer. Now the "wild" peoples of Asia appeared, with tents along the shores. The expedition often obtained oarsmen from these peoples.

Between Turuchansk and Dudinskoy the land became very sparsely populated. North of Turuchansk the forest was less tall, and at Vershininskoy at $68^{\circ}55'N$ it grew so short and thin that the forest limit could be placed there. But isolated and small trees were found even to the north of Dudinskoy. The tree which

The Yenisey River from Yeniseysk in the south to Yenisey Estuary in the north. Simplified map from Nordenskiöld's reports.

seems to endure the north wind best is the larch. In comparison it may be mentioned that the Cembra pine and the larch attain gigantic dimensions in the neighbourhood of Krasnoyarsk and Yeniseysk.

They reached Dudinskoy on July 28, having travelled 2000 km by boat. Here they met their companion Sahlberg, who had arrived one week earlier! They had expected to see many houses in this famous village, and were surprised at finding only 7-8 small decayed houses, besides a relatively large but half-completed house and a small wooden church.

Troubles on the lower Yenisey

A continuous northerly gale with a rough sea prevailed during their stay at Dudinskoy. This forced them to anchor their boats in the Dudinka River, which flows into the Yenisey about 1 km from the church village.

It turned out that it would be impossible to go to Golchika with the boats the group had used thus far. No oarsmen could be obtained for such an enterprise. Sotnikoff, the rich merchant of Dudinskoy, advised the expedition to go by the steamer *Alexander*, which was expected. At the Briochovski Islands they would meet one of his assistants, and in a letter Sotnikoff gave him orders to supply the expedition with a boat and crew.

On August 9 the steamer *Alexander* arrived in Dudinskoy. It left at midnight with the river group and collections on board. They reached the Briochovski Islands on August 11. On the way they met Sotnikoff's assistant and handed over the letter, which he read before answering tersely: "Impossible. At the most I can let you have one man."

This was no help to the expedition. Yachmenyeff, the "commander" of the *Alexander*, then announced that he could supply a large boat with 23 men, if the group paid their salaries. Once the ship arrived at the Briochovski Islands, the "commander" was informed that a boat and oarsmen were welcome. But the "commander" now said that he would not compel his crew, so he asked his men if anybody would go voluntarily—and they would not. It was stated that the steamers had to start the voyage home on September 6 at the latest.

Mr. Yachmenyeff had previously said that there was great danger in going to Golchika, and that his shipowner had forbidden him to do so. Nevertheless, he was willing to go if paid 300 roubles. Moreover, he would leave the Briochovski Islands as soon as the expedition and its collections had been landed. This would compel the group to stay where they were, without a boat or oarsmen, and with no reliable information on the steamers' dates of departure. If the

Ymer did not reach them, they would have to stay until the river froze at the beginning of the winter. Even with the small boats which were available among the islands, they would not have dared to risk their collections. The boats were small, flat-bottomed with no keel, and hardly adapted for rowing along the rocky shores in rough weather.

On August 13 the *Alexander* steered south towards the Nicandrov Islands. Although men and boats were available here, only one boat could be obtained and it had space only for 2-3 persons. The rest of the expedition members and the collections would have to stay. Such an alternative was out of the question. So the river group decided to "wait and see", sticking together in the hope that the *Ymer* might reach them.

The *Alexander* left the islands on August 25 and proceeded to Tolstonos, where the expedition members settled down for the time being. The time among the islands and at Tolstonos was used for scientific work. These islands apparently originated from sandbanks which had formed in the river. Driftwood in great masses had collected upon the sandbanks, where a luxuriant vegetation later developed. Under the upper layers of earth, partly mouldered logs were to be found. In addition, the scientists found an opportunity to study the fish life in the Yenisey.

On September 4, Feodor arrived with a letter to Théel from Nordenskiöld, dated August 28. Théel learned that the *Ymer* had waited for the group on the river for 17 days, and that the cargo had been landed and stored at the simovie Korepovskoy, entrusted to the care of Feodor. The letter also announced that the *Ymer* was to start her voyage home on September 1. Feodor had been at the place to see her weigh anchor.

Nothing remained but to arrange for the return journey of the boat group—and for the sale of the wares which had been landed. The wares were to be sold according to orders given by Nordenskiöld in his letter. The best arrangement would be to transport the wares to Yeniseysk now, in the autumn. Therefore Théel decided to visit Yachmenyeff, who should be with the *Alexander* near Dudinskoy, and try to induce him to go to Korepovskoy. Already on the same evening, Théel and Brenner left in a small boat.

About 60 km north of Dudinskoy, they sighted Kritmanoff's steamer. They decided to ask this "commander" to take the wares aboard. In any case he had to go north to the islands. Kritmanoff was, however, worried as he had lost several days, and now he feared the advance of winter. So he could not undertake the voyage. But he was willing to take the expedition to Yeniseysk.

In a letter Théel informed his friends at Tolstonos that they should travel with Kritmanoff's steamer to

Dudinskoy and meet him and Brenner there.

Théel and Brenner then continued the boat journey southward, and reached Dudinskoy in the afternoon. Yachmenyeff had already left, but Sotnikoff was much interested and promised to have the wares fetched already in the autumn. His steamer was, though, long in coming—not until September 10—and was not ready for departure until the 14th.

Théel did not have an enviable position. Already in Nordenskiöld's letter to him, there had been a somewhat irritated tone because of ensuing extra costs. And now Théel had, figuratively speaking, struck against a wall: everything seemed to be impossible. In 1915 Théel assessed his dilemma:

"What was the cause of all these troubles? Was it a plan to lay hands upon all these wares in the following summer? The fact is that nobody knows where the wares have gone and never, as far as I know, has a single farthing from any sales come to Sweden."

On September 11, the rest of the expedition arrived in Dudinskoy on board Kritmanoff's steamer. That night they left with Brenner for Yeniseysk. Théel alone remained, awaiting the departure of Sotnikoff's steamer.

*The homeward passage.
Flora in the Yenisey valley*

The boat group, except Théel, reached Yeniseysk on October 4 after a toilsome but interesting tour. Whenever the steamer had stops, either due to commercial interests or to collect wood for the ship's steam engine, the expedition members made short excursions in the neighbouring country. These excursions were important, as they enabled the phyto-geographical notes from the downstream tour to be checked. It was also possible to study the flora in a different phase of development than that in early summer. The zoologists too found much of interest.

The region through which they travelled embraces approximately the same latitudes as Scandinavia. A basic issue concerns the degree of similarity between these two regions. Apparently the flora of the Yenisey valley is quite different from that of Scandinavia. The expedition's collections included about 700 species of vascular plants, of which about 200 were unknown in Scandinavia.

The forests along the Yenisey consist to a considerable extent of non-Scandinavian trees, notably larches. Among the species of trees which are found in both regions, the most important are birch, pine, aspen, bird-cherry and mountain ash.

On September 14, Théel left Dudenskoy on board Sotnikoff's steamer. The course was northward at first, and on the 16th they arrived at Okhotsk Island, where a barge loaded with salted fish was to be fetched. Here Sotnikoff made it clear that he had to return at once, in order to avoid being caught by the winter.

Without having achieved anything, Théel set off upon the voyage home. On October 19 he reached Yeniseysk, where it was deep winter with snow and cold weather; but the freeze-up had been delayed, thanks to a preceding period of milder weather. The river group was now assembled after four months of absence. During this time they had travelled 4,500 km along the river, and had visited 60 habitats where collections had been acquired. Great kindness had been shown to the expedition.

On October 29 they reached Tomsk, and on December 9 their long journey ended in Stockholm after an absence of nine months.

SUMMARY

Thus, Nordenskiöld had proved that the sea route from the Atlantic could be used for carrying trade, at least during part of the summer—but only when considering the weather and ice conditions. The voyage of the *Ymer* showed that harbour facilities had to be arranged. Furthermore, a fleet of suitable river craft would be needed to transport the cargoes.

Safety requirements also called for reliable marine charts, and such navigational aids as beacons and lighthouses. These would be of particular value in waters with such low and monotonous coast-views as those in western Siberia. This was practically illustrated during the voyage of the *Oscar Dickson* in 1880–81 (see p. 141). Ice-breakers would naturally be needed as well. At the time, of course, airplanes and radio were still to be invented. None of these special requirements existed in the present world—they were desiderata for the future. How they were fulfilled is briefly discussed on p. 150.

The voyages of the *Pröven* and the *Ymer* had, to Nordenskiöld, yielded experiences which he could use for realizing an old vision of mankind: navigating along the North-East Passage.

16. THE NORTH-EAST PASSAGE

EARLY RUSSIAN EXPLORATION IN THE SIBERIAN ARCTIC AND THE NORTH PACIFIC

The Russian exploration and occupation of Siberia may be said to have opened in 1577, when a horde of Don Cossacks under Yermak Timofeyevich (d. 1584) passed through the Ural mountain range in order to evade punishment from the Tsar Ivan IV for their plundering.

As they penetrated further into Siberia, they found a land in many ways similar to Russia. They felt familiar with the large river systems, which enabled them to travel easily in the vast region by applying the old hunters' method of using light boats, which could be carried on the back between rivers if necessary. Eventually the boats could be left behind and new ones be built at the next river. In this way practically the whole of Siberia was within the reach of the invaders, though often in opposition to the local population.

Already in 1581, Yermak sued for mercy and presented his Asiatic conquests to the Russian Tsar. Thus the further conquest of Siberia was carried out together with the Russians. An important procedure was to establish small forts at suitable places in the river systems. These forts could then be used as starting-points for further conquests of new land—or for defence. Some of the forts soon grew to become villages or towns, such as Yakutsk at the Lena.

The long Siberian arctic coast could then be reached by boats more or less floating downstream along the northern rivers to their estuaries. In favourable terrain near the estuaries, base stations could be established, from which the arctic coast could be investigated by boat in the summer or by dog sledge in late autumn, late winter and spring; food stores could be laid up at the base stations, often in part by fishing and hunting in the neighbouring country. Written reports on this exploration, however, often ended up in archives in Siberia, and the outside world learned little about them—even in Russia.

In 1644 Cossacks had built a fort near the mouth of the Kolyma River, and two years later a group of Cossacks travelled in boats downstream to the Polar Sea, where they met tribes of Chukchis. In 1648 Cossacks sailed eastward along the arctic coast in two vessels, which they had built themselves. The expedition's leader was the enterprising Semyon Dezhnev. One ship was wrecked, but Dezhnev's ship rounded the easternmost headland of Asia and proceeded south-westward into the Gulf of Anadyr.

Dezhnev and his Cossacks had made a geographical discovery of utmost importance. They had found that Asia and America were separated by water—that is, if not connected via a land bridge further to the north. Anyhow, a seaway existed between the arctic coast of eastern Siberia and the Pacific Ocean. However, the report about this discovery was buried in an archive in Yakutsk, and was not found until almost 100 years later by a German scientist, Gerhard Friedrich Müller.

Meanwhile Russians and Cossacks had penetrated as far east as the peninsula of Kamchatka.

The rapid conquest of Siberia may be exemplified by a few dates:

Tobolsk, in the west, was founded in 1587.

Turuchansk, at the Yenisey, was reached in 1609 and became a centre of the fur trade in about 1620.

Yakutsk, at the Lena, developed from a fort (ostrog) built in 1632 into a town and a centre of administration.

Irkutsk was founded in 1651.

Okhotsk, at the Sea of Okhotsk, was originally a fort, founded in 1647.

The peninsula of *Kamchatka* was discovered in 1697.

A more systematic investigation was initiated by Peter the Great (1672–1725, Tsar since 1682). At the end of 1724 he suggested to the Russian Admiralty that it send an expedition to Kamchatka. This led to a number of expeditions, which started in 1725 and were to go on until 1743. Peter's successors, Catherine I (Empress 1725–27) and Anna (Empress 1730–40), were in favour of the explorations in Siberia.

The expedition activity may be classified in two groups:

1. two naval enterprises with bases at Okhotsk and in Kamchatka, 1725–43, commanded by Vitus Bering (1681–1741), a Dane in Russian service;
2. the Great Northern Expedition of 1734–43, investigating the arctic coast of Siberia.

Often the two naval expeditions are included when referring to the "*Great Northern Expedition*".

In 1725, Bering was dispatched through Siberia to Okhotsk and Kamchatka, together with ship's crews, carpenters, shipwrights, and equipment and timber for ship-building. Two decked ships were to be built in Kamchatka. The land transports were time-consuming and meant a tremendous concentration of manpower and energy as well as privation.

Bering's voyages

Bering first went north in 1728. Two ships had been built, the *Fortune* and the *Gabriel*. With these, Bering

reached the east cape of Asia situated at about 66° N, and proceeded still further north to 67°18'N. No land was then seen to the east or north, so a sea route did exist along the East Siberian coast and further to the Pacific Ocean. With this important discovery Bering was satisfied and returned to his base.

All this had already been discovered by Dezhnev in 1646, but his report was still buried in Yakutsk. Once it had been found, the strait between Asia and America was to be given the name of Bering, and the east cape of Asia obtained the name Cape Dezhnev. The question as to a land connection between America and Asia was still not definitely settled, but Bering had seen the Siberian coast turn north-north-westward.

On September 20, 1728, Bering was back in Kamchatka, and in 1730 he visited St. Petersburg. He delivered a report on his expedition to Empress Anna, but he was widely criticized. It was considered that he could have done more to solve the problem of an eventual connection between Asia and America: now there still lingered doubts.

Bering himself pleaded for a continuation of the investigations. The interest of the authorities was awakened. They now wanted to continue—or rather to increase—the expedition activity and let practically the whole of the long Siberian coast be included, as well as part of the American west coast. This activity is generally referred to as the *Great Northern Expedition of 1734–43*, though it should be remembered that the exploration was carried out by a number of separate groups or expeditions travelling by sea and by land.

Bering was commander of the two ships, which were to search for the American coast. Moreover, he supervised the transport through Siberia of equipment and materials which were to be used by the expeditions and other groups included in the Great Northern Expedition. This was a colossal undertaking, which lasted eight years.

Bering's second expedition of 1741–42 used two ships, which had been built at Okhotsk: the *St. Peter* commanded by Bering, and the *St. Paul* commanded by Captain Aleksey Chirikov. The naturalist on board the *St. Peter* was a German, Georg Wilhelm Steller (1709–46); the second-in-command was a Swede, Lieutenant Sven Larsson Waxell (1701–62), born in Stockholm. Waxell had come to Russia in 1725 and had entered the service of the Russian Navy. In 1733 he volunteered for a post in Bering's second expedition. Waxell served in the Russian Navy during the rest of his active life.

On June 4, 1741, the two ships left their home port in Kamchatka–Petropavlovsk, which was named after them. The course was first set east-south-east, in order to search for a large land area which had been

falsely reported to exist north of the Pacific Ocean. However, no land was found. In weather with low visibility the two ships became separated and, after some waiting, the *St. Peter* proceeded alone towards east-north-east. On July 16 at 58°14'N, a cloudy sky cleared up to reveal high snow-covered mountains, among them a volcano.

America had been discovered by coming from the west. The other ship, the *St. Paul*, had also proceeded eastwards and reached the American coast, but somewhat farther to the south than the *St. Peter*.

The *St. Peter* had a home passage full of hardships. Bering and many of the crew fell ill with scurvy. In late autumn the ship suffered shipwreck on a desolate uninhabited island, not very far from Kamchatka. This was later named Bering Island. Bering died from privations and scurvy not long after the arrival. The responsibility fell upon Waxell to take the survivors through the winter, to have them build a new ship, and to take it to Petropavlovsk with survivors and scientific material on board.

After the expedition, Waxell wrote a report in German on the preparations and events connected with the expedition. Not least important are the descriptions of the immense preparations—taking all of eight years—before the expedition could start from Kamchatka in 1741. Waxell's report was to be more or less buried in an archive in Russia, and was not published until 1940.

The expedition's naturalist, Steller, had carried out valuable observations and had assembled a fine collection of animals, notably marine animals. The two ships had discovered America's west coast roughly between 56° and 60°N. Here, geographical names such as Waxell Ridge and Mount Steller bring back to mind the discoveries of Bering's second expedition.

The exploration of the north coast of Siberia began in 1734 and ended in 1743. This too was a gigantic undertaking and stands high in the annals of geographical investigations. The practical idea behind it was the hope of finding the shortest sea route between the western and the eastern possessions in the large Russian Empire—that is, between the White Sea and Kamchatka. But several scientists were also attached to the research work, in the Arctic and in other parts of Siberia.

From five bases located near the mouths of some of the large northern rivers, ships and sledgers set out, the ships often in pairs. Stores and provisions had been sent northward along these rivers beforehand, and at some places along the coast, huts had been built from drift-timber.

The exploration of the coastal zones was mainly carried out by four marine units:

Bering's two expeditions from Kamchatka to Bering Strait in 1728 and to America in 1741–1742. From the report of the Swede, Sven Larsson Waxell (1701–1762), lieutenant in the Russian Navy (above). (Waxell, S.: Den stora expeditionen, Swedish edition 1953.)

Adolf Erik Nordenskiöld in the "studio" on board the *Vega* during the North-East Passage wintering at Pitelkai in 1878–1879. (A.E. Nordenskiöld's Photographic Collection, Royal Swedish Academy of Sciences.)

Research regions of the Great Northern Expedition, 1734–1743. This systematic investigation of Siberia was initiated by Tsar Peter the Great.

1. One unit with the ships *Expedition* and *Ob* investigated the coast between the White Sea and the Ob estuary.
2. The ships *Tobol* and *Ob-Pochtalyon* worked in the sector between the Ob and Yenisey estuaries, and further eastwards to Cape Sterlegov situated at long. 89°E.
3. A unit with the ship *Yakutsk* worked in the area between the rivers Lena and Khatanga, and further westward along the Taymyr Peninsula to the extreme east of unit 2, namely to Cape Sterlegov.
4. One unit worked in the sector between the Lena Delta and the Kolyma estuary.

In other words, the Great Northern Expedition investigated practically the whole of the Northern Sea Route, or the North-East Passage.

These explorations included, of course, Bering's two voyages already described:

1. The first voyage in 1728 from Kamchatka to the Bering Strait area;
2. The second voyage in 1741–42 from Kamchatka to the American west coast between lat. 56° and 60°N.

Among events after the Great Northern Expedition of 1734–43, we should note the observation in 1770 by Ivan Liakhov, a fur trader, of reindeer coming from the north over the sea ice. Quite logically, he concluded that there must exist land farther north. This led to his discovery of the Liakhov and Malor Islands, followed by that of several other islands constituting the New Siberian Islands, the latest being that of New Siberia Island in 1806. These revelations proved to have economic value, because of the very rich occurrence of mammoth tusks in the region.

In the beginning of the 19th century, the islands were visited mostly by parties travelling with dog sledges across the ice from the mainland in the autumn and spring. It was found that the ice in the region was dangerously thin in several areas, and even open water was met with.

For three years (1809–11) a Swede in Russian service, Mathias Hedenström (1780–1845), carried out survey work among the New Siberian Islands together with a Russian tusk "hunter" named Sannikov. This work was followed by investigations by two Russian naval officers, P.F. Anjou and Ferdinand Wrangel, in 1820–24 along the East Siberian coast and among islands to its north. These travellers reported on observations of unknown land seen in the distance. This may in some cases have been distant islands, but in other cases only illusions of land due to mirages. The many reports gave rise to the hypothesis of a land of continental extension situated in the Polar

Sea. Similar observations had been made now and again ever since the first half of the 18th century.

The Great Northern Expedition of 1734–43 had surveyed the long coastline of Siberia in its essentials. Indeed, the many participants in this huge enterprise had done most admirable work. Moreover, the expedition's maps had in some areas been improved by later Russian ventures. It was, therefore, not to be an unknown coast which the Swedish Vega Expedition, in 1878–79, followed when it navigated along the North-East Passage.

NORDENSKIÖLD PLANS AN EXPEDITION ALONG THE NORTH-EAST PASSAGE

The voyages of the *Pröven* in 1875 and of the *Ymer* in 1876 had given Nordenskiöld experiences which were of utmost importance in connection with his further planning of voyages towards the east. He had obtained direct proof of how the warm river-water in the summer spreads from the estuaries of the two giant rivers Yenisey and Ob. The warm water moves eastward along the coast, deflected by the coriolis force of the Earth's rotation, and the current is also influenced by the winds.

In the Kara Sea, he had obtained evidence of how the warm water affects the melting of the ice, and thus creates a usable sea route between the Atlantic and the Ob–Yenisey rivers in the latter half of the summer and the beginning of autumn.

By analogy, similar improvements of the ice conditions might be expected farther east, especially induced by the rivers of the Khatanga, Lena and Kolyma, although the effects might not be so pronounced as in the Kara Sea. A critical region would be the waters off the Taymyr Peninsula with Cape Chelyuskin, the northernmost point of the Eurasian continent. Near the Bering Strait, whalers and sealers had long been operating and the conditions were better known.

Nordenskiöld also got to know the regions east of Dickson Harbour by thorough study of the literature on travels in that area. A short survey of these travels is given in his plans for the Vega expedition. Already started to plan his great expedition, he already knew almost all that it was possible to learn about these regions at the time.

In connection with his previous arctic expeditions, he had acquired contacts with authorities and with influential and wealthy men, both in Scandinavia and in Russia. In Sweden he was supported by King Oscar II and by Oscar Dickson—and in Russia by Alexander Sibiryakov, the gold-mining magnate.

After the Yenisey expedition of 1876, he turned to King Oscar and inquired on the possibilities of getting support from public funds for the planned voy-

age. The King promised to arrange a meeting with Swedish arctic travellers for discussing the feasibility of a voyage through the North-East Passage. Nordenskiöld was asked to present his views about the ice conditions prevailing along the north coast of Asia.

The meeting took place in the Royal Palace in Stockholm on January 26, 1877. It began with a dinner, and afterwards the programme of the projected expedition was presented. The ensuing discussion dwelt to a great extent upon the ice conditions and the currents near the crucial point of Cape Chelyuskin. The King declared himself convinced of the practicability of Nordenskiöld's plan. He wanted to support the enterprise economically, not only in his capacity of King but also as a private person. Oscar Dickson, too, promised financial aid. From Sibiryakov, Nordenskiöld had already obtained means for continuing research in the Siberian Arctic. The costs of the expedition were later shared alike between the three sponsors, with Dickson acting as banker.

The men and the ships

The first names in the list of expedition members soon appeared, among them a few from Nordenskiöld's previous ventures: Kjellman, Stuxberg and Palander. Nordenskiöld was especially satisfied that his friend Palander, from the expeditions of 1868 and 1872–73, applied for the post of ship's commander.

The choice of a suitable ship was important. There had been negotiations for buying a British sailing yacht, the *Pandora*, which in 1875 and 1876 had cruised in the Canadian Arctic under Sir Allan Young. However, she was bought by Gordon Bennett of the "New York Herald" for his arctic expedition of 1879–81 under George W. De Long. This expedition was to end in great tragedy.

Nordenskiöld obtained his ship, the *Vega*, from a Swedish firm of shipowners, Ishavet by name. The company owned two ships, the *Vega* and the *Capella*, which were used for whaling and sealing operations. The *Vega* was built in Bremerhafen, Germany, in 1873. She was a three-masted barque with a steam engine. Her hull was of oak, protected against the ice by an "armour" of greenheart, a kind of hardwood.

Her data were as follows:

Length: 43.4 m
Beam: 8.4 m
Draught: 4.5–5.0 m
Engine: 60 nom. HP (about 200 ind. HP)
Max. speed with steam power: 7 knots.

The *Vega* was a good sailer, making nearly 10 knots in a fair wind.

On behalf of Mr. Sibiryakov, three smaller ships

were to accompany the *Vega* during part of the North-East Passage: the *Fraser*, *Express* and *Lena*. The *Fraser* was a steamer, the *Express* a sailing vessel. Both were to leave the *Vega* at Dickson Harbour, proceed upstream along the Yenisey River, and ship corn for the return voyage. The *Lena* was to accompany the *Vega* all the way to the Lena Delta. She would then proceed upstream to Yakutsk and join the river transport system. She had been specially designed for the purpose and built in 1877 at Motala, Sweden. Her length was 25 m, beam 5 m, draught not fully 2 m.

Besides carrying cargo to and from Siberia, the three ships were to serve as depot ships to the *Vega*. The sailing vessel, the *Express*, would also carry coal for the *Vega*, the *Fraser* and the *Lena*.

Nordenskiöld obtained additional help from the Swedish State. The *Vega* was overhauled and refitted at the naval base of Karlskrona, and provisions were obtained from naval stores. The crew, taken free of charge from the Swedish Navy, consisted of two officers and 17 men. There were also two foreign officers, one from the Danish Navy and one from the Italian Navy.

THE SCIENTIFIC STAFF AND SHIP'S COMPANY OF THE *VEGA*

Adolf Erik Nordenskiöld (1832–1901), Ph.D., professor, geologist, leader of the expedition.

Adolf Arnold Louis Palander (1842–1920), lieutenant in the Swedish Navy, commander of the *Vega*.

Frans Reinhold Kjellman (1846–1907), Ph.D., botanist.

Anton Julius Stuxberg (1849–1902), Ph.D., zoologist.

Ernst Bernhard Almquist (1852–1946), M.B., doctor of the expedition, lichenologist.

Eric Cornelius Brusewitz (1844–1919), lieutenant in the Swedish Navy, second-in-command of the *Vega*.

Giacomo Bove (1853–1887), lieutenant in the Italian Navy, in charge of the hydrographical work.

Andreas Peter Hovgaard (1853–1910), lieutenant in the Danish Navy, in charge of the meteorological and geomagnetic observations.

Oscar Frithiof Nordqvist (1858–1925), Finlander, lieutenant in an Imperial Russian Guard regiment, interpreter, assistant zoologist.

Rudolf Nilsson (1837–1909), ship's master.

Frans August Pettersson (1835–98), chief engineer.

Oscar Fredrik Nordström (1855–99), second engineer.

Carl Olof Carlström (1845–1903), stoker.

Olof Ingelsson (1849–1913), stoker.

Ola Trulsson Öman (1843–1900), seaman.

Gertan Adolf Carlsson (1843–1906), seaman.

Carl Alfred Lundgren (1851–87), seaman.

Otto Wilhelm Hansson (1856–1929), seaman.

King Oscar II of Sweden (1829–1907) supported Nordenskiöld's polar explorations not only in his capacity of King, but also as a private person. (Nordenskiöld, A.E.: *Vegas färd kring Asien och Europa...*)

Baron Oscar Dickson (1823–1897). The most important benefactor in the history of Swedish polar research. (Nordenskiöld, A.E.: *Vegas färd kring Asien och Europa...*)

Adolf Erik Nordenskiöld (1832–1901) at the peak of his career. Famous leader of the *Vega* voyage 1878–1880. (Nordenskiöld, A.E.: *Vegas färd kring Asien och Europa...*)

Alexander Sibiryakov (1849–1933), a Russian gold-mining magnate, from whom Nordenskiöld obtained the means for research in the Siberian Arctic. (Nordenskiöld, A.E.: *Vegas färd kring Asien och Europa...*)

David Andersson Asplund (1827–1900), boatswain, cook.

Carl Nyström Smälänning (1839–1914), boatswain.

Carl Petter Magnusson Levin (1844–99), boatswain, steward.

Petter Magnus Jansson Lustig (1845–1906), boatswain.

Carl Jansson Ljungström (b. 1845), boatswain¹.

Per August Andersson Lind (1856–1909), boatswain.

Per Olof Johansson Fäste (b. 1856), boatswain¹.

Sven Andersson (1847–1928), carpenter.

Thomas Anton Boström (1857–1916), assistant to the scientific staff.

NORWEGIANS

Johannes Henriksen Haugan (1825–99), sealer.

Peder Ulrik Johnsen (1845–1924), sealer.

Peter Marinius Sivertsen (1853–1918), sealer.

Altogether there were 30 persons sailing with the *Vega* along the North-East Passage: 9 officers and scientists, and 21 men below the rank of officer. The representative of Sibiryakov, named S.J. Serebrennikov, was a passenger on board the *Vega* between Tromsø and Dickson Harbour.

The commanders of the three ships which sailed with the *Vega* were:

Lena: Hans Christian Johannesen (1846–1920), sealing captain, Norwegian.

Fraser: Emil Nilsson (1850–1921), captain of the merchant navy.

Express: Gundersen, captain of the merchant navy.

The voyage of the *Vega* has been related in many different contexts, some of which are here given in the references.

There are four original narratives:

1. *Nordenskiöld, A.E.*: "The voyage of the *Vega* round Asia and Europe". Two volumes; see List of References.
2. *Palander, L.*: "NO-Passagen förbi Sibiriens nordkust och genom Beringssundet utförd under svenska ishavsexpeditionen åren 1878–79" (The North-East Passage along the north coast of Siberia and through the Bering Strait, carried out during the Swedish Arctic Expedition of 1878–79). Pp. 43, 1 map; Karlskrona 1879.
3. *Stuxberg, A.*: "Minnen från *Vegas* färd, etc." (Reminiscences from the voyage of the *Vega*, etc.). Pp. 358, 1 map; Göteborg 1890.
4. "*Sven Anderssons journal förd å ångfartyget Vega*

under expeditionen åt Norra Ishavet åren 1878–1879" (Sven Andersson's diary written on board the steamer *Vega* during the Arctic expedition in 1878–1879). Published by Bengt Garting in 1979.

Nordenskiöld's work—the official report—is wordy and contains many long addenda on different subjects, which placed his report of the *Vega* expedition in the background. Palander's report was apparently completed during the stay of the *Vega* in Yokohama, Japan. It gives a clear and trustworthy description of the ship's voyage, showing her route on a map with the coastlines as known before the expedition, and with preliminary additions and alterations made during the voyage.

The diary of Sven Andersson, or "Vega Sven", was written for his wife Mari during the expedition as far as Yokohama, Japan. Andersson, who was the carpenter on board, here gives an idea of how life on board the *Vega* was experienced by the crew below the rank of officer.

The present account of the voyage builds mainly upon the works of Nordenskiöld and Palander, but some events and situations have been elucidated with the help of quotations from the diary of Vega Sven.

The first leg: from Karlskrona to Dickson Harbour in Western Siberia

On June 22, 1878, the *Vega* left Karlskrona, the naval base in southern Sweden. København was visited on June 24–26 in order to load provisions for 30 men during 24 months. The next stop, from June 27, was at Göteborg where provisions and coal stores were replenished. Moreover, the scientific equipment, sledges, pemmican for sledging trips, and two dogs were taken aboard. Here the expedition was joined by five members: Kjellman, Stuxberg, Nordqvist, Almquist, and a servant to Nordenskiöld.

On July 4 the *Vega* left Göteborg, not to return to Sweden for almost two years. The voyage northward along the Norwegian coast was delayed by a persistent fresh headwind, and not until July 17 did the ship reach Tromsø, where Nordenskiöld and three Norwegian sealers embarked. The crew and scientific staff with assistants were now complete.

Some additions to the equipment and the stores were made: coal and water, and warm clothes including furs. Excluding coal for heating, the *Vega* would be able to proceed some 6 400 km on her steam engine alone, approximately corresponding to the distance between Tromsø and the Bering Strait.

On July 21 the *Vega* started upon her long and—in some ways—precarious voyage. She was now accompanied by the *Lena*, having a crew of nine and provi-

¹ Still living at the time of the 50th anniversary (1930) of the return, 1880, of the *Vega* voyage along the North-East Passage and around Euroasia.

sions which were expected to last 16 months. The route went inside the belt of islands and skerries, until Mäsöy at Nordkapp was reached. Here the two ships had to stay for three days because of a severe north-westerly gale. Not until July 25 were they able to stand out to sea and proceed eastward, with the course set for Goose Land in Novaya Zemlya.

The *Lena* left at the same time as the *Vega*, with orders that, in case of separation, she was to proceed to Chabarova at the entrance to the Yugorskiy Shar, where the expedition flotilla of four ships was to assemble before starting the voyage along the North-East Passage proper.

A rather hard wind with a rough sea forced the *Lena* to slacken her speed. The two ships were not to meet until July 31 at the prearranged meeting-place in Proliv Yougorskiy, the southernmost entrance to the Kara Sea. The *Vega* steered towards the southern part of Goose Land where, in conditions of ice, an ice-free lane had often been reported to lead southward along the land. However, there was no ice now and the weather was fine.

At the entrance to the sound of Yougor Shar (Proliv Yougorskiy) a steamer was sighted. It proved to be the *Fraser* which, with the *Express*, had arrived at the meeting-place already on July 20, ten days earlier. The *Fraser* had gone out to search for the *Vega*. The two ships anchored off Chabarova in the evening of July 30. Next day the *Lena* arrived, and the whole flotilla was assembled.

Chabarova is a small and humble village, inhabited in summer by Samoyeds and a few Russians and Russianized Finns. The Samoyeds have their reindeer on Ostrov Vaygach. The Europeans come to barter with the Samoyeds and for fishing and hunting. Before leaving the place, Nordenskiöld found time to procure an ethnographical collection by bartering with the natives. He also visited a place of sacrifice on Ostrov Vaygach, from which a few objects now "happened" to disappear. In the harbour, the *Lena* was bunkering from the *Express*.

On the morning of August 1, the flotilla left Chabarova. The weather was excellent, and the Kara Sea was found to be ice-free as far as the eye could reach. Until some years earlier, the Kara Sea had been more or less unknown in scientific respects; but the voyages of Norwegian sealers, and the observations and collections obtained during Nordenskiöld's two expeditions with the *Pröven* and the *Ymer* in 1875 and 1876 respectively, had resulted in a fairly good grasp of its physical features. In particular, the current along the eastern coast of Novaya Zemlya moves southward, and with it pack-ice and drift-ice are carried south, often blocking the entrance to the Kara Sea via the

three sounds Yugorskiy Shar, Karskiye Vokota (the Kara Gate) and Matochkin Shar. The ice disintegrates and disappears, though, generally during the summer.

The depths in a channel along Novaya Zemlya and a little farther south reach 300 m or more, but otherwise the Kara Sea is fairly shallow. Its smooth bottom rises slowly towards the east from depths of some 90 m to 30 m or less.

The oceanographical conditions are influenced by the supply of fresh water from the giant rivers Yenisey and Ob. The currents in the eastern part of the Kara Sea move eastward. During the summer they create a surface layer of warm and almost fresh water, resting upon salt and cold water with temperatures about -2.7°C and providing quite different environments for the life in the sea.

The weather remained fine and the sea was ice-free when the flotilla proceeded north-eastward. On August 3, Captain Johannesen of the *Lena* received orders to take Almquist, Nordqvist and Hovgaard to Ostrov Belyy, north of the Yamal Peninsula. They were given 36 hours for studying natives, animals and plants, after which the *Lena* was to pass through the sound between the island and the mainland, then proceed to Dickson Harbour where the flotilla would assemble. After separating, the *Vega* with the *Fraser* and the *Express* passed through belts of drift-ice, but their progress was not much impeded.

Towards evening, Ostrov Belyy was sighted from the *Vega*. This is a very low island and the sea near it is shallow; at a distance of 20–30 km the depths were found to be only 7–9 m. The island and Yamal Peninsula are composed of sand particles coming from the Yenisey and Ob.

On August 4 the swell indicated that the sea must be free of ice over a considerable area. The sea-water had gradually changed its properties: the salinity had decreased and the content of particles had increased. Now the water to the north and north-east of Ostrov Belyy had attained a yellowish-grey colour and was opaque, but became almost drinkable after filtering.

On August 5 the three ships sailed east in an almost ice-free sea. The depths were low; sometimes only 9 m was sounded, and the bottom was extremely smooth. The fog and the fresh breeze, combined with a rough sea due to the shallow water, hindered the voyage.

At 03.00h on August 6, land was sighted from the *Vega*, and soon the ships anchored near an islet to the west of Dickson Island (Ostrov Dickson)—as they found later. A visit ashore gave Kjellman a rich harvest of plants, some of which he had never before seen in the Arctic. The ships then moved to Dickson Harbour on the eastern side of Dickson Island. Palander

shot a polar bear and, as had been the case during the expedition of 1875, the bear had only lichens and mosses in his stomach.

The harbour, which had been found by Norden-skiöld in 1875, was now mapped by Bove. Relics of a hut were found on an islet at the northern entrance to the harbour. Nordenskiöld comments:

“It is the best harbour on the whole stretch of coast along northern Asia—as far as is known. It is surrounded by rocky islands and islets in all directions, and is therefore perfectly sheltered. The anchorage has a good clay bottom. The harbour can be entered both from the north and from the south-west... I am convinced that a day will come when there will be large storehouses and many dwelling-houses—used throughout the year—at Dickson Harbour. Now, on the contrary, the region is uninhabited all the way to Golchica in the south.”

This was certainly a correct prophecy (compare p. 150).

The rocks around Dickson Harbour consist of diorite, which is hard but moulders easily. The hills are therefore often so decomposed that they form enormous mounds of stones. They are covered by a rich flora of lichen, and on the fields between them is a fairly rich flora of phanerogams. In the sea, however, no large algae were found, and this was explained by the water samples which were brought up. The salinity was as low as 3 per mille at the surface as well as in the bottom layers, and the temperature was also nearly constant with depth, at +9° or +10°C. In the spring and the beginning of the summer, when the snow-melting has taken place, the sea water ought to be practically fresh here, while in the cold season it is probably as cold and almost as saline as at the bottom of the Kara Sea. Thus, the changes in environment are very great and a poor marine fauna should be expected. Yet such was not the case.

The *Lena* arrived on August 7 from her visit to Ostrov Belyy with Hovgaard, Nordqvist and Almquist. The object of the visit had been to make studies in botany, zoology and ethnology. The *Lena* had left the *Vega* at 11.00h on August 2. In spite of rain and fog they managed to find the sound between the island and Yamal, which Nordenskiöld later named Malygin Sound. It was a voyage characterized by continuous soundings in shallow water, with depths ranging between 3.5 m and 10 m. The *Lena* anchored near the south point of the island, with a depth of 3.5 m at about 1.5 km from the shore. The landing party had to leave their boat about 300 m from

the shore and wade to the island.

Ostrov Belyy is only about 3 m high, and consists of nothing but sand. Next to the shore the fine sand is free of vegetation, but where the surface rises somewhat it is covered with a black and white carpet of lichens and mosses. Only along the marshy shores of the numerous small lakes does the colour become weak green. Only 17 species of higher plants were found. Nor could an astronomical determination of position be carried out, because of rain and fog.

In the night the ship crossed the sound, at a place where a number of Samoyed tents could be seen. She had to anchor more than 2 km from the Yamal shore, but it was found impossible to come ashore; the water was too shallow. Some distance farther east, it was somewhat deeper and they managed to land. The coast was steep here, 9 m high, and beyond the edge of the cliff extended the tundra with swamps, brooks and fairly rich vegetation. However, they were prevented by brooks and ravines from reaching the Samoyed camp.

The *Lena* then steamed eastward in a channel with depths ranging between 10 and 16 m, but could not take advantage of it all the way into deep water. She had to turn westward and round the north point of Ostrov Belyy before setting course for Dickson Harbour, where she arrived on August 7.

This visit to the northern part of Yamal Peninsula, as well as Nordenskiöld's visit during the expedition of 1875, probably involved the very first scientific studies of the physical features of the peninsula.

Meanwhile the *Vega* had bunkered from the coal store of the *Express*, and it was now the turn of the *Lena*. On August 9, the *Fraser* and the *Express* left Dickson Harbour in order to ship cargo at Yakovyeva, some way up the Yenisey (see further p. 138). The *Vega* and the *Lena* departed early in the morning of August 10. A critical part of the North-East Passage lay ahead.

THE VOYAGE OF THE VEGA AND THE LENA ALONG THE WESTERN SIDE OF THE TAYMYR PENINSULA, 1878

The course was set for Ostrova Kamennyye (Stone Islands). It was overcast, the highest air temperature was +10.4°C, the water temperature +10° becoming +8°, and the salinity was low. No ice was seen during the day. The *Vega* sailed under a south-easterly breeze. Small rocky islets and islands were passed, but these were not on the chart, and great care had to be exercised. A keen look-out was held, and continuous soundings were taken as the ships moved along.

The shelf off the Siberian coast is broad, and the coastal waters are shallow. Moreover, the charts were

Louis Palander (1842–1920). Commander of the *Vega*. (top left). (Nordenskiöld, A.E.: *Vegas färd kring Asien och Europa...*)

The captain of the *Lena*, Hans Christian Johannessen (1846–1920) (middle left). (Nordenskiöld, A.E.: *Vegas färd kring Asien och Europa...*)

The scientific members of the *Vega* expedition: Frans Kjellman (1846–1907) botanist; Anton Stuxberg (1849–1902) zoologist; Ernst Almquist (1852–1946) doctor to the expedition; and Oskar Nordqvist (1858–1925), Russian interpreter and assistant zoologist (above). (Nordenskiöld, A.E.: *Vegas färd kring Asien och Europa...*)

The steamer *Lena* accompanied the *Vega* to the Lena Delta, August 1878. (Nordenskiöld, A.E.: *Vegas färd kring Asien och Europa...*)

especially unreliable along the Taymyr Peninsula. To make matters worse, the coastal zone here is infested by ice and treacherous fogs—a combination which makes ice navigation very hazardous, with the fog hiding eventual lanes and openings in the ice. As a rule, soundings were taken every hour when the water was deep, not less than 13–18 m. At shallower depths, soundings were taken every quarter of an hour; and when the ships moved in coastal waters with depths between 5 and 7 m, the sounding line was sometimes used for days on end. The *Lena* or the steam launch of the *Vega*, both having less draught than the *Vega*, were then often sent ahead to scout the depths, although this was impossible in situations with fairly dense ice. The greatest depth which was sounded during the entire voyage in Siberian waters was 125 m, to the east of Cape Chelyuskin. Nowhere else were depths greater than 36 m found, even far from land. Usually the *Vega* sailed in waters of 9–12 m; near the coast 5–7 m were usually attained.

The Russian charts, which were used in the central parts of the North-East Passage, were based upon surveys from the 17th and 18th centuries. Not until beyond the Kolyma River were the charts based upon more recent measurements, namely by Admiral Wrangel in 1821–1823. The coast here was fairly well represented but, in the Taymyr section of the Passage, the coast was shown much too far to the east (see p. 139). Furthermore, the charts contained only a few depth-figures; they were rather similar to land maps.

On August 11 the two ships lay at anchor on the lee side of a small, unknown island, while a heavy north-easterly gale with rain was raging. In the evening with the wind abating, they proceeded along the coast. On the 12th they met with drift-ice, which was rather broken and allowed the ships to proceed in the right direction, but in a somewhat irregular way. Along with the ice, fog began to appear, though it often lifted for a few hours early in the morning and soon after midday.

On August 13, with a dense fog, they observed that the *Vega* was heading against land, but they managed to stop her in time and anchor. When the fog lifted, they found that the “land” was an isolated mound of stones in the sea.

During the rest of that day and during the 14th, the ships lay in dense drift-ice and were surrounded by a thick fog; it was impossible to find a way out. But later in the evening the fog lifted for a few hours, allowing an approach towards land, where the ice was most open. They were near Ostrov Taymyr and anchored in a bay at the south-western side of the island. This was called Aktinia Bay, due to the great number of Actiniaria which the scraper took up here.

They were forced to spend three days and a half at this place, detained by a persistent fog. Still, they were able to make excursions in the surroundings. The rock consisted of layers of gneiss forming low ridges, which had become so disintegrated by the frost as to become gigantic mounds of stones covered by lichens. Between the ridges lay small valleys and plains, covered with a continuous carpet of green vegetation—a mixture of grass, sedges and many species of moss and lichen. The animal life, though, was poor.

One excursion was made with the steam launch into the sound between Ostrov Taymyr and the mainland. The sound was found to be very shallow. They noted a strong west-going current with a speed of 3–5 knots.

The fog lifted on August 18, and the two ships were able to continue the voyage. They saw many islands, but the survey could only be carried out in a very rough manner, because of the rather dense fog which lingered. They met with ice, but saw only fairly small pieces. Few warm-blooded animals were noticed; during the 18th, for instance, they did not observe a single bird.

At the north point of Eurasia:

Cape Chelyuskin, August 19–20, 1878

On August 19 they continued to steam along the coast, mostly in a very dense fog which, now and again, lifted to reveal land. Sometimes the two ships had to signal with their steam whistles in order to avoid being separated. The sea was as smooth as a mirror, and only occasionally were a few pieces or fields of ice visible.

Towards the evening of August 19, a dark headland appeared in the fog to the north-east, and beyond it a bay opened towards the north. Here the two ships anchored at 18.00h on August 19. For the first time in history, a ship lay at the northernmost point of Eurasia. The event was celebrated on board with wine and toasts, flying flags and a salute of gunshots.

The north point of Asia is a fairly low headland, divided into two tongues with a small bay in between. The eastern promontory reaches somewhat farther north than the western. A mountain ridge, with smooth slopes, extends from the eastern cape inland in a southerly direction. This seemed to attain a height of about 300 m. Its crest was free of snow, as was the lowland below. No glacier extended from the mountains, there were no lakes in the lowland, and no high mountain peaks were seen. Nordenskiöld commented:

“The landscape was the dullest and most desolate I have seen in the high North.”

The flora was in some ways similar to that on Ostrov Taymyr, but poorer. The severe climatic conditions were manifested by many flowering plants, which tended to form very dense hemispherical tussocks for protection.

They observed a large group of brant geese (*Branta bernicla*), apparently migrating to warmer lands from some polar land situated north of Cape Chelyuskin. This observation gave Lieutenant Hovgaard occasion to equip an expedition a few years later, with the object of searching for this hypothetical land (see pp. 149, 186 and 443).

All brooks and rivers were now dry, but their beds indicated a fairly rich flow of water at times of melting snow. There were no traces of human beings, but narratives from the 17th century seem to indicate that Siberian nomads have driven their herds of reindeer to this region. It also seems possible that Russian hunters from Khatanga have reached this far. Chelyuskin must have been at the cape in 1741, as his map outlines the coast here quite correctly.

The *Vega* stayed at Cape Chelyuskin until midday of August 20. Nordenskiöld wanted to obtain a good determination of the position of the cape from solar altitudes. His result was lat. $77^{\circ}36'.8N$, long. $103^{\circ}17'.2E$, referring to the less northerly western cape.

In the meantime, the *Lena* was sent north for dredging. She met with thick and rather dense ice, eight nautical miles to the north of the anchorage. Here the depth increased rapidly. The animal life on the bottom was rich; many large starfish and ophiurids were caught.

*Along the eastern side of
the Taymyr Peninsula*

Nordenskiöld wished to steer straight for the New Siberian Islands (Novosibirskiye Ostrova), hoping to find "new land" on the way. The course was therefore set east to east-south-east. Progress was fairly good on August 20–21 in spite of fog. The drift-ice was scattered to begin with, but less disintegrated and thicker than the ice which they had encountered earlier. In the night towards the 22nd, they passed through rather dense ice, and later in the day the fog became so thick that it was impossible to get any idea of the ice's distribution. At midday the course was changed to about south, but the ice blocked the way, so they moved to an ice-floe and awaited better visibility.

On the two occasions when the two ships had been moved to ice-floes, the trawl-net had been laid out. The drift was slow towards the north-west, but the outcome of the trawling was exceptionally rich—in fact the richest during the whole passage north of Siberia. The depth varied between 60 and 100 m; the water

temperature was 0° to $-0.6^{\circ}C$ at the surface, and -1.4° to $-1.6^{\circ}C$ near the bottom. The salinity was high, almost of ocean "standard". Nordenskiöld noted:

"It is remarkable that a temperature below the freezing point of fresh water should be favourable to the development of such extremely rich animal life as was found here, and in spite of the total darkness which prevails during the greater part of the year on the bottom of the ice-covered sea."

When they had managed to come out of the ice, the course was set towards the land which had been sighted on the morning of August 23. The coast stretched from north to south and the *Vega* sailed rapidly along the coast, without any help from the steam engine. The distance to the land was about 10 km and the depths were 13–15 m.

On the 24th they still sailed along the coast, at a distance of 10 km and with depths about 33 m. The land had now become higher and they could see beautiful mountain ranges inland.

The weather was fine during the forenoon of the 24th, and often not a piece of ice could be seen. Many walruses, black guillemots and auks appeared. A short visit was paid to the little island Ostrov Preobrazheniya, off the mouth of the bay of Khatangskiy Zaliv. The vegetation on the island was much richer than at Cape Chelyuskin, with regard to the numbers of both species and individuals. The position of the place was more southerly, but above all the warm water of the Khatanga River exerted its influence here.

The passage along the Taymyr Peninsula was now completed. It had been characterized by the great eastward displacement which the region exhibited on the map. The passage southward during the previous few days had thus taken place overland according to the chart (see Fig. 137).

The bright nights of the polar summer were coming to an end. Already at 22.00h it was rather dark. They left Ostrov Preobrazheniya at 21.00h on the 24th, and passed the north-eastern promontory of the river mouth—or so they thought. In reality it was the north-eastern point of Ostrov Bol'shoy Begichev, whose insular nature had not yet been discovered.

*Eastward ho! The Vega and the Lena separate:
August 25–30, 1878*

On August 25 they followed the coast, passing across Bukhta Nordvik. Then the coast turned eastward, and so did the two ships. The depths varied between 7 and 14 m. In the morning they met with fog, but later in the forenoon it cleared up; in fact this day proved to

be one of the warmest and finest they were to experience during the whole passage north of Siberia. But the coastal waters were shallow, and they had to sail so far away from the coast that the land could scarcely be seen. They passed several “torosses”, a Russian word for heaps of ice blocks which have formed under pressure, due to ice floes piling up and breaking apart like lumps of sugar. The “torosses” often form upon shoals, and may not melt in the summer if large enough, so they serve as a shoal warning to mariners.

During August 25–27 the weather was superb and the sea free of ice. The water temperature had again risen, to +5.8°C, and the salinity had decreased because of the water from the rivers in the region—the Khatanga, Olenek and Lena. The influence of the rivers was also experienced in another way: the ships had trouble in avoiding a large sand-bank, stretching north-south. It had probably originated from the sand particles in the water from the Olenek and the Lena Rivers, the former being situated due south of the sandbank.

After circumventing the sandbank, they steered for the northernmost river mouth in the Lena Delta, where a pilot from Yakutsk was to be waiting for them. He would guide the *Lena* upstream to Yakutsk. But there is more than one river mouth in the northern delta. A sea-mark would therefore be set up to mark the deepest river mouth.

It had been the intention that the *Vega* would accompany the *Lena* to the river and stay there for a few days, while observations were carried out and collections were made. In the night towards the 28th they were near the delta. The weather was fine, though cloudy. The wind was light and there was no ice to be seen. The occasion was excellent for continuing the voyage eastward, so the two ships parted some distance out to sea, the *Lena* steaming towards the Delta to begin her long voyage up the river, while the *Vega* headed east.

As far as they could tell, the worst parts of the North-East Passage lay behind them—the entrance to the Kara Sea and the passage along the Taymyr Peninsula. The temperature of the air reached +4°C, the water temperature was +2° to +3°C, and the salinity was 18 per mille.

On the afternoon of August 28, the *Vega* sighted the two small islands of Semenovskiy and Stolbovoy. The waters were shallow, sometimes 6–7 m for long distances, and disintegrated ice was met with, sometimes reducing the speed and forcing the ship to make detours. The animal life was extremely poor, both above and below the sea surface. The bottom consisted at some places of hard-packed sand—or perhaps frozen sand—and the trawl-net did not bring up any

animals. But elsewhere the bottom was clay and the marine fauna was rich.

For two days they had not been able to determine the latitude astronomically. They could do so on the 28th, and found that the ship had been displaced about 60 nautical miles northward, apparently due to the flow of water from the Lena and Yana Rivers.

Nordenskiöld's intention was next to visit the southernmost of the New Siberian Islands, namely Ostrov Bol'shoy Lyakhovskiy (Lyakhov Island), in order to search for relics of mammoths and other animals. Here, in the plains between highly disintegrated hills, occur abundant bones and tusks of mammoth, mixed with horns and skulls of some species of ox and horns of “rhinoceros”, as the old reports said. The remains are imbedded in a mixture of ice and sand.

The *Vega* approached the western part of the island, which was found to be free of snow and glaciers; nor were there signs of any previous glaciation. However, due to the shallow water near the island, they could not come closer than 4–5 nautical miles. With due regard to a fog which was developing, they had to give up any thought of landing, and to steer south for Cape Svyatoy Nos on the mainland. This was reached in the night towards the 31st, after some hard work in the ice.

From Cape Svyatoy Nos to Chaunskaya Guba, August 31–September 5, 1878

The water in the sound was highly mixed with river water, and its temperature was fairly high, even down to about 10 m. The animal life was poor in species, but rich in individuals. The trawl-net also caught pieces of mammoth tusks and a great many pieces of wood, mostly twigs and sticks, which sometimes were a nuisance to those working with the trawls.

They were now favoured with fine weather and mostly ice-free water. The coast was very low and the coastal waters were shallow. The *Vega* steered an east-south-easterly course not very far from the land, which generally was not seen from the ship. Progress was good for two days.

On September 1, though, the ship passed an area with ice. The carpenter Sven Andersson noted in his diary:

“Last Sunday it was beautiful weather, but there was ice all around us and the drinking-water was rationed, a tankard per man.

We had a hard time; first we scrubbed the deck, then we scraped on the sea bottom the whole day. They will not let us be in peace; they got two tubs of clay, we were to sift it, and we made such a mess all over ourselves, and we were busy with it the whole of Sunday.”

On September 2 the temperature was as high as +5.6°C, but in the following night the wind became northerly and the temperature fell to -1°C. In the night towards the 3rd, the drift-ice became dense and the temperature was below freezing. It was snowing at times, and the deck of the ship became covered with snow—as were also Ostrava Medvezh'i, which were reached at midday on the 3rd.

East of the Bear Islands, thick ice had drifted south towards the coast, although a coastal lane survived. The higher animals were few here, but lower ones occurred in greater numbers in the sea. The course was set for the unexplored Wrangel Land, which had been seen from a distance by the Russian Admiral von Wrangel during his expedition of 1821–23. Also natives in the area had seen this land, but not one had set foot on it. In 1867 an American whaler had come only 12 nautical miles from its southern coast.

On the morning of September 4, after hard work against the ice, the *Vega* was blocked by heavy ice cemented together by newly frozen ice between the floes. Nothing remained but to steam south and find the coastal lane of more or less open water near Cape Bol'shoy Baranov. Here the lane was 3–4 nautical miles wide and had depths of 12–14 m. From now on, the ship was to stay near the coast, where fresh and relatively warm water was supplied by the rivers.

On the afternoon of September 5, the *Vega* crossed the mouth of the wide Chaunskaya Guba. The ship was proceeding under both steam and wind. It would be the last time in 1878 that she was under sail. The ice was becoming so dense and the route so winding that the sails could not be used with advantage.

*Chukchis, ice and dark nights:
September 6–28, 1878*

The night towards September 6 was the first when darkness prevented sailing in the ice. Later on, they were to moor the ship to some floe or piece of grounded ice during the darkest hours. Nordenskiöld writes:

“At midnight the sun was now 12° to 13° below the horizon, and the nights were now so dark that we had to put up with lying still for several hours moored to some large grounded ice. Further loss of time was caused by the dense fog, which often prevailed in daytime and forced Captain Palander to proceed with uttermost care. The passage along the north coast of Asia was becoming somewhat monotonous. Even the most eager polar traveller may get tired of ice, shoals and fog and nothing but fog, shoals and ice.”

At dawn on September 6, the mountainous Cape Shelagskiy—to the east of the “Guba”—was sighted. A short distance east of the Cape, the first natives, Chukchis, were met: they came rowing out to the *Vega* in two skin boats. No verbal communication with them was possible, though. Later the ship was to pass one or more native villages each day.

The first meeting with the natives was described by Sven Andersson in his diary for September 6:

“This morning there came 3 boats¹ with people, they were wild and wanted to come aboard, but we had to use a gun and shoot before we could steer away. Their boats were of sealskin; they were some 30 human beings, shaggy and brown and ugly.”

Nordenskiöld depicts the same event:

“Now, however, an agreeable change has set in, as we have at last come into contact with natives.”

They found that the Chukchis did not know a single word in Russian, but a boy among them could count to ten in English. They also knew single words such as “ship”, which proved that they had more contacts with American sailors than with Russian tradesmen.

The 7th, Sven Andersson wrote in his diary:

“We saw so many seals and there were so many people on board, and we almost could not get rid of them, but when the captain blew the steam whistle and let loose the pigs, they became frightened and ran immediately straight down into their boats.”

It should be noted that the relationships between expedition members and natives soon became the very best.

On the same day, Sven Andersson's diary also contains the following lines:

“We are lying at the same ‘piece’ of ice. They are so nasty, those in command, they do nothing but call us names and shout at us: work and hurry up, you devils. We scarcely get time for eating. That's how they are. If I had known as much as I do now, they wouldn't have got me into their clutches.”

The strain was apparently beginning to tell on scientists, officers and men alike.

At Cape Shelagskiy the most difficult part of the

¹ Nordenskiöld and Palander here say 2 boats.

The *Vega* and the *Lena* at Cape Chelyuskin, the northernmost tip of Eurasia at 18.00 h on 19 August 1878. This event was celebrated with wine and toasts, flying flags and a gun salute. (Nordenskiöld, A.E.: *Vegas färd kring Asien och Europa...*)

Two Chukchi sealskin boats approaching the *Vega*. This was the first meeting with the natives. Later the relationship between the expedition members and the Chukchies became quite friendly. (Nordenskiöld, A.E.: *Vegas färd kring Asien och Europa...*)

voyage had begun. The *Vega* would have to pass through dense ice which she struck repeatedly, often gaining only some two ship's lengths between consecutive blows.

On September 7, however, they moved through open ice. The swab and the trawl gave a rich harvest, but in the following night they became surrounded by ice and fog. In the morning they had to moor the ship to a piece of ice near the shore. They were visited by many Chukchis who invited them to call upon their tents, and the offer was accepted.

The shore consisted of a low bank of sand, situated between the sea and a lagoon or fresh-water lake. Beyond these the land rose, becoming lofty hills in the distance. The tents of the Chukchis were generally pitched upon the sandbank.

That same day, they had passed Cape Yakan to the south of Wrangel Island; but on September 8–11 the ice was almost impenetrable. They had to moor the ship to a piece of ice and await movements in the ice-field, which might help them to advance some kilometres or at least a few ship's lengths. They had to keep up the steam in order to be able to take advantage of the slightest improvements in the ice situation.

Fog, shoals and grounded ice were an everyday occurrence. They had to force the ship through the ice in depths of 5 m or less. Often she became "beset" between two pieces of grounded ice and had to be blasted free. At times the tops of the grounded ice had to be cut away in order to make it float.

On September 12 they reached North Cape—now called Cape Schmidta—and passed it, but met with severe ice and had to return. Here they spent six days. The cape consists of two headlands, with a shallow bay in between, where the ship found protection against the ice and, at the same time, became enclosed by it. The *Vega* people got on well with the local Chukchis. The scientists, notably Almquist and Nordqvist, found interest in the ruins—or rather relics—of some old huts. They also carried out excavations for tools left by the legendary people, called Onkilon, who are said to have lived here but were driven away by the Chukchis a few hundred years ago.

The long stay at North Cape may be considered as decisive for the forced wintering of the expedition. It was not until 14h on September 18 that the ice dispersed and the *Vega* could continue her voyage towards Bering Strait, "creeping" along the sandy shore in depths of about 5 m.

The season was well advanced now. Low temperatures could be expected, rendering navigation in ice impossible. The temperature was below freezing. On the evening of the 18th—in darkness—the *Vega* ran aground. She floated again at 04.00h next morning,

undamaged but causing some anxiety. During September 19 the ship advanced about 80 km, but in the following days, September 20–25, she advanced very little in spite of repeated blows against the ice. When possible, the steam launch was set on the water and sent ahead to scout the depth.

Sven Andersson, the carpenter, wrote in his diary on September 22:

"This was the worst Sunday I have had since I came on board. The professor insists that he must go forward, but the others say it is impossible; when Palander says stop, then it is stop, for he understands."

On September 26 they passed Cape Vankarem in fairly open water, thanks to relatively warm water from the river with the same name. In the evening they doubled Cape Onman, to the west of the mouth of Kolyuchinskaya Guba.

Next day, they passed across the mouth of the Guba and, in the evening, anchored some distance to the west of the north-eastern headland of Kolyuchinskaya Guba.

In the evening the steam launch was sent along the coast eastward, to investigate the ice conditions and the depths near the headland. From a nearby hill they got a view of the ice farther east. The reports were optimistic enough: the *Vega* would be able to double the headland, and beyond it stretched an open lead along the coast. The man who had climbed the hill also reported that the natives were apparently having a celebration of some sort on the other side of the hill: there were fires round a camp of tents, and shouts were heard.

It was a wonderful night, with only a light wind or a calm; the temperature was -2°C . In just a few days they would have reached Bering Strait. The men stayed on the western side of the hill, relaxed and optimistic, feeling satisfied. They had turned over in their minds whether they should visit the Chukchis, but had come to the conclusion that they should not. In the words of Nordenskiöld:

"Instead we lingered on the shore. The ship could not weigh anchor this evening in any case. We made an enormous log-fire from driftwood, around which we soon gathered, talking merrily about the remaining part of the voyage in seas where not cold but heat would trouble us, and where our progress would at least not be impeded by ice, permanent fog and unknown shoals. None of us then imagined that, instead of the heat of the tropics, we were to put up with the

winter of a pole of cold, frozen in upon an open roadstead under almost incessant blizzards, and with a temperature which often fell far below the freezing-point of mercury.

The evening was wonderful, the sky was clear, and the air so calm that the flames and smoke from the log-fire rose high into the sky. And the temperature was agreeable and invigorating."

The atmospheric conditions were, in other words, such that ice formation was taking place on the sea. In the drift-ice, the floes were becoming cemented together by this recently formed ice, producing an invincible obstruction to the *Vega*.

Next day, September 28, they doubled the headland to the east of the anchorage. But beyond the headland, the lead along the coast—now covered with ice which had formed during the previous night—became rapidly more shallow as the *Vega* proceeded. Ultimately she had to turn away from the land and make her way among the drift-ice and pieces of grounded ice. The recently formed ice had, however, so effectively cemented the old ice that the *Vega* had to give up trying to force a path. She moored to a piece of grounded ice and awaited a change in the ice situation, which might offer a possibility of reaching open water near Bering Strait.

The experiences of American whalers and sealers indicated that such an outcome seemed highly realistic. Nordenskiöld's and Palander's own experiences from Spitsbergen in 1872–73 were similar. However, during the following days low temperatures prevailed, and the thickness of the "new ice" increased continuously. Yet 4–5 km to the east there was still open water along the coast.

A forced wintering:

September 29, 1878–July 18, 1879

On board the *Vega*, people were hopeful that a way would open towards the east and release them from their prison. As the days passed without any improvement, they began to accept their fate—a forced wintering, which might have been avoided if they had only arrived a few hours earlier at the anchorage by the mouth of Kolyuchinskaya Guba. These hours could have been spared at a number of places during the voyage, not least at North Cape.

The *Vega* would have to spend the winter in an open roadstead, exposed to the drift, pressure, and piling-up of the ice in conditions with strong wind from the north. The ship had, however, been given some protection by mooring her to a piece of grounded ice resting upon the bottom at a depth of 9 1/2 m and 1,400 m from the shore. This ice had run aground

during an interval with a high-water level, and therefore it might come afloat in another situation with high tide. Things could have been worse, as the ship had at first been temporarily moored 200 m nearer the shore, where the bottom was just a few inches below the keel of the *Vega*. During a severe gale in the middle of December, the ice piled up over this grounded ice, which would then have led to a catastrophe to the ship if she had stayed there.

During the initial days of their captivity, the new ice between the ship and the coast was not capable of sustaining the weight of a man. The arrival of the ship had caused great excitement among the Chukchi population, and from the *Vega* they could observe how men, women and children were running up and down along the shore, making attempts to test the treacherous ice and come aboard the ship. Not until October 3 were the first Chukchis able to cross the intervening ice to the ship.

The piece of grounded ice, to which the *Vega* was moored on September 29 and where she remained till the end of her captivity on July 18, 1879, had the dimensions: length 40 m, breadth 25 m, height above the sea surface 6 m, depth below the surface 9.5 m. It protected the ship well throughout her stay, and not until the high summer of 1879 did it melt enough on top to come afloat.

The "harbour" of the *Vega* was located at lat. 67°04'49"N, long. 173°23'02"W, and 1.4 km from the shore. The distance to Cape Dezhnev—or East Cape—was 120 nautical miles.

The coastline consisted of a sandbank, upon which many of the tents of the Chukchis were pitched; beyond it there were lagoons of salt and fresh water. The land itself was a plain, slightly undulating and interspersed with valleys dug out by rivers and brooks. At the time of the arrival of the expedition, the land was not yet snow-covered, though the ground was frozen and covered with rime. The botanist was able to get an idea of the local flora, which was then quite unknown. There was no forest, but short bushes of willow and carpets of crowberry were seen. A few flowering plants, such as lingonberry, cloudberry and dandelion, were collected by Kjellman.

As their captivity began, they were aware of the possibility that the ice might break up and drift northward, setting them free. But soon they understood that they would have to make preparations for the winter.

The snow which collected on the deck had at first been swept away, yet from now on it was left there until it formed a layer of densely packed snow or ice, which gave good heat insulation to the ship. For the same purpose, snow was thrown up along the sides of

The *Vega* in her winter quarters at Pitelkai, in the ice in an open roadstead. From a photo by Louis Palander. This is the only picture of the wintering *Vega*. (Nordenskiöld, A.E.: *Vegas färd kring Asien och Europa...*)

An evening at ease in the gunroom of the *Vega* during the winter of 1878–1879. (Nordenskiöld, A.E.: *Vegas färd kring Asien och Europa...*)

the *Vega*. A staircase of ice led up from the surrounding ice to the gunwale. A large tent, specially constructed, was pitched from the bridge to the bow. The after-deck was thus free and the aft end of the tent was open, giving fresh air access to the interior of the ship. However, drifting snow could then also enter the tent, as it did along the sides and at the bow. Here the blacksmith of the ship had his place of work, and it was also here that visiting Chukchis gathered in daytime throughout the stay of the expedition, and where they were bartered with and fed.

The *Vega* people had passed from one pattern of life into another. The ship's routines, and the scientific work, were in some ways different from those during the voyage in the North-East Passage, although in other ways they were unchanged. Life had become somewhat monotonous in spite of the new surroundings and the new style of existence. This was probably most true for the sailors on board, since many of their tasks were the same as before.

Sven Andersson, the carpenter, notes his specific tasks in his diary. The words often vary little from day to day, until he finally omits to mention his duties:

"October 27, Sunday: It was as usual, sweeping the deck, pumping the ship dry, then it was food. At 9 o'clock it was instruction, at 10 worship, the captain preached the Gospel and the Sermon. All people were there, the professor too. It lasted till 11. Today it has rained. It is not cold, 0 degree, and now when I sit and write it is 12 o'clock.

October 28, Monday: In the morning it was mild weather. It was as usual, sweeping the deck and pumping the ship dry. Then food. When that was done, it was all hands ashore to drag ice and saw up. I and another fellow were to saw up firewood and fetch water. Then I was free till 6, then I had the watch till 8, then I was free for the night."

The *Vega* was indeed leaking badly (see p. 141).

During the winter Kjellman and Stuxberg could not devote themselves to their respective disciplines, botany and zoology. Instead, the scientific work was concentrated upon meteorology, geomagnetism, aurora and tidal observations. As these observations went on day and night, many persons were involved here: in the winter they numbered 11, of whom 9 were scientists or officers, the remaining two being the 2nd engineer O. Nordström and the seaman C. Lundgren.

It was impossible to get a sufficiently firm and stationary foundation on the ice for the geomagnetic recording instruments. A geomagnetic observatory

had to be built on the shore, 1400 m from the ship. Since the observers could easily handle the meteorological observations as well, these and geomagnetic observations were carried out at this place. The observatory was necessarily made from nonmagnetic material. Ice blocks were chosen for the walls, and boards for the roof. As drifting snow eventually began to enter through various openings, the whole building was covered with a sail.

The size of the observatory was 3.6 x 3.0 m. Palander was the master-builder. It was commodious, but cold, as no suitable heating arrangements were possible; a stove had to be of a nonmagnetic material, which could not be procured here.

The geomagnetic variation instruments were mounted upon heavy wooden blocks, whose lower parts had been placed in pits in the frozen ground, which were then filled with a mixture of sand and water. Each observer had watches of six hours, five being spent in the observatory.

Walking to and from the observatory would have involved a very grave risk in darkness and in situations with low visibility, if the "road" had not been marked. For this purpose, ice poles were sawn up and placed along the route 12 m apart, with sounding-lines stretched between them.

The observatory aroused the interest and wonder of the Chukchis. They called the building *Tintinjaranga*, which means "ice-house", a name that was also adopted by the *Vega* people.

The meteorological observations were at first carried out six times daily, i.e. every four hours. This occurred near the ship before the observatory was ready to be used, on November 1. From then until April 1, meteorological as well as geomagnetic observations were now carried out every hour. On April 1 the ice-house was abandoned, and the observations were again conducted every four hours near the ship.

The observation activity was an important part of the fixed routines during the wintering. It was a lonely routine and by no means a warm one, especially as the roadstead of the *Vega* was both windy and cold. Nor was the work without danger in conditions of strong wind, drifting snow and reduced visibility. But the observation duties were refreshing and full of interest.

Nordenskiöld was responsible for the observations of aurora displays, which here took the form of one or more arcs, fairly near the horizon to the NNE. There they remained more or less unchanged for hours, and from one day to the next.

The winter quarters of the *Vega* were situated in the marginal zone of the mighty winter anticyclone of Asia. The area was swept by cold winds at low levels, nearly always from NW-NNW. Coldest, though,

were the winds from S–SW, sent by the extremely cold regions in the inner parts of north-east Siberia. To judge from the cloud-drift, the winds in somewhat higher layers were south-easterly. This flow was relatively warm, and possibly the air had a higher temperature due to foehn effects.

Monthly mean temperatures, and the highest and the lowest temperatures (°C) observed in respective months during October 1878–June 1879, are given below. Again, the geographical coordinates of *Vega*'s winter quarters were 67°05'N, long. 173°23'W.

	1878			1879	
	Oct.	Nov.	Dec.	Jan.	Feb.
Mean	-5.2	-16.6	-22.8	-25.1	-25.1
Max.	+0.8	-6.3	+1.2	-4.1	+0.2
Min.	-20.8	-27.2	-37.1	-46.1	-44.2

	1879			
	March	April	May	June
Mean	-21.6	-18.9	-6.8	-0.6
Max.	-4.2	-4.6	+1.8	+6.8
Min.	-39.8	-38.0	-26.8	-14.3

The *Vega* was heated with the help of four iron stoves. In the living quarters of the ship, the temperature was generally +12° to +17°, but in the night it sometimes became +5° to +10° and the bulkhead might then become frosted.

The combination of fresh to strong winds with low temperature called for extra precautionary measures, especially when visibility was very low—as was generally the case due to the drifting snow in situations with strong wind. The meteorological/geomagnetic observers got their fair share of these adverse weather conditions.

Tidal observations were started at the beginning of December. A home-made apparatus was mounted on board the *Vega*, and readings were made every hour. The tides were low, the difference between ebb and flow being only 15–20 cm at spring tide.

At this latitude, 67° 05' N, on the darkest day of the year—December 22—the sun was still partly above the horizon, thanks to the atmospheric refraction, and it was so light that one could easily find one's way in the surroundings between 9 and 15 o'clock without the help of a lamp.

Two holes in the ice were kept open during the wintering: one was a safeguard against fire, and the other was used for the tidal observations.

A gale in the night towards December 15 gave rise to enormous movements within the ice, and the situation of the *Vega* in the open roadstead became precarious. Next time in a similar situation it might

happen that the *Vega* would become crushed with all stores of provisions. For the sake of safety, a depot was therefore established on the shore—containing provisions, guns and ammunition for 30 men during 100 days. The depot was not guarded, but no attempts were made by the native population to get hold of these riches.

Great care had been exercised to obtain the very best diet. Here the expedition could benefit from the experiences of the Spitsbergen venture of 1872–73. Among the more substantial components may be mentioned: preserved and fresh potatoes, sauerkraut, preserved vegetables, rice, barley-grain, red beans, macaroni, preserved onions, bacon, dried fish, meat extract, and dried fruit. In addition, snaps or rum was served for dinner.

To break the monotony of life, the *Vega* people made a point of celebrating certain red-letter days, notably the birthdays of expedition members and of sovereigns in their "homelands." Naturally, Christmas and New Year received ample attention. Lectures on diverse subjects were held by the experts on board, but there were no theatrical or musical performances.

By barter with the Chukchis, it was possible to serve fresh fish once a week during certain periods of the winter. Hunting, though, contributed nothing substantial.

Great care was also devoted to serving antiscorbutics. Nordenskiöld had intended to bring a large amount of cloudberry "porridge", but the harvest of cloudberry failed in Scandinavia in the autumn of 1877, and sufficient amounts could not be procured, so cloudberry had to be eked out by cranberry juice.

The doctor reported no case of scurvy, or of any other serious diseases. There did occur, however, cases of gastric catarrh and mild cases of pneumonia. The good state of health may also be ascribed to exercise in the fresh air, both during routine duties and in connection with excursions. Great attention, too, was paid to upholding cleanliness. In the beginning of the winter there were slight cases of frostbite, mainly due to inexperience.

The men's clothing was good. In summary, it consisted of thick woolen underwear, a blouse of sailcloth, and high roomy boots of sailcloth with leather soles. For insulation, sedge grass (*Carex vesicaria* L.) was used. The foot was dressed in one or two pairs of socks, then wrapped in a felt cloth. The sailcloth blouse could be supplemented with a loose hood of felt, the combination making what we nowadays call a windproof.

These special hoods had been purchased in Russia, where they were used by the military forces. On the

Tintinjaranga (the ice-house), the observatory on the beach at Pitlekai during the winter of 1878–1879. (Nordenskiöld, A.E.: *Vegas färd kring Asien och Europa...*)

The dress worn by the expedition members of the *Vega* during the winter (left). (Nordenskiöld, A.E.: *Vegas färd kring Asien och Europa...*)

Young female Chukchi beauty at the wintering site. (A.E. Nordenskiöld's Photographic Collection, Royal Swedish Academy of Sciences.)

hands were worn mittens of sealskin and chamois, lined inside with sheepskin and bordered with fur round the wrist. In late winter and spring, coloured spectacles were worn to shade the eyes.

The coast where the expedition wintered was desolate, low and exposed to the sea. Beyond the sandbank, as already noted, were lagoons and lakes with salt or fresh water; inland the tundra rose slowly. The sandbank consisted of fine dry sand; within and atop it, there was a great amount of whale bones. Below these lay coarse-grained sand, frozen and devoid of whale-bones. The bones were not relics of whale hunting, but had originated at a time when the beach was 20–30 m lower in relation to the sea surface. In other words, they were subfossils.

The winter quarters of the *Vega* were near a small Chukchi village called Pitleki. The sites or tent villages of the Chukchis were scattered along the eastern part of the North-East Passage, from Cape Shelagskoy (long. 172°E) in the west to the Bering Strait (long. 170°W) in the east. The coastal Chukchis live by hunting seals, whales and walrus. Inland are the nomadic Chukchis who keep reindeer. The total number of the Chukchis was estimated by the *Vega* people as about 3000. The *Vega* people were on excellent footing with the Chukchis, and were also able to help them during the winter when food became scarce.

The two groups procured various items and food from each other by bartering. In this way the expedition obtained a good ethnographic collection. The ship was visited by some 20–30 Chukchis each day. Nordqvist learned their language and produced a small dictionary, which proved to be of great help in the intercourse between foreigners and natives. The *Vega* people made excursions with the Chukchis, visited their homes, and gradually came to know their society and way of life quite closely. No long sledge journeys were made, mainly because there was anxiety lest the ice might break up during the absence of a field party.

During the winter open water occurred off the coast, marked by a dark water-sky among the clouds, but the open area never reached the ship. In January the Chukchis reported that open water used to form and remain for some time, yet the ice bonds of the ship persisted.

The Chukchis suffered from a lack of food, and the people in the nearest village, Pitleki, moved eastward. Food was also supplied from the ship.

It seemed as if the northwind and the cold would never end. Until June 15, the ice thickness was practically constant at 1.5 m. The sun climbed in the sky and the temperature rose, of course, but—excepting a

few days with temperatures above 0°—it was well below freezing till the middle of June.

Then, at last, a marked rise in temperature occurred, resulting in rapid melting and evaporation of the snow. At the end of June the ground was almost bare; the vegetation grew rapidly and migratory birds appeared.

The Vega is freed.

The voyage homeward

Around June 20, water was collecting on the ice, and communication with the shore became difficult. This especially troubled the botanist and the zoologist, who were now finding objects of interest ashore. In the first days of July, the ground was so free of snow that the shore revealed its ugliness, being littered with debris from hundreds of years of Chukchi residence.

On July 17 the fast-ice came loose from the shore, and a wide area of open water was formed. But the pieces of grounded ice remained, and so did the fast-ice between them. On July 18, at dinner-time on the ship, the “boarders” noticed a slight rocking motion: the *Vega* was free. Two hours later, at 15h30, she hoisted flags and proceeded on her route along the North-East Passage, driven forward by steam and sails.

East Cape (Cape Dezhnev) was passed on the morning of July 20, and at 11.00h the *Vega* was in the middle of the Bering Strait. The North-East Passage was completed. This marked the fulfilment of a dream ever since 1553, when Sir Hugh Willoughby started the long series of expeditions in pursuit of this great goal of polar exploration. The rest of the voyage of the *Vega* may now be told in brief.

From July 21 until August 31, the ship visited a number of places in the Bering Sea area: St. Lawrence Bay on the Siberian side, Port Clarence opposite on the Alaskan side, and next—on the Siberian side—Konyam Bay, St. Lawrence Island and Bering Island.

On August 19 the ship left Bering Island. Arriving on September 2 in Yokohama, Japan, she stayed until October 11, when she started her homeward voyage. This interval was filled with parties, festivities, excursions and sightseeing, arranged for the scientific staff and the officers of the ship. Here it is of some interest to quote from the diary of Sven Andersson, the carpenter:

“September 12 [i.e. 10 days after the expedition arrived in Yokohama]: ...Believe me, Mari, we don’t get any money, none of us, we are not allowed to go ashore, none of us, but *they* are there every day, the officers.

September 18: This afternoon we were free, all of us, because our Minister [of Naval Affairs,

Simplified version of *Vega's* voyage in 1878–1879, which was sent with a report by Louis Palander, commander of the *Vega*, to the *Tidskrift i Sjöväsendet* from Yokohama, Japan.

The expedition ship *Vega* – still a whaler in her general arrangements.

From above: section through the ship, interior fittings below deck, plan of upper deck.

Below deck: the plan of the interior fittings in the stern show the cabins of the scientific members and of the commander of the ship. These cabins surround the gunroom. (Nordenskiöld, A.E.: *Vegas färd kring Asien och Europa...*)

who was Fredrik Vilhelm von Otter, the commander of the *Sofia* in 1868; see p. 53] had telegraphed to the captain that we should be free, because he [von Otter] invited us to dinner.

September 21 (Sunday): The men have been ashore, but I and two others have not been allowed to go, as we had been hovering about in the dock without permission.... They have not said a friendly word to any man yet, imagine that."

The voyage home was characterized by a succession of celebrations and parties, which appear highly unreal in the light of present-day conditions. This part of the voyage of the *Vega* is, however, outside the scope of our narrative.

The voyage ended on April 24, 1880, beneath the Royal Palace in Stockholm, where King Oscar II gave a reception and a dinner. *Vega Day*, the 24th of April, has since been the festival day of the Swedish Society of Anthropology and Geography (SSAG), when the *Vega Medal* is presented to prominent figures in the geographical sciences.

Since April 24, 1930, the voyage of the *Vega* is also commemorated by the *Nordenskiöld Monument* outside the Swedish Museum of Natural History in the north of Stockholm and—not least—by the *Vega Fund* from which workers in geography and related sciences can obtain grants for their research.

Louis Palander, the commander of the Vega

Already before his return home to Sweden, Palander obtained the rank of captain in the Swedish Navy; he also acquired Swedish nobility with the name of *Palander af Vega*. He became aide-de-camp to King Oscar II, and the Swedish Parliament granted him a national reward of 4000 Sw.Cr. per year.

According to the obituary written by Admiral Charles de Champs in "Tidskrift i Sjöväsendet", 1921:

"When the latter point was dealt with in the Second Chamber of the Swedish Parliament, someone maintained the opinion that Palander could not be given as much credit for the happy outcome of the daring voyage as Nordenskiöld, who had planned the enterprise, for which reason Palander should not be given as great a reward as the 'actual leader' of the voyage.

It was on that occasion that Mr. Liss Olof Larsson stood up in the chamber and declared... 'that Nordenskiöld and I would probably not have been able to accomplish that feat, but certainly Palander and I would have.'"

Larsson was an MP of ready wit in the debates, and Palander got his reward.

Palander's origins were in Finland. His grandfather, who was born there, became a medical officer in the Swedish Navy, and Palander's father was a naval officer stationed at Karlskrona, Sweden. Louis Palander began his career as a naval cadet when fourteen years of age. Thenceforth he was attached to the Navy, except during 1865–66 when he sailed in the merchant service in South and North American waters.

Palander was made a rear admiral in 1900, a vice admiral in 1903, and an admiral in 1910. He was appointed to the post of Minister of Naval Affairs in 1901–05. His predecessor was his intrepid chief during the Spitsbergen expedition with the *Sofia* in 1868, F.W. von Otter.

Palander was a member of the following arctic expeditions:

1868 Second-in-command of the *Sofia* during the Spitsbergen expedition for attaining a high northerly latitude (see Chapt. 9).

1872–73 Second-in-command on the Spitsbergen expedition with the *Polhem*, wintering at Mosselbukta as well as commander of the *Polhem* (Chapt. 13).

1878–80 Commander of the *Vega* during her voyage along the North-East Passage and round Eurasia.

1882 Commander of the flotilla of two gunboats, the *Urd* and the *Verdande*, which carried the Swedish Polar Year expedition to Spitsbergen (Chapt. 18).

In 1913–14 Palander was chairman of the Swedish Antarctic Committee, which was planning an antarctic expedition in co-operation with Great Britain. Its secretary was the geologist Johan Gunnar Andersson. The plans had to be given up because of the outbreak of World War I in 1914 (see p. 376).

THE VOYAGES OF THE FRASER AND THE EXPRESS AFTER PARTING WITH THE VEGA AND THE LENA

On August 9, 1878, the steamer *Fraser* and the sailing vessel *Express* left Dickson Harbour, while the *Vega* and the *Lena* proceeded eastward along the North-East Passage. The *Fraser* towed the *Express* up the Yenisey estuary. On August 11 the two ships reached Korepovskoy, where in 1876 the *Ymer* had unloaded the wares that later seemed to have disappeared (see p. 109).

Feodor, the Cossack who had assisted Nordenskiöld in 1875 and 1876, was engaged as a pilot, and proved

The route between the *Vega* and the observatory on the beach at Piteleikaj was marked with ice-poles connected with sounding-lines as a precautionary measure in situations with strong wind and low visibility. In the polar regions the Aurora often takes on the form of a fairly flat arc (above). (Nordenskiöld, A.E.: *Vegas färd kring Asien och Europa...*)

The *Vega* arrived in Stockholm on 24 April 1880, the Vega Day, and anchored beneath the Royal Palace where King Oscar II gave a reception and a dinner (above).

(F. Goldberg Collection.)

Soviet exploitation in the North-East Passage up to and soon after World War II. (Armstrong, T.: *The Northern Sea Route*, 1952)

to be as careless as ever. However, once a fisherman had been engaged for this purpose, the ships passed rapidly among the Briochovsky Islands in depths varying between 30 and 50 m. On August 15 they anchored in a good harbour at Saustrovskoy at a simovie, where the wares were to be unloaded and new cargo was to be taken aboard. This place was situated at the forest-line. A jetty was built next day; the unloading started on the 17th and was finished on the 20th. The wares that had been brought to Siberia were nails, horseshoes, horseshoe-nails, bar iron, tobacco, salt, petroleum, and an iron barge in pieces with accessories such as anchors.

The *Fraser* now went upstream to Dudino in order to load wares—tallow, wheat, rye and oats—to be carried on the home voyage. On September 2 the ship went back to Saostrovskoy, where the *Express* had meanwhile received her own cargo.

On September 7, the *Fraser* and *Express* started the return voyage down the river. At Tolstonos they met the steamer *Moskwa* of Bremen, Germany, with the shipwrecked crew of the Norwegian steamer *Zaritzka* on board. The latter had run aground in the mouth of the Yenisey and been deserted by her crew. A few days later, when the *Fraser* found the *Zaritzka*, it was found possible to pump her dry and get her afloat, repair the engine and take her to Norway.

The three ships then crossed the Kara Sea, passed through Matochkin Shar and reached Hammerfest on September 26, with full cargo—and an extra ship, also fully loaded. These cargoes were the first to be shipped between the Yenisey and Europe.

We shall later have occasion to make the acquaintance of the commander of the *Fraser*, Emil Nilsson (see pp. 142, 152 and 264).

THE VOYAGE OF THE LENA AFTER PARTING WITH THE VEGA

The deltaland of the Lena River is vast and contains several branches. A ship passing through this region needs a pilot on board to show the way, and finds it essential to choose the right river mouth when approaching from the sea.

Once the *Lena* and *Vega* had separated on the night of August 27/28, the *Lena* headed towards the north-easternmost point of the Lena Delta, where a sea-mark should be found according to previous arrangements with the pilot. But no pilot was there, nor any flag-pole.

The *Lena* therefore proceeded 40 km westward along the delta, and back again—but in vain. She then steered east, with no better result. Captain Johannesen decided to choose the easternmost mouth of the river, and from here he was able to continue

upstream without the guidance of a pilot.

The maps of the area were 140 years old, and fairly useless because of the many changes which had taken place in the river-beds of the delta. The *Lena* ran aground, and was visited by Tungus natives. In vain Captain Johannesen tried to make them understand that he was badly in need of a pilot. Next day, September 4, the *Lena* got afloat and could start her long voyage up the river. On September 7 they had passed through the delta and were heading along the main river.

On the 8th they reached the first settlement, Tas-Ary, but not even here were they able to make themselves understood by the Tunguses. When they came to the next settlement, Bulun, on the following day, they intended to just pass by, but the steamer was greeted with shots of delight from all available guns ashore—so the *Lena* anchored. Two public servants and a priest came aboard. It was remarkable to witness the enthusiasm which was shown by all at seeing a ship arrive from the north and the outside world.

The *Lena* continued her voyage on the 9th, and reached Yakutsk on September 21, 1878. She was the first ship to come as far as the centre of Siberia from the ocean. The *Lena* was laid up in winter quarters at Yakutsk. She was destined to serve in the river traffic along the Lena for many years to come (see p. 257). Her commander, Hans Christian Johannesen, stayed with her until 1881, when he went overland home to Norway. We shall meet him, too, at a later stage (see p. 306).

The four ships of the Nordenskiöld flotilla, *Vega*, *Fraser*, *Express* and *Lena*, which had left Sweden and Norway in the summer of 1878, were thus able to accomplish their missions. They and their crews had reached their destinations and delivered their wares—and they had opened the sea routes of the North-East Passage.

THE ULTIMATE FATE OF THE VEGA

The *Vega* was to all appearances a strong ship, and she had been handled with utmost care by her commander, Lieutenant Louis Palander, during her voyage along the North-East Passage. The expedition of 1878–80 was a great and a daring feat.

After the expedition it was found that the voyage had probably been an even greater challenge than anybody had imagined. When the ship was taken to Göteborg for a careful overhaul, before being delivered to the previous owners, she proved to have one very serious weakness in her construction: the keel was not of oak but of beech, which is a much weaker kind of wood. The overhaul before the start of the expedition had failed to disclose this weakness.

Moreover, the keel was found to be seriously affected by shipworms. The *Vega* had thus begun her voyage with a serious handicap. This fact explained the leak which required the ship to be pumped dry every day (compare p. 133).

After 1880 the *Vega* was used by her owners, Aktiebolaget Ishavet of Göteborg, for whaling and sealing operations, until 1901 when she was sold to a shipping company at Sandefjord, Norway, and then to a shipping company at Dundee, Scotland.

In April 1903, the *Vega* left her home port in order to hunt whales in the north of Baffin Bay. On the way she visited Upernavik in north-western Greenland, and on May 29 she proceeded into Melville Bay. In the night towards May 31, a severe southerly gale was raging. The *Vega* was caught between the fast-ice along the coast and the drift-ice which was approaching from the sea. The position of the ship was then 74°23'N, 58°45'W, i.e. not far from Devil's Thumb.

All attempts to free the ship were in vain. On May 31, extremely thick blocks of ice were pressed against the ship's planking on the port side, which burst with a terrific crash. The boats were lowered onto the ice and necessary provisions were loaded in them. Worst of all was that the forecastle of the crew had been destroyed, and the men had come down upon the ice more or less half-dressed.

The nearest settlement was Upernavik 200 km to the south. The men had insufficient clothing, no equipment for sleeping, and no tents. They would have to be on the move all the time to avoid frostbite. On board whalers or sealers in those days, common precautionary measures were to let every man keep some food and extra clothes in a bundle beside his bunk. Apparently these measures had not been taken in the present case.

The boats were dragged over the ice, 7–8 men being assigned to each boat—the total number of men being 44. After proceeding in this way for a few days, they were attacked by a severe gale, but they found shelter by turning the boats upside-down. Some of the men fell asleep and woke up with frostbite; the more experienced men kept moving their limbs, and escaped unharmed from the gale.

They reached open water and their struggle diminished, but they were driven into the open sea by the currents. Yet finally the wind became northerly and helped them to reach Upernavik, one boat arriving on June 5, the remaining ones on the 7th.

All men were now in a miserable state, but on June 13 they were able to continue their boat tour. Five days later they reached Ritenbenk to the west of Disko Island, from where they were carried home on board the Norwegian steamer *Nor*.

The *Vega* had endured a hard and toilsome life, reaching 30 years of age before her unexpected end. Her greatest achievement was the voyage along the North-East Passage and round the continent of Eurasia, a feat which will preserve her memory for many years to come.

THE VOYAGE AND SHIPWRECK OF THE OSCAR DICKSON, 1880–1881

The pioneering voyages to the Yenisey

The North-East Passage, notably its western part, was thus already opened for commercial traffic around 1880. Fortunately the ice conditions did not seem to preclude fairly regular traffic. But for greater safety, hydrographical surveys and reliable sea-charts would be needed. Sea-marks and lighthouses had to be set up and, last but not least, harbours had to be built for trans-shipments between ocean-going and river craft. A special fleet of river craft would also be needed and, in the long run, icebreakers.

Two rich merchants and owners of gold mines were highly interested in the new transport system which was being developed in the Siberian Arctic: Michael Konstantinovich Sidorov, and Alexander Mikhoylovich Sibiryakov (1849–1933).

The British sea-captain Joseph Wiggins (1832–1905) and Adolf Erik Nordenskiöld were pioneers in the field. Wiggins was involved in the sea traffic between the Atlantic Ocean and the Yenisey and Ob Rivers from 1874 until 1905. Nordenskiöld was the first to reach the Yenisey on his expedition with the *Pröven* in 1875. He was also the first to pass through the entire length of the North-East Passage with the *Vega* in 1878–79.

In addition, as we have seen, three commercial voyages were associated with the voyage of the *Vega*: those of the *Fraser* and the *Express* from Europe to the Yenisey and back, and the voyage of the *Lena* from Europe to the Lena and upstream to Yakutsk. After these voyages, Nordenskiöld was no longer practically involved in the development of the sea traffic along the North-East Passage.

There was, however, one Siberian enterprise where Swedish sailors and Swedish shipbuilding industries were involved: the voyage of the steamship *Oscar Dickson* in 1880–81. An iron steamer, the *Oscar Dickson* was built in 1880 at Kockum Engineering Works, Malmö. She had been ordered by Alexander Sibiryakov, who intended to use her for the river traffic along the Yenisey, and for voyages between this river and Europe.

The ship was therefore given properties adapted to ocean-going as well as river traffic. She was flat-bottomed, and her draught when fully loaded was

3.3–3.6 m. She could carry 500 tons, and had a 75-horsepower engine. With full load she was able to reach 10 knots; her mean speed was 8.5 knots. In short, the *Oscar Dickson* was a strong ship, with regard to both power and hull; her steel plating, for instance, was 3/4 inch thick. Her length was 48m and her beam 7.2 m.

A hazardous passage in the ice of the Kara Sea

Delivered at Malmö on August 1, 1880, the ship was immediately taken to Göteborg to be equipped. Here her crew was signed on and her cargo loaded. It was late in the season and the work went on day and night.

The cargo consisted of parts of two paddle-steamers. One of these belonged to Sibiriyakov, and was intended for the traffic between the Yenisey and Lake Baikal along the Angara River. The other steamer, a mere hull, was to be transported to Irkutsk and was intended for the traffic on Lake Baikal. These two steamers had been constructed at Motala, Sweden, and their final assembly was to be carried out in Siberia.

Commander of the *Oscar Dickson* was Captain Emil Nilsson (1850–1921), who in 1878 had commanded the *Fraser* in connection with the *Vega* expedition. He was a good seaman and would later command two other Swedish expedition ships, the *Sofia* in 1883 and the *Antarctic* in 1898 (see pp. 152, 264).

With the ship went W. Fraser, an engineer of Motala Engineering Works. He and another man from the same works were to lead the assembly of the two paddle-steamers in Yeniseysk. There were also three Norwegian sealers to serve as arctic experts; the crew was otherwise Swedish. And finally, on the outward voyage Sibiriyakov joined the expedition at Hammerfest—together with K. Lönnholm, engineer and interpreter. The ship had provisions for 17 men during one year, which was sufficient even for a wintering and a slight increase of the number of men on board.

The *Oscar Dickson* left Göteborg on August 9, 1880. She was heavily loaded and steered badly, according to the Norwegian sealer P. Johnsen. But in other respects she behaved well in the heavy sea that was met with after she left Göteborg.

The *Oscar Dickson* had started upon a voyage which all on board expected to be of a routine nature. However, the voyage was doomed to become one long adventure—and, to Sibiriyakov, a great economic loss—although there were no losses of lives. The reasons for the difficulties were several.

The start had taken place so late in the season that there was little or no reserve of time. The ship was overloaded. The owner of the ship—and of the main

part of the cargo—was on board. Apparently the commander of the ship was not outstanding in regard to her navigation and safety.

The voyage was narrated by four authors in the journal *Ymer* of the Swedish Society of Anthropology and Geography. They were A. Sibiriyakov, the ship's owner; E. Nilson, her commander; W. Fraser, engineer and representative of Motala Engineering Works; and P. Johnsen, Norwegian sealer and expert on polar navigation.

Their reports cover different parts of the later stages of the expedition; otherwise the authors deal with the same sequence of events, but from different points of view. The article by Johnsen contains several critical remarks concerning certain stages of the voyage. It should be noted that he possessed considerable experience from the Kara Sea; among other things he had taken part in the voyage of the *Vega* along the North-East Passage.

The *Oscar Dickson* arrived in Hammerfest on August 21, and left the same day. Sibiriyakov and Lönnholm joined the expedition there. After bunkering at Vardö, the course was set for Yugorskiy Shar, and in the night towards August 25 they anchored off the Samoyed village of Khabarova, where they stayed for a few hours before proceeding eastward. However, once past the eastern entrance to the sound, they were met with great masses of ice, which the ship was unable to penetrate.

Consequently they steered into Kara Bay, hoping to find fairly open water on the way to the Yenisey. But even here pack-ice blocked the way. A new attempt to proceed eastward was made off the Kara Gate, with the same result. In the dark of the night they had to pass westward through this treacherous sound, with its many underwater rocks and shoals.

The ship continued north along the western coast of Novaya Zemlya, in an attempt to pass through Matochkin Shar. But off the eastern entrance to this sound—in the Kara Sea—ice was again met with. Unhappily, it was fast and dense along the east coast of Novaya Zemlya.

On August 31 they were back in Matochkin Shar, and anchored near the eastern entrance during a severe gale with hurricane winds. The gale went on blowing from the north-west for three days. They were hoping that the winds would break up the ice and make it move away from the east coast.

A passage to the Yenisey might be found by circumventing the ice to the north. So for the fourth time, the *Oscar Dickson* steered into the Kara Sea. The ice was soon encountered, but it was possible to steer northward in fairly open water until Cape Middendorff (lat. 76°N) was reached. Here the ice came close upon the

land. It was now fairly cold, and new ice was forming on the water.

Once again the ship returned to Matochkin Shar, hindered in her progress by the newly formed ice. The ship was back in the sound on the 5th, but in the evening she ran aground at full speed. Not until the 7th did they get her afloat, after much hard work to move the coal ashore. Still, the ship had not suffered any damage.

On August 8 they proceeded westward through the sound, and anchored in the evening near its western entrance. There they found a message from two other seafaring men, stating that these had been prevented by ice from passing into the Kara Sea and were continuing north of Novaya Zemlya, in order to reach the Yenisey by that route.

Instead, the *Oscar Dickson* headed south along the west coast of Novaya Zemlya towards the Yugorskiy Shar, to try her luck once again in the south of the Kara Sea. Near the Yugorskiy Shar they met the schooner *Nordland* of Tromsø, under Captain Magnus Arnesen (see p. 310). Sibiryakov had hired her for carrying coal, salt and iron-wares for the Yenisey. She had been hindered by ice and was now on her way to Arkhangelsk in order to reload her cargo there, according to previous orders. She was now towed by the *Oscar Dickson* to Chabarova at the western entrance to the sound, where the two ships anchored on the evening of September 11. This was the third time for the *Oscar Dickson*, while the *Nordland* had just come from the south of Kara Bay, where ice had blocked her way.

The two ships stayed at Chaborova for eight days, during 12-19 September, anxiously awaiting westerly winds that might drift the ice away from the western coasts of the Kara Sea, and thus open a way to the Yenisey via Kara Bay and along the Yamal coast. Meanwhile coal was transferred from the *Nordland* to the *Oscar Dickson*, which had consumed much coal in her futile attempts to find a passage more or less free of ice.

On the 19th, the steamer *Neptun* arrived from the river Ob. They were informed by her captain that the ice conditions in Kara Bay were now favourable. Next morning the *Oscar Dickson*, towing the *Nordland*, proceeded eastward through the sound and then along a north-easterly course across the Kara Sea. Only light ice was met with and the outlook seemed bright. However, northerly cold winds had started to blow with temperatures falling to -7 or -8°C. When they had come off Ostrov Belyy the whole sea was covered with newly formed ice. It did not block the way, but soon the old drift-ice appeared in great masses.

The captain steered a course south of east, hoping that the warm water from the Ob and Yenisey would keep the drift-ice away, so that it would be possible to enter the Yenisey estuary. The ice was, however, now close upon land at the western land tongue of the river mouth. So the two ships went north hoping to find open lanes leading eastward. The formation of new ice between the floes of the drift-ice went on, and in the night the two ships had to move around in order to avoid becoming "beset".

They decided to enter the drift-ice after it had become light, and try to find an opening eastwards. As they were near the Yenisey, open water should also be close at hand. If this plan failed, they intended to try reaching the river Ob.

At dawn on the 24th, they found themselves surrounded by drift-ice in all directions, so they steered south and east. After a few hours of hard work against the ice, land appeared to the west, which was taken to be the western tongue of land at the river mouth, Matte Sale. Soon land also appeared to the east. It was taken to be Sibiryakov Island. If that were correct, the worst should by now be over.

But when they had passed through the old drift-ice, new ice masses came drifting, and these were impossible to handle. They tried to navigate through openings in the ice and set courses between east and south. The depth was low and variable, between less than 5 and as much as 12 m. All day they worked hard in the ice, and towards evening they entered very shallow water. Attempts were made to leave the area, yet the ice pressed the ships up onto the shoal, where they remained in spite of all efforts to get afloat.

Prisoners in the ice

The captain of the *Oscar Dickson* was by now of the opinion that they would have to winter in the ice at this place. It would be necessary to let the crews of both ships spend the winter on board the *Nordland*, which was a strong wooden ship, whereas the *Oscar Dickson* was of iron. The hold of the *Nordland* was fitted up to receive the additional men.

While this work was going on, the drift of the ice stopped. There was now fast-ice between the ships and the land that could be discerned from the mast-head.

On October 2, Captain Nilsson and six men left the ship. They reached the shore, where they set up a mark and placed a report concerning the freeze-up of the ships. They also met a Samoyed, and explained the situation to him in sign-language. They wanted him to visit the ships, but he dared not travel so far across the ice with his reindeer, having no food for them. It was later learned that he was rich, owning some 1500

reindeer. Captain Nilsson and his men returned to the ships rather exhausted.

A few days later, a second party left the ships with the intention of contacting the inhabitants of the tundra, and getting them to send on letters with information on the present situation. But this expedition failed, as no Samoyeds were found—although traces of many sledges were seen in the snow around the mark which had been erected a few days earlier. It was thus deemed necessary to dispatch a larger party to the nearest inhabited place, which was Golchika at the Yenisey.

October 12 (the 10th according to Fraser) was to have been the date of departure, but on this day an extremely severe gale broke out, with the wind at times reaching hurricane force. The water level rose 9 feet, the ice was broken up and the ships came adrift, all bad enough—but worse because the engine of the *Oscar Dickson* had been put in order for the winter. Moreover, they had now begun to transfer provisions from the steamer to the sailing vessel; many of the provisions had even been stored temporarily on the ice, when the wind suddenly increased.

Both ships were drifting disabled, and were soon separated in the snow-fog. Meanwhile the engine of the steamer was put in order, and luck was with the ship, as she now drifted into deeper waters where she could not be pressed down by the ice. When darkness fell, they were able to find protection behind a piece of grounded ice. The boats were prepared and provisions were transferred to the grounded ice as a precautionary measure.

It was a night full of anxiety, but when dawn came at last, they discovered to their surprise that the *Nordland* was quite near. Next morning it was decided that the crew of the schooner should be transferred to the steamer, as there were not enough provisions on board the former. From now on, there were 27 men on board the *Oscar Dickson*. It should be recalled that the ship had been provisioned for only 17 men for one year.

The drift-ice had gathered round the steamer. The captain decided to have it cut away in order to liberate the ship. The aim was to reach the Yenisey or, at any rate, find a more suitable place for wintering. After one day and a half of hard work from all men, the ship was set free, but the *Nordland* was deserted. In her attempt to reach the Yenisey, the steamer soon came into very shallow waters, though she avoided running aground.

Now it was decided to proceed into Gyda Bay, between the estuaries of the Yenisey and Ob, in hopes of meeting Samoyeds. After four days of battle with the ice, they moored the ship along the fast-ice about

5 km from the western land tongue. The position was determined as 72°12'N, 77°E, and the depth was 5 m. The long narrow inlet, called Gyda Bay on the maps, did not exist—as the captain was later told by the Samoyeds.

The captain, accompanied by a few men, visited the shore in order to meet Samoyeds. This time (October 20 according to Fraser) he had better luck. The Samoyeds had come to the shore to collect driftwood for their planned journey south. They accompanied the ship's party aboard and were well treated there. The problem was to make them understand that a few people from the ship wished to come with them. There existed, though, no common language for such a discussion.

However, Sibiryakov believed that the Samoyeds might take three men and let them come to some small "village", where means of conveyance might be obtained for continuing the journey. Sibiryakov was firmly determined to go himself, and for companions he chose Fraser and Lönnholm, the engineers from Motala Workshop. They were given the most essential equipment and provisions from the ship's stores. The Samoyeds seemed to warn them against going, but the decision was firm. It also involved organizing relief expeditions to the remaining 24 men.

A winter sledge tour over the tundra

The travelling party consisted of about 20 men, women and children, as well as the three men from the ship. The caravan included 300–400 reindeer and some dogs, besides three tents among the equipment. The journey started on October 22. Progress was very slow, due to the great number of reindeer and to the few hours with daylight. Breaking camp in the morning lasted 3–4 hours, and the start did not take place until midday.

The guide had three reindeer in front of his sledge; otherwise only two reindeer were harnessed to each sledge. Sometimes about ten sledges were tied together in a file, so that only one man was needed to drive them all. Only 12–15 km were covered per day. The temperature was low, -30°C or lower, a minimum being estimated as -50°C from temperature observations at Nadym; on this occasion the Swedish snaps was frozen solid in its bottles.

How these days were experienced is evident from Fraser's report on the journey:

"When we now try to recollect the events of this journey, we are surprised at their meagreness; we scarcely know what we were doing during the long span of two months. We did not keep a diary. For more than a month none of us wound

up his watch. The only words from the Samoyed language, which we could use when addressing the Samoyeds, were *sauvo*, good, and *adam*, bad. When one day in gloomy monotony equals the next, when one lives the life of the savage, deprived of even the most humble occupation of one's thoughts, and when one cannot exert any influence on one's fate, but must be moved along mechanically, then the mind and soul become apathetic. If to this are added the distress and the feeling of uncertainty, it is easy to understand that our sole thought was concentrated on just the sustenance of life."

Thanks to the care they received from the Samoyeds, they survived. They arrived in Nadym, at the Ob estuary, on December 22. Here they met the first Samoyed interpreter, and were informed that the ship had frozen up in the *Gyda Bay*.

At Nadym they left their Samoyeds, who were to proceed in the same slow manner as previously and would need 20 days to reach Obdorsk (Salechard) at the Ob. Instead, the men hired four sledges with four reindeer in front of each, and with four Samoyed drivers.

They left Nadym on December 23 and arrived in Obdorsk (Salechard) on the 28th. At the time, this place had a population of 700 inhabitants. It was perhaps best known for the market which was held from December 15 to January 15. During the few days they spent here, their economic situation was put in order, and arrangements were made for two relief expeditions to the ships in the Gyda Bay. One group, with provisions and suitable clothes for 25 men, would leave immediately and was expected to reach the ship within 20–25 days, as no herd of reindeer would be brought along. The other expedition was mainly to bring back persons who were ill. The three men of the Sibiryakov group left Obdorsk (Salechard) on January 1, 1881. They travelled south through sparsely inhabited regions, with "stations" (yurtas) along the River Ob. On February 12 they reached Moscow.

A winter in the ice

After Sibiryakov, Fraser and Lönnholm had left the ship on October 22, preparations for the winter began. The beach was carefully searched for driftwood, yielding an enormous amount of logs. Some of these were raised upright, for transport to the ship later on. The engine was prepared for the winter. Tents and sleeping-bags were made, besides many other things needed on an overland journey in a cold climate.

The temperature was already low, and condensate

formed on the bulkheads facing the outside air. The living quarters were arranged most advantageously in view of these troubles. A heat-insulating wall of snow was built round the ship, and her sources of warmth—ovens and central heating—were distributed or used very effectively. The work was organized, and rules were established. Meteorological observations were carried out every four hours, at 00.00h, 04.00h, 08.00h, 12.00h, 16.00h, 20.00h, the observers being the two captains and the mates of the steamer. Lemon juice and alcohol were distributed regularly to the crew in order to prevent scurvy. Later on, when the temperature became very low, the galley was transferred into the engine room. This measure "killed two birds with one stone" by helping to heat the engine room at the times of cooking.

After November 12 the sun was below the horizon day and night, not to appear again until January 28. December was dark and windy, one gale blowing for ten consecutive days. During these ten days they could stay outdoors only with great difficulty, as the ordinary sailor's clothes were quite unsuitable. With sailcloth specially carried for the purpose, windproofs were constructed—with hood, blouse and trousers—and boots of sailcloth were distributed among the men from the stores on board. The equipment was thus the same as on the *Vega* expedition (see p. 134). But the material was insufficient, so in some cases clothes had to be sewn from sails, and a few men received boots of reindeer skin.

Christmas and New Year were celebrated in the traditional way. The weather in January was characterized by a succession of gales, with great amounts of snow which accumulated round the ship. The temperature was low, at -35° to -40°C . There was always work to do. Besides clearing away the snow from the entrances to the ship, the collecting of drift-wood from the shore went on steadily. The land could not be seen from the ship for a month, due to darkness and drifting snow. The "road" to the shore had to be marked at intervals of 60 m. Sometimes the wind increased suddenly. The passage between the ship and shore was therefore by no means free of dangers.

Once the sun returned on January 28, life became more cheerful, and the work became easier as the days grew longer. In February the weather was mostly fine with clean air and aurora displays, which at times covered almost the whole sky. The temperature was still low, its minimum being -42°C according to Captain Nilsson, or -40.6° in the meteorological summary (see p. 148).

On February 9 the snow was cleared away from the saloon portholes, where the lamp could already be turned off for five hours.

In the night towards February 22 a severe gale raged, at times with winds reaching hurricane force. There was much movement within the ice. Halfway to the shore, a high wall of ice formed parallel to the coastline. The ship was shaking badly, but suffered no damage. A dark water-sky to the north indicated clearings of open water.

The severe gales returned in March, though they were now more short-lived. The coal was now used up, and it was necessary to bring more wood aboard than previously. Experience of ice and weather conditions indicated that extra safety measures were essential. Provisions, clothes and boats were therefore transported to the shore, in case of critical situations. The transports were heavy owing to the large accumulation of snow.

One such situation, unexpected, occurred on March 23 during a frightful storm. Sea water forced its way between the ship's hull and the ice, and penetrated onto the deck. This was critical indeed; at a maximum the water level reached almost half a metre above the deck, and every measure had to be taken to make the entrances to the ship watertight. The predicament was caused by the immense accumulation of snow around the ship, due to the formation of snow dunes after each gale. There the snow surface reached about 3.5 m above the level of the railing of the ship. As a consequence, the ice itself bulged downwards and the ship became situated in a bowl.

In March the weather was variable and the temperature was rising. Life on board was becoming dull, especially as the inmates longed to meet other human beings. Every day during the winter they had expected the relief expedition which had been promised—but it never turned up.

In April the warmer weather partially melted the snow upon the ice, and it was difficult to walk over the ice to the shore. The ship also began to heel over until one could hardly walk on the deck. Yet everybody was in good health, and the dreaded scurvy had not appeared.

Relief expeditions

On April 23, at last, the relief expedition was seen approaching the ship. It consisted of 2 Russians, 4 Samoyeds, 38 reindeer and 15 sledges, the first living creatures seen since October 20. The caravan had travelled in high winds, extreme cold and darkness, and had covered some 1800 km to reach the ship. The joy of the six newcomers to have finally reached their goal was unmistakable.

They delivered the things they had brought along—mainly fur coats intended for the past winter. Conversation was impossible, as they only spoke Russian and

Samoyed, which none on board the ship knew. Still, messages could be conveyed with sign-language. Their journey had been hard. They had been attacked by wolves, which had killed several reindeer. Now they were surprised at finding the ship's party healthy; they had pictured something quite different. Captain Nilsson inferred from their gestures and talk that a large relief expedition was being organized when they left Obdorsk.

The visitors left again after a few hours, and with them went five men from the ship, which was thus left with 19 men. The caravan was destined for Obdorsk (Salechard).

In May the intense solar radiation, combined with the reflection from the snow, caused snow-blindness. A remedy was sought by wearing metal plates with narrow slits, but these were a mere nuisance. Cool water-compresses were used to alleviate the pain, and after a few days' stay indoors the patients were quite restored.

There were now 24 hours of daylight. Seals basked in the sun, and Samoyeds had come to hunt them.

On May 21 the second relief expedition arrived. It brought replenishments to the ship's provisions. Six men from the caravan remained and pitched their tent near the ship. They were to stay throughout the summer, as watercourses, lakes and swamps on the tundra made travelling very difficult or impossible.

A week later, on May 28, a third relief expedition arrived, this time from Dudinskoy at the Yenisey river. It brought replenishments to the provisions, and also coal for the ship's engine. This caravan was very large and consisted of 1000 reindeer and 300 sledges. On June 1 it returned to Dudinskoy.

They also received frequent visits from Samoyeds now, and help with the transport of driftwood was obtained from many of these. There was much water on the ice, and the snow was mixed with the water, making passage across the ice extremely toilsome.

On June 7, a party under Captain Arnesen started from the *Oscar Dickson* and proceeded north to find the *Nordland*. They returned after four days without having seen the ship.

Summer and a shipwreck

At the beginning of June, preparations were made for the summer break-up of the ice. A large opening was dug around the stern of the ship, to free the rudder and the propeller from the ice. At the same time the engine was put in order. The break-up in the Yenisey generally occurs at the end of May or beginning of June. At the same time it happens that the water-level may rise intensely, and this can affect the ice even in Gyda Bay.

As July began, there was much water on the ice and all communication between land and the ship was cut off. The stores in the depot ashore had previously been transferred to the ship, except for a few things which might be of initial help in case of a shipwreck. The Samoyeds had moved ashore and farewell greetings had been exchanged. The ship's party now stayed entirely on board, and were engaged in cleaning and painting the *Oscar Dickson*. The days were, however, extremely dull; the men awaited the break-up of the ice, and this was late in coming. Temperatures were around +3°C. A steady look-out was kept from the masthead; it was imperative to observe any variations of the ice conditions, preferably the formation of clearings with open water.

The break-up occurred on July 25, but not in the way they had been dreaming of. On this day a strong north-westerly wind was blowing. Open clearings soon formed all around the ship, but not at the ship itself, which was still gripped in the centre of a drifting ice-field.

Three days later this ice-field opened, and the ship was released from the prison where she had stayed for 9 months and 8 days. The engine had been put in order and it now only remained to raise the steam. As soon as possible, attempts were made to force a way out of the ice-field, but it proved to be too densely packed. The ship was moored to a piece of ice, with which she drifted south. New openings and leads opened, and the ship entered them in an effort to push north towards open water. These procedures were successful, and on July 30 she reached quite ice-free waters. All dangers and troubles seemed to have come to an end.

But a few hours later ice appeared to the north. Now it was fast-ice connected with the land to east and west. Next day a large ice-field was dislodged from the main field and drifted southwards, but the *Oscar Dickson* managed to circumvent it and reach the fast-ice about 5 km farther north than the previous position. The ship was moored to the edge of the fast-ice. Next day analogous manoeuvres were carried out, and the captain began to hope that he would reach the ice-free Kara Sea in this way. The position was 72°31'N, 77°12'E, and the depth was 12 m.

Until then, there had been no ice-pressures within the drifting ice, but these were to come. On August 2, a light southerly breeze blew and drift-ice was seen approaching from the south, towards the fast-ice edge and the ship. Nobody was especially anxious, but as a safeguard the ship was moved into a little bay in the fast-ice. Besides, the captain knew that the tide would soon set towards the south. However, the drift-ice came ever closer, and soon it clashed with the station-

ary fast-ice, producing irresistible pressure. Within a few minutes, the ship was squeezed and crushed between the floes.

The catastrophe was awe-inspiring: floes were broken and raised on edge, some were pressed under the bottom of the ship, and some of the boats were at times thrown in the air to fall between the pieces of ice. It was, however, possible to drag two boats onto the flat fast-ice at some distance from the ship, which was now heeling over and virtually prevented anyone from standing upright on the deck. The men, 19 in number, were on the ice with two empty boats, and no provisions or spare clothes.

Some bread was secured from the condemned ship, but the two boats did not have enough room for all the men, so it was necessary to go aboard the *Oscar Dickson* and try to get a larger boat. This was done after much hard work, and the men also collected some provisions and spare clothes. The ship was full of water, resting on the ice which had been pushed below her bottom. To rescue still more equipment was now impossible.

The men began to drag the boats southward over the ice, a very slow and laborious procedure. After two hours the ice opened, enabling them to set the boats on the water and find a way south among the pieces of ice. They were not yet far from the ship—only a few hundred metres. Her funnel and the upper half of her mast could still be seen. After 24 hours of rowing, the men reached the place where they had previously left their tent near the shore.

The next thing to do would be to sail into the Yenisey River, hoping to meet a European steamer or a river steamer which might carry the men to Norway, or at least to Yeniseysk. But first of all, they spent time fishing in order to obtain further provisions.

On August 22 a severe *southerly* gale was blowing, and with good visibility on the 24th it was found that the ice had disappeared below the horizon. The captain asked the men if they wanted to go with him to the Yenisey River, but most of them wanted to go overland to Obdorsk with the Samoyeds. Only four men were willing to sail in one of the boats. One of the four Samoyeds was asked to come with the captain and serve as an interpreter.

On the evening of August 24, the boat party left the tent and their companions, and tacked northward. Next day they landed and put up a mark, as well as a report concerning the shipwreck of the *Oscar Dickson* and the travels of the ship's party. Then they tacked along the coast and, late in the night, ran into shallow waters. There they were stopped and had to remain, awaiting daylight. During the night a north-westerly wind arose, and when they tried to reach deeper water

with reefed sails, they entered such a rough and breaking sea that they were forced to land and find some rest in a tent improvised from the boat's sails. The land was apparently uninhabited.

After 36 hours they again put to sea. A fine south-westerly breeze was blowing. They sailed along the coast and rounded a point, where they were to set the course into the Yenisey mouth. However, the wind increased and they had to land and pitch a tent on the tundra. Here they were able to dry their clothes and the provisions round large log fires.

Seven days after they had left their companions in Gyda Bay, they reached the first inhabited place, Sopochnaya korga (at abt. 72°N). They observed a European steamer, the *Louise*, but their signals could not induce her to stop. The tide was low and their boat rested in the ooze.

They stayed for two days at Sopochnaya korga, and were able to procure some provisions. Then they proceeded up the river, spending the nights with the natives, who were very friendly. On September 6 they arrived at Nikandrovski Island, about 400 nautical miles from the tent in Gyda Bay. After three days they boarded a paddle steamer and were transported upstream to Yeniseysk, and at the end of December they were back in Sweden. The Samoyed had left them at Dudinskoy and continued with reindeer to Obdorsk. The remaining men left Gyda Bay on September 28 and travelled overland to Obdorsk, taking three months to get there. They returned to Sweden on February 5.

The voyage of the *Oscar Dickson* had been an expensive enterprise. In part this may have been due to the fact that the owner of the ship and of most of the ship's cargo, M. Sibiryakov, was on board. His economic considerations were in some cases favoured over requirements of safety and navigation. In addition, when the destination of the voyage was almost reached, the waters north of Gyda Bay were apparently mistaken for the Yenisey estuary—for no astronomical fixes had been obtained. Here the charts were utterly unreliable, and of course no sea-marks existed; the coast was low and indefinite when seen from the sea.

The wintering was led excellently by Captain Nilsson, and the ultimate shipwreck of the *Oscar Dickson* was not due to any erroneous judgement of the situation. Finally, the overland relief expeditions were late in coming, but Sibiryakov cannot be blamed for that: he had done what was feasible in the given situation.

This was the last Swedish contribution to the navigation of the North-East Passage. Captain Emil Nilsson was later to serve as ship's commander to two Swedish arctic expeditions, namely Nordenskiöld's

Greenland expedition of 1883 and Nathorst's expedition of 1898 to Svalbard and the surrounding seas.

TEMPERATURE (°C) IN GYDA BAY, 1880–1881

Lat. 72°14'–72°25'N Long. 76°14'–77°12'E

(From H.E. Hamberg, *Ymer* 1883, pp. 146–149.)

	1880			1881	
	Oct.	Nov.	Dec.	Jan.	Feb.
Mean temp.	-11.6	-17.6	-22.4	-30.6	-33.9
Max. temp.	-1.9	-5.0	-8.1	-18.8	-15.0
Min. temp.	-21.3	-29.4	-36.3	-39.4	-40.6*
	1881				
	March	Apr.	May	June	July
Mean temp.	-20.4	-17.6	-8.6	-1.5	+1.3
Max. temp.	-1.3	-3.8	±0.0	+4.4	+7.5
Min. temp.	-38.8	-31.3	-26.3	-8.8	-2.5

*Captain Nilsson gives -42° in his report.

ACTIVITY IN THE NORTH-EAST PASSAGE AFTER THE VOYAGE OF THE *VEGA*

Nordenskiöld's pioneering ventures with the *Pröven* in 1875, the *Ymer* in 1876, the *Vega*, *Express*, *Fraser* and *Lena* in 1878, were to be followed by trade in the western section of the North-East Passage, with voyages between the Atlantic and the Yenisey and Ob Rivers. The most prominent pioneer during these years was the English sea-captain Joseph Wiggins (1832–1905), who from 1874–1905 carried out a great number of freight voyages.

From 1910–16 Jonas Lied, a Norwegian businessman, organized freight voyages between Norway and the Yenisey. These were partly successful, but had to be discontinued because of the October Revolution in Russia in 1917. In 1913, Fridtjof Nansen was invited to join one expedition, and he enhanced the firm's public image. Moreover, he took the opportunity to travel in other parts of Siberia. After the October Revolution, the North-East Passage—or the Northern Sea Route, as it is called in Russia—developed into an important maritime highway (see p. 150).

To begin with, let us consider a number of expeditions which conducted voyages along much or all of the North-East Passage.

The American expedition in 1879–1881 with the Jeannette, led by George W. De Long

This expedition was intended primarily to reach the North Pole, secondarily to sail along the entire North-East Passage from west to east, and lastly to assist the *Vega* expedition if necessary.

Its ship, the *Jeannette*, was “beset” in the ice in September 1879, near Herald Island to the east of Wrangel Island (Ostrov Vrangelya). The ship drifted westward with the ice, until she was wrecked on June 13, 1881, near the New Siberian Islands. The crew attempted to reach the Lena Delta in three boats, and one boat failed to do so. The other reached the delta, but De Long and 11 men perished there in October 1881, during a march southward (compare p. 259).

The Norwegian expedition of 1893–1896 with the Fram, led by Fridtjof Nansen

This expedition was inspired by the discovery of equipment from the *Jeannette* expedition off South Greenland, indicating a major drift of the ice from Eastern Siberia across the Polar Sea and south along east Greenland.

In one season, July–September 18, 1893, the *Fram* proceeded along the North-East Passage. On the latter date she had reached a position to the west of the New Siberian Islands, and was on her way northward to become enclosed in the ice, according to plan. In the summer of 1896, having completed her drift in the ice, she reached open water off northern Spitsbergen.

The Russian expedition of 1900–1903 with the Zarya, led by Eduard von Toll

The aim of this expedition was to sail through the entire North-East Passage, while looking for the “mysterious” Sannikov Land which supposedly lay north of the New Siberian Islands. The ship, *Zarya*, followed the route of the *Fram* to the New Siberian Islands. There and on the De Long Islands, the expedition worked for two years. It was discontinued in 1902 because of the death of Toll and three of his men in that year. The *Zarya* went aground and was wrecked at Tiksi near the Lena Delta.

The expeditions of the Russian icebreakers Taymyr and Vaygach in 1910–15

The main purpose of these expeditions was hydrographical surveying of the entire North-East Passage, starting from the east. Their leaders were I.S. Sergeyev in 1910–13, and B.A. Vilkitskiy in 1914–15.

The ships worked from Bering Strait to the Kolyma during 1910–11. In 1912 they operated from the Kolyma to the Lena Delta; then they should have proceeded to Arkhangelsk, but ice blocked the way and they returned to Vladivostok. During 1913, they surveyed westward from the Lena Delta, and discovered the eastern part of Nikolaus II Land (later renamed Severnaya Zemlya; compare p. 443). Ice blocked the way westward, and the ships had to return to the Pacific.

In 1914, after a push north towards Severnaya Zemlya, the ships passed Cape Chelyuskin, but had to spend the winter on the western side of the Taymyr Peninsula, and reached Arkhangelsk in September 1915. *The second voyage through the entire North-East Passage was thus completed.*

During five seasons, hydrographical surveying had been carried out along the whole Siberian coast, from Bering Strait in the east to Barents Sea in the west. Scientific observations had been made, and new lands had been discovered. B.A. Vilkitskiy became a Vega Medalist in 1926.

The Norwegian expedition of 1918–1925 with the Maud

Leaders: Roald Amundsen, 1918–1921; Oscar Wisting, 1921–25. Scientific leader: Harald Ulrik Sverdrup.

The original aim of this expedition was to drift with the ice from the Bering Strait region across the Polar Sea. In order to reach the starting-point of the drift, the *Maud* would have to follow the entire North-East Passage, preferably in one season.

1918 The *Maud* departed from Vardö, Norway, in July. There was much ice in the Kara Sea, but the ship was able to pass beyond Cape Chelyuskin. She had to winter about 30 km east of the Cape.

1919 The *Maud* was freed and continued eastward. More ice was met with than during previous expeditions; there was only a narrow lead between the ice and the land. The ship wintered in Chaun Bay, inside Ayon Island. Sverdrup spent 7 1/2 months with the Chukchis inland.

1920 The *Maud* was freed on July 6 and departed for Nome, Alaska, to take in provisions before entering the ice. Nome was reached on July 27. *This was the third time the entire passage had been navigated, and the Maud was the fourth ship to do so.*

Only three men were now willing to stay with the expedition, among them Sverdrup and Wisting. The *Maud* departed from Nome on August 8, 1920, in order to try and come into the ice. First, however, Cape Serdtse-kamen was visited. It is situated some 80 km to the east of Pitleki, the winter quarters of the *Vega* in 1878/79. The intention was to take aboard a few Chukchis to serve as seamen. The ice conditions were severe, and Cape Serdtse-kamen was not reached until September 1. Here the *Maud* had to winter; her propeller had been damaged and would need to be repaired next summer. The ice broke up several times near the shore in October, and in November before the ship was frozen up for the winter.

In 1921 Pitleki was visited. In May, Amundsen left the ship for Nome and Seattle. Six young Chukchis

were hired to serve as crew. The *Maud* left her winter quarters on July 1. In Bering Strait she was towed by the cutter *Bear* of the U.S. Coast Guard as far as St. Lawrence Island. From there she sailed alone to Seattle, arriving on August 31. The voyage had been trying: the crew consisted of three Norwegians and six Chukchis, and the latter were not used to the sea. Preparations to continue the expedition were started at Seattle and—scientifically—by Sverdrup in Washington D.C. Amundsen prepared flights over the Polar Sea. A young Swedish meteorologist and oceanographer, Finn Malmgren, was engaged by Amundsen to assist Sverdrup in the scientific work. The *Maud* expedition is treated more in detail on p. 407.

Russian activity along the North-East Passage after 1890

To begin with, activity along the North-East Passage was conducted by private persons, Russians and non-Russians. The state authorities were more or less indifferent. Cargoes were carried on board foreign ships, mainly British, and the English sea-captain Joseph Wiggins was very active.

But two events drew the authorities' attention: the building of the Trans-Siberian Railway in the 1890s, and the Russo-Japanese war in 1904–05. In the former case, shipping facilitated the transport of rails. In the latter case, a famine in central Siberia was more easily alleviated thanks to sea- and river-transport, the Trans-Siberian Railway now being fully utilized for transporting military material and personnel to the theatre of war in the Far East.

After 1894 hydrographical surveying was carried out in the Kara Sea and in the estuaries of the Ob and Yenisey. A strong icebreaker, the *Yermak*, was built in England in 1898. She became a prototype for later icebreakers and was in active service right up to 1963, though she had not been used in the Arctic after 1934.

After the Russo-Japanese war of 1904–05, greater interest was focused upon the sea route in its entirety. The new status of the North-East Passage was created largely by an expectation of transferring naval ships rapidly to the Far East in critical situations.

In 1910–15 hydrographical surveying was carried out along the entire North-East Passage by the two small icebreakers *Taymyr* and *Vaygach*, which were sister ships. In this connection new land, Severnaya Zemlya, was discovered and studied in 1913 and 1914. *In 1914–15 the entire North-East Passage was navigated by the two icebreakers. This was the fourth passage along the entire Sea Route.*

An important step was the decision in 1913 to set up *scientific stations* in the Siberian Arctic. During the

First Polar Year in 1882–83, Russia had kept a scientific station at Sagastyr in the north of the Lena Delta. From 1913 onward, scientific stations were established along the North-East Passage, at first preferably in its western part. Despite the awakened interest of the state, there were still private persons who were responsible for most of the activity, among others the Norwegian Jonas Lied in the years immediately preceding the revolution in 1917.

The October Revolution in 1917 meant a rapid stride forward in the development of the North-East Passage. The state had now become earnestly engaged in the project. In 1920 the *Committee of the Northern Sea Route* was formed, abbreviated *Komseverput*. The committee was charged with the task of making the route practically usable for freight to and from the mouths of the Yenisey, Lena and Kolyma. The difficulties were great to begin with, as experienced personnel and suitable equipment were not readily available. For instance, a river fleet and harbours had to be built.

During World War I, in 1914–18, Russia had procured a number of strong icebreakers, but merchant vessels were lacking and had to be hired from Great Britain and Norway. The leader of the marine operations was stationed either on board an icebreaker or in the headquarters at Dickson Harbour which had become a centre of the traffic.

Freight trade was started already in 1911 in the eastern part of the Northern Sea Route. Both Russians and Americans then carried cargo from the Pacific to the mouth of the Kolyma River.

In 1932 a small icebreaker, the *Sibiryakov*, passed through the Northern Sea Route in one season. The ship was used for a scientific expedition organized by the Arctic Institute in Leningrad, under the leadership of Professor Otto Schmidt. *This was the fifth passage through the Sea Route, and the first to be carried out in one season.* It took place 53 years after the voyage of the *Vega*.

Komseverput was responsible for the scientific investigations in the Russian Arctic. Scientific stations were established, Severnaya Zemlya was explored in 1930–33, weather and ice conditions were observed, geomagnetism and the propagation of the radio waves were studied. The icebreakers usually had a scientific staff on board. Most of these studies, observations and measurements would be of use to the navigation in the Sea Route. More of the work was, of course, done in the west of the Sea Route than in the east.

In 1932 a reorganization of the administration of the Russian activity in the Arctic was decreed. The *Chief Administration of the Northern Sea Route*, abbrev-

viated *Glavsevmorput*, now took over all Russian activity in the Arctic, even purely economic enterprises.

The ambition was to develop the Sea Route and take precautionary measures. The polar stations thus came under *Glavsevmorput*, which also became the central icebreaker authority, with ten icebreakers in service (in 1934). Among other institutions or activities under *Glavsevmorput* were: the polar flights, the geological investigations in the Arctic, the ice forecast service, the Arctic Institute (established in 1919), the institute for economic exploitation of the polar regions, and the Hydrological Institute. Professor Otto Schmidt of the Arctic Institute became supreme chief of this tremendous organization.

The shipping routes were classified into three groups:

1. The Kara Sea routes with traffic between the Atlantic and the Ob–Yenisey.
2. The route from the Pacific to the Kolyma.
3. The routes to the Lena or through the Northern Sea Route as a whole.

A natural disadvantage is the short navigational season of 70–120 days, from June to mid-November. The times for loading and unloading were long and had to be shortened.

There were few harbours along the Sea Route—primarily Dickson, situated off the Yenisey estuary. Some harbours lay farther upstream, such as Igarka on the Yenisey and Nizhnekolymsk on the Kolyma. The latter harbour was soon surpassed by Ambarchik off the Kolyma estuary. To the east of the Lena Delta, the harbour of Tiksi was established. Dickson was a main station along the route, and already in 1916 a radio station had been established here; from now on, it became an operational base for the shipping in the Kara Sea, while some of the harbours became coal stations. For the long shipping routes it was necessary to bunker on the way.

Glavsevmorput built freighters of her own, loading 2000–3000 tons, intermediate between an ordinary freighter and an icebreaker. River freighters were also built for the communications with the inland.

In 1933 a marked rise in the shipping occurred along the Sea Route; for example, shipping to the Lena was opened at this time. The Northern Sea Route was now becoming a fairly normal sea route, and this period coincided with the optimum of the improvement in climate which had been going on for the past 50 years. But setbacks were coming.

In 1937, 26 ships—including six of the eight serviceable icebreakers—were caught in the ice in different parts of the Northern Sea Route and were forced to winter. It was something of a catastrophe, and wild

political discussions ensued. The human factor had played various roles in it, and changes of leadership occurred.

The old icebreaker *Yermak* liberated most of these ships. But one of those, the *Sedov*, which had become “beset” on October 23, 1937, drifted with the ice as the *Fram* had done in 1893–96 (see p. 149). She did not come free until January 1940, north-west of Spitsbergen.

The traffic went on during World War II. Cargoes then consisted, among other things, of war material from the USA.

Aeroplanes had been used for ice reconnaissance since 1924. From 1930 onward, they became an important part of the safety service. Soon large long-distance “polar planes” were flying along the Sea Route and over the Polar Sea. In 1937 flights were made across the Polar Sea via the North Pole, with destinations in southern California. In the same year a scientific station with four men was established on the pack-ice at the North Pole. The station drifted southward and along eastern Greenland, where it was evacuated by an icebreaker.

In 1941 “polar planes” with scientists on board landed on the ice in the Polar Sea. They stayed until the planned observations and measurements had been carried out, after which the same procedure was repeated at another station. A new era in the use of aeroplanes for scientific research in the polar regions had been opened. After 1950, scientific stations were established on a routine basis by Russia and the USA in different parts of the Polar Sea, some operating for 2–3 years before being deserted because of the drift.

After 1958 Russian, American and British submarines operated under the polar ice. Their scientific results were remarkable, not least as regards the measurement of underwater topography and its geological implications.

Characteristic of the postwar period has also been the introduction of very strong and effective icebreakers. Many of these were built in Finland. In recent years extremely strong nuclear-powered icebreakers were built: the *Lenin* of 44000 HP in 1959, the *Sibir* and the *Arktika*, both of 75000 HP and built in 1977. The *Arktika*, in 1977, became the first ship to reach the North Pole.

In fact, developments in the Russian Arctic have been tremendous since the pioneering voyage of the *Vega*. At the same time the economic development of northern Siberia has proceeded.

17. NORDENSKIÖLD'S LAST EXPEDITION: THE GREENLAND EXPEDITION OF 1883

Planning, members, and ship

During the wintering on board the *Vega* at Pitkeki in 1878–79, the scientific staff often discussed probable targets of future Swedish polar expeditions.

Their ambitions were mostly directed towards:

1. The North Pole;
2. Archipelagoes to the north of the Siberian coast, notably the New Siberian Islands and possible lands north of Cape Chelyuskin (then undiscovered: compare p. 125);
3. The Antarctic continent and off-lying archipelagoes and islands.

After the *Vega* expedition had returned home, however, these proposals were looked upon in a somewhat different light. The Siberian region was to be visited by expeditions from other countries, and expeditions to the Antarctic would be too expensive.

Instead, the lure of Greenland had come into the foreground. During Nordenskiöld's expedition of 1870 (p. 63) a visit to the marginal zone of the inland ice had been attempted. With the experience gained, a push further inland was now desirable.

In 1870 very rich collections of plant fossils had been brought together on Disko Island and on the Nugssuaq Peninsula. This work was to be continued, but now by an expert on the subject.

While preparing his expeditions to the Siberian sector, Nordenskiöld had devoted himself to historical geography and cartography. These studies had continued after the *Vega* expedition in connection with his work on the expedition report. In fact historical cartography was to become Nordenskiöld's greatest interest during his later years.

In Greenland, he fancied, there awaited important discoveries about the old Norse colonization during the Viking age and the Middle Ages. Not least, it would be valuable to determine where the so-called East Settlement (*Austbygden*) had really been situated, in south-eastern or in south-western Greenland. Here Nordenskiöld's opinion was opposite to generally accepted ideas.

As to the Greenland inland ice, Nordenskiöld considered, from pure physical considerations, that the inland probably were *free* of inland ice. This region, presumed to be free of any ice-sheet, would be *surrounded*—not *covered*—by inland ice. The ice-free inland was, according to Nordenskiöld, conditioned by dry

and relatively warm foehn winds, coming from the high inland ice surrounding the ice-free land. Perhaps the inland of Greenland was even wooded. However, Nordenskiöld had not considered the effects of drifting snow.

A proposed Greenland expedition should thus have the following aims:

1. A push towards the interior of the Greenland inland ice;
2. A palaeontological investigation of the Disko–Nugssuaq region;
3. Possibly a visit to the Cape York district further to the north;
4. A visit with the ship to south-eastern Greenland.

Oscar Dickson became sole sponsor of the expedition. It was essential to find a suitable ship: she should not be very large and should have a relatively small draught to let her pass in shallow waters; she should be a steamer and her power should be fairly great. With these demands her bunkers would need to be relatively small—resulting in repeated bunkering which, of course, could be executed both in Greenland and on the way to and from Greenland. In Nordenskiöld's opinion it was not necessary to strengthen the ship against ice:

“The ship cannot force the ice, and if the ship is jammed her robustness is of no avail.”

One ship which roughly corresponded to Nordenskiöld's demands was the iron steamer *Sofia* of the Swedish Post Office Department. She had already been to the Arctic during Nordenskiöld's Spitsbergen expedition of 1868 (compare Chapt. 9). Since then, in 1876 she had run aground in the Baltic during a severe blizzard and was deserted by her crew, but was carried by waves and wind across the shallows, and was later salvaged and repaired.

Many people had warned Nordenskiöld against using her; he should especially refrain from taking her into the East Greenland ice; nor would the ship stand a severe gale in the North Atlantic, according to the critics.

As a precautionary measure in case of engine breakdown, the *Sofia* was rigged to become a sailing-ship. Her commander was Captain Emil Nilsson (1850–1921), who had previously commanded the *Fraser* in 1878 and the *Oscar Dickson* in 1880–81 (see pp. 140 and 142 respectively).

The scientific staff consisted of the following persons:

Adolf Erik Nordenskiöld (1832–1901), Ph.D., professor, geologist, responsible for astronomical and

archeological observations, leader of the expedition.

Alfred Gabriel Nathorst (1850–1921), Ph.D., palaeontological and botanical studies, second leader of the expedition.

Johan August Berlin (1851–1910), M.D., doctor to the expedition, botanist.

Carl Wilhelm Forsstrand (1854–1928), Ph.D. (1886), journalist, zoologist.

Gustaf Isak Kolthoff (1845–1913), taxidermist, zoologist.

Axel Hamberg (1863–1933), undergraduate, responsible for the hydrographical (oceanographical) observations, assistant geologist.

Carl Johan Otto Kjellström (1855–1913), sergeant in the Swedish Army, surveyor and photographer.

Two Lapps took part in the expedition. They were specially chosen for the sledging tour on the inland ice:

Anders Pavasson Rossa (b. 1844)

Pava Lars Nilsson Tuorda (b. 1847)

The crew of the ship was Swedish except for two Norwegian sealers, *S. Kræmer* (b. 1847) and *R. Sevaldsen* (b. 1844). Additional participants were as follows:

G. Flink (undergraduate, b. 1849) was to conduct geological and mineralogical investigations in Iceland. He was sponsored by *Oscar Dickson* and may therefore be considered as a member of the expedition. *Count H.F.G. Strömfelt* (b. 1861), B.Sc., and *R. Arpi* (b. 1853), B.A., also intended to carry out studies in Iceland, the former in botany, the latter in philology.

The scientific staff of the Nordenskiöld expedition comprised seven scientists, while the ship's company and the assistants to the scientists numbered 17. Besides, three scientists travelled by the *Sofia* to Iceland and left her there.

During the previous Swedish expeditions, there had not been any specialist in paleontology among the scientific staff; the collections had then been studied by the Swiss paleobotanist *Oswald Heer* (1809–83). In the autumn of 1883 Professor Heer died, but *A.G. Nathorst* was now ready to take over his task.

The expedition plans included a study of old Norse settlements in Greenland, for which Nordenskiöld would be responsible. He was, of course, a mere amateur in this field.

Axel Hamberg, who conducted the observations in physical oceanography, was aged only 20 but had many interests, and on the expedition he did very fine work in spite of his youth.

ALONG THE GREENLAND COASTS

The *Sofia* left Göteborg on May 23, 1883 and stopped at nearby Marstrand to restow her cargo, free of friendly but disturbing visitors. On May 25 she left Sweden, fit for the sea and with coal for a passage of 11 days on board.

The course was shaped for Thurso in northernmost Scotland, where four days were spent. On June 2, Eskifjordur on the eastern coast of Iceland was reached. Strömfelt and Flink had chosen this place as a starting-point for their botanical and geological research. To Nordenskiöld the visit offered a good opportunity to visit the source of Iceland spar, a mineral well-known in the optical industry.

On June 6, Reykjavik was reached, in good time to avoid a severe gale. Finally on the evening of June 10 the expedition left for Greenland. The course was set for Cape Dan (near present-day Angmagssalik), and already in the morning of the 12th the Greenland coast was sighted. It seemed to lie fairly near. No ice was sighted, and from the crow's nest it was reported that the waters were ice-free all the way to the coast. Apparently the *Sofia* would reach the hitherto unaccessible south-eastern Greenland coast without further trouble.

In Nordenskiöld's opinion, this part of the coast had been easy of access in times past. According to him, it had constituted the true Austbygden (East Settlement). But the *Sofia* people were the "victims" of an optical illusion: the air is generally extremely clear, so distances are misjudged, and to begin with only the upper parts of the mountains were seen, the lower parts appearing gradually as the ship came closer. At last the look-out announced:

"Dense ice along the coast as far as the eye can reach."

The course was therefore shaped towards the south along the ice-edge. Occasional tests were made of the properties of the ice, which was similar to the heavy ice that occurs north of Spitsbergen. Nordenskiöld wrote:

"The sea surface consisted of a cold current, which packs the ice against the land. This polar current is, however, not very thick. Already at a depth of some tens of fathoms there follows a warm current, no doubt coming from the south, as shown by the careful temperature measurements of Mr. Hamberg. The depth of the sea was often rather considerable. The bottom consisted of big stones which tore the trawl-net to pieces and prevented dredgings."

The *Sofia* steamed along the ice-edge in calm weather, but the land was often veiled or hidden behind fog or mist. Now and again the air cleared up, revealing high mountain ranges and grand valleys.

On the 15th, near Cape Farewell at the south point of Greenland, a rising wind forced them to heave-to for a few hours. On the 16th there was a calm, and in a smooth sea the *Sofia* headed towards the land. They met with ice and icebergs, which had been very rare along the eastern coast. As Nordenskiöld did not want to enter the ice in the middle of the night, the time was used for zoological dredgings and oceanographical measurements.

Next morning, on June 17, they sighted a schooner sailing in the coastal trade. The two ships exchanged services, the *Sofia* was piloted to Julianehaab, and she towed the schooner. These services were prolonged to include the passage Julianehaab–Ivigtut, inside the skerries.

The expedition spent four days at Julianehaab. The engine was overhauled, excursions were made in the surrounding country, and preparations were already begun for the voyage along the East Greenland coast in the autumn. Nordenskiöld hoped to engage a Danish-speaking Eskimo catechist for this voyage.

On June 21 the *Sofia* left Julianehaab in very fine weather, calm and warm. Here they had an early opportunity to see the inland ice in the distance. Nordenskiöld found it difficult to understand why the types of trees which, in Siberia, reach far to the north–70°N or more—cannot grow on the coasts of south-western Greenland.

In the forenoon of June 22, the ship anchored in the harbour of Ivigtut. They were treated with great friendliness by people who were occupied with extraction of the lustrous mineral cryolite.

The expedition members were now keen on starting their scientific work, notably the inland-ice tour. The visit to Ivigtut was therefore short. Additions were made to the ship's stores of provisions and coal, and on June 23 the *Sofia* left for Egedesminde. Until near Frederikshaab, the route passed inside the skerries, and for this purpose two kayak-men had been hired to serve as pilots. Much drift-ice was encountered, and at times the ship had to force a passage through the ice fields.

Beyond Fredrikshaab the sea was practically ice-free, and the ship proceeded easily northward along the coast. On June 26 they entered the archipelago of small islands which surround Egedesminde. It was very much like a woodless Scandinavian archipelago.

Unfortunately the surroundings became blotted out by fog. Several futile attempts were made to find an approach to the colony. It was deemed best to leave

the area and proceed to Godhavn on the south coast of Disko Island, 40 nautical miles to the north. Disko Island and Nugssuaq Peninsula, which during the expedition of 1870 (p. 69) had yielded very rich collections of fossils, were now to be further studied by Nathorst and Hamberg, the former being a well-trained palaeontologist. They were to be left in this region with two hired Greenlanders, a whaleboat, a tent, provisions and other suitable pieces of equipment.

Godhavn was left on June 28. The ship proceeded north-east along the Disko coast, after having penetrated into the sound Vaigat (= windy place). The land party was left at Ujaragsuksuk on the north-eastern coast of Disko Island, from where they were to start their geological and palaeontological investigations as well as studies of the local flora.

The ship then proceeded to the colony of Egedesminde, where she arrived on June 29. The expedition was very warmly received by Mr. H. Hörring, divice chancellor of the Greenland Trade, and by Mr. Andersen, the inspector of Northern Greenland.

THE MARCH ON THE INLAND ICE

The approach, participants and equipment

The inland-ice tour was to start from the same place as during the expedition of 1870: the ship would have to enter the Auleitsivik Fjord, some 30 nautical miles south of Egedesminde. At its innermost end, the inland ice reaches the fjord. The middle parts of the fjord are very narrow, and strong tidal currents tend to occur here between the fjord mouth and the widening inner part of the fjord, called Tasiusarsuak (the large lake), where the inland ice protrudes. On the ice-free land to the north of the inland ice a base camp was to be pitched, and from there the ice march would begin—just as in 1870.

In 1870 Nordenskiöld had found that the edge of the inland ice had advanced during the previous 50 years. He was therefore somewhat worried that the edge had now advanced still further.

The *Sofia* succeeded in traversing the narrow parts of the fjord, despite fast currents interspersed by eddies laden with pieces of glacier ice. Finally the ship anchored in a well-protected harbour, Sofia Harbour. It was surrounded by gneiss hills 200–300 m high, partly overgrown with crowberry, various species of osier, mosses and lichens.

The weather was beautiful, the sky almost free of clouds and the air extremely dry. The temperature of the water in a waterfall was found to be +12.3°C. According to information received by Nordenskiöld, the place had not been visited since he and his party were here in 1870.

Alfred Gabriel Nathorst (1850–1921), palaeontologist and 2nd leader of the Greenland expedition of 1883. (Nordenskiöld, A.E.: Den svenska expeditionen till Grönland 1883.)

Oswald Heer (1809–1883), the Swiss plant palaeontologist. He was in charge of the plant-fossil material from the early Swedish expeditions (see p. 198). (Nordenskiöld, A.E.: Den svenska expeditionen till Grönland 1883.)

Two Lapps of the 1883 Greenland expedition, Pava Lars Tuorda (b. 1847) and Anders Rossa (b. 1844), most noted for their skiing tour on the Greenland Inland-ice. (A.E. Nordenskiöld's Photographic Collection, Royal Swedish Academy of Sciences.)

Map of southernmost Greenland. The 1883 expedition tried in vain to penetrate the area via suitable sounds for reaching the east-coast. (Nordenskiöld, A.E.: Den svenska expeditionen till Grönland 1883.)

Now the rocky foreland to the ice was swarming with people.

THE INLAND-ICE GROUP CONSISTED OF TEN MEN:

Nordenskiöld, leader, geologist, responsible for astronomical observations.

Berlin, the doctor of the expedition.

Kjellström, surveyor.

Johannesen, second mate.

Andersson, seaman.

Jonsson, seaman.

Sevaldsen, Norwegian sealer and hunter.

Kræmer, Norwegian sealer and hunter.

Tuorda, Laplander.

Rossa, Laplander.

The following men were initially to assist in transporting the equipment over the bare land and during the first part of the ice-march:

Most of the officers and men of the *Sofia*

Mr. Hörring, divice chancellor of the Greenland Trade.

Mr. Olsen, a Danish "uteligger" (missionary).

Greenlanders from Egedesminde, some being members of the crew of Mr. Hörring's sloop, and others acting as pilots or advisors to the expedition.

Finally we should mention the editor Lars Möller of the illustrated Eskimo newspaper *Atuagagdliutit* (reading), published at Godthaab. He was also a draughtsman, and was now writing articles about the expedition for his paper.

During July 1-3, while preparations for the ice-march were going on, the scientists roamed the countryside in pursuit of their interests and duties. The ice-free land was characteristic of a region which had lost its cover of inland ice not so very long ago. Observations of it would be most valuable to the interpretation of similar deposits from the Ice Age, for instance in Scandinavia (compare p. 64).

For transporting the equipment over the bare land to the edge of the inland ice, carts were to be used instead of sledges. A place for the ascent of the inland ice had been chosen, about 5 km from the seashore. The edge of the inland ice bordered here on a little lake, formed by melt-water coming from the ice. The ascent of the ice did not present any difficulties; the transport of equipment to the ice was very laborious, but there were many men to help.

The little lake was passed via its outlet, which could be forded, and the carts with equipment were ferried across by a small boat. At the ice-edge, the equipment was loaded on sledges of a type which, in those days, was commonly used in the winter by sellers at the market-places. The carts and boat were left at the ice-

front, and another few kilometres were covered with the sledges. This march was hard, and the surface of the ice was very rough. In the night towards July 5, the first camp was pitched on the inland ice.

THE EQUIPMENT ITSELF CONSISTED OF THE FOLLOWING ITEMS AMONG OTHERS:

One fairly large "officers' tent".

One sleeping-bag, blanket, and inflatable rubber mattress for each man, and bellows for inflating the mattresses.

Spare clothes, Icelandic sweaters, a wide blouse of sailcloth, a woolen nightcap, etc., for each man.

Shoes of sailcloth (16 pairs) with lining of sedge grass (*Carix vesicaria*) and foot-cloths of felt; ice-nails fastened to soles of iron or leather.

Plates and coffee-cups, of iron-plate coated with tin; a spirit stove for cooking.

Provisions and spirit for 50 days.

Two guns.

A small medicine chest, coloured glasses, compasses, binoculars, two chronometers, a prismatic circle, a small sextant (in reserve for the prismatic circle), a mercury horizon, 3 aneroid barometers, thermometers, magnets (for investigating the clay ooze on the ice), a plane-table (for surveying), a camera, glass tubes, bottles, a bundle of pressing-paper (for plants), nautical tables, etc.

Alpenstocks (walking-staffs) of ash wood.

Six sledges; sledging harnesses strong enough to withstand falls into glacier crevasses; a Manila rope, carefully tested for strength; a pair of oars (originally for the small boat), in case rubber mattresses must be used as boats on melt-water lakes on the inland ice.

Tobacco, cigars, matches and tools.

THE MEALS DURING THE ICE-MARCH WERE:

Morning: Coffee, bread, butter, cheese.

Midday: Bread, smoked ham, alternately corned beef or sardines, snaps.

Evening: Tinned meat.

THE DAILY RATIONS PER MAN WERE:

Bread	530	g
Butter	85	"
Cheese	45	"
Smoked ham	105	"
Tinned meat	255	"
Coffee	35	"
Sugar	25	"
Snaps	4.2	cl

(The weights given in pounds are converted here to grams.) These rations proved to be satisfactory, while

not unnecessarily rich. In addition, 0.7 litres of spirit were used daily for cooking. The Norwegian hunter Kræmer acted as cook during the ice-march.

The weight of all the equipment for the march was about 850 kg, when loaded on the six small sledges. This load would have been easy to drag in flat country; but here on the rough surface of the inland ice, the loads had to be relayed, by covering the same distance three times. The daily marches were consequently short to begin with, especially when crossing or circumventing the many watercourses on the inland ice. Sometimes these streams had to be bridged over with the help of alpenstocks. The streams were often swift and their banks steep.

Conditions in the marginal zone

It was now at the height of the snow-melting in the marginal zone. Morasses of slush formed over wide areas, and water collected to form lakes where the topography was suitable—composed of almost flat depressions. To these obstacles should be added the crevasses of the ice, which came into view as their snow bridges melted away. In some areas the surface of the inland ice consisted of ridges and peaks with narrow valleys in between.

The melting also gave rise to water-filled cylindrical hollows, 30–90 cm deep and from 1 mm to 1 m or more in diameter. Called *cryoconite hollows* by Nordenskiöld, they were a severe latent threat to the expedition, as they might easily cause fractured legs. To Nordenskiöld they held great scientific interest, as their bottoms contained a thin layer of dust, which he had named *cryoconite* (= ice dust) and assumed to originate partly from outer space.

With increasing height, the temperature dropped until the melting ceased. Then the march became easier and the covered distances longer. The conditions during the melting of the snow in the marginal zone were also experienced by Nordenskiöld during his ice-march of 1870 (compare Chapt. 10).

The difference was that Nordenskiöld and Dr. Berggren in 1870 had carried their sleeping-bag (only one for two persons) and provisions on their backs; they were two middle-aged gentlemen on a promenade in sunny surroundings. Now, in 1883, there were ten men in the march, with much equipment and heavy sledges to haul. However, just as in 1870, the weather was generally fine in 1883, and the course of the march could be exactly determined by measuring solar altitudes (p. 160).

If one has a choice, the marginal zone should be avoided during the season of melting snow. In the cold season, on the other hand, the surface layers of the atmosphere are cooled down considerably and

bitter downslope winds occur. This is also a season to be avoided. But from late spring until the beginning of summer, there is a fairly long period with neither melting nor very cold weather or strong downslope winds.

The march inland

The geographical positions of the camps on the inland ice are given according to the measurements of solar altitude. The longitude difference is referred to "Camp 0" at the fjord, where the Greenlanders were awaiting the return of the ice party. The ice party pitched their first camp on the ice in the night towards July 5. During a reconnaissance in the morning, it was found impossible to proceed eastward; so they had to return to the neighbourhood of the ice-edge, and from there march north of east for two days.

July 5: start from Camp 1 220 m a.s.l. The going was somewhat difficult, with deep crevasses and ravines. The Greenlanders had grown tired of the sledge-hauling and wanted to return, although the march still had the character of a cheerful hunting picnic. They camped near a headland protruding into the ice.

July 6: start from Camp 2 290 m a.s.l. In the morning one of the Lapps was sent out to reconnoitre the way. He reported that it was not possible to travel due east, but by marching a somewhat more northerly course for one day they might be able to go east. Nordenskiöld decided that the "relief party" would have to return to the ship at the end of the day's march, in order not to detain the ship. The belongings of the relief party were therefore left at Camp 2, and only the equipment of the "inland-ice party" was loaded on the six sledges.

The ice was rough, and very soon Nordenskiöld realized that it would be impossible to carry the whole of their equipment, which was intended for 50 days. The provisions were thus reduced by a fifth, and would now last for 40 days.

Camp 3 330 m a.s.l., was reached after the march on July 6. A farewell dinner was served here, and then the relief party returned to the ship.

The inland-ice party was alone at last. It had a hard time to begin with, as the loads were still too heavy to handle on the ice surface and had to be carried in halves. As before, each distance was covered three times, so the daily marches were short. Moreover, the men faced many obstacles such as crevasses, rivers, and very rough ice, which led to detours and delays. They used pedometers to measure the distances, which of course included all their detours. The actual distance between two camps was much less than the pedometer measurement, but the camp positions were still determined by measuring solar altitudes.

A daily routine was developed, basically as follows.

At 08.00h, Nordenskiöld roused the cook to make coffee and wind up the chronometers. Half an hour later, breakfast was served. Then the men washed, bundled up their sleeping-bags and mattresses, packed the tent, loaded and lashed the sledges, and resumed their march. At midday they halted in the open air, but seldom for long because of the chilly winds.

In the evening, the camp was pitched rapidly, and soon the soup and coffee were cooking. The scientists of the party attended to their duties. Dr. Berlin, who was also a botanist, collected ice algae or treated anyone who had been troubled by the strong sunlight. Kjellström photographed, or entered the day's march on his map. Nordenskiöld measured the solar altitude to determine the position, and read the barometer. The camp was prepared for the night; rubber mattresses were inflated and laid down with the sleeping-bags. The evening meal was then eaten, and the clothing was looked after.

The character of the inland ice surface varied during the march, and could be better or worse. Nordenskiöld classified the surface conditions as follows:

Pinnacled ice: low hillocks surmounted by pinnacles or crests of ice up to 6 m high, sloping steeply, densely packed, often almost impassable with the sledges due to crevasses.

Tufty ice: areas with "tufts" of ice, 0.5–2 m high, rather clean and rounded on one side, but fairly steep and greyish with "cryoconite" (see p. 65) on the other side. The "tufts" are often so close together that there is no room for sledge-runners between them, and this type of terrain is very hard for travellers.

Depressions in the ice: often bowl-shaped and with a lake in the bottom. Frequently watercourses flow into or from such areas.

Plains covered with slush: observed by the expedition at heights of 1100–1200 m a.s.l.

These surface conditions ultimately put an end to the progress of the sledging party. Only the Lapps, who were skiing and not encumbered with heavy equipment, could pass through this region and reach the dry snow desert beyond, with its excellent skiing conditions at altitudes above 1600 m a.s.l.

The sledging party encountered plenty of crevasses and melt-water rivers, and was threatened by all the dangers and discomforts of the holes created by melting (compare the conditions in 1870: pp. 65–67). At first the march covered only a few kilometres per day (see Table p. 160). On July 10, Nordenskiöld decided to give up the relaying and to march with full loads on the sledges. The daily distances then lengthened.

They passed areas where the snow was somewhat coloured, due to "cryoconite" and to diverse kinds of

organisms. Carmine-coloured snow, after melting, proved to consist of a carmine layer above a whitish-grey bottom sediment. The "cryoconite" could easily be collected in the melt-holes (see p. 65), where a layer of this "ice-dust" had formed with a thickness of 1–2 mm.

According to Nordenskiöld, such airborne dust should consist partly of cosmic components, and partly of terrestrial dust which had been distributed over the inland ice by the winds. A Swedish geologist, Dr. Nils Olof Holst (1846–1918), who in 1880 travelled in south-western Greenland and visited the inland ice, concluded that the "cryoconite" is a moraine ooze which has dried and been scattered by winds.

Dr. Berlin's collections of the flora of algae from the inland ice supplemented the results of the Greenland expedition of 1870, as did the results from the Spitsbergen expeditions and the collections of Holst. The collections of ice algae were studied and analyzed by Professor Veit Breicher Wittrock (1839–1914) after the expedition had come home.

From July 16 onward, the conditions seemed to improve, with smoother ice that made progress easier. The rivers were still a hindrance, but they were becoming shallower.

On the evening of the 18th, the Lapp Anders Rossa requested permission to reconnoitre by skiing eastward for some distance. He returned after six hours, having covered a distance of twice 27 km, as shown by the ski tracks that the sledgers followed for the next two days. Rossa's performance was to influence Nordenskiöld in deciding to let the two Lapps, unburdened by any great load, ski eastward to see what lay beyond the horizon.

In the night towards the 21st, rain mixed with snow fell, and the snow-cover was transformed into a watery slush. This virtually prevented sledging, and made the stay on the inland ice almost unbearable. It happened in an area where the sledging conditions before the rain must have been fairly good. The time had come to turn back.

Camp 18, the farthest point of the sledging party, situated at 1510 m a.s.l. They pitched their tent here on July 21. No dry place could be found for the tent, but they could rest well on their rubber mattresses.

The Lapps' skiing tour

Lars Tuorda was sent eastward scouting. He returned to say that the conditions were bad, but he still wanted to ski farther east. Nordenskiöld decided to send the two Lapps eastward as far as possible, yet he considered that they should be back within 24 hours. Lars Tuorda asked for permission to stay away for three or

four days, and Nordenskiöld agreed, although with some misgivings. In a written instruction the Lapps were told not to be too intrepid.

As mentioned, Nordenskiöld believed that the interior of Greenland was not covered by any inland ice, so the two skiers were told to collect flowers and grass. They were allowed to be away for *four* days, but the sledging group would only await them for *six* days. If the sledgers had to leave Camp 18, a sledge with provisions and suitable equipment would be left for them. Probably the sledgers would be forced to leave Camp 18—for fear of drowning—and wait at the previous Camp 17.

The skiers were supplied with 2.5 kg bread, 2 boxes of sardines, 2.5 kg corned beef, 0.85 kg butter, 0.42 kg cheese, 1/2 bottle of brandy, 12 cigars and 6 twists of tobacco. They also carried two compasses, an aneroid barometer, and a pocket watch.

The Lapps started their skiing tour at about 03.00h in the morning of July 22. The sledging party remained at the camp, and spent the day making an inventory of the remaining provisions and washing their clothes. The tub was simply a hole in the snow, whose frozen crust was pierced with the foot; the water was already there.

Next day, the sledgers started transporting equipment to Camp 17, a task completed on the 24th. Nordenskiöld worried over the Lapps; much could have happened to them. But already on this same day, they returned at about noon after an absence of 57 hours. The snow had been ideal for skiing, and they estimated the distance they had covered towards the inland as 21 old Swedish miles (about 230 km, 1 old Swedish mile = 10.7 km) a figure which Nordenskiöld considered “on the whole reliable”. In other words, their turning-point had been at lat. 68°32'N, long. 42°51'W, in the centre of the inland ice, and almost halfway to the east coast.

However, the Lapps had no means of *measuring* distances, and such an estimate is necessarily uncertain in a featureless desert of snow. They read their aneroid every 3 old Swedish miles (32 km), and with these data the heights of the inland ice along their track were computed, to be given in the reports of the expedition. With later data available, a comparison will be made below.

Let us examine, to begin with, what the Lapps had to tell about their remarkable skiing tour. Distances are given here in km.

Beyond 54 km from Camp 18, they found no water and the snow was dry. Farther on, the snow surface became quite flat, and the temperature was -5°C. Lars Tuorda had never before experienced such flat skiing ground; the skis slid gently over the snow. The Lapps

suffered much from thirst. At their turning-point they made a fire with the signal staff and melted water in a tin. The snow was smooth and packed by strong winds. No bare land could be seen. The inland ice climbed in steps: first a small rise, then a flat plain, again a small rise, and so on.

The Lapps had rested for four hours in a pit in the snow because of bad weather, but they had not slept for 2,5 days. They observed two ravens when they were about 55 km from Camp 18.

Thus, the Lapps did not discover any ice-free land nor oases in the interior of Greenland. Instead, Nordenskiöld pinned his expectations upon old tales mentioning a narrow sound which—not very far north of their route—supposedly cut through Greenland from west to east. This hypothetical sound was, for instance, shown by Paul Egede’s map of Greenland from 1788.

Back from the ice

After the Lapps had been given a short rest, the sledging party broke camp on July 25 and started the homeward march. The weather had deteriorated, and the temperature fell considerably—to about -15°C—after the sun went below the horizon in the night. The rivers had run dry and the ice-hillocks had shrunk by melting, but the crevasses had widened and become more covered by snow, so they were more dangerous than on the outward march.

Land was sighted again on July 31, and on August 3 they were back at their tent at Sofia Harbour, where the Greenlanders were waiting for them. The inland-ice party had been on the march since July 3, for 31 days. The Greenlanders at Camp 0 were very glad to see them, having believed that the sledgers had perished.

August 5th was devoted to a rest after the hard toil of the preceding month. But on the 4th and 6th, their equipment was brought together, part of it from the edge of the inland ice. They had one large boat available, yet it did not suffice for both sledgers and Greenlanders and their equipment as well. A party consisting of Nordenskiöld, Berlin, Kjellström, the two Lapps and three Greenlanders crossed the isthmus north of Tasiusarsoak and reached South-East Bay, where two umiaks (Greenlandic women-boats) awaited them for the passage to Egedesminde (compare with the expedition of 1870, p. 69). The other group travelled in the large boat via the Auleitsivik Fjord to Egedesminde. The two groups arrived there on August 9 and 10 respectively, and on August 16 the *Sofia* came to fetch the party. Next day she left for south-western Greenland and the east coast.

THE ICE-MARCH OF NORDENSKIÖLD IN 1883

<i>Date July</i>	<i>Camp No.</i>	<i>Lat.N</i>	<i>Long.W</i>	<i>Diff. long.</i>	<i>Distance from Camp 0 (km)</i>	<i>Distance between camps = daily march (km)</i>	<i>Altitude m a.s.l.</i>
3	0	68°21.6'N	51°03.4'W	0	0		0
4	1	-	-	-	-	-	220
5	2	-	-	-	-	-	290
6	3	68°21.9'N	50°53.0'W	10.4'	7.0	-	330
7	4	68°23.2'N	50°42.1'W	21.3'	14.4	7.4	390
8	5	68°22.5'N	50°39.2'W	24.2'	16.4	2.0	420
9	6	68°21.3'N	50°34.8'W	28.6'	19.4	3.0	450
10	7	68°23.2'N	50°25.8'W	37.6'	25.5	6.1	530
11	8	68°24.6'N	50°13.6'W	49.8'	33.7	8.2	600
12	9	-	-	-	-	(8.9)	770
13	10	-	-	-	-	(8.9)	950
14	11	68°25.2'N	49°34.3'W	89.1'	60.4	(8.9)	940
15	12	-	-	-	-	(6.8)	1010
16	13	68°23.5'N	49°14.1'W	109.3'	74.1	(6.8)	1070
17	14	68°23.8'N	48°58.9'W	124.5'	84.4	10.3	1190
18	15	68°26.6'N	48°44.9'W	138.5'	93.8	9.4	1260
19	16	68°29.1'N	48°26.4'W	157.0'	106.4	12.6	1390
20	17	-	-	-	-	(4.6)	1450
21	18	68°30.1'N	48°13.0'W	170.4'	115.5	(4.6)	1510

Data on the ice-march. The geographical positions of the camps were determined by Nordenskiöld with a prismatic circle and a mercury horizon for obtaining solar altitudes, when possible. Latitudes and longitudes were computed from Nordenskiöld's data by the astronomer Edvard Jäderin. The height of the inland ice was determined from aneroid barometer readings at the different camps and, as a reference, at Egedesminde near sea level six readings per day were made, every four hours.

The ice-march was easterly, approximately along a parallel circle, so the distances between the camps have been computed from the longitude differences between them and the base camp (Camp 0). For these computations a latitude of 68°25'N has been used.

From the table it is seen that the distance to Camp 0 from the turning-point (Camp 18) was about 116 km. The average daily march—or distance between camps—in the interval from Camp 6 to Camp 18 was 7.25 km. These figures are worthy of remembrance in our days of motorized transport by land and air.

The two Lapps of the Greenland expedition in 1883, Anders Rossa and Pava Tourda, obtained Nordenskiöld's permission to go skiing towards the interior of the inland ice. They were asked to collect flowers and grass, as Nordenskiöld believed that the interior of Greenland was not covered by ice. (Nordenskiöld, A.E.: Den svenska expeditionen till Grönland 1883.)

The most important project was a 4-week sledge tour on the inland ice in search of ice-free land, using small and robust sledges. Note the dignified A.E. Nordenskiöld "strolling" alongside the sledges (right).

(Nordenskiöld, A.E.: Den svenska expeditionen till Grönland 1883.)

Cooking on the inland ice during the 1883 Greenland expedition. The picture gives a good idea of the equipment used, notably the sledges and the tent (below). (Nordenskiöld, A.E.: Den svenska expeditionen till Grönland 1883.)

Comments on the Lapps' skiing tour eastward

The skiing tour of the Lapps will now be discussed in terms of the data which Nordenskiöld supplied in his travel account *Den andra Dicksonska expeditionen till Grönland*, Stockholm 1885.

The Lapps started their tour from Camp 18 (see the above table) at 03.00h on July 22. At distances of estimated 3 old Swedish miles (about 33 km) they halted to rest and read their aneroid barometer—namely at Stations a, b, c, etc. in the table below. At the turning-point, Station g, they had according to their estimates travelled 224 km eastward. They ended their tour at Camp 17, where the sledging party was waiting for them. This took place at about 12h on July 24 after an absence of 57 hours.

With the distances as estimated by the Lapps, the longitude of Camp 18 as given in the previous table (48°13.0'W) and the latitude 68°40'N, we obtain the position of the *turning-point g*: 68°40'N, 42°51'W. This may be compared with the track on the map p. 163, where a change in latitude can be seen, from 68°30'N to 68°40'N. We then obtain the following table, building upon the Lapps' report.

Station	Estimated distances in km according to the Lapps	Altitude m a.s.l.
Start		
Camp 18	0	1510
a	32	1580
b	64	1560
c	96	1610
d	128	1630
e	160	1740
f	192	1860
g Turningpoint	224	1950

The route is entered on the map published by Exp. Polaires Françaises, Missions Paul-Émile Victor in July 1953, giving the measurements of the height of the Greenland inland ice as obtained during the French expeditions of 1948–52 (see Fig. p. 163). By interpolation, this yields an altitude of 2530 m for the turning-point, as against the 1950 m given in the table according to the Lapps. *The altitude 1950 m is instead found by interpolation at latitude 68°40'N, long. 46°00'W, which is in fact the position of point c.* If the altitudes are correct, as is probable, the distance covered towards the east from Camp 18 will then be about 96 km, i.e. only 43% of the stated 224 km.

The value 224 km, which must have been covered in one day and one night—or some 450 km in little more than two days, seems in any case much too large. It is remarkable that Nordenskiöld could state that

the distance covered should be regarded as “on the whole reliable”. With the evidence obtained from the French measurements of the altitude of the inland ice, it is embarrassing to recall the long-distance skiing competition which was arranged at Jokkmokk, in Swedish Lapland, on April 3–4, 1884, to commemorate the feat of the Lapps (cf. Nordenskiöld 1885, pp. 239–249). However, we assume here that the vertical dimensions of the inland ice have not changed. And at all events, the skiing tour of the Lapps must be considered a good piece of work.

Fridtjof Nansen, in the report on his Greenland expedition of 1888–89, when the inland ice was crossed for the first time, comments (on p. 647 of the Swedish edition) that the altitude during the Lapps' skiing tour increased so little with the distance inland, as compared with Nansen's own experiences, that he was forced to conclude that the Lapps had highly overestimated the distances they had covered. Nansen even gives 70 km as a probable value of the distance between Camp 18 and the turning-point. This is in fair agreement with the 96 km obtained here from the French measurements of altitude.

The scientific results from Nordenskiöld's march on the Greenland inland ice, combined with those of 1870, were extraordinary enough. For the first time the interior of the inland ice was studied. The conditions in the marginal zone during high summer had been revealed: crevasses, prodigious melting that causes characteristic surface conditions; microscopic algae, and—as described by the Lapps—a “desert of dry snow” farther inland. The hypothesis of snow-free land in the centre of Greenland could be abolished, probably to the sorrow of Nordenskiöld.

SOME LATER EXPEDITIONS ON THE GREENLAND INLAND ICE

Nordenskiöld's marches on the Greenland inland ice were to inspire two of the most prominent polar explorers of all times: the Norwegian Fridtjof Nansen (1861–1930) and the American Robert Edwin Peary (1856–1920). Nansen was inspired during the autumn of 1883 by a newspaper article about Nordenskiöld's Greenland expedition of 1883. This led ultimately to his expedition of 1888, when the Greenland inland ice was crossed for the first time. His expedition was to initiate a Norwegian polar exploration effort that would dominate the field in the following years.

Peary and the Danish lieutenant Maigaard started their march in 1886 from Disko Bay, at the same place as Whymper had used in 1867 (see p. 65). They proceeded inland for 24 days, from June 8 to July 2, and returned on July 24.

The inland ice of Greenland has been crossed

The Norwegian clergyman Hans Egede (1686-1758) initiated the Danish colonization of Greenland.

Map depicting the tour of the Lapps, 1883, by using altitude measurements carried out by French expeditions, 1948-1952 (see p. 162).

Sketch explaining a light phenomenon observed by the 1883 expedition in a South Greenland fjord (above). (see pp 169-170).

The palaeontological investigations by Nathorst in Western Greenland, 1883, were highly successful. The picture gives examples of some plant fossils from the Tertiary (right). (Nordenskiöld, A.E.: Den svenska expeditionen till Grönland 1883.)

Greenland inland ice routes of the Nordenskiöld expeditions in 1870 and 1883. The skiing route of the Lapps is shown by a broken line. At intervals of an estimated 32 km aneroid barometer readings were taken—later giving the altitude above sea level. The altitudes are entered on the map along the route.

Temperature (°C) at Eismitte in 1930–1931

	<i>Jan.</i>	<i>Feb.</i>	<i>March</i>	<i>April</i>	<i>May</i>	<i>June</i>
Mean temp.	-41.7	-47.2	-39.4	-31.0	-20.3	-15.6
Max. temp.	-20.8	-23.2	-16.7	-13.0	-6.8	-3.5
Min. temp.	-64.2	-64.3	-64.8	-57.9	-45.3	-30.0
	<i>July</i>	<i>Aug.</i>	<i>Sept.</i>	<i>Oct.</i>	<i>Nov.</i>	<i>Dec.</i>
Mean temp.	-11.2	-17.0	-21.7	-35.8	-43.2	-38.5
Max. temp.	-3.0	-6.0	-8.8	-14.1	-19.1	-19.8
Min. temp.	-28.5	-33.4	-40.1	-55.6	-58.5	-56.0

several times since then, both by dog-sledge and by tractor.

In 1930–31 a German expedition, under the geophysicist Alfred Wegener (1880–1930), established three scientific stations at about 71°N. One station lay in the marginal zone of the inland ice near the west coast. A second station, *Eismitte* (*Mid Ice*), was in the centre of the inland ice at an altitude of 3000 m a.s.l.; and a third station lay near sea level in Jameson Land, in the Scoresby Sound region in east Greenland.

At *Station Eismitte*, three men spent part or all of a year in caves built within the ice. The meteorological observations from this station gave a first idea of the extremely cold climate which prevails on the inland ice in central Greenland. In the same period, 1930–1931, a British expedition under H.G. (Gino) Watkins had a station on the inland ice in southern Greenland (see p. 451). In recent years, deep borings have been made into the ice, allowing determination of the variations in climate during the past 100–150 000 years. Seismic measurements of the thickness of the inland ice have been carried out during tractor tours, and these measurements also give an idea of the topography of the land beneath the ice. No attempt will be made here, however, to discuss the latest expedition activity on the Greenland inland ice.

Geological work in the Vaigat region

While the inland-ice party was studying the ice, the geological group, consisting of Nathorst and Hamberg, worked along the Vaigat to the north of Disko Island. Already on June 28, 1883, they had been taken by the *Sofia* to the little settlement of Ujaragsuksuk, where they arrived on the 29th. The *Sofia* then steamed to Auleitsivik Fjord, where Nordenskiöld intended to start his ice-march.

The geological group included two Greenlanders from Godhavn as assistants. The group was to lead a camping life. For that purpose they had a military tent—not very suitable here—and for their transports they had a large boat.

The palaeontological work during the expeditions of 1870 and 1871 had given most valuable results. These studies were now to be supplemented by Nathorst, who was specializing in this branch of geology.

On the first day of their stay, the men reconnoitred the surrounding country. They found that the sedimentary strata occurred up to about 300 m a.s.l. and were followed by basalt mountains, some of which were rather high, reaching up to about 1300 m a.s.l. They enjoyed the scenery over the Vaigat and the Nugssuaq Peninsula beyond.

Very soon they noticed that their boat was much too large to be handled by the two Greenlanders, so they hired another 2–6 men for their excursions, depending upon conditions. Their excursions from Ujaragsuksuk were directed towards both the south-east and north-west. The strata from the Tertiary were found at 435 m a.s.l. at Isunguak to the south-east, but at Ujaragsuksuk at less than 300 m.

The underlying strata from the Cretaceous period made rich contributions to their collections. In order to optimize collaboration with the Greenlanders, prizes were offered for the finest pieces of rock. Among the fossils which were found here should be mentioned a leaf, as well as fruits and male flowers of the breadfruit tree.

The fossil collections which were brought together at Ujaragsuksuk filled three large barrels and one box. A detailed stratigraphic and palaeontological investigation remained to be done, but time did not permit this. After each excursion they returned to Ujaragsuksuk, which naturally wasted time but was considered necessary because of previous arrangements with the ship.

During their stay they got to know the strong warm foehn winds, which come from the inland ice. The weather was otherwise fine at Ujaragsuksuk. On July 7 they rowed across the Vaigat to Atanekrdluk, where they pitched camp. Their collections were left at Ujaragsuksuk. Two extra Greenlanders came with

them. The sea was calm, and fortunately so, as their boat was heavily loaded.

Atanekrdluk is a small mountainous hillock about 100 m high, connected with the Nugssuaq Peninsula by a low isthmus. Here were several huts, used temporarily by the Greenlanders. The geological investigations were to be carried out chiefly along a ravine on the mainland, so they pitched their tent here in spite of the undrinkable water which came down from the ravine above—just a mass of mud owing to the strong melting which was going on. They were forced to melt pieces of glacier ice that was floating in the sea, in order to get drinking-water.

This place has become famous in palaeontological literature. Nathorst writes:

“Atanekrdluk is without any doubt the finest habitat of plant fossils that exists anywhere. Its first repute was gained from the Tertiary plant fossils in clayey iron stones, which the ‘uteligger’ [missionary] Jens Nielsen discovered at the beginning of the 1850s.”

The slope at about 360 m a.s.l. contains several blocks, which are extremely rich in fossil prints. It is natural that the first fossil collectors would find rich harvests here, as they had only to scrutinize the loose pieces of rock. But at the time of Nordenskiöld's expedition of 1883, these habitats had been searched so thoroughly that one could not count on many new finds of fossils. One had to turn to excavations in the fresh strata.

Plant fossils from Atanekrdluk were obtained by scientists of some previous Swedish expeditions, notably by Nordenskiöld in 1870, but also during the expedition of 1871. As early as 1859, Otto Torell had found fossils here. The Dane K.J.V. Steenstrup had brought home to Denmark a most comprehensive collection.

The Swiss Oswald Heer had, among other things, analyzed the Swedish collections of Tertiary fossils from Spitsbergen and Greenland, as well as Danish collections. Before his death in 1883, he had reported 187 species of Tertiary plants from the habitat of Atanekrdluk. The Tertiary flora included a great number of trees; even some carbonized tree trunks with roots were found.

Still more “fame” fell upon the habitat of Atanekrdluk after Nordenskiöld's discovery in 1870 of a flora from the Cretaceous period. The strata containing this flora were situated at a height of about 60 m, which is to be compared with the altitude of the Tertiary finds at 360 m a.s.l. Heer mentioned that the Cretaceous flora had demanded an annual mean temperature of about +20° C—meaning subtropical cli-

matic conditions—while for the Tertiary flora he gave +12°C, considerably lower.

The fossils now collected by Nathorst and Hamberg filled more than four boxes. Their palaeontological investigations had been amply rewarded, but the fine weather was followed on July 13 by rain and winds of gale force.

They were expecting the ship now. According to plan she should have arrived already on the 10th. To begin with, Nathorst had not wanted the ship to appear at all: the palaeontological research was yielding such fine results, and he would not give up the field-work here. But now—with the research practically completed, harder weather descending, and their provisions beginning to run out—the ship was longed for. Besides, they were starting to worry that something had happened to the ship.

But the ship did arrive, on the 15th. She had been delayed by an intense calving from the inland-ice glacier to the bottom of Auleitsivik Fjord, which first made the ship a prisoner in Sofia Harbour, and then forced her to run the gauntlet in the narrow fjord. It had indeed been a narrow escape.

A visit to Melville Bugt and the Kap York region

The expedition plans now called for a visit to Kap York, north of Melville Bugt, where Nordenskiöld wanted to obtain samples of the meteoric iron boulders reported from this area. But first the ship had to bunker for the trip, and in order to get the coal they would have to mine for it themselves, at Ritenbenk to the east of Disko Island. In addition, Nathorst needed large barrels for his rich collections.

On board the *Sofia* there were now four scientists: Nathorst (who was leader of the expedition in Nordenskiöld's absence), Forsstrand, Kolthoff and Hamberg. While the mining was going on, Nathorst and Kolthoff worked at Atanekrdluk, the former with botany and geology, the latter with entomological studies. Eight species of butterflies were caught; these had not previously been seen during the expedition.

On July 21 the ship, with Nathorst and Kolthoff on board, left for Upernavik, the northernmost “colony” of the Danes. The first stage in the palaeontological research at the Vaigat was now completed. Nathorst was justifiably satisfied: he had found 11 new strata with fossils in the ravine on the mainland, and a few on the little peninsula. Here he had collected several fossils of species which were new to science. He enjoyed the prospect of meeting Oswald Heer with news of his finds—but the latter died before this encounter could take place.

The *Sofia* arrived at Upernavik (lat. 72°47'N) on July 22. Now the renowned Greenlanders Hans

Hendrik, who had come aboard at Godhavn, had taken up his duties as pilot to the expedition. Hans Hendrik had been a member of Kane's expedition of 1853–55, and had taken part in the highly adventurous expedition of Hall in 1871–73; a few years later, in 1875–76, he went with the large British expedition under Nares.

They were warmly received by the Danish "colonial chief", and were promised coal also upon their return from the Kap York district. Further, they could send home their collections on board a ship, which was due to sail for København within a few days.

They left the same day at about 23.00h. The next place to visit was Tasiusak, the northernmost "uteligger" (missionary) place, where they would obtain a pilot who was "familiar" with the southern and eastern parts of Melville Bugt. While waiting for the pilot, the scientists had good opportunities for scientific studies in the surroundings.

At about noon they left Tasiusak in order to cross Melville Bugt, a region of evil repute. The passage was somewhat hampered by a combination of fog and ice, and there were several stops, which were eagerly used for hydrographical observations. Their new lead, which had been constructed at Upernavik, made the soundings easier than before.

Hans Hendrik had never seen so much ice in Melville Bugt, and doubted that they would ever reach Kap York. The spring and summer of 1883 had been very cold in Greenland. The route of the *Sofia* became somewhat erratic, but at last they did reach the coast beyond Kap York. In the afternoon of July 26, they observed flocks of little auks, flying in a definite direction. This indicated that the *Sofia* must be near land, and in the evening a mountainous coast with high snow-covered peaks and glaciers appeared. Soon Hans Hendrik recognized the cone-shaped island Conical Rock. Kap York was situated to the east, but in this direction lay impenetrable ice; only to the north was the ice more open.

The wind had increased, and it was desirable to find shelter for the *Sofia* in a good harbour. To the north-east they saw a small ice-free fjord opening west. The *Sofia* entered this fjord, Ivsugigsok, and soon anchored near its bottom.

There were polar Eskimos on the shore, and friendly relations were established very soon. These Eskimos have a culture quite different from that in the rest of Greenland. They had been discovered at Kap York in 1818, by the British expedition under Captain John Ross to find a North-West Passage. The Eskimos usually spent the summer here, but in the winter they lived on an island in Wolstenholme Sund. Nathorst writes:

"These Eskimos have no kayaks or any other kind of boat, a circumstance which has awakened great astonishment in the Danish 'colonies', where they cannot imagine an Eskimo without a kayak. And their hunting-tackle is pretty simple: a few harpoons of bone, bag nets for capturing Little Auks, a knife—that is all. But with this tackle they kill both seals and polar bears, and in the winter also walruses. It is almost humiliating to us civilized men to see how this people, living among snow and ice and almost without implements, can not only sustain life but even thrive in the best of well-being."

The rest of the 26th was devoted to scientific studies. The geologist investigated the mountains and the local flora; the zoologist collected animals, the hydrographer gathered red snow, and the captain of the *Sofia* was busy with ethnographical studies.

On July 27 two kayaks were sent eastward to reconnoitre. They reported that the ice lay close upon the land: there was no possibility to reach Kap York and the meteoric iron blocks there.

Nathorst observed this day in the north of the fjord

"...several strange marks emanating from the stay of the Eskimos at the place, such as some slabs of stone erected at intervals of a few feet and forming straight lines, stone cairns (graves?), etc., but I did not have time to make any thorough investigation."

Similar observations had apparently been made earlier in north-western Greenland and the Smith Sound area. These marks have been attributed to old Norse hunters coming from southern Greenland (note by the author).

The ice, which since the previous day had come close upon the fjord, was now entering it. Next day, the 28th, the whole fjord was filled up with ice, except near the northern shore where the *Sofia* now became enclosed between the ice and the land. The ship was thus captured in the fjord, and on board it was discussed what to do if the captivity became prolonged. A sledge tour to Kap York and the meteoric iron boulders there was contemplated, but this plan was abandoned in view of the highly uncertain situation and the agreements with Nordenskiöld.

Anyhow, on July 29 the ice had become so open in the fjord that they managed to escape and pass Conical Rock, where they got an idea of the huge ice masses which had gathered off the coast. The *Sofia* forced her way through the ice, and in the evening, when the yellow rocks of Kap York were disappearing in the

distance, they steered into a vast open area, where they stopped to carry out oceanographical and zoological work (down to 490 m).

They thought that they had definitely got rid of the ice, yet in the night towards July 30 they had to pass through a rather extensive ice field. The 30th was devoted to hydrographic and zoological work (depth 1450 m). They were at lat. 74°30'N, long. 64°30'W, and steered east in order to reach Upernavik. Soon they met thick pack-ice without any open leads. They steered south but, next day, they were surrounded by ice; all directions were barred to them except to the north. They now turned north to find a lead opening towards the coast; their coal stores were running low.

At 16.00h they reached the position where they had turned south the preceding day, but the ice was open. After one hour they were past the worst ice and entering an area with rotten ice. At 01.00h on August 1, the ship encountered a heavy swell, which indicated that they were free of the ice. The same evening they reached Upernavik, where they bunkered. Next day they visited Pröven, situated south of Upernavik. Here they replenished the coal stores, and on August 3 they left for the south.

Their Kap York mission was ended. The meteoric iron boulders at Sovalik had not been reached—a disappointment, of course, to Nordenskiöld. But many valuable observations in natural history had been carried out, not least in oceanography, so they were satisfied. Considering the low ice-worthiness of the *Sofia*, one is tempted to say that they should also have been thankful to return safely and with the ship undamaged—aside from a number of dents on her hull. Moreover, an anchor with nearly 200 m of chain had been lost. The ice conditions had in part been extremely severe, and only one ship besides the *Sofia* seems to have penetrated as far north as Kap York. This was the relief ship *Proteus* to the Greeley expedition, and she had been crushed in the ice (compare p. 186).

There still remained palaeontological research to do at the Vaigat and at Umenak Fjord. Hareöen, situated in the western mouth of the Vaigat, was also to be visited. However, when the *Sofia* approached this island on August 4, the breakers along its shores seemed too hard to permit a landing. The *Sofia* therefore proceeded towards Patoot, on the northern side of the Vaigat and a little north-west of Manik. Nathorst and Kolthoff were landed here, while the *Sofia* proceeded to Ritenbenk at the south-eastern mouth of the Vaigat in order to have her engine and boiler overhauled.

Nathorst and Kolthoff spent four days at Patoot, August 5–8. The region is most interesting from a

geological and palaeontological point of view. Here occur both plant and animal fossils, including sea urchins and bivalves. They indicate that some fossils have been deposited in the sea, while other strata at the same place have been deposited in fresh water. These fossils—which belong to the Cretaceous period, younger than the Atane series—had been discovered by the Danish geologist K.J.V. Steenstrup.

Other interesting finds were the traces of an intense and extensive earth-fire from long ago. Nathorst gathered rich harvests of fossils. Above the Patoot series lay Tertiary rocks, and here Nathorst found the marked guide horizon which also exists at Atanekrdluk and on Disko Island. Kolthoff was at first dissatisfied over the entomological finds, but he moved to higher localities at 750–900 m, with a less advanced season, and discovered a flourishing vegetation that yielded abundant collections of butterflies.

On August 9 they heard the steam whistle of the *Sofia*, but fog had settled over the area, and not until the following day was it possible to board the ship. She proceeded to Nuqssuaq at the north-western tip of the Nuqssuaq Peninsula, where five Greenlanders were hired for a trip westward with the ship. Nathorst, Kolthoff and two Greenlanders were then taken to Hareöen, and they pitched camp on the south-eastern side of the island.

Here, too, valuable fossils were obtained, and Kolthoff was satisfied over his collections of insects. But they were worried about the ship, as the wind had risen to almost full gale force after she had left. In fact the *Sofia* did experience troubles, and the Greenlanders on board proved to be very poor sailors.

A few hydrographical and zoological series could be taken before the ship had to seek shelter in the bad harbour of Nuqssuaq on the 11th. However, she got into a critical position due to heavy swell, combined with an iceberg which drifted into the harbour and threatened her, so she had to put to sea again.

Nathorst, Kolthoff and the two Greenlanders were fetched on the 12th, after some coaling operations on the way. The *Sofia* arrived at Egedesminde on August 16. The whole expedition was now assembled without any losses of life and limb. But the homeward voyage could not yet begin.

The old Norse colonization and the first Danish colonies in the 18th century

There remained an attempt to visit south-eastern Greenland, where the East Settlement (Austbygden) of the old Norse colonization had been situated according to Nordenskiöld. Moreover, some of the areas of Norse colonization in south-western Greenland were to be visited, i.e. the *real* East Settlement. As

pointed out above, the great explorer's views about the locations of the East and the West Settlements were in conflict with official and general opinion. A few historical notes will be of value.

The Viking Age was a period of intense activity in the "Norse" countries of Scandinavia. Popularly the Vikings have long been regarded as mere robbers, but they were certainly good warriors and sailors. Their profound influence upon neighbouring countries, for better or worse, was largely due to their development of a superb type of vessel. The "Viking ship" was strong and elastic, easily handled, seaworthy and extremely shallow in draught.

Around 800 A.D. the Vikings struck westward to the British Isles, present-day France and the Faeroes, followed by Iceland, Greenland and North America. The Norwegians mostly concentrated upon very long voyages to the west. The Danes sailed southwest, while the Swedes generally travelled southeast through Russia to the Arab world and the Byzantine Empire. The Vikings were also—or became—traders, colonists, peasants and soldiers; some of them were poets, and many loved adventure.

As for the Norwegian voyages, the Shetlands, Orkneys and Faeroes were probably occupied already in the eighth century. Iceland was discovered around 860–870, and soon afterward came heavily loaded "emigrant ships", by which time Irish monks were living on the island. The occupation is recorded in detail by the old Icelandic *Landnámabok*, which even names individuals. Among the settlers were numerous Danes and Swedes, as well as Celts from Ireland and Scotland. Within a couple of generations, the influx was completed.

Greenland was discovered about 900, and in 985 Erik the Red sailed there. He had been declared an outlaw and, while waiting for his sentence to expire, he investigated the land and fjords in south-western Greenland. Returning to Iceland with tales of a luxuriant "green" land, he inspired people to go with him and stay. Two separate communities were formed: the East Settlement in the present-day district of Julianehaab in south-western Greenland, and the West Settlement in the region of Godthaab farther north. The settlements were not on the coast, but some way inland along the fjords and the valleys.

Connections were upheld with Iceland and Norway, and the initial events were described in the Icelandic sagas. The eagerness to accomplish great deeds, too, endured at first. Erik's son, Leif Eriksson, discovered North America in 1000 AD, and attempts to colonize it were made by Torfinn Karlsevne in 1001. The location of this new land, "Vinland", is debated; it may have been situated somewhere be-

tween Cape Cod and northern Newfoundland. Archaeological finds of Norse origin have, for instance, come to light in the latter area.

The West Settlement (Vesterbygden) perished around the middle of the 14th century. The causes are not known with certainty. Hypotheses point to a deterioration in climate which occurred at the time. The fall of the settlement may also have been a consequence of an invasion by Eskimos from the north, which in turn might have resulted from a climatic decline. The connections with Iceland and Norway were severed, and this too may have partly owed to the worse climate, as well as to the contemporary Black Death in Europe.

The East Settlement (Austbygden) survived until at least 1500. Finds suggest that the inhabitants degenerated during the last stages of the colony's existence. Then a veil is drawn over the Norse colonization in Greenland. As to the fate of the colonies in America, the sagas are silent, but events occurred there which may indicate that they were still in existence a few centuries after their foundation.

The next remarkable and far-reaching event in the history of Greenland was the landing of the Norwegian priest Hans Egede (1686–1758) near present-day Godthaab on July 3, 1721. It should be noted that Norway, at that time, belonged to Denmark. Hans Egede was a clergyman from northern Norway. In 1708 he began to take an interest in the fate of the Norse colonies in Greenland. After all, their inhabitants had once been Christian and they were his fellow countrymen. They had disappeared and he considered that it was his duty to search for their descendants and preach the Gospel to them.

Hans Egede had a long way to go before he and his wife Giertrud Rask, with the help of the Danish King Frederick IV and the merchants and sailors of Bergen, Norway, were able to sail for Greenland on board the ship *Haabet* ("Hope") of Bergen. Near the present "colony" of Godthaab on July 3, 1721, the ship steered towards land. On a small island, named Haabets Ö, Egede built his first missionary station, from where he began preaching to the Eskimos. No descendants of the Norse settlers were ever found.

Such was the beginning of modern Greenland. Missionary work and teaching, combined with trade, were to be followed by Danish administration and scientific research. Hans Egede worked in Greenland until 1736, his son Paul later exerted great influence there. It is beyond the scope of this book to describe the Danish activity in Greenland after Hans Egede's arrival.

All his life, Hans Egede believed that the East Settlement had been situated on the east coast of

Greenland. In western Greenland, he had found ruins of Norse houses. Thus in August 1723 he launched a boat tour southward, accompanied by the mate Erik Larsen. His intention was to round Cape Farewell and follow the east coast northward, in hopes of locating the East Settlement here. He found house-ruins, and the ruins of a church not far from Cape Farewell (in the Julianehaab district). Indeed he had found the East Settlement, but he believed it to be part of the West Settlement. And he did not reach the east coast; he had to turn back before he came so far.

In a biography of Hans Egede, Louis Bobé writes:

"Hans Egede's pioneering expedition is peculiar, in that he was the first to rediscover and traverse the centres of the East Settlement. The reason why he neither then nor later realized that he had done so, was that he was still influenced by the topographical errors of Torfæus. Not until 1794 did H. Eggers show, with great ingenuity, that the real position of the East Settlement was in the present Julianehaab district—without, however, prevailing in his view. Thirty years later, H.F.J. Estrup tried to maintain that descendants of the old Norsemen might be found on the east coast, and as late as 1883 Nordenskiöld still clung to the belief that the East Settlement was to be sought on the eastern side of Greenland.

Hans Egede's expedition, and his description and map of the route traversed, gave the first comprehensive view of the southernmost coast of Greenland, as laid down in his later maps of 1735 and 1741, and thus he became the guide of all future travellers towards the south."

It should be added that Hans Egede also initiated the Danish colonization of Greenland.

With the Sofia in south-western Greenland.

A light-phenomenon in the fjord water

The *Sofia* was ready for sea when she arrived at Egedesminde on August 16, and the same day she started her long voyage home. Her next stop was at Ivigtut, where some stores were taken aboard, and some equipment was sent home by the sea connections of the mine. The expedition stayed from the 19th until the 23rd. Hydrographical measurements and zoological dredgings were carried out in the deep fjord, and during excursions botanical and entomological collections were assembled. A luxuriant valley, Grønnedal, was visited, as were the inner portions of the Arsuk Fjord where the inland ice has an outlet to the fjord.

From Ivigtut the *Sofia* proceeded inside the skerries to Julianehaab, arriving on August 23. The head of the "colony", Carl Lützen, had promised to find an Eskimo interpreter for Nordenskiöld, but this had proved impossible. He provided the expedition with stores of different kinds. Excursions were made with the ship into the Igaliko Fjord, where they visited the house-ruins which are attributed to the "estate", Brattahlid, of Erik the Red. Nordenskiöld considered the main building smaller than he had anticipated. The foundation wall indicated a house smaller than an ordinary crofter's cottage in Sweden.

The return voyage took place in the darkness, and here an interesting phenomenon was observed—but not explained.

Nordenskiöld writes:

"As we steamed along the narrow fjord in calm weather on a smooth sea, we observed suddenly on the sea surface astern of the ship a broad but sharply limited belt of light. It shone with a uniform, somewhat yellowish glow, rather like the light from some phosphorescent substances. In spite of the fact that we proceeded with a speed of 4-6 knots, the light got nearer to us. When it reached the ship, it seemed as if we had steamed forward in a sea of fire or molten metal. After a while the light passed by the ship, and it disappeared ultimately on the horizon ahead. Unfortunately I did not have time to examine it with the spectroscope or take any water samples, before the performance was over. It was apparently of a different kind than the ordinary bluish-white phosphorescence of the sea, which *at the same time* appeared rather clearly in the wake of the ship. As the light was perfectly uniform, it cannot have been phosphorescence produced by a shoal of fish that had swum past the ship. A shoal of fish should, besides, have revealed itself by some motion on the water surface, which at the moment was smooth as a millpond; and the phosphorescence from the fish would probably have produced a bluish light, not such a pale yellowish light as appeared here. The Eskimos declared that a glacier river, which debouched in the neighbourhood, spread a thin layer of clayey water across the surface of the fjord. They believed that it might have a bearing on this grand natural phenomenon, which they had never seen before. No aurora was seen in the sky, which was rather densely covered by clouds.

This remarkable natural phenomenon, which our scientists could not explain, is described in the logbook of the *Sofia* for the night towards the 25th of August."

The present author has seen a phenomenon which might provide an explanation. In 1937–38, I worked at the oceanographical station of Bornö in the Gullmar Fjord, north of Göteborg (see p. 404). On one occasion in the winter, brackish water from the inner part of the fjord spread out towards its mouth. The boundary between the two water masses probably had the character of a wedge-shaped front, separating the less dense brackish water from the denser saline water beneath it (see Fig. 163). The brackish water advanced with a speed similar to that described from the Igaliko Fjord, and the displacement was excellently shown by the meerscham which gathered on the surface at the line of separation (front) between the water masses, thanks to the convergence in the flow here.

Phosphorescence of the sea is mainly produced when the marine organisms in question are disturbed, as by the movement of a hand, oar, or ship. The organisms may also be disturbed by turbulent motion near the surface of separation between two water masses, where phosphorescence should thus occur. The light should be bluish, but may become yellowish when passing through the clayey brackish water on top. Nordenskiöld also speaks of a sharply limited light, and this should occur at least along the front itself (see Fig p. 163). In other words, the Eskimos were probably right in their presumption of the cause of the light-phenomenon in the Igaliko Fjord.

Northward along the East Greenland ice

The *Sofia* left Julianehaab on August 26. Her nearest destination was Fredriksdal, where Moravian Brethren were running a missionary station. Nordenskiöld hoped to get an Eskimo interpreter from this station in view of the planned visit to the east coast. The place lay near Cape Farewell. According to the missionaries, the *Sofia* was the first European ship to anchor here.

The manager of the station, Pastor Jacob Brodbeck, declared himself willing to go with the expedition and act as an interpreter. First, though, he had to obtain permission from his superior, living some tens of kilometres to the north. After doing so, Pastor Brodbeck found two Eskimos to serve as pilots for the *Sofia* during her passage through the narrow sounds in southernmost Greenland. By this route, Nordenskiöld hoped to reach the east coast, where he would steer northward in presumed ice-free waters along the coast.

The *Sofia* left Fredriksdal on August 29 and started her passage through the narrow sounds north of Cape Farewell. It proved to be a very dangerous region for ships, in spite of the fine weather. The sounds were

narrow and deep, in fact too deep for anchoring; there were strong tidal currents and ice, which either barred the way or came drifting with the currents and threatened the ship. Moreover, the nights were dark now.

There was nothing to do but give up the attempt to get through. They passed near Fredriksdal, where the two Eskimos left the ship. The *Sofia* then had to fight against the ice off Cape Farewell. On September 1 she could proceed northward, though not in a coastal lane but outside the ice. At several places it seemed that open water reached all the way to the coast, yet when approaching land the ice soon came into sight and barred the way, just as they had experienced on the outward voyage.

Hamberg, who was responsible for the oceanographic observations, was busy taking hydrographic series both in the cold south-going East Greenland current and the warm Irminger current from the south. Hamberg measured the temperature and the salinity of the sea water at different depths from the surface to the bottom. The measurements indicated that the cold East Greenland current rested upon warm water, and that the thickness of the cold current increased with the depth of the sea bottom—being roughly 100 m deep with the bottom at 100–200 m, increasing to roughly 350 m for bottom depths of 750 m. Sometimes the transition between warm and cold water was very sharp.

It was now late in the season, and the coast in the south was known to be uninhabited by Eskimos. So Nordenskiöld would not take any risks of being caught in the ice; moreover, the stores of coal were limited.

A visit to south-eastern Greenland

On August 4 an effort was made to pass through the ice at about lat. 65°N. Here the outer ice-edge was encountered about 20 nautical miles from the land. They managed to penetrate the ice and emerge into the ice-free coastal lane, which was 3–4 nautical miles wide. The mountains reached the sea in very steep slopes, without any grassy lowland.

The *Sofia* had reached the coast of south-east Greenland at a place where the “colony” of Angmag-salik is now situated. A landing was made in a bight, but they could not find any usable place for anchoring, or shelter for the ship. A reconnaissance was carried out from some mountain tops, and revealed an excellent harbour quite nearby. It was a fjord with several arms and only a rather narrow mouth. They named it King Oscar Harbour.

This was the first harbour on East Greenland south of the Arctic Circle where any ship had ever anchored, at least within the latest centuries. Nordenskiöld tried to identify it with the harbour of Sand from Ivar

Bardsön's Saga. He reported foundation-stones from a small house of the same kind as the Norse house-ruins in south-western Greenland. They also found two stone cairns on mountain summits. These may have served as marks for ships entering the safe harbour.

Immediately after the ship had anchored in the south-western corner of the harbour, the landing-parties went ashore. The harbour was surrounded by beautiful little valleys, covered with smooth grassy spaces and luxuriant groups of osier bushes. The mountains, which reached heights at around 1000 m a.s.l., were found to consist of granite, gneiss and diorite, as is true of many places in western Greenland. Nordenskiöld writes:

"The vegetation seemed to me more luxuriant, and the grassy spaces less mixed with mosses, than in the fjords of the same latitude on the Greenland west coast which I had visited."

In one of the valleys was a river. Here they observed footprints of human beings, some so fresh that the sand had not dried. Probably the natives had taken to flight when they observed the *Sofia* coming out of the ice and heading for the harbour. Nathorst followed the footprints rather far inland. He was alone, which worried the others, as nobody knew what the reactions of the Eskimos would be.

Unfortunately no Eskimos were met or seen. Nordenskiöld was disappointed. He thought that he might have got important information from them concerning the land and people, if not also information which could resolve the question of the position of the old Norse Settlement. New attempts were made to meet Eskimos, but in vain. However, they

found old sites, tent rings, graves and broken hunting implements.

The *Sofia* left King Oscar Harbour already on September 6, the intention being to proceed somewhat to the north and find a large fjord. This had been reported by east-coast Eskimos to the Danish arctic traveller Holm, and to Pastor Brodbeck who was now on board the *Sofia*.

The passage through the ice was now more difficult, especially in its dangerous stretch at the outer ice-edge, where a strong swell tossed the ice-floes against each other. They had to steer south and east to circumvent a tongue of ice before they could proceed north. The mouth of the fjord was suspected to lie south of Ingolf's Fjell, and they could see a deep fjord penetrating between the mountains in this area.

Nordenskiöld considered the situation: the stores of coal were running low, and the critical passage through the outer edge of the ice had looked more formidable this time. The course was therefore set for Reykjavik, where they arrived on September 9. Nordenskiöld arrived in Göteborg on September 27, although whether he did so with the *Sofia* is not stated in his report.

This was his last expedition. The glorious Nordenskiöld epoch in Swedish polar research history had expired. The decade that followed upon the Greenland expedition of 1883 was characterized by a marked decline in expedition activity. Yet new men were waiting or dreaming to come forward, as we shall see. A remarkable boom of expedition activity ensued in 1895–1910.

By then, however, a new type of polar research had been introduced, involving collective international polar research at fixed stations: the Polar Year or the Geophysical Year.

A PERIOD OF PREPARATION
1882–1895

18. THE POLAR YEAR 1882–1883

THE PHILOSOPHY BEHIND THE POLAR YEAR

The first Polar Year was a characteristic feature of its age. For several years, synoptic methods had been used for studying large-scale courses of events or processes in nature. These are methods by which a scientific process can be summed up and simplified from a great number of observations—such as a synoptic weather chart that has been analyzed to reveal the weather systems of atmospheric flow, anticyclones and cyclones with their fronts, areas with precipitation, and so on.

The use of synoptic methods is perhaps most obvious in *meteorology*, where they are used, for example, to forecast the weather. During the Crimean War (1853–56) a severe gale caused shipwrecks among the fleets of the allied forces, France and Great Britain. An investigation showed that these losses might have been avoided if it had been possible to follow the movement of the storm-centres on the map. The time was ripe for organizing weather services or meteorological institutes in different countries, and in Leipzig an organization was discussed which would further such a development. In consequence, the *International Meteorological Organization (IMO)* was created. This was a forerunner to the *World Meteorological Organization (WMO)* of our days. IMO, like WMO, was to create uniform rules and stipulations for the meteorological observation activity, and for the publication of observations. IMO became officially organized in 1878, and its first international congress was held in Rome that year.

Synoptic observations and methods also occur in the geophysical discipline of *geomagnetism*. The great German scientist and traveller Alexander von Humboldt (1769–1859), already in 1829–36, appealed for a world-wide network of geomagnetic stations to be established—as well as stations of relatively short duration. In this way it would be possible to gain a global outline of the geomagnetic variables.

Geomagnetic disturbances or “storms” are global phenomena which should be studied synoptically. The two German scientists Karl Friedrich Gauss (1777–1855) and Wilhelm Eduard Weber (1804–91) founded the “*Magnetischer Verein*”, based at Göttingen in Germany.

The “*Verein*” developed into an international organization, which among other things prescribed special days for simultaneous observations of the geomagnetic variables: declination, inclination and (horizontal) intensity.

The *aurora* was at this time an enigmatic phenomenon, which also had to be studied synoptically. Objectives were to get a general view of the geographical position of the aurora, changes in its extent and position, and its variations with time. Such studies would perhaps help in reaching an explanation of how and why the aurora occurs.

It was these three scientific disciplines—meteorology and studies of geomagnetism and the aurora—that formed the initial plans for the Polar Year. The observations were to be carried out at the same times and uniformly at all stations. The stations had to be placed and distributed on Earth in a satisfactory way, rather than occurring densely in some regions and sparsely or not at all in others. However, the polar regions evidently represented deplorable gaps in the global station network. It is also characteristic that the scientific expeditions to the polar regions had pursued different aims and had worked at different times, in a way which was all but synoptic.

Plans, organization, and scientific stations

In 1872–74, an Austrian-Hungarian expedition tried to sail along the North-East Passage by going north of Novaya Zemlya. Its ship, the *Tegetthoff*, became “beset” in the ice and drifted to Franz Josef Land—which was then discovered, named, and explored in its eastern and northern parts. The expedition was forced to abandon the ship and return in small boats to civilization.

One of the expedition’s two leaders, Lieutenant Karl Weyprecht (1838–81) of the Austro-Hungarian Navy, subsequently maintained that it was more important during a polar expedition to search for scientific knowledge than to discover headlands, bays and islands. He appeared officially at the Meeting of German Natural Scientists at Graz in 1875, and proposed that scientific stations should be established in the northern as well as the southern polar regions. Synchronous observations should be carried out at these stations, and would lead to better knowledge of the polar conditions than had the more sporadic observations from previous polar expeditions. Of course, there was nothing to prevent other scientific disciplines from being attached to the Polar Year stations, or long sledging tours from being carried out. The stations might thus resemble ordinary wintering expeditions.

He who champions a great cause is often inclined to prejudice, and to disregard for the achievements of forerunners. Weyprecht was, and this fact irritated, among others, A.E. Nordenskiöld. In Nordenskiöld’s report on the Yenisey expedition of 1875, he wrote in a footnote:

"During the first general assembly of the 48th meeting of German Natural Scientists and Physicians, the famous German Polar Explorer Lieutenant Weyprecht has declared his conviction that the scientific results, which have been yielded by all the polar expeditions that have been dispatched until now, have not corresponded to the costs which have been spent upon them—because specialists have not taken part in these expeditions—and Herr Weyprecht's statement seems to have gained great approval from many learned geographers with claims to literary and expert knowledge. One might, though, have expected that these Gentlemen should have been familiar enough with the arctic literature to know that the expeditions which have been dispatched from Sweden have always brought with them a scientific staff of specialists, by whom the physical features of Spitsbergen have been investigated in a manner which makes this distant ice-covered land one of the best known on Earth..."

One becomes aware of Nordenskiöld's irritation, even from his choice of capital letters!

During the following years Weyprecht tried to interest scientific academies and geographical societies in his plan. In 1877, he and his patron, Count J.N. Wilczek, set up a detailed program which was to be discussed at the international meteorological congress in Rome that year. However, the congress was postponed till 1879, and meanwhile the chancellor of Germany, Otto von Bismarck, established a commission of leading scientists who recommended the plans—as did the meeting in Rome. With that, the plans had made considerable progress.

A special international congress met at Hamburg in October the same year, with representatives from eight states including Sweden. A plan for the scientific work was drawn up: eight stations should be founded, and the observation period would be August 1, 1882–September 1, 1883. This reinforced observation activity was named the *Polar Year, 1882–83*. The states involved could now start their preparations.

An International Polar Year Commission had been established and, in the states which were to take part in the "Year", National Polar Year Commissions arose to organize the activity. The Swedish deputy at the meeting of the International Polar Commission was Professor August Wijkander, member of the Swedish Spitsbergen expedition of 1872–73 (see p. 77).

Twelve scientific stations were established in the Arctic and the Subarctic. In the Southern Hemisphere, there were no stations in the Antarctic and

only two in the Subantarctic zone. In addition, about 40 stations in the temperate zones were to be included in the observation activity. The Polar Year stations within or just outside the Arctic, and the stations within the Subantarctic zone, are seen from p. 176.

The Polar Year received, for natural reasons, the greatest support from meteorological organizations. It was also most important to ensure opportunities for studying the geomagnetic variables and their disturbances in the polar regions. The conditions there were only imperfectly understood, and the disturbances are stronger than in lower latitudes. As regards the aurora, it occurs more often in the polar regions, especially in the so-called auroral zone in the regions more or less bordering on the Subarctic.

The *Polar Year* was thus a Geophysical Year, but this designation was not created at that time. The historical term "Polar Year" should now preferably be replaced by "Geophysical Year" (see further p. 511).

Weyprecht was never to see his dream realized. He died in 1881, one year before the beginning of the Polar Year.

Planning a Swedish Polar Year station

In the autumn of 1879, the Royal Swedish Academy of Sciences petitioned the Government for 60 000 Sw.Cr. to finance Swedish participation in the Polar Year, but no proposition was handed to the Parliament. Instead Mr. Lars Olsson Smith (1836–1913), a wealthy wholesale dealer and industrialist in Stockholm, presented this sum of money one year later. In this way the role of Sweden in the Polar Year was made possible. The Swedish Navy, however, took care of the transports of equipment and personnel to and from Spitsbergen, as well as supplying some of the men in the group of "workers".

For organizing the Swedish contribution to the Polar Year the Royal Swedish Academy of Sciences established a Polar Year Committee having the following members:

Professor Daniel Georg Lindhagen (1819–1906), secretary to the Royal Swedish Academy of Sciences.
Professor Erik Edlund (1819–88), physicist; in 1858 he had organized the Swedish network of meteorological stations.

Professor Adolf Erik Nordenskiöld (1832–1901).

Professor Robert Rubensson (1829–1902), head of the Central Meteorological Office of Sweden.

Mr. Lars Olsson (*L.O.*) Smith (1836–1913), sponsor to the expedition.

Captain F. Malmberg was chosen as leader of the expedition. He was the head of the Nautical Meteorological Bureau in Stockholm. The scientific staff—in

Count J.N. Wilszek. The patron of Weyprecht (top left). (Payer, J.: *Upptäcksresor i Norra Polarhavet*.)

Nils Ekholm (1848-1923), meteorologist, leader of the Swedish Polar Year Station 1882-1883 at Kapp Thorsden, Spitsbergen (top middle). (Royal Swedish Academy of Sciences.)

Lieutenant Karl Weyprecht (1838-1881). Initiation of the Polar Year (top right). (Payer, J.: *Upptäcksresor i Norra Polarhavet*.)

The station Kapp Thorsden and Isfjorden as seen from the "anemometer hill". The *Urd* has come to take the expedition home (above). (Ekholm, N.: *Introduction historique*.)

Position of the observing stations in the Arctic and the sub-Arctic during the Polar Year, 1882-1883 (left). (Wallen, A.: *Polaråret*, *Nordisk Tidskrift*, 1933.)

SCIENTIFIC STATIONS DURING THE POLAR YEAR, 1882–1883

ARCTIC AND SUB ARCTIC STATIONS

<i>Station</i>	<i>Lat.</i>	<i>Long.</i>	<i>State</i>	<i>Leader</i>
Jan Mayen	71°N	8°W	Austria-Hungary	Lieutenant E.v.Wohlgemuth
Godthaab, Greenland	64°N	52°W	Denmark	Dr. A. Paulsen
Fort Conger, Canada	81°N	65°W	USA	Lieutenant A.W. Greely
Cumberland Sound, Baffin Island	65°N	67°W	Germany	Dr. W. Giese
Great Slave Lake, Canada	62°N	115°W	Great Britain, Canada	Capt. H.Ph. Dawson
Point Barrow, Alaska	71°N	156°W	USA	Lieutenant P.H. Ray
Sagastyr, Lena Delta, Siberia	73°N	128°E	Russia	Lieutenant N. Jürgens
Dickson Harbour, Siberia*	74°N	82°E	Holland	Dr. M. Snellen
Novoye Karmakuli, Möller Bay,				
Novaya Zemlya	73°N	53°E	Russia	Lieutenant Andreyev
Sodankylä, Finnish Lapland	67°N	27°E	Finland	Assistant E. Biese
Bossekop, Altenfjord, Norway	70°N	23°E	Norway	Assistant A. Steen
Kapp Thordsen, Spitsbergen**	78°N	15°E	Sweden	N.G. Ekholm, B.Sc.

* The Dutch Station was planned to be placed at Dickson Harbour, 74°N, 82°E, but the expedition ship was caught in the ice in the south of the Kara Sea, at roughly 70°N.

** The Swedish station was planned to operate from Mosselbukta in northernmost Spitsbergen. Ice prevented the expedition ships from reaching Mosselbukta; instead the station was located at Kapp Thordsen in Isfjorden.

SUBANTARCTIC STATIONS

<i>Station</i>	<i>Lat.</i>	<i>Long.</i>	<i>State</i>	<i>Leader</i>
Cape Horn (Orange Bay),	56°S	68°W	France	Lieutenant Courcelles-Seneuil
Tierra del Fuego				
South Georgia (Royal Bay)	54°S	37°W	Germany	Dr. C. Schrader

Germany also operated a station of second order in the Falkland Islands at 52°S, 59°W.

addition to him—was to consist of three persons: N. Ekholm, E.O. Solander, and V. Carlheim-Gyllensköld. Besides these scientists, the personnel of the station was to include manual workers for the more practical tasks and routines.

Captain Malmberg, however, fell ill towards the end of the summer of 1881 and had to resign from his commission. In September the same year he was replaced by Ekholm as leader of the expedition.

After further changes, the definitive list of the station personnel became the following:

SCIENTIFIC STAFF

Nils Gustaf Ekholm (1848–1923), chief of the station, responsible for meteorological and astronomical observations.

Salomon August (S.A.) Andrée (1854–97), Master of Engineering; technical tasks, studies of drifting snow and atmospheric electricity.

Vilhelm Carlheim-Gyllensköld (1859–1934), B.Sc., responsible for aurora observations and studies of optical phenomena; photographer to the expedition.

Richard Henrik Albert Gyllencreutz (1850–1914), M.B., doctor to the station personnel.

Emil Otto Solander (b. 1858), B.Sc., physicist, responsible for the geomagnetic observations.

Henrik Allan Stjernspetz (1850–1920), lieutenant in the Swedish Army; topographical research.

WORKERS

Nils C. Andersson (b. 1860), carpenter and glazier.

Peder U. Johnsen (1845–1924), sealer from Tromsø, sailmaker.

Ole Ingebregtsen Kulseth (b. 1849), sealer from Tromsø; chief of the workers, the carpenter and the mason.

Carl Jonsson Ljungström (b. 1845), boatswain in the Swedish Navy, responsible for the stores of provisions, chef.

Oluf L. Olsen (b. 1862), sailor from Tromsø, cook.

Otto J. Sundberg (b. 1855), blacksmith in the Swedish Navy.

In particular, Johnsen possessed considerable arctic experience. He had been a member of the expedition with the *Vega* along the North-East Passage and

round Eurasia in 1878-80 (p. 121), and had taken part in the voyage and wintering of the *Oscar Dickson* in 1880-81 (p. 141).

All told, the personnel of the station numbered 12 men-6 scientists and 6 workers. The expedition was under government protection, which entailed several benefits for those in public service.

During the preparations, Ekholm received valuable help from some of the other members. Dr. Gyllencreutz gave advice on provisions, Stjernspetz planned leisure occupations and hunting, and Andrée dealt with the acquisition of fuel and building-timber.

Mosselbukta on the Spitsbergen northcoast-the winter quarters of Nordenskiöld's expedition of 1872-73 (p. 79)-had been chosen as Sweden's Polar Year station. A hut was already there, and Norwegian sealers had reported as recently as 1881 that it was in good condition. The measurements would gain in value here because of the comparisons that could be made between the two years of observation. Moreover, it would be possible to reduce the amount of building-material or timber of other kinds that had to be brought.

As an alternative to Mosselbukta, Kapp Thorsden at Isfjorden was chosen, where the Swedish company Isfjorden in 1872 had built a fairly large house (see p. 73). This alternative would be used in case the Spitsbergen north coast were blocked by ice in the summer of 1882.

Ice obstacles

Two Swedish Navy gunboats, the *Urd* and *Verdande*, were placed at the disposal of the expedition for the transport up to Spitsbergen. Commander of the flotilla was Captain Louis Palander, who had commanded the *Vega* during her passage round Eurasia in 1878-80. This was to be his last visit to the polar regions.

THE CREWS OF THE SHIPS WERE:

URD

Captain Adolf Arnold *Louis* Palander (1842-1920), commander of the flotilla and of the *Urd*.

Lieutenant Carl Wilhelm *Thure* von Eckerman (b. 1853).

Lieutenant *Otto* Ludvig Beckman (1856-1909).

Dr. *Adolf* Vilhelm Thorén (1852-1904), naval doctor.

Six non-commissioned officers and 32 men.

VERDANDE

Captain *Georg* Johan Sjöberg (1842-96), commander of the *Verdande*.

Lieutenant *Seth* von Konow (b. 1854).

Lieutenant Carl Ludvig *Arnold* Munthe (b. 1856).

Six non-commissioned officers and 33 men.

The members of the station-group were distributed upon the two ships. Moreover, Dr. Otto Pettersson (1848-1941) took part in the cruise for studying the sea-ice. He was later to make great pioneering contributions to Swedish oceanography (p. 404).

The two ships left Karlskrona on June 15. Their route was laid via Stockholm, Köbenhavn, and Göteborg, to load diverse equipment. The personnel of the Polar Year station embarked at Göteborg, and Tromsö was reached on July 6. Here the expedition stayed for three days while coal and provisions were loaded, such as salted and dried fish, herring, three reindeer with calves and reindeer-moss for food during the passage to Spitsbergen.

The *Urd* and *Verdande* left Tromsö on July 9. The weather was fine, but for some fog at Björnöya. The voyage was not disturbed by ice, only a few bands being passed. Late in the evening of July 12, the two ships anchored in Grönfjorden near the mouth of Isfjorden. Several Norwegian fishing vessels were staying in the neighbourhood, including the Norwegian yacht *Bjona* with the two geologists Nathorst and De Geer on board (see Chapt. 19).

The information obtained here about the ice conditions was anything but favourable. Open water existed in the mouth of Isfjorden, but the inner portions of the fjord still held much ice. Most discouraging was the fact that no sealer had been able to sail further than Magdalenefjorden at the north-western corner of Spitsbergen.

The *Urd* and *Verdande* left Grönfjorden on July 13 and steered slowly northward in fog off Prins Karls Foreland. Farther north the visibility improved, but ahead there was ice-blink in the sky, indicating that the ice was near. They soon met with compact ice and had to steer into Danskegattet, where they anchored. But ice drifted into the sound from the east and threatened the ships, so they left this harbour and proceeded towards Norsköyane to the north-east.

A visit to the summit of Ytre Norsköya revealed that the ice was compact to the north as well as east. A fresh southerly or south-westerly wind would probably be able to clear the waters, but it would involve a risk to the ships, which were not ice-strengthened. Thus on the same evening-the 16th-they abandoned the exposed position and found shelter from the ice in Magdalenefjorden, inside Gravneset, a harbour from the whaling days of the 17th and 18th centuries. They awaited developments in the ice situation until July 20, when they steered north again, but they met with compact ice already at Amsterdamöya.

If the observations for the Polar Year were to start in time, on August 15, it was now just about time to

have a look at the alternative station site, Kapp Thordsen on the northern side of Isfjorden. They cast anchor here on July 21, about 500 m from the shore, where the depth was 18 m.

The Polar Year station at Kapp Thordsen

The landing-place was situated about 3 km east of Kapp Thordsen proper. The coast consisted of a vertical cliff about 30 m high, occasionally penetrated by ravines which had been dug out by brooks coming from inland. These ravines afforded easy ascent to a plain which extended from the edge of the cliff. The plain sloped slightly upward inland for 500 m, then became a fairly steep slope to the mountains. The latter were about 300 m high, and beyond them a plateau rose inland to a further plateau at about 500 m.

The plain nearest to the shore was covered by clayey soil and frozen water, which melted in the summer down to a depth of some 30 cm. Mosses and phanerogamous plants were plentiful. The vegetation seemed more luxuriant than anything previously seen in Spitsbergen. The shore cliff was of clayey shale, not very hard; below it the shore consisted of slaty gravel, flooded at high tide, but exposed to 20 m from low water. The difference in level between low and high tide was later found to be about 2 m.

As mentioned (p. 73), Nordenskiöld had in 1864 found strata here containing phosphorite, which were considered profitable for mining. An additional investigation had been carried out by Wilander and Nathorst in 1870 (Chapt. 12). The company Aktiebolaget Isfjorden was then established to extract fertilizers from the phosphorite. In 1872 two ships had come to Kapp Thordsen in order to set up a "colony" and start the mining. Their venture failed, but buildings and materials were left, and would now be of utmost value to the Swedish Polar Year expedition.

Before the landing of equipment could start, the site for the station had to be investigated. It was most important to learn whether the area was affected by local magnetic disturbances—especially since magnetic rocks, hyperite, occurred here. Ekholm and Solander investigated the matter on the following night, and found the conditions favourable. Only for the wind measurements would special arrangements be needed. Thus reassured, the group moved ashore.

The Kapp Thordsen "colony" had used the largest ravine as a means of reaching the plain above. A *décauville* trolley-line had been built from the shore *aslant* up the slope of the ravine, then 700 m inland to the dwelling-house (compare p. 73). For getting the trolleys up—or down—the slope of the ravine there was a winch on the plain above.

The group recovered a couple of trolleys, one boat,

and a few baskets of coal. Everything had sunk into the gravel and clay, but was usable after an overhaul or repair. On the plain near the cliff, there was also a considerable stock of building-material, iron bars and beams, boxes of nails, sledgehammers, a forge, and so on. It was all in good condition, though rusty. Near the dwelling-house, about 800 m to the north-west of the "harbour", lay another stock of building-material and many kinds of tools.

Close to the house was a large grave surrounded by a fencing of planks, with a cross inscribed in Norwegian:

"Here repose the remains of 15 men who died here in the spring of 1873.

Peace be with their remains."

East of the house, near the ravine, stood another cross with no inscription. This was the grave of two men belonging to the same group of sealers. They had died earlier and been buried on January 19 in the same year (compare p. 93).

The dwelling-house was in very good condition, despite its ten years of abandonment. A corridor passed through it from one long side to the next, where there were entrances. On each side of the corridor were two rooms, making one at each of the house's four corners. An exterior flight of stairs led up to the attic, a single room with storage-rooms along the long sides. In the attic a great amount of building-material was stored, mostly for heat-insulating purposes.

Andrée was told to make a plan for modifying the house in a way to suit the aims of the expedition (p. 181). The large room in the attic was fitted up to accommodate the workers, and was connected by a staircase with the kitchen, which had originally been part of the corridor. The scientific staff had their rooms on the ground-floor. Ekholm and Gyllencreutz occupied rooms of their own, while the other four men shared rooms in pairs. On the ground-floor a small dining-room was arranged, besides a large work-room for the observers—the "library". The house was also provided with an annex containing one large room devoted, for instance, to handicrafts. Vestibules were built in front of the entrances to protect them. Several of these modifications were not completed until far into the autumn.

The landing of equipment began on July 24 and took 15 days. This work was troublesome and sometimes had to be interrupted because of a rough sea, as the shore was quite unsheltered to winds and waves from the fjord. A depot was established near the cliff, from where stores would be brought up to the station

during the coming year. Another depot was formed at the other end of the trolley-line, near the dwelling-house. Personnel from the ships helped to land the stores and transport them to the station.

At the same time, the members of the land expedition carried out building-work. The dwelling-house was modified, a shed for gunpowder was built at some distance from the house, a geomagnetic observatory was erected about 100 m from it, a thermometer screen was set up, and a pigsty as well as a pigeon-house were added to the complex.

On August 5 the work had progressed far enough to occasion a celebration, with the ships' officers as guests. Afterwards the members of the land expedition were invited to dinner on board. In the evening, the *Urd* and *Verdande* weighed anchors and sailed for home.

Developing a routine

More building remained to be done, and the scientific instruments had to be mounted. In the latter case, extra effort was required, because the expedition's plans had been based largely on the assumption that they were to winter at Mosselbukta, where the mounting of instruments would have been much simpler than here at Kapp Thordsen. For example, the wind measurements now had to be performed on a mountain about 500 m from the station and at 260 m a.s.l. (175 m above the house). The wind conditions down at the station were far from representative. As the wind recording was done in the house, all the electric cables were needed and batteries had to be constructed.

The measurements of aurora and cloud heights called for two theodolites, mounted at a fair distance from each other and connected by a telephone cable. One of them had to be placed near the wind gauge on the mountain, as the cable from there to the wind recorder in the house was also needed for the telephone connection between the hut and theodolites, which meant an extra climb for one of the observers. The wind gauging "swallowed" practically all cables they had.

The permafrost introduced extra troubles when a *fixed* instrument-mounting was desired, especially for the geomagnetic measurements. A crafty device was resorted to here. A watertight wooden box was placed in a pit in the ground, and surrounded by frozen clayey earth. Within the box an instrument pillar was built with bricks and cement.

The meteorological observations commenced on August 15, the geomagnetic observations six days later. But the auroral observations required darkness, and had to wait. All observations were made once

every hour, and Göttingen time was used, 23 m 28.5 s after local "Kapp Thordsen time". As soon as the observations had begun, they could not be stopped—so the scientific staff stepped onto a "treadmill" which had to continue until the voyage home, independent of weather and wayward instruments.

The six observers shared the routine alike. Their service was split up into equally long watches: 03h–08.00h, 09.00h–14.00h, 1.005–20.00h, 2.001–02.00h. They worked in shifts throughout their one-year stay without any holidays. In the long run, this routine became rather tiresome. There were detailed rules for the order and time in which the different observations should be made. Delays might occur, and in such situations the correct times had to be noted.

The wind measurements from the neighbouring mountain started on October 4. Andrée had invested a great deal of energy here, due to the scarcity or lack of suitable material. Henceforth Ekholm and a worker inspected the wind equipment once every week, an undertaking which was often not entirely safe during the polar night.

The expedition brought practically no furniture: there had been no place on board the two naval ships. The intention had been that the workers were to construct the necessary furnishings, such as tables, chairs, cupboards, shelves, wash-stands and drawer-chests. This would certainly have sufficed to keep them occupied during the autumn! However, they were busy enough with repairing and modifying the dwelling-house, as well as setting up the other huts and observatories. The furniture production therefore fell upon the scientific staff, and not until the beginning of the polar night was it possible to transfer such labour to the workers.

The workers did not operate in shifts and had the privilege of sleeping undisturbed during the night, but their daytime was fully engaged. In mid-November their daily duties and schedule were defined on an order-list.

This list clearly shows the differences between past and present-day expedition life:

- 06.30h The workers are roused, lamps are lighted, the workers get up and make their beds; the room of the workers, the workrooms and the dining-room are put in order. The lamps are cleaned and filled with paraffin oil.
- 08.00h The workers have breakfast.
- 08.30h The members of the scientific staff have breakfast; the workers begin their work.
- 1.003h Pause. The workers have dinner.
- 14.00h The workers resume their work.
- 14.15h The scientific staff has dinner.
- 16.00h The workers have coffee.

- 16.15h The workers resume their work.
 18.00h The day's work ceases. The outer workroom is put in order; the lamps are cleaned and filled up with paraffin oil.
 19.30h Supper.
 21.00h Time for bed.
 21.30h The lamps are put out in the room of the workers.

On Sundays and holidays, the work paused and a religious service was held at 10 o'clock, but otherwise the routine continued as usual. On Saturdays the house was tidied up, and the fireplaces were swept.

Life at an observation post like Kapp Thordsen is poor in external events, and it was perhaps well that the daily schedule was so regimented. Yet the members of the scientific staff had their observations, which gave no quarter. The observations concerned large-scale courses of events, which always varied and kept their minds awake.

Food and health

The expedition's doctor, Gyllencreutz, and Ekholm had given much consideration to the provisions. Lack of appetite among the members should be avoided if possible; the menu was to be full of variety, the food served in a stylish way, and fresh meat offered to a great extent. The expedition had brought some pigs and accommodated them in a pigsty; a few reindeer with calves had also been brought. Hunting made further contributions to the menu: seal, reindeer, eider and—later on—eider eggs. A rich supply of snaps, brandy, wines and beer made for an atmosphere of gaiety during meals. Ekholm's official report on the expedition contains a long description of the dishes that were served, and it provides appetizing reading. In other words, the expedition members lived well.

Special care had been devoted to the problem of scurvy, which at least earlier was the great curse of the wintering polar traveller. The station personnel had a memento of this illness before their very eyes. At the same place, 17 shipwrecked sailors had perished ten years previously in spite of a comfortable house and ample provisions. What they had lacked was a wise order-list.

On the north coast—at Mosselbukta—Nordenskiöld's expedition was threatened by scurvy at the same time. The reason there was that two transport vessels of the expedition had been caught by the ice, and the many unexpected mouths had rendered the store of provisions quite insufficient (see pp. 81 and 85).

The Polar Year expedition had an ample supply of the antiscorbutic foodstuffs that were relied upon before the discovery of vitamin C, such as lime-juice,

cloudberry jam, and many other kinds of juice and jam. Physical exercise in the open air, too, was still considered a good prophylaxis against scurvy. Daily walks were prescribed, although not always taken during the polar night.

To the east of the dwelling-house, a multipurpose house was built, containing a coal-shed, a blacksmith's workshop and a sauna. In the sauna, snow was melted to provide fresh water during the period from the end of November until the end of May, when the brooks were dry or frozen. Once a week, the men had a sauna bath followed by cooling outdoors in the snow, a healthy routine and an agreeable relaxation.

The practical tasks were numerous, and attempts had even been made in the summer to engage two extra men, by making inquiries on board Norwegian sealing vessels. But none wanted to spend the winter at a place where so many of their fellow countrymen had died. Apparently it had given rise to a superstitious fear.

During the summer, Alfred Nathorst and Gerard De Geer had carried out geological investigations in Isfjorden, visiting the station several times with their ship, the *Bjona*. They last called here on September 1, 1882. On this occasion Gyllencreutz undertook an important assignment: persuading the excellent cook of the *Bjona* expedition to occupy the same post at the station. The present cook had proved to be good for nothing.

On September 12 they had their last contact with the outer world, when two tourists visited the station, notably the French geographer and mountaineer, Charles Rabot (1856–1944) (see p. 213). They saw the last ship, although from a distance, on October 10. From then onward, it would not be until June 26 that the next ship crossed the horizon.

The polar night

The dark season was approaching. October 10 was the last day with sunshine, due to mountains and clouds. The sun disappeared on October 26 behind an unbroken horizon. On November 2 it was necessary to use a lamp for all hourly observations throughout the day. Twilight lingered in daytime, but already on November 7 the stars were visible even then. On the 12th, the twilight was marked to the south at midday; after November 26 the difference between day and night was very small.

Of the polar night's four months, two were characterized by darkness day and night, while one in the autumn and one in the spring had twilight by day. The polar night is always a strain, not least because the darkness restricts the opportunities for a refreshing outdoor life. It was important for each member of the

Kapp Thorsen, the Swedish Polar Year station, 1882-1883, seen from the south-west. (Ekholm, N.: Introduction historique.)

The station seen from the south-east. The anemometer was mounted on the summit of the left mountain. (Ekholm, N.: Introduction historique.)

The Arctic garden. 1 Box with soil from Sweden. 2 Radish. 3 Cress. 4 *Nemophila*. 5 Dill. 6 Clover. 7 Grass. 8 Spitsbergen plants (transplanted). 9 Table and benches, a) Oats, b) Barley.

Plan of the dwelling-house (above)

Ground floor

- A) workroom for scientists (Library)
- B, C, D, E) rooms for scientists
- F) Dining-room
- G) Kitchen
- H) Workroom for workers
- I) Workers' room

First floor

- I) Workers' room
- L, M) Space for housing various utensils

(Ekholm, N.: Introduction historique.)

The officers of the *Urd* are invited to refreshments in the Doctor Richard Gyllencreutz' Arctic garden at Kapp Thorsen, August 1883. Fourth from the left Nils Ekholm. Third from the right is Salomon August (S.A.) Andrée. (Royal Swedish Academy of Sciences.)

expedition to get his daily dose of fresh air with a walk—and, as mentioned, there existed a rule to that effect. The workers had to transport stores every day between the harbour and the station, so *they* got the daily dose, but the observers did not.

No actual illnesses occurred at the station. Minor ailments arose at times, but did not encroach upon the work. The doctor pointed out in his medical report that this good state of health must have been due to the high quality of the food—both the provisions from home and the fruits of hunting excursions. He mentioned, though, that health had been less satisfactory during the winter. Among other things, he pointed out that winter had brought a general mental depression, which might have been simply indifference but was combined with great irritability or, alternatively, with excessive energy. There emerged a disposition to sleep and eat at irregular hours. Sleeplessness and loss of appetite were also characteristic. He found these symptoms to correspond with the frequent experience of people who have suddenly changed from a physically active to a sedentary life. In his judgment, the workers did not show these negative symptoms, as they were occupied with manual work. The observers, on the other hand, led a monotonous and sedentary life.

In spite of the fact that walks were prescribed, these had probably not been longer than down to the shore and back again, totalling about 1.5 km. The doctor considered, however, that the sauna baths and the care that was devoted to the food compensated for the effect of what, in other respects, had been an unhealthy way of life.

According to Ekholm, the symptoms of workers and those of observers did not differ so greatly. He argued that the existing differences may have been due to the observers' work in shifts by day and night, compared with the workers' undisturbed time for rest. Further, he thought, the darkness itself may influence the mind to become partly depressed and partly irritable. By contrast, the doctor attributed this influence to the isolation and monotony of the long polar night. Negative effects were thus neutralized by good food, regular work and diversion.

To the observers, in any case, the polar night was the most interesting time of the year. They lived among the phenomena and natural events that they had come to investigate. Their varied investigations enhanced the excitement that could be derived from the observational work: one could, for example, make comparisons between meteorological and atmospheric electrical phenomena. Diverse optical phenomena appeared in the sky, the drifting snow was a stimulus to studies, the geomagnetic disturbances and the

aurora suggested further relationships, and so on. As shown above, the doctor also found opportunities for profitable physiological and psychological studies.

The library of the station was of great pleasure to all the personnel. Nor were leisure activities lacking. The observers enjoyed chess, backgammon and billiards; the workers occasionally played cards. There were also entertainments, organized by Gyllencreutz and Carlheim-Gyllensköld. Whenever a celebration was called for, it gave rise to a banquet—especially at traditional times such as Martinmas, Lucia Day and Christmas.

The relatively severe climate had no apparent effect on the men's state of health: they caught no colds and suffered no frost injuries. Much work was devoted to regulating the temperature indoors. Sometimes it rose to +40°C, so that doors and windows had to be opened. Under all conditions the rooms were aired every day. With certain winds, the ovens smoked heavily and were almost impossible to fire up. The thermometer indoors might then fall below freezing.

Very low temperatures did not occur, the lowest of the year being -35.5°C on January 2. All men wore woolen clothes, and almost all carried wool-lined caps and fur-lined mittens. But it was rather seldom that anybody wore a fur coat, except the observers during prolonged spells of observation. Otherwise they often went to work without changing their dress much. An observer might sit in his shirt-sleeves indoors, then go outside in his jacket to make observations. During the coldest periods, everyone used high boots of sail-cloth with the feet surrounded by sedge grass. The experiences of previous Swedish expeditions proved to be valuable.

In January daylight increased gradually, at first almost imperceptibly, then ever more rapidly. On January it was possible to read the letters in the observation log outdoors in the middle of the day, and on the 29th the first twilight was observed at 07.00h. On February 9 it was full daylight at 11.00h, and the thermometer could be read without a lamp. The sun could have been observed on February 16, but the mountains to the south delayed its first appearance until the 21st. The polar night was now ended.

They had passed through the dark period without being attacked by the scourge of scurvy, and with no serious mental symptoms. The only certain result of the darkness was a yellowish hue of the skin, but it was so faint that they would not have noticed it, if they had not been looking for this previously observed phenomenon. Andrée volunteered to avoid the daylight in daytime for another month, with the same effect as well as loss of weight and some weakening.

As for the domestic animals brought from home,

the pigs thrived in their cold sty, seemingly happy as long as they got their food and fair protection from the wind and snow. The doves stayed indoors in the artificial light in the outer workroom. They thrived as well, and the females laid several eggs. In autumn and spring the doves were free, but they remained in the neighbourhood of the observatory, despite the fact that two of them were carrier pigeons. A couple of pointer dogs which had come with the expedition did not suffer from the cold, although they were short-haired. In the middle of the winter, the bitch gave birth to pups, and the four which were allowed to live grew in size and thrived.

The return of daylight and life

With daylight, the personnel at the station could give up their confined habits of the dark season. As on all wintering polar expeditions, this meant a feeling of regeneration. Excursions and hunting trips could be undertaken, and the work proceeded more smoothly.

On March 27 they were visited by a polar bear, which an observer fired at—and frightened. In the beginning of April they observed footprints of bears.

During the spring they made three excursions on the ice of Isfjorden, in order to make hydrographic, geomagnetic and meteorological measurements for comparison with those at the station. Moreover, to get a sufficient check on the geomagnetic observations at the station, another geomagnetic observatory was built in May.

Towards the end of April they were surprised at the strong solar radiation and its effect upon the snow cover. The temperature in the thermometer screen proved to be 2–3° higher than the reading of a sling thermometer outside the screen. The temperature was still well below 0°C, but the effect upon the snow was strong near solid bodies. At the end of April the “warm” weather was felt oppressive when working outdoors, even with the temperature as low as -10° or -15°C. The temperature remained below 0°C until May 26, when it rose to +2° or +3°C. Summer had come. The snow continued to melt away, and from now on they could fill their need of fresh water from the brooks in the surroundings.

On May 27 the thickness of the snow cover on the plain around the station was 84 cm; on June 4 it was 31 cm and, besides, one tenth of the ground was free of snow; on the 11th the ground was covered with snow to 50%, and on the 16th the plain was free from snow except in the ravines. The plateau above the station, however, remained under snow until the beginning of July.

At the same time, the whole of Isfjorden was covered with ice, but on June 18 open water could be seen

at the mouth of the fjord. On the 21st the ice was criss-crossed by cracks, and on July 4 there were only scattered floes which covered about a third of the fjord surface. On July 10 the ice had disappeared and was not to return.

On June 26 the first ship of the year was observed, but 30–40 km of ice lay between her and the station. This ship carried the station personnel’s mail, which had been collected for 10 months.

At the station they followed with interest and joy how nature revived during the spring and early summer. The storm petrel—or Arctic fulmar—had been observed already in February, and the black guillemot in March. Then, from April, other migrating birds began to arrive: on April 14 the snow bunting, on May 26 the wild goose, and in early June the eider. On June 2, *Saxifraga oppositifolia* began to flower, and many other arctic flowers emerged soon afterward.

In June, Gyllencreutz arranged a little arctic garden near the dwelling-house. During the polar night he had cultivated garden cress and radishes indoors in a big pot, with earth brought from home. The cress shot up after eight days and reached a height of 7–8 cm, producing a delicious salad. The experiment with the radishes failed, but was successful after the return of daylight.

In the garden-to-be, the thawing out of the ground layers was speeded up by peeling off the uppermost thawed layer each day and collecting it in a heap. Asphalted millboard was then placed upon the frozen ground and covered with thawed-out earth. In this way it was possible to get a layer of earth 30 cm deep, which was fertilized with potash, and the sowing took place on June 10. The location, at the south-western side of the house, was sheltered from winds between east and north. It became a “park” for social gatherings. Frequent watering was necessary, as the ground dried up rapidly. In addition, plants of the local flora were transferred to the “garden” with their respective earth. The experiment was partly successful. Some plants lived for a few weeks. On August 10 they reaped excellent radishes—with a diameter of 2 cm—and cress. Clover and other plants covered the flower-bed, giving it an agreeable impression. A sketch of the garden is given on p. 181.

Summer and departure

On July 3, one of the expedition’s Norwegian hunters was landed on one of the Gåsøyane to the east of the station. He was fetched on July 21 together with 400 eggs of eider, a great number of sea-fowl and four seals.

On July 5, Stjernspetz and three of the workers tried to reach the mouth of the fjord. They returned

TEMPERATURE (°C) AT KAPP THORSEN, 1882–1883

Lat. 78°28.5'N, long. 15°42'E, height above sea level 77m

1882	July	Aug. (15–31)	Sept.	Oct.	Nov.	Dec.		
Mean temp.	-	+2.4	-1.4	-3.5	-8.6	-18.5		
Max. temp.	-	+6.5	+4.7	+6.4	+1.0	-2.9		
Min. temp.	-	-4.3	-9.4	-16.1	-25.4	-30.7		
1883	Jan.	Feb.	March	April	May	June	July	Aug (1–23)
Mean temp.	-16.0	-8.5	-16.7	-7.0	-5.0	+1.8	+4.4	+5.7
Max. temp.	-4.4	+2.1	-2.7	+2.7	+5.7	+7.2	+11.6	+13.6
Min. temp.	-35.5	-25.5	-26.6	-22.8	-15.9	-4.2	+0.8	+1.3

on the 8th, having collected mail from several Norwegian ships in Grönfjorden. Moreover, on a small islet near Bohemanneset they had found boxes which contained letters, newspapers and books for the expedition. They now received greetings and news from relatives and friends. The latter, in turn, would soon get news from the expedition, as Stjernstedt had delivered the outgoing mail to a sealer, which was already on her way to Norway and reached Tromsö on July 23. Consul A. Aagaard, the representative to the expedition, sent a telegram to Stockholm on that same day, with information about the happy wintering.

On July 12 two Norwegian sealing skippers paid a visit to the station, and from one of these the expedition hired a large boat for their excursions. Their own boat had been damaged and repaired only provisionally. Towards the end of July, two boat excursions were made, on July 26–29 and 31, for the purpose of making geomagnetic observations.

The date of the voyage home was approaching. During July 30–August 2, Stjernspetz built a pier at the “harbour”. It was simply a stone caisson, placed so far from the shore that the depth was 1 m at low tide. The stone caisson was connected with the shore by a bridge resting upon wooden trestles. With this arrangement, the loading of equipment would be rapid.

During August 3–8, Stjernspetz stayed at Dicksonfjorden and had just enough time to map it. At the “harbour”, Ekholm mounted a mareograph along the stone caisson and began a series of readings of the water level for determining its tidal variations.

On August 10, early in the morning, the *Urd* arrived to bring the expedition home.

HER CREW NOW CONSISTED OF:

Captain James *David* Barclay (1837–90), commander.
Lieutenant Carl *Govert* Georg Kempff (b. 1851).
Lieutenant Josef (*Joe*) Gustaf Ekelund (b. 1860).

Dr. *Alfred* Hyllengren (b. 1852), ship’s doctor.
Nine non-commissioned officers and 40 men.

Ekholm would have preferred to stay until September 1, in order to complete an entire year of geomagnetic observations, but the orders to Captain Barclay were that the ship was allowed to stay for only 15 days at the station. It was therefore determined that the observations should finish at midnight of August 23/24, and that everything and everybody should be ready for departure in the course of the 24th. Until then, all equipment which was not absolutely necessary should be taken aboard, and that was easy now: there was a downhill slope from the station to the harbour, and the loading of the boats of the *Urd* was facilitated by the pier of Stjernspetz.

After the conclusion of the observations at midnight on August 23/24, the packing was completed. Here the entire personnel of the station took part, while people from the ship conveyed the packages aboard.

The last work consisted of cleaning up the “court-yard”. Then the shutters were mounted in front of the windows. At 17.00h on the 24th, all was on board, but the crew and workers were given permission to rest during the night. Not until 06.00h on the 25th of August did the *Urd* weigh anchor. The course was set for Grönfjorden, where a sick hunter was taken aboard. The *Urd* started her voyage home via Tromsö, and arrived on September 6 in Göteborg.

A POSTSCRIPT

The Swedish Polar Year expedition was well planned and carried through in the field. Its members returned home healthy, and no severe accidents or deaths had happened. The scientific programme was accomplished in the best way, apart from the fact that the observations were not made on the north coast of

Spitsbergen—as planned from the beginning—because of the pack-ice.

The observations in meteorology, geomagnetism and auroral studies were published in detail a few years later, as was a comprehensive historical report on the activities and events during the expedition, written by Ekholm.

The meteorological observations were used some years later—together with the observations from the other Polar Year stations—for studies of the arctic climate. Ekholm employed his experiences from Spitsbergen to elaborate the methods of measuring air humidity at low temperatures.

The geomagnetic and auroral observations were still valuable several years later, for example when the Norwegian Kristian Birkeland (1867-1917) established that aurora and geomagnetic “storms” are consequences of a flow of electrically charged particles from the sun. The observations of aurora were utilized as late as 1940 by the famous Swedish physicist Hannes Alfvén.

After the return home, Ekholm held a lecture on the expedition at the Swedish Society of Anthropology and Geography (SSAG). A short summary was published in *Ymer* for 1884. Ekholm mentioned here the feast which was given to the officers of the *Urd* and *Verdande* on August 5, 1882, on the eve of their voyage home:

“The leave-taking was celebrated in the evening of the 5th (of August) with a party, which the prospective inhabitants arranged for the officers of the ships in the newly fitted and ideally arranged house. On this occasion a toast was proposed to the sponsor of the expedition, and in doing so the station was named *Smith's Observatory*. It was considered that this name might be proposed because, in the opinion of those present, the ‘Colony’ itself did not yet possess any established name, and the old well-known name of Kapp Thordsen was considered to refer to the Cape itself, which was situated about 3 km from the ‘Colony’, or perhaps also—in a more general meaning—to the entire large tongue of land which juts out into Isfjorden.”

A.E. Nordenskiöld, who attended the gathering, naturally congratulated Ekholm, but he lodged a firm protest: not because the name of Mr. Smith had been used, but due to the fact

“..that in this case the blunder had been committed of naming a place which already had a name. It is often a weakness, with people who set out on

travels of geographical discovery, that they wish to enrich the map with new names, and if this alone had been the case here, I would not have raised my criticism, especially since, as mentioned, the given name was taken from a person who, with all reason and right, should be honoured. But I protest because this place in the geographical literature has a history, greater than any other place in Spitsbergen, yes, more remarkable than most other places within the arctic regions. In order to prove this I beg to be allowed to recall in memory some traits out of that history...”

Nordenskiöld then gave a summary of the history of the Spitsbergen “Colony”, although without mentioning the name of Per Öberg (compare p. 73). His statement ended thus:

“As the place consequently already has a name in the annals of natural science, of geography, of popular travel books, of diplomacy and of the Norwegian Storting (Parliament), and as the Swedish Spitsbergen expedition of the previous year has only been a guest there, I consider it unjustified to give the place a new name. In my capacity as one of the owners of the house, I protest against this and I request that my statement be entered in the report of the proceedings of the Society.”

In *Ymer* of 1884 the resumé of Ekholm’s lecture was granted two and half pages, and Nordenskiöld’s statement a little more than two. Of course Nordenskiöld was right: the name “Kapp Thordsen” was better. But, one may ask, who exhibited the worst judgement, Nordenskiöld or the editor of *Ymer*?

The Swedish Polar Year expedition had been concentrated upon collecting extensive observation material. There were neither deaths nor serious accidents to report, nor any newly discovered lands. Everything had passed off according to plan—except the ice obstacles in 1882—and there was nothing for the press to devote much attention to. The same applied to the majority of the Polar Year expeditions. Yet there were two exceptions: the Dutch expedition under Dr. M. Snellen, and the American expedition under Lieutenant A.W. Greely.

Shipwreck and disaster

The Dutch had intended to place their station at Dickson Harbour (see p. 176). For that purpose the expedition had hired the Norwegian steamer *Varna*, but she was caught in the ice in the Kara Sea to the east

of Vaigach Island in September 1882. She drifted with the ice in the southern portion of the Kara Sea, together with the ship *Dijmphna* of a Danish expedition under Lieutenant A.P. Hovgaard (1853–1910), a member of the Vega expedition of 1878–80, who was going to look for the undiscovered islands that supposedly lay north of Cape Chelyuskin (see p. 126).

The observations of the Dutch expedition began on October 9 and proceeded until December 24, when the *Varna* was damaged by the ice and had to be abandoned. The crew and the expedition members were transferred to the *Dijmphna*, where the observations could be taken up again on January 15. On July 24 the *Varna* sank, and on August 1 the Dutch expedition with the crew of the *Varna* left the *Dijmphna*. They began a hard retreat with sledges and boats towards Vaigach Island, which was reached on August 19. Six days later they had the good luck to meet two Norwegian steamers and to be taken to Norway. The *Dijmphna* drifted in the ice through the Kara Gate on September 21 and was free four days later.

The American expedition, under Lieutenant Adolphus Greely in the northernmost part of the Canadian Arctic, developed into a tragedy—in fact one of the greatest polar tragedies that have ever occurred. It may be added that, in spite of this, the documentation of the expedition and its tragic end has been supplied in detail.

The expedition was in its general structure a military enterprise and, besides the obligatory observational programme, long sledge tours were made for exploring the surrounding lands. The expedition was transported by the *Proteus* to its base at Fort Conger (81°N), situated at Lady Franklin Bay in the north of the long sound between north-western Greenland and Ellesmere Island. The expedition landed at Fort Conger on August 18, 1881, one year before the start of the Polar Year.

In the following summer, 1882, the *Proteus* went north with provisions and additions to the equipment, but failed to reach Fort Conger. A new attempt to reach the station was made with the same ship in the

summer of 1883, the intention now being to take the expedition home. This time the *Proteus* was crushed by the ice in the entrance to Smith's Sound, and very little of its cargo was secured—so little that the ship's crew could neither winter nor establish a depot for the Greely expedition, to be used if the latter were forced to go southward. After a most dangerous boat tour of about a month's duration, the crew of the *Proteus* reached Upernavik and Godhavn in west Greenland, where they embarked the American ship *Yantic*.

When no ship arrived at Fort Conger during the third summer in 1883, it was decided to evacuate the station and go south. With four boats the expedition reached Cape Sabine in the autumn. This headland is situated on the western side of Smith's Sound. Here a hut was built, with one boat serving as a roof. The rations of food now had to be reduced considerably.

Already at an early stage, lack of discipline had appeared among the expedition members, but it was now magnified. For example, theft of provisions, tendencies to mutiny, and even cannibalism occurred. After May 24, 1884, the death-struggle of the expedition started. One man was executed at this stage—the others felt that their lives were threatened by him. When the relief ship arrived in June, 1884, seven extremely weak survivors remained out of an expedition of 25 men. Among the survivors was Greely.

The scientific observations, however, were secured to a great extent. The disaster was due mainly to the optimistic outlook on the prevailing ice conditions. Nobody—at home or at Fort Conger—had any doubts as to a successful relief in 1882. There was, besides, much indecision at home. L.P. Kirwan is crushing in his criticism:

“At home there was indecision, incompetence and corruption, worse even than during Wilke's antarctic expedition; and up north, courage, madness, death.”

(Translated from the Swedish edition of Kirwan's book.)

19. THE GEOLOGICAL SPITSBERGEN EXPEDITION OF 1882

NATHORST AND DE GEER

The plans, the men, and the ship

After the economics of the Swedish Polar Year Station had been settled, Otto Torell took the opportunity to plan a small geological expedition which might use the same transport facilities, to and from Spitsbergen, as the Polar Year expedition. Torell was at the time head of the *Geological Survey of Sweden*. He applied for means to carry out such an expedition in the most inexpensive way.

An alternative would be to transport the expedition to and from Spitsbergen on board a Norwegian sealer. For transports within the research area, a boat might be hired together with four men.

The effective time for geological field work would, however, be unnecessarily short with such arrangements, so it was deemed most practical to hire a Norwegian sealer for the entire summer and become independent. Means for the extra costs might be obtained from funds, institutions and private persons, the main costs being covered by the state.

The Royal Swedish Academy of Sciences appointed Adolf Erik Nordenskiöld and Otto Torell to formulate a plan for the geological survey, to choose two geologists for the investigations, and to reach an agreement with them.

The two geologists chosen were attached to the Geological Survey of Sweden, and were:

Alfred Gabriel Nathorst (1850-1921), Ph.D., geological and botanical studies, leader of the expedition.

Gerard Jakob De Geer (1858-1943), B.Sc., conducting studies in glacial and general geology; photographer to the expedition.

Nathorst possessed previous arctic experience. In 1870 he and Hjalmar Wilander had made geological investigations in Spitsbergen, mainly for the purpose of ascertaining whether the phosphorite strata at Kapp Thordsen could be worked with profit (see Chapt. 12). Since 1877 he had been a geologist of the Geological Surveys of Sweden and assistant to its chief, Otto Torell. De Geer had no previous arctic experience. Since 1878 he had been an assistant geologist of the Geological Survey.

Both these scientists were destined to become recognized in their respective branches of geology, Nathorst in plant palaeontology, De Geer in glacial

geology and the Ice-Age complex of problems. They were also to become great polar travellers and leaders of polar expeditions. They would be worthy successors to Adolf Erik Nordenskiöld.

Programmes for the investigations were written by Torell, Nordenskiöld, and the mining geologist A.E. Törnebohm (1838-1911). In brief, the expedition was to study the Hecla hook formation, which was thought to be of Silurian origin, and its transition towards Archaean rocks below as well as younger rocks above. The glacial and geological studies were said to be of special value for interpreting deposits from the latest Ice Age in north-western Europe.

The latter studies could be made in any region of Svalbard. Studies of the relation of the Hecla hook system to younger kinds of rocks might be done at Sörkapp, the inner portions of Hornsund, and the mouths of Bellsund and Isfjorden. The age of the Hecla hook system might be determined from that of the Liefdebay system in the north-eastern parts of Isfjorden. The young, post-Miocene strata might be studied in the Bellsund region, and south of the stretch of coast between Grönfjorden and Adventfjorden. The expedition did not intend to go north beyond Isfjorden.

The extra costs, which arose from making the expedition an independent enterprise, had the advantage that a few extra studies could be made: a reconnaissance to find out whether a triangulation network could be arranged along the west coast of Spitsbergen, in addition to zoological studies and post-Miocene investigations. Fossils would be looked for.

The yacht *Bjona* of Tromsö was hired. Her owner, Captain Marcus Johnsen, was to come with the expedition as commander of his own ship. With the captain included, the crew counted seven men and one boy. Among the crew was the cook Oluf Olsen. At the end of the summer he was to be transferred to the Swedish Polar Year station in the capacity of cook (p. 180).

The *Bjona* was a small vessel, length 17 m, beam 5.2 m. Nathorst expressed great satisfaction with the ship, but soon he found that she had one drawback. At first he described his accommodation on board as follows:

"The cabin was relatively roomy and it was pleasantly fitted up, newly painted, on both sides equipped with a rather spacious, though of course low bunk, in front of the bunk a stationary bench, inside which there was room for drinks, etc. The middle part of the wall, which separated the cabin from the hold, was occupied by a square table; above it hung a mirror on the wall, on each

side of the mirror a bookshelf, in which the books were securely housed and easy of access, even with a rather rough sea. In the corners there were small cupboards with shelves for pottery and odds and ends; inside the entrance was a stove and, moreover, a wardrobe, separated from the cabin by a door. On the whole, the fittings were thus both comfortable and agreeable to me, even in an unexpectedly high degree, because I had prepared myself for a space as cramped as on the expedition of 1870 with Wilander (p. 73), when we could not stand upright in our small cabin, the dimensions of which were the least possible."

Yet a few days after they left Tromsø, Nathorst wrote:

"On the following day the wind increased more and more, and we sailed rapidly northwards. But now an inconvenience presented itself, something we had not imagined previously: from the rolling of the ship, the bilge water began to move about and filled the cabin with its disgusting fumes and forced us to remain on deck, in spite of the chilly and rainy weather. The ship had unfortunately not been cleaned completely after her voyage to Finnmark in the previous spring with a cargo of fish, and the ensuing consequences from this we now had to experience, bad enough as sufficient disinfectants were not available on board. The unbearable and no doubt poisonous fumes gave rise to an illness with fever, similar to seasickness; on the voyage home it was forestalled by taking quinine."

South-western Spitsbergen, June 12–23, 1882

The *Bjona* had left Tromsø on June 1. On the 6th they were about 100 km from Björnöya, according to dead reckoning. But the island was not sighted on this day or the next. They had no chronometer on board, so no reliable longitude determinations could be made. They suspected that they had come off course, so they gave up thoughts of a visit to the island and set course for Sörkapp. The wind became northerly and they steered north-east, but came into dense ice. Then they headed west to reach open water, where they followed the ice edge north-west.

On the 10th they got a latitude determination, which showed that they were at the latitude of Sörkapp. They steered north-east and, on the 11th, sighted the stretch of coast between Bellsund and Hornsund. The lower parts of the mountains were seen, but the upper parts were shrouded in clouds. To the north Prins

Karls Forland was visible, snow-covered and lighted up by the sun. The clouds disappeared, the wind calmed down, and a very beautiful view presented itself to the east: the whole of southern Spitsbergen, even Hornsundstind, lay in front of them, dazzling white at an estimated distance of 40–50 km.

In the evening they received a little wind and steered towards Dunöyane to the north of Hornsund. On the 12th they were still far from land. The bottom-scraper was laid out and they got a fairly rich harvest. Then they lowered a boat and rowed to the Isöyane, which, however, were now covered with snow. From a geological point of view, an old shore-formation with *Mytilus* and whale vertebrae were the only things of value. Off the Dunöyane they saw an enormous number of little auks.

On the 13th they at last had some wind and were able to reach Dunöyane. They anchored and took the opportunity to row to the mainland, a little to the south of the magnificent glacier, which was now named Torellbreen. This glacier is most characteristic because of its interesting moraine formations.

They wandered in the snow across the low-lying plain, to reach the enormous southern lateral moraine of the glacier. From the blocks here they obtained information on the kinds of rocks which occurred farther from the coast. Flowers had already appeared in bare places, even upon the moraine: *Saxifraga oppositifolia* with its bright-red flowers; *Salix polaris* with both male and female flowers; on the moraine *Draba alpina*, and *Papaver radicum* with large buds. The way back to the boat was most tiresome.

Next day, June 14, Nathorst measured a base-line on Store Dunöya, and with its help he could determine the distance between two points upon two of the other islets. This gave him a longer base-line for ascertaining the positions of nunataks, moraines, mountains and coastlines in the neighbourhood. He made a rather good preliminary map, which was later improved during the wanderings on the glacier. Nathorst believed that he had found fossils from the Heclahook system the first ones ever found, if he was right. Similar discoveries were later made by him in Trygghamna at the mouth of Isfjorden. The fossils must then belong to the Silurian formation, coeval with part of the schists which build up the Scandinavian high mountains.

On June 16 an excursion was made to Torellbreen. They used skis this time and were able to cover a long distance on the glacier. Crevasses could be distinguished from a distance and be avoided. To De Geer in particular, this was a most instructive excursion because of the moraine formations of different kinds which were seen.

Next day, the 17th, De Geer paid a visit to the northern part of Torellbreen, this time for study of its median moraine. On both sides of the median moraine, the glacier protruded with a barrier cliff about 100 m high, but at the moraine there was a small triangular plain free of ice. To the east of this plain the barrier cliff was precipitous, though not broken up, and thus allowed the glacier to be scrutinized from a short distance. The glacier front was almost black from inner moraines of fine gravel and a great number of scattered stones.

At the inner corner of the plain, a river emerged from the glacier and then flowed between high walls of hard-frozen snow or ice. On the bottom of this river-valley there was at several places a bank of gravel, which was of great interest because it reminded of Swedish eskers. On a small field of boulders farther down, several depressions in the gravel were found. Regular and somewhat elongated, they resembled Scandinavian kettle-holes. In the middle of these depressions, some ice still remained.

De Geer made a sketch of the valley and the moraines. Then the men skied up on the glacier to the large median moraine, and followed it inland as far as it could be traced. The snow was at places only some 10 cm deep on the glacier. In spite of this, the moraine disappeared rather soon, though its lower part had been several hundred metres wide. The median moraine therefore seems to have the character of an *inner* moraine in its upper reaches. The blocks were of Heclahook origin, and striated blocks were rare.

The party returned to the *Bjona* at midnight towards the 18th. On the same day they sailed to Hornsund, where they anchored in Isbjörnhamna at the fjord mouth. They stayed here only for two days: the ice conditions, the snow-covered ground and the weather largely prevented scientific work. It seemed better to postpone the visit until the autumn.

Thus, on the morning of June 21 the *Bjona* left Hornsund and tacked northwards. The weather was fine and they had a magnificent view of the mountainous coast; even Hornsundtind was clear of clouds. But the weather was too fine to suit Nathorst. Just to the north of Dunöyane, the wind abated into a calm. On the expedition of 1870 the periods with light winds had been few, but now Nathorst wanted wind; the calms were a mere nuisance. He longed for a boat with a small steam-engine to be used both for towing the ship and for excursions in situations with no wind. He would advise future Spitsbergen travellers not to forget this item of equipment.

On the 22nd the weak winds prevailed. A mountain between Torellbreen and Dunderbukta to the north seemed from the sea to be of interest, and Nathorst

decided to have a look at it; the ship was sent to Bellsund. But now the wind was rising, and followed by fog and rain. The boat trip was not agreeable, nor was the march in deep snow to the mountain, across a wide plain which separated it from the coast. There was still rain and fog when they reached the mountain, but they were able to observe that the rock belonged to the Heclahook formation.

They reached the ship near Kapp Lyell at the mouth of Bellsund at 03.00h on June 23. Once again they got a calm. Later the same day, though, they were able to sail to Kapp Lyell. They anchored near the strata with plant fossils, which A.E. Nordenskiöld had discovered in 1873 (p. 91). A large number was collected, but the strata were not all accessible because of snow, which also covered the surroundings of Recherchefjorden.

Bellsund, June 23 July 8, 1882

Consequently, the *Bjona* was taken on June 24 to Van Keulenhamna at the entrance to Van Keulenfjorden. An excursion to mountains, from where the entire Van Mijenfjorden could be seen, showed that the latter fjord was covered with ice all the way to its western end up to Axelöya, which here acted as a barrier to the ice. Van Keulenfjorden itself was covered with ice up to Eholmen, an island at the entrance to Van Keulenhamna.

On June 26 they had an excursion to Axelöya, where a great amount of fossils was collected. There was a fine view towards Midterhuken, with its upright strata. This mountainous headland divides Bellsund into two fjord-arms, Van Mijenfjorden and Van Keulenfjorden. De Geer found on Axelöya glacial striations which showed that Van Mijenfjorden had once been filled with a large glacier. Previously on Eholmen he had found striae indicating that Van Keulenfjorden, too, had once been filled with glaciers.

On June 28 boat excursions were made in different directions. De Geer investigated Axelöya and the southern side of Van Mijenfjorden. Nathorst studied Midterhuken and the northern side of Van Keulenfjorden. To begin with, he found the geological conditions at Midterhuken somewhat complex. It is situated in an area where very marked folding has taken place, resulting in almost vertical strata, and even inversions where older strata rest upon younger ones.

It was warm and summer-like on the southern slope of the mountains, and the vegetation was developing rapidly. Nathorst climbed Midterhuken-fjellet, but clouds of fog formed round the summit. He continued his studies of the mountain during June 29-July 1; among other things he found, on the western

Selected geographical names in the Isfjorden region. The map is also relevant to Chapt. 20.

part of the mountain, pieces of coal and schist with fossils of plants from the Carboniferous period. De Geer spent his time investigating the other parts of Van Mijenfjorden; like Nathorst he was fascinated by the magnificent folding which had once taken place here.

They finished their work in the Bellsund region by studying Axelöya, Fridtjof-breen with its surrounding mountains, and finally Recherche fjorden with Kapp Lyell. At the latter place they continued the search for Tertiary plant fossils. They also visited the old beach terraces here and collected subfossil muskels; moreover, they found a splendid inversion in the stratification with older strata resting upon younger ones. In Recherche fjorden they observed lateral moraines, which jutted out into the fjord, showing that the glacier at the bottom had receded quite a lot.

The work in the Bellsund region was finished on July 7. The two geologists had worked hard, and Nathorst's right hand was so strained by using the geological hammer that he had become unable to use it for some time.

Several cod-fishing vessels were entering the fjord during July 5-8, and Nathorst grumbled:

"Spitsbergen is not what it used to be the delight of staying in a region where human beings relatively seldom set foot exists no longer here."

INVESTIGATIONS IN THE ISFJORDEN REGION JULY 9- SEPTEMBER 5, 1882

Meeting the Polar Year expedition

The *Bjona* left Bellsund on July 8, but the wind changed as usual into a calm. On the following morning they had not even reached the fjord mouth, and not until the 9th did they reach the mouth of Isfjorden. In Grönfjorden they could see eight fishing-vessels, and still more ships lay farther out at sea.

The *Bjona* had come here to meet the *Urd* and *Verdande* with the Swedish Polar Year expedition they expected mail and additional equipment. The two gunboats were expected on July 12, so meanwhile there was time for investigating Festningen ("the fortress"), a wall-like rock from the Cretaceous period situated west of the mouth of Grönfjorden. Time was also spent arranging their notes and collections. Finally at 22.30h on July 12, the *Urd* was seen steaming into Grönfjorden, and soon she was followed by the *Verdande*. The two geologists were received on board the *Urd* and were welcomed by Palander and the officers of the two ships and by the Polar Year party. They had an agreeable evening together. Next day, visits were exchanged between the gunboats and the *Bjona*.

The gunboats received depressing news just before they were to leave for Mosselbukta. The ice was reported to be dense and strong off the north coast of Spitsbergen as far as Amsterdamöya in the west, suggesting that it would be impossible to establish the station at Mosselbukta.

Geological work and mapping in Tempelfjorden, July 13-24, 1882

July 13 was a warm and sunny day with a calm. The *Bjona* could not start her voyage towards Sassenfjorden in the south-east of Isfjorden until the evening. But she did not come far. With a few exceptions, this was her last day with fine weather for the rest of the summer.

Next day the wind freshened and the *Bjona* headed east with good speed. Nathorst enjoyed seeing unforgettable views from his and Wilander's expedition of 1870: Kapp Thordsen, Adventfjorden and Billefjorden, among others. They anchored on the south side of Sassenfjorden opposite the magnificent mountain Templet, very much like a cathedral with buttresses.

On July 15 they sailed further into Sassenfjorden. The charts indicated a range of hills here, but in reality the fjord continued as a broad and flat valley with a network of streams. This valley, Sassendalen, was said to be the best ground for reindeer in Spitsbergen. Their intention was to obtain fresh meat, but they found that two boats of hunters were already there with the same objective, resulting in a decrease of the number of animals in the area. In compensation, they saw a fjord which stretched towards the northeast. It was not given on existing maps, and was later named Tempelfjorden by Nathorst. At its bottom was a glacier with beautiful moraine formations, Von Postbreen. The mountains along the fjord were like similar to temple-buildings with buttresses.

Nathorst and three men wandered into Sassendalen, but they turned soon to the left and climbed Coloradofjellet, 406 m high. On the way they managed to shoot a reindeer. The terrain was toilsome. The summit of the plateau-formed mountain consisted of Permian marl-schist, which had mouldered into a wet and sticky clay. At lower levels the ground was barren and lacked vegetation; there were sharp-edged pieces of flint, which were harmful to the shoes.

The mountain slopes were criss-crossed by very narrow valleys, some 50 m deep in places, but often so narrow as to be unnoticeable until one stood at their edge. They are, so to speak, miniatures of the Colorado canyons and from this property the mountain received its name.

The way back to the ship took them along the northern side of Sassendalen. Here the vegetation

was extremely luxuriant, and Nathorst gathered a valuable botanical harvest, which outweighed the nuisance of fording the many water-courses.

De Geer's group walked into Sassendalen along its northern side. As mentioned, the valley was not entered on any maps, as no expeditions had visited the area. Like Nathorst, De Geer found the vegetation luxuriant in fact richer than on the west coast, where fog retards the development. At many places they passed across grassy spaces, which were bountiful where small brooks oozed forth.

They followed the valley some 20 km until they reached the front of a glacier, Rabotbreen. In the middle of the valley was a broad river, perhaps the largest in Spitsbergen. The river had a smooth flow, and De Geer considered that it could be used by expeditions travelling towards the east coast. A small boat or a flat-bottomed rowing-boat might be used for transporting the equipment. They were back at the ship in the morning of the 16th.

During the day, Nathorst spent 12 hours taking care of the botanical collections from the previous day. De Geer used the time for learning to handle the camera, which had come up with the gunboats. The wind increased during the day, and in the evening they decided to seek shelter with the ship in a small bay south of Templet. This proved to be a good harbour, which now acquired its name, *Bjonahamna*. The wind increased to full gale on the 17th. It was still blowing on the 18th, and only short excursions in the surroundings could be made. The discovery of Tempelfjorden resulted in changed plans for the next few days: the fjord had to be mapped, and they had the instruments for an accurate survey.

On July 20 Nathorst and four men rowed into Tempelfjorden, to set up signals and begin the measurements. On low points of land they used logs of driftwood for the purpose, sometimes with pieces of ice to be seen better; they also used cairns of stone or even gypsum. The positions of the different points were determined, and the points were connected by free-hand, eventually being checked by taking bearings. The mapping of the northern side of the fjord was finished, and Nathorst was about to start the surveying on the south side, when fog and rain forced him to return to the *Bjona* on the morning of July 20. He had, however, noticed that the low shores of the southern side of the fjord were covered with a tremendous amount of driftwood.

It rained throughout the 20th; nor was the weather good on the following day. On the 22nd, an improvement enabled Nathorst to resume his triangulations and carry out geological studies. He found sub-fossils of *Littorina littorea*, including large specimens, in the

gravel near the harbour; and he encountered limestone which was rich in *Fusulina*. Fossils of the latter species had not previously been seen in Spitsbergen.

De Geer had meanwhile become familiar with the camera. On the 22nd, he and some men from the ship rowed to the bottom of Tempelfjorden; next day they climbed Von Postbreen and walked inland. Of special interest were the beautiful median moraines, dozens of kilometres long. In one of these, they found pieces of bituminous limestone, rich in a small fossil which Nathorst later recognized as *Fusulina*.

On the 24th they rowed to the southern side of the glacier. Gravel banks similar to Scandinavian eskers although smaller were observed. Shells from mussels indicated that the front of the glacier had changed its position since the Ice Age.

Excursions in Billefjorden, July 25–August 4, 1882

On July 25 the *Bjona* sailed to Skansbukta. Along the way they passed a small bay which was "cartographically unknown". It was later mapped by De Geer, and was then named Gipsbukta from the neighbouring mountain Gipshuken.

When they passed Gåsöyane they observed the two gunboats, *Urd* and *Verdande*, lying off Kapp Thordsen. Apparently they had not succeeded in reaching Mosselbukta and had now been forced to choose the alternative site, Kapp Thordsen. The *Bjona* did not reach Skansbukta until next day; the usual calm foiled the planning.

A boat was sent to the gunboats in order to get information on their date of departure. The geologists wanted to send their collections home to Sweden and letters as well. The answer was August 6.

On July 28 the summits of the mountains were shrouded in newly fallen snow, but that did not prevent the geological work. Nathorst went to Gåsöyane and Gipshuken to study the strata. These belonged to the ura-series and contained fossils of Carboniferous plants, which he and Wilander had discovered in 1870 (see p. 73). On Gåsöyane he found blocks with *Fusulina* limestone in a brook-ravine.

On the 29th it rained. Time was taken to write letters and make fair copies of the observational notes. At 21.00h the two gunboats arrived in Skansbukta, to spend the Sunday at a more sheltered place than off Kapp Thordsen. The *Bjona* people were invited to breakfast on the *Urd*, and to dinner on the *Verdande*. They were also given the favour of having their barrels and boxes with collections transported home to Sweden free of cost.

The next few days were devoted to the surroundings of Billefjorden. De Geer, during the stay at Skansbukta, had investigated the soil of the valley

inside the bay and the strata in the mountains west of the valley, which belonged to the bergkalk. One of the strata, the spirefer limestone, formed the upper surface of a plateau, from whose edge several waterfalls rushed down.

On July 31, Nathorst went on a boat tour into Billefjorden. De Geer went with the *Bjona* to Gåsöyane, and would later meet Nathorst at Mimerbukta on the western side of Billefjorden, south of the characteristic mountain of Pyramiden (934 m a.s.l.). The Russian coal-field Pyramiden was later to be established there.

Nathorst walked along the western shore of Billefjorden. At Skansbukta he had collected a great amount of fossils. It rained all the time, so he camped early before reaching Mimerbukta. Next day he walked along the shore, while the men followed him in the boat. At Mimerbukta they found the *Bjona* at anchor. Nathorst then remained at Mimerbukta, while De Geer on August 1 went by boat to the bottom of the fjord. On its western side he had a look at the glacier, which was later named Nordenskiöldbreen by him and Nathorst.

De Geer climbed a mountain to the south of the glacier, which he wanted to photograph. The upper limit of the erratic blocks was determined; photographs were taken and angles measured. He then went to the northern side of the glacier in order to camp, and had to pass the glacier front, where dangerous calving was taking place.

Next day, August 2, De Geer and two men went up the glacier along its northern side. Everywhere protruded flat outcrops of Archaean rocks, very like the similar rocks in Sweden; their surface was polished, striated and covered by blocks. Roped together, they passed a lateral glacier and reached the ice-cap at about 600 m a.s.l. There was no time for walking inland; instead they climbed a mountain in the neighbourhood. The summit, covered with densely packed snow, was found to be at 1200 m a.s.l. (1124 m a.s.l. according to the latest Norwegian measurements). Near the summit, the vegetation on the nunatak consisted only of mosses and lichens.

To the south-west they could see the southern side of Isfjorden, and should if visibility had been better have seen the mouth of the fjord, as well as the high mountain which was later named Nordenskiöldfjellet. Westward they had a free view to the alpine landscape west of Billefjorden, and eastward to the ice-cap (here later called Lomonosov-fonna) which extended towards a distant mountain-group. To the north-west they could see Wijdefjorden, with open water in spite of the ice-blockade on the north coast; there were no obstructions from mountains, only glacier ice. Later, during the Swedish–Russian arc-of-

meridian measurements, De Geer's observations from the nunatak at 1124 m were to be of great value (see p. 348). The mountain bordering Nordenskiöldbreen on its northern side now bears the name De Geerfjellet, including the nunatak.

De Geer photographed and sketched the surroundings and measured angles; but soon the nunatak was enclosed in fog clouds, which approached from the ice-cap. They waited for four hours, yet the clouds grew denser and it started to blow. Following the ridge south-west, they finally reached their tent. After some rest they sailed to Mimerbukta, where the *Bjona* lay at anchor. Meanwhile Nathorst had worked along Billefjorden.

Kapp Thordsen and Adventfjorden August 5–17, 1882

On August 4, a fresh to strong wind blew in the inner portions of Billefjorden. The *Bjona* was to sail to Kapp Thordsen and transfer the collections of the expedition to the *Urd*. When coming out of the fjord they met with the usual calm weather. De Geer photographed the eastern side of Billefjorden as the ship passed along.

They arrived at Kapp Thordsen and the gunboats early in the morning of the 5th. They were invited to take part in the inaugural ceremony of the observatory Smith's Observatory in the evening.

Next day, August 6, the wind increased and the *Bjona* became lively at her anchor, with an insufferable stench from the bilge-water as a consequence. De Geer could not endure it and hurried aboard the *Urd*. There was an onshore wind, and Captain Johnsen of the *Bjona* worried about his ship, so he weighed anchor and left for shelter in Adventfjorden. Nathorst and De Geer, with a manned boat, were to go with the *Urd* to Kapp Starostin at the mouth of Isfjorden. Before the gunboats left, however, Captain Palander gave a farewell party to the Polar Year expedition and the geologists. The *Bjona*, at anchor in Adventfjorden, was reached on the morning of the following day, August 7.

In the evening a group, consisting of Nathorst, De Geer, Stjernspetz and one of the crew of the *Bjona*, went into Adventdalen along its western side, to look for the lake which was said to exist somewhere. But instead they mounted the plateau to the west of the valley, then climbed south-west to a mountain, which they measured to be almost 890 m a.s.l. and named Lars Hierthafjellet. The plateau consisted of a greenish sandstone of Tertiary age, forming a very sterile ground. Near the summit of the mountain, Nathorst found fossils of marine mussels, and in the neighbourhood fragmentary impressions of leaves. Weathered

rock fragments were found to be rich in impressions of plants.

To the north of the mountain there was a small glacier sloping north-north-east, Larsbreen. They followed it, with their bags and pockets full of fossils. The passage down the lower portions of the glacier was somewhat troublesome because of its steep slope.

They reached the ship on the morning of August 8, and the day was spent labelling and packing the collections. Nathorst also took the opportunity to botanize, with good results in the immediate neighbourhood of the harbour, on present-day Hotellneset.

On the 10th, Nathorst and De Geer went to the eastern side of Adventfjorden, intending to look for the *Mytilus stratum* which had been discovered here by Blomstrand during the expedition of 1861. No subfossils were found this day, however, as both geologists became involved in other matters. Nathorst climbed the mountain slope in order to study its stratification. De Geer determined the altitude a.s.l. of some terraces, and found fossils in a bituminous schist. These resembled the fossils of the coniferous tree found at Festningen. He also noticed a coal seam, and near it plant fossils.

Nathorst, too, collected a rich harvest of present-day plants. Arriving aboard at midnight, he saw that

“De Geer had laid the table and lighted a fire in the cabin, the temperature of which, +28°C, felt rather agreeable. On the way home I had been freezing very much, for my overcoat had been tied together to make a sack for carrying the fossils after bags and nets had become filled”.

On August 12, De Geer went to the *Mytilus* strata on the eastern side of the fjord. Nathorst, who was not feeling well, studied the flora in the neighbourhood of the harbour, and happened to find dwarf birch (*Betula nana*) in a patch on the slope. The dwarf birch was found at Colesbukta for the first time in Spitsbergen by Nathorst in 1870 (p. 73), and no other habitat had been found since then.

In the morning of August 13, the mountains on the eastern side of the fjord were covered halfway down with newly fallen snow. Since coming to Adventfjorden, Nathorst had been thinking of climbing the high mountain to the south-west of Adventfjorden.

*Nordenskiöldfjellet a herbarium of
the Tertiary period*

On August 13 the weather was clear and fine in the morning, but a little cool, reminiscent of an autumn day in Sweden. Accompanied by the captain of the *Bjona*, Nathorst mounted the plateau about 450 m

above the harbour. They walked across utterly barren ground, almost devoid of vegetation and covered with fragments of rocks, or at places with a stony wet clay into which the foot sank. To the south-west they could see the summit rising from the plateau. It was easy to climb, as they had only to follow a smoothly rounded ridge leading as far as the summit. Now and then the top was shrouded in clouds, but at times the sky was clear. The summit was white from the snow-fall of the previous day. At about 915 m a.s.l. according to Nathorst (about 800 m in reality) they found the same plant-bearing strata as they had found on Lars Hiertafjellet. Some of these fossils were very beautiful, and they took with them the finest ones as much as they could carry. They found plant fossils all the way to the summit.

Nathorst writes:

“.. this horizon will surely, after a closer search, yield an immensely rich harvest of Tertiary plants. It should be followed towards Colesbukta and into the interior valleys.”

It was interesting to note that a certain fixed limit existed as to the spread of the *living* plants. No plants except lichens grew at levels higher than 800 m a.s.l., corrected value (see below).

During the latter part of the climb it started to snow, and it was cold; at least it felt cold, as they had not brought any mittens! It was snowing while they stayed on the summit, and visibility was reduced. Only once were they able to see the mountains to the south, though dimly. Nathorst remarks that the view must be extensive in clear weather. He measured the height of the summit as 1150 m; the real value is 1050 m a.s.l. His aneroid was erroneous.

Nathorst noted:

“This must be a convenient place of observation, as the flat summit consists of blocks of sandstone piled upon each other and suitable for building huts for signalling and refuge.”

Is Nathorst here referring to arc measurements, or possibly to meteorological observations? Anyway, it is unlikely that he was thinking of a military observation post. It may be remarked that during the Second Polar Year in 1932–33, Sweden had a meteorological station here (p. 470), and during World War II Norway used the hut built in 1932 as a military observation post.

Before leaving the summit they built a top cairn, about 2 m in height.

“The size of the mountain, as well as the beauti-

ful fossils it contained, seemed to be a good reason for naming it '*Nordenskiöld's mountain*'."

The next day, August 14, was very windy and no excursions were made. The ship came adrift and they had much trouble before they could cast anchor again. The day was agreeable, though: the Norwegian steamer *Forsög* arrived with mail to them from home. This ship used to come to Spitsbergen in the latter part of the season, to buy codfish from the Norwegian fishing-vessels.

The investigations on the eastern side of Adventfjorden had gone on since August 10. De Geer, especially, was engaged here with his studies of the *Mytilus* layers. By digging in the shore terrace, he could make observations of stratification and process of formation. The layers were photographed and drawn, their height a.s.l. was determined by levelling, maps were drawn, and so forth.

On August 16 Nathorst carried out a boat excursion westward to Colesbukta, to investigate the stretch of coast between this bay and Adventfjorden. Where possible, he walked along the shore while the boat followed him near land. The results were rich and valuable from both botanical and geological points of view. Several "new" coal seams were observed, some of them 60-70 cm thick. He also found marine bivalves from the Tertiary.

As they came nearer to Colesbukta the rocks fell steeply into the sea, so Nathorst had to board the boat. The weather deteriorated and became "anything but agreeable, or rather, it was appalling, with rain, wind and snow".

The wind was against them and the sails were too small, so the tacking against the wind was highly uneconomical. They camped on the western side of Colesbukta, in a tent where there was scarcely room for the four of them but they kept warm.

Next day, the 17th, they sailed to the eastern side of the bay to look for dwarf birch. They found the old habitat, but also several other such places near the mouth of the bay. At one spot the ground was quite covered with dwarf birch. Also some other species of plants occurred in very great numbers. Nathorst writes:

"Surely, Colesbukta is worthy of a careful investigation in botanical respects. It was hard to tear oneself away, but as the botanical studies must yield to the geological work, I was obliged to return to Adventfjorden."

The trip back to Adventfjorden was cold and on one occasion critical. Nathorst was occupied with draw-

ing a profile of the whole stretch of coast.

*Liefdebay strata and the Heclabook layer,
August 18-27, 1882*

On August 18 they sailed with the *Bjona* to Sassenfjorden and anchored near Diabasodden (Hyperite Hat). Nathorst went ashore to take bearings, for connecting his map of Tempelfjorden with the map of the rest of Spitsbergen. However, it was blowing too much for any careful measurements to be done. Instead he left Sassenfjorden with the *Bjona*, while De Geer remained to study the geology of the fjord's southern shore. The *Bjona* sailed towards Mimerbukta but ran aground. She had to stay there until the high tide was on the way, and the voyage could be continued to Mimerbukta.

Nathorst spent August 19-21 here studying the geology and botany of the region. He was mostly alone and received assistance only with carrying the very rich collections of fossils aboard. In a lateral valley to Mimerdalen he found fossil remains of teeth, bones and scales of fishes; also rich plant fossils were found. Moreover, the present-day flora contributed to his collections. The previously so sterile Liefdebay strata were manifesting themselves rather richly, and Nathorst had obtained a very good idea of the mutual relations between them. He was now satisfied with life.

De Geer at Sassenfjorden found that the mountain on its southern side consisted of schists of Permian origin, and higher up the strata belonged to the Triassic period. Most interesting was a large fault of at least 500 m. He camped below the mountain which contained this fault and climbed it. After the return home, the mountain was to be named Marmierfjellet after the leader of the French Recherche expedition (see p. 19). This was done at the special request of the French geographer and mountaineer Charles Rabot.

On August 20, De Geer sailed to Gipsbukta, which was surveyed. Of special interest here was the fault which passed through Gipshuken, a continuation of the previously observed fault in Marmierfjellet. De Geer camped on one of the Gåsöyane, and on the 21st he left for Kapp Thordsen to await Nathorst with the *Bjona* there. The wind increased to almost a full gale, but De Geer managed to reach Kapp Thordsen. Owing to the heavy breakers, he could not land until about 10 km west of the cape. On the same occasion, the *Bjona* was lying in Billefjorden with calm weather.

Not until late in the afternoon was the *Bjona* reached by the first breaths of air, which gradually carried her into the area with high winds. Once there, she headed with good speed towards Kapp Thordsen. But the sea was too rough for anchoring there, so they continued

and dropped anchor to the west of the cape. On the way, they noticed De Geer's boat and understood that he was now in good care at the observatory.

Next morning Nathorst mounted Tschermakfjellet near the anchorage in order to study the Triassic strata near its summit, which contain an abundant amount of brachiopodes, as he had found in 1870. These strata are different from the Triassic strata below but they are still Triassic. In the afternoon he walked overland to the observatory, and was glad to find De Geer and his group in good health.

While Nathorst was away from the *Bjona*, the captain of the sealer *Hvidfisken* had visited the ship. He reported that the ice on the north coast now reached farther south than previously. In other words, during the entire summer it would have been impossible to reach Mosselbukta.

The summer was drawing to a close. The plan had been to make a geological survey of the whole Isfjorden region. There remained the coastal regions between Kapp Thorsen and Alkhornet at the mouth of Isfjorden, as well as Nordfjorden and its two arms, Ekmanfjorden and Dicksonfjorden.

On August 24 the *Bjona* weighed anchor and headed into Nordfjorden, but the wind died down. Nathorst was landed at Kapp Waern, the south point of the peninsula between the two fjord arms. He wanted to do botanical work on the plain which occupies the peninsula in its southern part, called Blomesletta. Of the 121 vascular plants which were then known from Spitsbergen, Nathorst had observed 115, and it was his aim to see the remaining six. Lack of time prevented him, though, from realizing this ambition.

Meanwhile the *Bjona* had been taken by the wind into Dicksonfjorden, and had cast anchor inside the spit of land on the western side of the fjord, Kapp Smith so named by the topographer Stjernspetz of the Swedish Polar Year expedition, who in 1883 surveyed Dicksonfjorden and the lowland to its north (p. 184).

On August 25, Nathorst undertook a boat excursion towards the interior of Dicksonfjorden. De Geer, who had much photographic work to do, stayed on board and later went to investigate Ekmanfjorden to the west.

At first the boat with Nathorst followed the western shore, where the Liefdebay strata of red and green sandstones and red clays appear below the bergkalk, rising gradually towards the north until they become predominant. The water in the fjord was quite red because of the weathering products from the red strata. At the mouth of a little valley, Nathorst found a cross-section of the loose-earth layers along a little river. Near the bottom of the small valley, a good

example of *varved clay* was seen. This was the only place in Spitsbergen where Nathorst had observed this type of sedimentation.

The fjord was too shallow for landing on the western side. Therefore they crossed the fjord and landed on the eastern shore, about 2.5 km from the bottom of the fjord, where they camped. At last it was warm and sunny weather in fact the finest day since the beginning of July.

Next day, August 26, Nathorst and the men walked on the eastern side of the lowland which, so to speak, constitutes a northward continuation of the fjord. Scales and carapaces of fishes are not uncommon in the Liefdebay strata, but they are rather fragmentary. On the 27th, Nathorst wandered with one of the men to the inner portions of the lowland, while the other two men went to the western shore to await Nathorst there. The lowland is quite flat, and it is not very long ago since it rose above the sea surface. Its previous boundary was indicated by a belt of driftwood.

Nathorst had intended to climb a mountain at the bottom of the valley, in order to get a view over Wijdefjorden to the north. But a northerly wind with snowfall restricted visibility and shrouded the mountain peaks. However, he was compensated by a westerly view with a glacier, its moraines, and beyond it mountain peaks, all consisting of Liefdebay strata. After fording the glacier river, his party continued the march along the western side of the lowland. After twelve hours they reached the boat, heavily loaded with stones. Late in the evening they returned to the *Bjona*. Nathorst was satisfied with what he had found during the day's march:

"Two findings this day may be mentioned here the grass *Glyceria kjellmani* Lange, new to Spitsbergen, and carapaces of *Cephalaspis* in the Liefdebay strata at the bottom of the mountains. The latter finding is of special importance, because the genus is characteristic of the very lowest Devonian strata and as the layers here are older than those in Mimerdalen, which belong to the boundary between the Devonian and the Carboniferous one has consequently to presume that the Liefdebay strata represent the whole of the Devonian period. Thus the still older Heclahook strata cannot be younger than the Silurian formation. It is not inconceivable that other Liefdebay strata may be found at Wijdefjorden which are older than those mentioned here, and therefore it is not impossible that part of the Silurian system might also be represented in this series."

*In the north-west of Isfjorden. Autumn.**August 28-September 5, 1882*

De Geer and three men had sailed to Ekmanfjorden on August 27. A meeting-place with the *Bjona* had been agreed upon, Bohemanneset, to which the ship steered on the morning of the 28th. The anchorage was not suitable in the present weather situation, with a strong northerly wind and shoals, so the ship was sent to Trygghamna. Nathorst wished to investigate the stretch of coast between Bohemanneset and Trygghamna during a boat excursion. With De Geer's work in Ekmanfjorden and along the coast to the south of Bohemanneset, the whole of Isfjorden would then be covered, except the coast between Grönfjorden and Colesbukta.

But Nathorst never came to Bohemanneset. On the evening of the 28th he was on board the *Bjona*, which was lying at anchor in Trygghamna. His diary depicts the situation in telegraphic style:

"Surrounded by glaciers and ice and pointed mountains. It is autumn. The crowds of birds at Alkhorner are gone; red and green snow."

Autumn had indeed arrived. On August 29 it was cold, wintry and windy, but some scientific work was done in the neighbourhood. On the 30th, there was thick ice in the water buckets on deck. A strong north wind blew, yet Nathorst sailed with the boat in order to investigate the coast to Bohemanneset. It had started to snow and the ground was partly white. The geological studies had become more troublesome. Nathorst therefore returned to the *Bjona* in Trygghamna, where the surrounding country was now covered with snow.

On August 31 it was still snowing. Worried about De Geer and his group, they weighed anchor around noon and tacked in snow-fog and hard wind to Kapp Thorsen. Considering the weather, they thought that De Geer must have preferred to go to the geophysical station rather than wait for them at Bohemanneset. Their surmise was correct. When they arrived at the station, De Geer had already been there a few hours.

As mentioned, De Geer and three men of the crew had left the *Bjona* on the 27th. The ship was then at anchor on the western side of Dicksonfjorden. De Geer rounded Kapp Waern and camped at Ekmanfjorden, just south-west of the mountain Kapitól¹⁾ (857 m a.s.l.) at a brook, which was rich in water and

through whose mouth they could pass with their boat. However, on the morning of the 28th, when it was low tide, the brook had run dry. Some distance from the shore, its water had petered down into the stony gravel.

Near their camp lay remains of a Russian hut. They carried out excavations and got a fairly good idea of the poor equipment of its previous residents. The finds were brought home. After the packing was done and photographs of the surrounding mountains had been taken, they sailed to Coraholmen, the small island in the middle of Ekmanfjorden. They camped next night below the mountain Kolosseum (653 m a.s.l.) in the north-western part of the fjord.

Their camp was near a large glacier, which they later named Sefströmbreen. On the 29th they investigated several sand ridges which were very reminiscent of Swedish eskers, though smaller. The glacier was photographed from the mountain, which lay south of the glacier, and from this position they witnessed some grand calvings which had almost brought disaster to their boat. The glacier had apparently shrunk a good deal lately, to judge from its moraines. Some of these now remained on the shore, while others protruded out of the fjord like islets. De Geer studied the strata of the bergkalk and those of the Permian and Triassic formations and the boundaries between them.

Their provisions were running low, and it was necessary to get fresh supplies by hunting reindeer. They sailed southward until they came to a grass-covered valley, but they did not get any reindeer here only some grouse. The night towards August 30 was spent north of the large glacier which lies south-west of Ekmanfjorden, later named Sveabreen. At last they found reindeer, on whose behaviour De Geer remarked:

"During this hunt I received confirmation of a statement by Norwegian hunters that the reindeer in Spitsbergen do not fear the noise of shots. From a hiding-place one can fire repeatedly without the reindeer fleeing, though one must not be seen by them. Probably this is a consequence of their experience of the roaring sound which arises when glaciers calve. This roar, which is sometimes heard a couple of times per hour, often resembles loud gunshots."

When they came out of the tent on the morning of August 31, they found that their boat was lying some distance from the shore, though tied to the stone that was used for an anchor. De Geer had to do some cold and fairly deep wading to reach the boat. Now they were all wet, just as the others had become on the

¹⁾ In his report De Geer apparently has mixed up the names of the two neighbouring mountains Kapitól (Capitoleum) and Kolosseum.

previous evening when they carried their booty of reindeer from the snow-covered hunting-grounds. In the heavy snowfall it was impossible to dry clothes.

They sailed to Bohemann-neset to meet the *Bjona*, but could not find the ship, even during a walk across the flat headland. It was still snowing and there was no place to shelter from the wind. Since yesterday they had no provisions except the bodies of the reindeer, and it was practically impossible to make a fire to cook any meat. Moreover, they had very little wood, and the wind was so strong that they feared that the tent would not stand. Everything justified a boat tour to the Polar Year station at Kapp Thordsen. With the help of a pocket-compass they steered towards Kapp Thordsen, in snow-fog and with unfavourable winds. They arrived early in the morning of September 1. A few hours later, with relief, De Geer saw the *Bjona* anchoring off Kapp Thordsen.

The snowfall had been detrimental to their plans. They had hoped to keep working until September 15, completing the planned investigations in the Isfjorden region and also having time for field-work at Bellsund and Hornsund.

They decided to sail to Grönfjorden and await developments in the weather situation. The geophysicists gave them some provisions, and in return their skilled cook Oluf left them to become the station's cook. The *Bjona* arrived in Grönfjorden on September 2. Between 20 and 30 fishing-vessels were now at anchor in the fjord.

On September 3 the weather was still bad, but they nonetheless made a boat excursion to the region of Colesbukta, where Nathorst on August 16 had found fossils of bivalves from the Tertiary. They obtained a good harvest and, very much satisfied, returned frozen and tired to the *Bjona* at 23.30h. Next day, the 5th, Nathorst studied the Festningen ridge, but the trip revealed that no comprehensive studies were possible as long as the snow remained on the ground.

Homeward. An unsuccessful attempt to land on Björnöya

It was time to sail home, but the winds were unfavourable, that is, southerly. At noon on September 6, a north-easter arose and the *Bjona* put to sea.

On September 10 they sighted Björnöya to the south, but the island was still far away. The wind was light, and the *Bjona* did not make much headway. Otherwise the weather was characterized by good visibility and a clear sky. On the northern side of the island they could see a well-built hut. It was probably that of the Norwegian sealer Sivert Tobiesen, known from his wintering here in 1865–66 (compare pp. 284 and 288).

Nathorst was most anxious to land. He wished to check his observation from 1870 (p. 73) of glacier striae running from east to west in the north-eastern part of the island. This would mean that the striae were not caused by local glaciers on the island. Instead, the striae would have to be taken as an indication that Björnöya had once been covered by a large ice-sheet. There probably existed glacier striae at several other places on the northern low portion of the island. Nathorst wanted to find and study these.

However, the captain considered it dangerous to land as long as there was a high swell with rough breakers near the shore. In the afternoon it clouded over, and a low fog formed. The nights were now dark and it was too late to make a landing, but a boat was prepared for an attempt the next day, the 11th.

In the night the *Bjona* drifted with the current towards the shore. This was not noticed by the crew, until white breakers appeared dimly in the darkness. The kedge-anchor was cast at a depth of 35 m; after very hard work the ship had been taken out of its dangerous position. On the morning of September 11, fog prevailed and there was a high swell. Nathorst had to give up hope of landing. He was not to realize this plan until 1898 (p. 266).

The *Bjona* reached Tromsø on September 15, and on the 25th the expedition was back in Stockholm.

POSTSCRIPT

The expedition had been small, but proved very rich in results and these had been obtained by two young men on the threshold of becoming outstanding scientists, in palaeontology and glacial geology respectively. One year later, in 1883, Nathorst was second leader on A.E. Nordenskiöld's Greenland expedition. He then had the fortune to continue his investigations in the fascinating regions of Disko Island and the Nugssuaq peninsula in western Greenland.

The collections of fossils from the previous Swedish expeditions had been studied by foreign scientists, notably the Swiss Oswald Heer (p. 155). After Heer's death in September 1883, Nathorst took over the responsibilities with regard to the scientific studies of the Swedish collections of plant fossils.

De Geer, the youngest of the two, had learnt much about glaciers and glacial deposits during his stay in Spitsbergen, experiences which he later could use successfully in his studies of the latest Ice Age in Scandinavia. But 14 years were to pass before he visited Spitsbergen again.

20. GUSTAF NORDENSKIÖLD'S SPITSBERGEN EXPEDITION IN 1890

A PRELUDE TO GREATER EVENTS

The Greenland expedition of 1883 had been A.E. Nordenskiöld's last visit to the Arctic. He still dreamt of visiting the polar regions, and followed with interest the expedition activity which was going on. Young men came to him for advice and support Nansen, Andrée, Björling and he offered his help with pleasure.

The remarkable Swedish polar research activity in the period 1864-1883 had been realized mainly thanks to three persons: Adolf Erik Nordenskiöld, Oscar Dickson and the King of Sweden and Norway, Oscar II. Nordenskiöld was the executive in the trio, and Dickson the financier, while King Oscar was both a private patron and the highest representative of the state with its resources notably the Swedish Navy which might be put into the enterprises.

When Adolf Erik Nordenskiöld left active polar service in 1883, there was no one in the country that could take over. Nobody possessed his authority, his competence and his relations with important persons and institutions. But several young men were planning for the future, when they would be able to enter the polar field as able scientists, expedition leaders and daring sailors.

To begin with, however, Adolf Erik Nordenskiöld went on contemplating new polar enterprises. The Canadian Arctic remained to be visited and studied. Yet, above all, in the south there was the lure of the antarctic lands and land ices.

A.E. NORDENSKIÖLD AND THE ANTARCTIC

The hypothetical continent *Terra Australis Incognita* had at long last been discovered in the first half of the 19th century. But instead of the realm that the old cartographers had envisioned, it was a cold polar land covered by ice and snow.

From around 1845, the Antarctic remained practically unvisited for 50 years. Not until the end of the 19th century was the interest of the scientific world directed towards it. After 1845, almost all the interest had been concentrated almost entirely upon the Arctic, but from time to time attempts were made to arouse concern with the southern continent, although at first mostly in vain.

During the 1880s, the German meteorologist Georg von Neumayer and the British oceanographer Sir

John Murray advocated a resumption of antarctic research. The latter presented a plan for a well-equipped naval expedition to the south. He was, however, quick to point out that he would have nothing to do with an expedition which lacked sufficient financial support from the very start.

The government of Victoria, Australia, became interested in the proposal and offered a contribution of British pounds 5000 if the British Government would contribute to the expedition as well. However, London rejected the idea.

In 1887, A.E. Nordenskiöld received a letter from "the agent general of Victoria, informing him of a programme for an antarctic expedition to be organized by the Antarctic Exploration Committee of the Royal Society of Victoria. He also got a telegram from the same committee, which according to Nordenskiöld read:

"Would he (Nordenskiöld) feel disposed to co-operate with the local society, each furnishing one vessel, Baron Nordenskiöld commanding? If so, what conditions? Could he be here by October? Our expedition will be commercial as well as scientific. Will his be the same?"

In 1889 a letter from the Swedish Foreign Minister was forwarded to Nordenskiöld and his patron Oscar Dickson through the Royal Swedish Academy of Sciences. It contained a reprint of a speech held on September 2, 1889, by the President of the Royal Geographical Society of Australasia, Ferd. von Müller. Here it was mentioned that the expedition planned by this society had not materialized; a suitable ship was not available.

Enclosed was a copy of a letter from the Swedish consul at Melbourne, who assumed that an expedition jointly equipped by Sweden and Victoria might expect a contribution of British pounds 5000 from the above-mentioned society.

At a meeting with Oscar Dickson, Nordenskiöld was promised an equal sum of British pounds 5000 on the condition that the task of fitting out the expedition was entrusted to Nordenskiöld and Dickson. In a lecture at the Royal Swedish Academy of Sciences on January 8, 1890, Nordenskiöld gave an account of the expedition plans, adding that the new expedition would leave Sweden in the autumn of 1891. Nothing was mentioned, however, concerning its destination in the Antarctic.

A.E. Nordenskiöld was now 58 years of age, and too old for active antarctic service. In fact, already at an early stage, he had decided that his son Gustaf Nordenskiöld (1868-95) would be the leader. He had

prepared him for the task in several ways, and in 1890 Gustaf had led a small and successful summer expedition to Spitsbergen. But he contracted pulmonary tuberculosis that autumn, and died a few years later. In any case, the Australians were unable to procure the money that was needed. Therefore, this antarctic expedition never materialized.

Such was the background of the Spitsbergen expedition of 1890, and the explanation for why a planned co-operation between Sweden and Australia in the Antarctic never materialized.

THE SPITSBERGEN EXPEDITION IN 1890

Plans and participants

The Spitsbergen expedition of 1890 was, to begin with, intended as a small and inexpensive expedition. Together with his friend, the zoologist Axel Klinckowström (generally called Klinckan), Gustaf Nordenskiöld planned to go with a Norwegian sealer to Spitsbergen, mainly at the expense of the participants. However, Oscar Dickson generously placed means at their disposal for hiring a ship and for enlarging their scientific equipment. Means were also obtained from another private person and from the expedition members themselves. The number of participants could now be increased: Henning Boheman, a medical student, was to act as "medical advisor" and assistant to the expedition; further, a taxidermist and extra people for test-mining could be engaged.

The plans in brief were as follows. At the end of May they would start from Tromsø on board a hired sealer. Weather permitting, a landing on Björnöya would be attempted, mainly for a few days of geological studies. Short visits would be paid to the Hornsund and Bellsund regions for geological and zoological investigations. Isfjorden would be the principal region of research; geological studies and test-mining were to be carried out in the rich coprolite strata at Kapp Thordsen and at other places.

The rich occurrence of Tertiary plant fossils in Nordenskiöldsfjellet would be studied and collections gathered. Collections of marine invertebrates from the fjords would be assembled and prepared according to the latest methods. Measurements of the temperature of the sea water, and photography of glaciers for later studies of their variations with time, were additional aims.

In late summer a push northward would be made with the ship, primarily to carry out zoological dredgings. At the end of August or beginning of September, the expedition would leave Spitsbergen for home.

The yacht *Lofoten* of Tromsø was hired. She was a sealer of the common type: length 19.2 m, beam 5.7

m, and depth 2.4 m between keel and deck. She was ice-strengthened. By agreement, she would be ready to sail on June 1.

Henning Boheman was taken ill just before the expedition left Stockholm, and was replaced by a sixth-former, Alfred Björling, who was interested in botany and polar exploration. He had previously contacted A.E. Nordenskiöld on polar matters and Nordenskiöld, who apparently found here a person of like disposition, supported him and was now able to let him go north, although no one in the expedition knew him. Björling reached the *Lofoten*, which with the expedition on board awaited him some 50 km to the north of Tromsø.

THE MEMBERS OF THE EXPEDITION WERE :

Gustaf Eric Adolf Nordenskiöld (1868–95), B.Sc., geologist and palaeontologist, photographer, leader of the expedition.

Axel Alexander Camille Rudolf Emanuel Klinckowström (1867–1936), undergraduate, responsible for the zoological studies and collections.

Johan Alfred Björling (1871–92), student, botanist, to conduct oceanographic observations and measurements.

Ernst Erikson, aged about 18, assistant to the zoologist.

For the test-mining three men were engaged, one being also a harpooner on board; the foreman was Klaus Thue, a rock-blaster.

The commander of the *Lofoten* was Marcus Johnsen, of Tromsø. He had commanded the *Bjona* during Nathorst's and De Geer's expedition in 1882. Including him, the crew consisted of nine men. Thus a total of 16 persons sailed with the *Lofoten*.

A hazardous skiing tour

The *Lofoten* left Tromsø on May 27, bound for the two islands Reinöy and Karlsöy. The intention was to wait for Björling there, and meanwhile investigate local caves. Björling arrived on May 31, and on June 2 the *Lofoten* stood out to sea (compare p. 213).

Björnöya was sighted on June 6, and next day they slowly approached the island. The wind was light and visibility good. Everything was prepared for a landing, but at a distance of 6–7 km, dense fog developed and enclosed the island. The fog remained for the next day, but time could be used to advantage for testing oceanographic equipment, as well as for collecting animals from the surface layers in a bag net which was dragged after the ship.

In the afternoon, visibility improved and the ship moved gradually towards the island under a light breeze. Yet once they were closer to the island it grew calm, and the fog returned. In the evening the wind

Gustaf Nordenskiöld (1868-1895), son of A.E. Nordenskiöld, geologist, photographer, leader of the expedition to Spitsbergen 1890. (Andersson, J.G.: *Antarctic*.)

Axel Klinckowström (1867-1936), zoologist, member of the Spitsbergen expedition 1890. (Klinckowström, A.: *Tre månaders dag, svenska Spetsbergs-expeditionen 1890.*)

The Spitsbergen mainland as seen from Indre Norsköya. Panorama-photo by Gustaf Nordenskiöld, who was a skilled photographer. (Nordenskiöld, G.: *Redogörelse för den svenska expeditionen till Spetsbergen 1890.*)

The gunroom of the *Lofoten* was fairly roomy and was used by the scientific staff. Reading in his bunk is Gustaf Nordenskiöld. The plant press belongs to Alfred Björling. (Klinckowström, A.: *Tre månaders dag, svenska Spetsbergsexpeditionen 1890.*)

increased to a fresh breeze, but the fog lingered, so Nordenskiöld decided that they should leave for Spitsbergen.

A good part of the voyage to Spitsbergen was also hampered by calms and fogs. On June 9 they met with ice, although at first it was open, consisting of small pieces. On June 12 and 13, they tacked under a fairly fresh breeze towards Sörkapp, and on the afternoon of the latter day land was sighted. The passage from Norway to Sörkapp had taken 12 days, as against 3–4 days under normal conditions with a sailing-vessel. On the 14th they got a fresh wind and rather high sea, which made a landing impossible. Moreover, the land was covered with snow, rendering geological studies practically impossible.

On June 15 they were about 10 km off Rotjesfjellet, a little to the north of Hornsund. Nordenskiöld had decided to investigate whether the passage across the ice-cap of present Wedel Jarlsberg Land the region between Hornsund and Bellsund was traversable. This study would be part of a reconnaissance for a possible arc measurement along western Spitsbergen. The *Lofoten* was to meet them at Recherchefjorden.

The participants volunteers were Nordenskiöld, Björling, Erikson and one sailor. Like the trip itself, their equipment was improvised. The skis were bad, intended only for short excursions on the glaciers; three pairs were covered with sealskin against sticky snow, but one pair did not have such an arrangement. They had a small tent and just two sleeping-bags of felt. The provisions consisted of ship's biscuits, tinned meat, and so on, for four days, as well as a spirit lamp and 1/3 litres of spirit.

At 18.00h on June 15, the party of four was landed at the foot of Rotjesfjellet, in a place where a narrow valley made the climbing easy. They carried their equipment in rucksacks, and expected that they would find smooth inland ice beyond the mountains. But when they had reached the highest point of the valley, they found that it was connected with another valley sloping down towards Hornsund, Revdalen. They were forced to mount the slope north of the valley, which was highly fatiguing; the snow was frozen hard, and they could not use skis on the steep slope. One man had to advance first and provide holes for the feet; the others followed after him, using the holes for climbing. At midnight they had reached a ridge connecting two mountaintops. The air temperature was -2°C and the altitude was 300 m a.s.l.

They continued their march northward, but were enveloped by fog and had to stop. It disappeared soon, so they were able to ski down the slope and reach a fairly large glacier, probably Vrangpeisbreen, leading to Eastern Torellbreen. The mountains in the area

were wild and steep. Sometimes the party was engulfed by banks of fog, which were carried by the wind. The snow was smooth and white, without any contrasts whatsoever. It was difficult to gauge distances, and generally these were underestimated.

They passed a few mountain ridges and climbed two, reaching about 700 m a.s.l. They suffered from thirst during the march; having only enough lamp-spirit to heat the tinned meat, they were often forced to eat snow. But during the later part of the march, they found melt-water on the glaciers. Late in the evening of June 16, they pitched their tent and rested for a few hours.

At 23.00h on the 16th, they began the march across the ice-cap between the heads of Recherchebreen and western Torellbreen. The surface was quite smooth and covered by old snow, frozen hard. They saw no crevasses, but at a few places lay weak depressions, which suggested the presence of crevasses. Early in the morning of the 17th, they reached the mountains to the east of Recherchebreen. Here they found several small pools of water and decided to camp.

It is difficult to place the latter stages of the march upon the map. Nordenskiöld's sketch-map only gives the roughest outline. During the night towards the 18th, they stayed put. Fog continued to enfold them, and they dared not lose their way among the mountains which they knew were ahead.

On the 18th they tried, despite the fog, to proceed towards the coast. All spirit was now finished and very little of the provisions remained. It was hard going. The snow was wet and stuck under Björling's skis, which were not provided with sealskins. He preferred to walk, which was difficult in the deep snow.

Finally they noticed that they had reached the mountains, and camped to await an improvement in visibility. Towards evening the fog lifted somewhat. Below the camp was a deep valley, which seemed to be a continuation of a bay. They thought they could discern the sea to the north, as well as to the south-south-west. Nordenskiöld imagined that the bay to the north-west was Dunderbukta; in reality it was Recherchefjorden.

Björling was exhausted, in part due to his unsuitable skis, and he was not in a state to continue the march. He needed a rest. But their supply of food was almost consumed, and it was essential to get help from the ship. So the other three left Björling alone in the tent with the packs, the sleeping-bags and the rest of the provisions. They started down the glacier, Recherchebreen, to find assistance for relieving Björling.

They found the distance to the *Lofoten* longer than

they had expected. The ship was not at anchor in Recherchefjorden, but farther west near Kapp Lyell; the inner portions of the fjord were ice-covered. After nine hours' march they reached the ship. Klinckowström volunteered to ski to the rescue of Björling with two men of the crew. By taking the boat to the bottom of the fjord, they shortened the distance they actually had to cover on skis.

After six hours they returned to the ship, but they had not reached Björling's camp. A blizzard was raging in the upper reaches of the glacier, and it had deleted the tracks of Nordenskiöld's group. There was nothing to do but return. On the 20th the weather improved, and three new men were dispatched, among them one from Nordenskiöld's group.

In the morning of the 21st, one man returned with the message that the group had reached the tent, but they had found it empty. Björling had left a message stating that, after waiting for a day and a half in vain, he had departed as fast as possible to the western side of Recherchefjorden. He had, however, mixed up this fjord with Dunderbukta and had gone in quite the wrong direction, as appeared from his traces. Joakim, one of the sailors, followed the traces, while the other two went down to the ship. A boat was now sent to Dunderbukta to meet Björling.

Joakim took up the chase and soon reached Björling, who was indeed going south. It appeared later that his pocket compass had the wrong polarity! Moreover, Björling seemed to be somewhat confused; he tried, for instance, to hide behind a stone. At any rate, by the evening of June 21 all were safe and sound on board the *Lofoten*. It had been a hazardous excursion, mainly because of youthful inexperience with regard to equipment, weather, and the physical features of the land. However, they had learned that the region in question offered good possibilities for transporting instruments and equipment to geodetic stations established on nunataks; the ice-cap surface was smooth and fine.

While the skiing tours for the rescue of Björling were going on, the *Lofoten* rode at anchor at the mouth of Recherchefjorden, in the company of two Norwegian sealers and an American fishing-vessel. The Norwegian hunters said that Isfjorden was probably still covered with fast-ice, and that ice existed at Nørsköyane in the north-west of Spitsbergen. There was thus time to spend in the Bellsund area. The cod fishing, which on Nathorst's and De Geer's visit in 1882 was conducted from several ships, had now declined.

While waiting for Björling, Klinckowström was occupied with dredging. Nordenskiöld photographed a glacier and searched for the strata with plant fossils near Kapp Lyell, but there was still too much snow.

Whalers in Spitsbergen

After Björling's arrival on board on the 21st, the *Lofoten* sailed to Midterhukén, the headland between the two fjord-arms, Van Mijenfjorden and Van Keulenfjorden. She anchored in the rather unsafe harbour of Midterhuk-hamna, south of the cape.

Next day a gale was raging and no boats could leave the harbour, but towards the evening the wind decreased. With four men, Nordenskiöld set out on a boat excursion to Axelöya, the elongated island guarding the entrance to Van Mijenfjorden. The intention was to measure a base-line, from the ends of which photographs would be taken with a photo-theodolite. This instrument would later be used for mapping the fjord. In the evening of June 23 Midsummer Eve the party was back at the ship.

On Midsummer Day the ship's party was given a rest. In the evening two ships were seen entering Recherchefjorden. One was a three-master of the ordinary Jan Mayen type (compare p. 39), and the other a small steamer used for harpooning whales.

On June 25, a boat was equipped for a short excursion to Axelöya. But on arrival there a severe gale broke out. It raged for another three days, and not until the 29th did it begin to abate. Some measurements could still be carried out and a photo was taken of the marked folding of the strata of Midterhukén. In the evening of the latter day, the party returned to the ship.

During their stay on Axelöya, the *Lofoten* had been on the point of drifting ashore. The harbour was practically unsheltered against the south-easterly wind, which now attacked the ship.

In the morning of the 30th, with decreasing wind, the ship sailed to Recherchefjorden, which was then free of ice. A calm with a clear sky prevailed, and the ship had to be towed into the fjord. Two whale carcasses were seen and smelled in the neighbourhood, a result of the hunting activities of the two whalers they had observed previously.

On July 1, Nordenskiöld photographed a panorama of Recherchefjorden and its grand glacier. The little steamer of the whalers had come into the fjord, and her captain was friendly enough to tow the *Lofoten* to the mouth of Bellsund. But even here, the wind had calmed down, and the fog continued. Not until July 4 did the *Lofoten* reach Grönfjorden.

Polar tragedy and wild disorder

Close to the anchorage they saw a small sailing-ship lying upon the shore. She was of a type used by the Norwegians for collecting eggs and down, and for reindeer hunting in western Spitsbergen. In October 1888, she had become shut up in Isfjorden by ice near

its mouth. Other ships outside the mouth observed her critical situation, but could do nothing. There had been talk of an expedition to rescue her crew of four men, but nothing was done. The men had disappeared, and nothing was heard of them in spite of rewards which were offered by the authorities.

While the *Lofoten* stayed at Grönfjorden, men from the ship found at Festningen, situated at the mouth of the fjord relics which were ascribed to the disabled ship: a seaman's chest containing a rusty table-knife, matches wrapped in a piece of a Swedish newspaper (probably taken from the house at Kapp Thordsen), and a bottle of carbolic acid bearing a label from the pharmacy in Vardö (which was the ship's home port). Near the seaman's chest, an overturned boat lay partly buried in the snow. To judge from the careful handling of the boat, it had probably served as an emergency dwelling to human beings. A close examination of the boat on the following day revealed nothing of interest, just a few oars and thwarts. Nothing was observed which might have helped to reveal the fate of the four men.

On his expedition of 1872–73, A.E. Nordenskiöld had found strata of coprolite at Festningen. The strata were considered thick enough for mining, and the three miners of the expedition were now to test the profitability of that site. During July 4–6, Gustaf Nordenskiöld was occupied with a geological investigation of the cliff at Festningen, as far down as the bergkalk strata.

During this stay, too, Björling passed across the mouth of Isfjorden in a boat, making soundings and measuring the water temperature at a number of depths. Klinckowström had been dredging.

On July 8 the *Lofoten* left for Kapp Thordsen, where the ground was now much less snowy than in the areas they had visited earlier. Björling took the opportunity to make soundings and measurements of the water temperature in a section between Kapp Thordsen and Bohemanneset. Next day the expedition assembled at Kapp Thordsen, and plans for the work were discussed. The *Lofoten* was to proceed to Skansbukta. Nordenskiöld and Klinckowström with three men would stay at Kapp Thordsen, while Björling remained on board the ship. On the 9th, she sailed to Skansbukta, a good harbour situated in the outer part of Billefjorden, where she had to await the arrival of Nordenskiöld's group, which now set up its base in "Svenskehuset" on Kapp Thordsen.

The house was found in great disarray. It had been looted by hunters and sailors; a few objects of value remained, scattered both outside and inside. The upper floor was not so messy, having apparently served as a lodging. Now the group discovered items

which had belonged to the crew of the ship that was shut up in the fjord in 1888. These things showed clearly that destitution had overcome them when they visited Kapp Thordsen. But no message from the "marooned" sailors was seen.

Fossil hunting at Kapp Thordsen, July 9–12, 1890

During their first day there, the group made short excursions in the surroundings first towards the north and east, where they found fossils from the Triassic. Next day, the 10th, they took the boat and rowed a few kilometres west, where Nathorst in 1882 had found fossil remains of saurians. For some hours they collected bones, especially a large limestone ball containing parts of a spinal column and several ribs of an *Ichthyosaurus*. This was taken arduously down to the boat, and freighted in the night to the *Lofoten* at Skansbukta. Nordenskiöld was anxious to do the final packing by himself.

When they rowed into Billefjorden, the current was outgoing and pieces of ice came floating with it. At last the boat could not make any headway, so they landed and walked to Skansbukta and the *Lofoten*. The boat group minus Klinckowström left next day, the 11th, and returned to Kapp Thordsen. While the ship was at Skansbay, Björling measured depths and water temperatures in a section across Billefjorden.

Nordenskiöld's boat group visited Kapp Thordsen, then continued westward along the land until they reached the mouth of a valley leading north called Sauriedalen (or, by A.E. Nordenskiöld, Rendalen). On the western side lay a mountain, Tschermakfjellet, which was visited the same evening. At the foot of the mountain they collected fossils from the Triassic period, and found considerable coprolite strata, in a ravine leading up along the slope of the mountain. They followed the ravine, which ended at an extensive plateau, and marched about 3 km across it to reach the summit. From here they could see far into Dicksonfjorden, but over the lowland north of it there were thin veils of cloud. After a brief rest they returned to the boat.

Next day, the 12th, they went up Sauriedalen along its eastern side. On the valley's bottom flowed a river. A short march took them to a brook flowing into the river; in its ravine they found fossils and saw considerable strata of coprolite. Higher up, the ravine was filled by a snowdrift in which the brook had created a tunnel. The party passed through this tunnel, about 120 m long.

They met with reindeer, which were remarkably fearless and did not react to gunshots (compare p. 197). Continuing along Sauriedalen they passed some ravines, in whose black schist they found several balls

of limestone containing fossils from the Triassic period. They got a good collection of these fossils.

Test-mining for fertilizers

After this excursion it was time to visit "Svenskehuset", where they arrived in the night towards the 13th. In the afternoon the *Lofoten* appeared; now the mining party was to be fetched at Festningen. If the test-mining there had given a negative result, it would be started in the rich layers which occurred at several places on Kapp Thorsen.

On July 14 the ship anchored off Festningen. During a week the three miners had obtained 2 tons, which were taken aboard, although Nordenskiöld considered this amount insufficient for economical mining.

On July 15 the *Lofoten* sailed to Trygghamna opposite Festningen. Nordenskiöld took panorama pictures with his camera: a landscape of glaciers and steep mountain slopes. The ship then entered Ymerbukta to the east with a big glacier, Esmarkbreen, at its bottom. Here the strata were almost vertical just as at Festningen and by sailing the short distance from one bay to the other, they passed from the Carboniferous to the Cretaceous period.

In the intermediate layers of the Triassic period, Gustaf Nordenskiöld observed the same coprolite strata as he had seen at Festningen. On the small spit of a moraine near the glacier front, a good opportunity arose to photograph the front of a glacier which ends in the sea.

A short row brought them to the eastern side of the glacier, where a lateral moraine formed a more considerable spit, Esmarkmorenerna. Beyond it penetrated a narrow bay (Morenekilen) on whose western shore they saw the collapsed ruins of some Russian huts. They started an excavation, but found nothing of interest except some wooden implements, a couple of human skulls, and some bones of bear and walrus.

The moraine consisted of gravel and silt, and it was devoid of vegetation. The eastern shore of the bay was a steep cliff, and beyond it lay an extensive lowland, Erdmannflya. From the clifftop, photographs were taken to illustrate the large glacier, Esmarkbreen.

Nordenskiöld wanted to continue investigating the coast up to Bohemanneset, which had not been studied by Nathorst in 1882 owing to unsuitable weather (p. 197). However, the test-mining had to be started at Kapp Thorsen, so they returned to Trygghamna and the *Lofoten*, against a headwind which was increasing to full gale.

On the 16th, Nordenskiöld studied the Triassic strata to the east of Trygghamna, without finding any strata rich in coprolite. On the 17th, the *Lofoten* sailed

to Kapp Thorsen, where some searching revealed a place in the cliff below a waterfall a few kilometres to the west of "Svenskehuset". This site was chosen for the test-mining. The strata were situated at the sea-shore and thus easily accessible. Meanwhile, Klinckowström was hunting reindeer to increase the store of provisions, and Björling collected plants.

Once the three rock-blasters were landed with their equipment, the *Lofoten* sailed across Isfjorden to Adventfjorden, where she anchored in the morning of July 19.

Fossil hunting on Nordenskiöldfjellet and neighbouring mountains, July 19–August 9, 1890

For two weeks they had almost exclusively been occupied with the coprolite strata. Now they were free to take up other geological tasks. August 10 was determined as the start of their push northward, allowing three weeks for geological studies and collecting in the Isfjorden region.

The most important object of research was Nordenskiöldfjellet, where Nathorst in 1882 had discovered an extremely rich occurrence of Tertiary plant fossils. Unfortunately, weather and snowy ground had prevented him from studying the locality in detail (p. 194). It was desirable to obtain a great amount of fossils from this habitat, and to study the extension and depth of the strata. Nordenskiöld considered that Adventfjorden would be the most suitable base for such studies.

During the 21 days the ship lay here, several excursions were made within an area extending between Adventfjorden and Colesbukta and some distance inland, up to 15 km from the coast. One disadvantage was unfavourable weather: where fossils occurred, the mountains were almost always shrouded in clouds, and there were very few clear days. Working in a fog is not very effective, as one gets no idea of the surroundings or stratification.

The first excursion took place on July 19. Nordenskiöld was accompanied by two men of the crew. They carried a small tent and a sleeping-bag for at most two men, their intention being to stay away for a few days. Nordenskiöld intended to cross the summit of Nordenskiöldfjellet, proceed into Björndalen beyond it, and pitch the tent in the southernmost part of the valley. This camp would serve as a starting-point for further excursions.

They mounted the stony slope up to the plateau at an altitude of 450–500 m a.s.l., above which Nordenskiöldfjellet "proper" rises. The latter has the character of an elongated horizontal ridge. The plateau, Platåberget at 480 m a.s.l., is formed by a green Tertiary sandstone, which is also found at other places

between Isfjorden and Bellsund, where it again gives rise to plateaus. They encountered reindeer here. These were both fearless and curious, and as they did not react to gunshots, a welcome contribution to the store of provisions was easily obtained.

Having left their packs on the lower part of the ridge leading up to the summit, they marched easily up along the slope of the ridge, which was covered with gravel of schist. At 580 m they became enveloped in fog, and at 900 m they found the strata containing fossils. Somewhat higher up, they were above the clouds and the sun felt warm. A few mountaintops rose above the cloud layer in the distance. They reached the summit after seven hours. The aneroid gave the altitude 1070 m a.s.l. (present official value 1050 m).

The ground was free of snow, but devoid of vegetation. A partly collapsed cairn of stones indicated Nathorst's visit here in 1882. They built a new cairn, about 3 1/2 m high. Then they followed the same route downward until they reached their packs. Here they pitched the tent and got some rest.

Next morning, July 20, they proceeded into the valley, Björndalen, west of Nordenskiöldfjellet. They marched south along the valley, which is about 10 km long and terminates at a rather large glacier. They pitched the tent late in the evening near the terminal moraines; the aneroid indicated 420 m a.s.l. This was to be their base.

One of the men now returned to the ship, while the other, Hans Selliken, stayed with Nordenskiöld. On July 21 there prevailed a dense fog during the whole day, and only short excursions could be made; but on the 22nd they started as early as possible, at 01.00h. The weather was better, though dense fog still surrounded the mountaintops. They first climbed a mountain near the tent, named Teltberget after its shape (height 1015 m a.s.l., new value 1028 m). In fact it is part of the ridge which constitutes Nordenskiöldfjellet; the ridge turns round Björndalen and passes via the summits of Håbergsnuten (1031 m), Håberget (865 m), Lindströmfjellet (965 m). (The altitudes given within brackets are the official values of Norsk Polarinstitut.) The ridge slopes down from Teltberget and runs along the upper reaches of Dryadbreen, where it is lowest. This incision cuts through the strata which contain fossils, and makes a fine place for gathering plant fossils. Nordenskiöld obtained a good collection here.

They descended along the ridge; in the lowest portion they were below the clouds and got a good view of the landscape. To the south was a large valley (Fardalen) running NE-SW, and in the bottom flowed a swift river. The sides of the valley were covered with

stones. Nordenskiöld had intended to ford the river and climb a mountain beyond it, but the river was impossible to ford here. Instead they climbed Lindströmfjellet, and found fossils all the way up to the summit at 935 m a.s.l. (966 m). Visibility was now good: to the south they could see Van Mijenfjorden and the mountains beyond it.

Marching back to their tent, they went part of the way along the ridge between Lindströmfjellet and Nordenskiöldfjellet, which in places was only a few metres wide.

On the 23rd there prevailed a strong wind, so Nordenskiöld decided to go down to the ship. Next day, the 24th, a gale was raging; but in the night towards the 25th, the weather was somewhat better. Nordenskiöld decided to march from Adventdalen to Colesbukta, where a boat was to meet him. Selliken accompanied him this time too. They brought no tent and only one sleeping-bag; the provisions consisted of tinned meat and a bag of ship's biscuits.

They started in the middle of the night towards the 25th, and were rowed to the bottom of Adventfjorden. Marching along Adventdalen, they turned right at the first lateral valley and entered Endalen, which they followed. After about 7 km they came to a glacier which reached the valley bottom, and after another 3 km to a point where a new valley, Fardalen, began with the same general direction but now sloping south-west towards Colesdalen, which is a continuation of Colesbukta. Among the stones, gravel and mud, which marked the watershed between the two valleys, Nordenskiöld found pieces originating from the fossil-bearing layers. These were terminal moraines of a glacier coming from the south, Brogerbreen. A few kilometres further on there was a second glacier, Dryadbreen, coming from the slopes of Teltberget.

During their further march along the valley, the weather began to deteriorate and a strong wind blew. They rested for a few hours behind some large stone blocks, but the cold made them resume the march. After a few hours they reached the lowland in Colesdalen, which ends to the west in Colesbukta. Other valleys meet here and, with their respective rivers, create a labyrinth of watercourses in the lowland. The men now had to wade across this lowland in order to reach the western side of Colesbukta, crossing some 40 watercourses of varying size. Their previous opponents of cold and wind were joined by heavy rain, which grew ever more intense.

After passing all the watercourses, they found that the southern side of the valley consisted of marshes. There was no vegetation on the mountain slopes, which might have delayed the downward flow, so the

watercourses expanded. Snow, earth and stones were washed off the slopes and slid down into the valleys, and in the marshes the water was rising. They hastened towards Colesbukta, where a tent and warm sleeping-bags were waiting for them.

Suddenly Nordenskiöld remembered that he had never told the boat-group whether the meeting-place was to be on the western or the eastern side of Colesbukta. The eastern side would be the most probable alternative from the point of view of the boat-group, but now Nordenskiöld was heading for the western side. And between the two alternatives lay the flooded marshes and the watercourses.

However, they kept marching towards the western side of the bay. The eastern side could scarcely be seen in the rain, but at last Selliken's sharp eyes discerned the outlines of two men. These had been keeping a lookout for them, and were now notified with a gunshot. A short row and a brief rest in the tent followed, whereupon they left for the ship and arrived on the 26th.

The tent was left standing, as Nordenskiöld planned to return to Colesbukta when the weather improved. Björling had come with the boat to Colesbukta for collecting plants. The bay and the adjoining valley are well-known owing to the luxuriant vegetation as judged by ordinary Spitsbergen standards including the dwarf birch found here in 1870 by Nathorst (pp. 73 and 194), and *Campanula uniflora* which is otherwise rare in Spitsbergen.

In Adventfjorden a second ship was riding at anchor, the British three-masted steamer *Minerva* belonging to Mr. Robert Ashton. The next two days were devoted to social gatherings: a dinner on board the *Minerva*, and a goose- and reindeer hunt in the Advent Valley.

On July 29 the weather was suitable for a boat excursion. Nordenskiöld decided to go to Colesbukta and visit a mountain south of Colesdalen, which he had intended to climb on the previous excursion, when the weather had interfered. Björling came with him, and they entered Colesdalen early on the morning of the 30th. Accompanying them were six men from the ship, to fetch six reindeer which had been shot a few days previously. As it turned out, all these reindeer had since been torn to pieces by hungry large gulls (*Laurus glaucus*). But two more reindeer were shot and taken back to the ship.

Nordenskiöld and Björling then climbed the mountain which was their goal. Its foot consists of hills of schist gravel, the same type as those found on Nordenskiöldfjellet above the 500-m Platåberget. These strata at Colesdalen are thus situated almost 500 m lower. At 543 m a.s.l. were found the strata with

plant fossils, and such fossils occurred all the way to the summit at 856 m a.s.l. (861 m). The party got a fine collection, notably a large fern and some huge leaves of deciduous trees.

From the summit they had a superb view of the topography of the land between Isfjorden and Van Mijenfjorden. A fairly large valley, Semmeldalen, was seen stretching all the way from the foot of the mountain to Van Mijen-fjorden, where it connects with the large Reindalen coming from the north-east. The lowland of the latter, with its many watercourses, extended like a map before their eyes. Nordenskiöld ends his description of the visit as follows:

"I have named this mountain after our distinguished plant palaeontologist Professor A.G. Nathorst, who has earned so much by his study of the ancient flora in the polar regions; it was his discovery of the strata with fossils on Nordenskiöldfjellet which induced me to turn my attention to the Tertiary strata of the high mountains."

After a walk of almost 24 hours, they were back at the tent and rested briefly. Then they had a short row to the ship in Adventfjorden on the afternoon of the 31st. The remainder of the day was spent in packing their newly acquired treasures.

On August 2 the weather was favourable for a visit to Nordenskiöldfjellet. The previous excursions had passed from present-day Hotellneset up along the slopes of Platåberget. Now Nordenskiöld wanted to use a route along a small valley, Blomsterdalen, leading southward from Hotellneset. The lower portions of this valley were free of snow, but covered with gravel and earth; higher up it was completely filled with snow-covered ice. The valley would be more practical for transporting loads of stones than the more direct way along the steep slopes.

Once the plateau was reached, there remained only a walk of about 10 minutes to the foot of the ridge which constitutes Nordenskiöldfjellet "proper". On the eastern side of this ridge is a glacier ending at the plateau, where large terminal moraines have been formed. These moraines originate from the fossil-bearing strata a few hundred metres higher up. Consequently the moraine is a true gold-mine to the fossil-hunter. A few hours' search for fossils gave a rich harvest, and Nordenskiöld decided to return later on with several men to carry fossils down to the ship, as well as to continue the search. One of his men was sent to the ship with a load, and told to bring another man up to the tent in Björndalen to get more loads.

Meanwhile, Nordenskiöld and Selliken continued by marching towards the summit of Nordenskiöldfjellet. But storm-winds on the ridge made them abandon this plan, and they went down into Björndalen. Walking along the slope and sheltered from the winds, they reached their tent in the south of the valley in the evening. The tent was somewhat damaged, and their belongings inside were soaked with water. However, they slept fairly well in the narrow sleeping-bag.

Next morning, August 3, two men arrived from the ship. After a short rest, they started together towards the low position of the ridge at the upper reaches of Dryadreen, where they had previously left a bag of fossils and would now look for still more fossils. During the gale, the sky had been quite clear, but now the wind had abated and fogs were gathering round the mountaintops.

This time they chose a route across the bottom glacier, Håbergsreen, hoping it would prove shorter. Nordenskiöld also wanted to study a glacier at that time of the year the latter part of the summer. Owing to the fog, it was impossible to get an idea of the extent of the glacier. They were not roped together and had to exercise great caution. But the bag with fossils was found, and several other fossils were collected on the way down to the tent.

In the forenoon of August 4, they were back at the ship with tent, fossils and all. August 5–7 was used for collecting fossils from the terminal moraines on Platåberget, and for carrying these heavy loads to the ship.

During the stay at Adventfjorden, Björling had devoted himself to botanical excursions in the surrounding country. He had also gone by boat to Bohemanneset, and measured depths and water temperatures between there and Adventfjorden. Klinckowström had been hunting in Adventdalen, and supplied his assistant with rich material for preservation. With primitive home-made tools, he had even managed to catch a large *håkjaering*, the shark of Spitsbergen waters.

A push northward before going home

The geological research in the Isfjorden region was completed, and the last phase of the expedition was to begin: a visit to the north coast of Spitsbergen. The *Lofoten* left Adventfjorden on August 9. First, though, she had to stop at Kapp Thorsen and fetch the “rock-blasters” with their material and coprolite samples. One ton was carried home, out of a total of 70 tons obtained in the coastal cliff during the three weeks of mining. The coprolite was found in seams 1–5 cm thick, their total thickness being 74 cm.

The “rock-blasters” were glad to be among friends again. The *Lofoten* then put to sea and headed for the mouth of Isfjorden. However, off Colesbukta the wind died down, and a calm was followed by a severe gale, forcing them to seek shelter in Grönfjorden on the evening of August 10. Nordenskiöld devoted himself to geological studies at the Festningen ridge, and not until the 13th was it possible to proceed north. On August 14–15 they got a new calm, but next they drifted with the current past the coast of Dei Sju Isfjella, whose slopes had a beautiful carmine-red colour caused by the “algae of red snow”.

On the 16th they entered the harbour at Norskøyane, situated in one of Spitsbergen’s regions of Archaean rocks. A boat excursion was made to the island of Klovningen, and on the 17th they visited Sabine’s “Observatory” on Indre Norsköya, where Sir Edward Sabine carried out pendulum observations in 1823. The spot is marked with a ring of stones. Sabine determined its position with great precision (lat. 70°49'48"N, long. 11°40'30"E). It was often used by later expeditions as a point of reference.

A panoramic photo was taken of the mainland to the south, with areas of red snow later marked in the picture. The red snow found by the expedition seems to have been among the most prominent ever observed in Spitsbergen. Samples of it were collected simply by skimming the surface layer of the snow cover and keeping the melt-water in a corked bottle. The algae were still alive when coming home to Sweden. In addition, Klinckowström used the scraper in Norsköysundet and found a very rich fauna at the bottom.

On August 18 the push northward started. The wind was good, but they soon got a calm and lay still near Flathuken, to the west of the mouth of Raudfjorden (Stora Rödebay). The depth was only 12 m, so Klinckowström took the opportunity to scrape the bottom, and Nordenskiöld measured the water temperature, which was found as high as +5.1° to +5.5°C from bottom to surface.

During the 19th they sailed northward under a light breeze, but a strong north-eastward current was perhaps the most decisive persuasion to proceed. Calms prevailed, and on the 20th ice was encountered. Björling took water samples at 80°20'N, 12°E, and measured the water temperature. This was +5.6° to +5.2° C in the layers 0 m 25 m, +3.9° at 50 m, +2.2° at 100 m, and +1.7° at the bottom (166 m).

On the 21st and 22nd, there was still dense fog with a calm. Seals were hunted, and several big ones killed (*Phoca barbata*). In the morning of the 23rd, it became possible to survey the extent of the ice, which could be seen all round the horizon except to the south and

east-north-east. The captain worried that the ice might close behind the ship, if a westerly wind set in. By taking the bearings to known mountain peaks, the ship's position was found to be 80°45'N, 14°40'E.

Under a fresh easterly breeze they steered south towards Verlegenhuken, and in the following night they passed this headland on an easterly course. At the entrance to Hinlopenstretet the wind increased, and near Lågöya they met with ice stretching along Nordaustlandet. Hinlopenstretet was filled with ice, except for a narrow lane along its western side.

They now had to return towards Verlegenhuken, and gradually the wind died to a calm as they left the "wind tunnel" of Hinlopen. Next morning, the 25th, a light breeze carried the ship westward past Verlegenhuken. Reports from sealers indicated that the ice which had stopped the ship was only a broad strip, which had been driven out of Hinlopenstretet by the southerly wind. It stretched in a semicircle from Lågöya to Verlegenhuken. North of it there had probably been open water.

On August 26 the *Lofoten* reached Biscayerhuken between Raudfjorden and Breibogen. A boat excursion was carried out into the fjord, while the *Lofoten* sailed to Norsköyane. Already that evening, the boat party came aboard the *Lofoten* at the meeting-place.

Before going home, a visit was to be paid to the Bellsund region. Nordenskiöld wanted to investigate the Tertiary strata on the northern side of Van Mijenfjorden. Klinckowström wished to see whether anything of ornithological value could be gained from the whale carcasses in Recherchefjorden (see p. 203), and Björling wanted to find out if the edge of Recherchebreen had changed its position since the visit of the French expedition in 1838 (p. 19).

On August 27 the *Lofoten* sailed southwards under a fresh breeze, which gave the ship a speed that sometimes reached 9 knots. But as usual the wind expired when they were near Fuglehuken, the north point of Prins Karls Foreland. It took almost five days, until September 1, to revive. Such fine weather for making excursions among the mountains had not occurred during their entire stay in Spitsbergen. But they were tied up on board, in a high and irritating swell. Besides, the ship was carried northward by the current, and only occasional puffs of wind enabled them to hold their position.

On September 1 they sailed south under a light breeze, and in the evening they reached the mouth of Bellsund. However, a strong wind was blowing out of the fjord, and gradually it increased to a full gale. They tried to tack up to Midterhuken, but gave up and sought shelter in Recherchefjorden, anchoring in the afternoon of September 2.

Several whale carcasses lay on the shore, indicating a successful hunt, and the zoologist added a few species of birds to his collection. Nordenskiöld made a boat excursion to Van Mijenfjorden, and past Kolffjellet to Sundevall-toppen, which was climbed. The height of the strata was observed, but few plant fossils could be obtained due to the snow-covered ground. The boat party reached the ship on September 6.

While the boat party worked in Van Mijenfjorden, Björling mapped the inner parts of Recherchefjorden. It appeared that the glacier had receded about 2 km from its position in 1838, when the French expedition visited the area.

After a short boat excursion to Kapp Lyell on the 7th, the *Lofoten* weighed anchor and started her voyage home. On September 20 she reached Tromsø.

Success and sadness

It had indeed been a successful expedition, not least when considering the youth of the scientific members (18-23 years) and the fact that this had been their first visit to the polar regions.

The plant fossils from the expedition were given to the rich collection of Tertiary plants at the Swedish Museum of Natural History in Stockholm. Professor A.G. Nathorst carried out the study of the collection. At the special request of Gustaf Nordenskiöld, he wrote a preliminary statement to be added to Nordenskiöld's travel report:

"...All the plant fossils belong...to the upper plant-bearing horizon, which was discovered by me in 1882 and which has now been established in the high mountains between Isfjorden and Van Mijenfjorden. The habitats, from which plant fossils belonging to the horizon referred to have been brought home, are Nordenskiöldfjellet, Teltberget, a mountain that Kandidat Nordenskiöld has named Nathorstfjellet, and also Sundevallfjellet.

The main part of the collections comes from Nordenskiöldfjellet, the same place where this horizon was first discovered in 1882, although only two man-loads containing 15-20 species could then be brought home because of unfavourable weather conditions. The collection now brought home amounts to a few hundred specimens of mineral, and is extremely interesting from a scientific point of view. Many of the species are found also in the collections of 1882, it is true, but there are also a great many previously totally unknown species, and the examples of species already known are in many cases more

perfect than in the old collections. Of some species there occur most comprehensive and informative series, belonging to leaves of different sizes. Remarkably enough, although the collection is so large, some of the species which were brought home from the same place in 1882 are now missing. As regards the state of preservation it is generally rather good, in many cases even excellent; as the leaves are often perfect, Nordenskiöldfjellet can bear comparison with Atanekerdluk in Greenland (compare p. 165), and it might in this respect even be superior to the latter habitat, which is rightly so famous."

The expedition of 1890 was expected to be an acid test of Gustaf Nordenskiöld. Negotiations were going on with the Australians concerning a Swedish-Australian antarctic expedition, and Gustaf Nordenskiöld was looked upon as the presumptive leader (see p. 199). However, Gustaf was taken ill. His friend Axel Klinckowström writes in his memoirs:

"In the course of the winter (1890–91) something took place, which to a high degree influenced my career. Gustaf Nordenskiöld, my friend and fellow traveller, had caught a serious cold after his return from Spitsbergen, when developing photographic plates in the cold unheated darkroom at Dalbyö (A.E. Nordenskiöld's estate south of Stockholm). In the latter part of the winter, pulmonary tuberculosis was contracted, and it was decided that he should go abroad to find a remedy before it was too late. It was also clear that all our thoughts of further polar travels together had to be given up for an indefinite period; to me, nothing remained but go my own way."

In 1891, Gustaf Nordenskiöld travelled to the USA and made ethnological studies of the cliff-dwellers in the Mesa Verde canyons, in the south-west corner of the state of Arizona. In 1893 the scientific results from this investigation were published in both Swedish and English. Gustaf Nordenskiöld's talents in landscape photography were evidenced here. Shortly before his death, he gave another demonstration of his skill with beautiful photographs of snow crystals.

Sven Hedin, the pioneering Asia traveller, was a friend of the Nordenskiöld family. In a letter from A.E. Nordenskiöld dated January 29, 1895, he read:

"Gustaf has, as you perhaps know, been very ill ever since last autumn (1894). He is better now and there is hope of his recovery."

To this, Hedin comments:

"It is strange that he could be so optimistic concerning Gustaf's illness. Gustaf was indeed hopelessly ill with consumption of the lungs, and his state of health probably deteriorated after he made the balloon flight on a raw and chilly day in the autumn if I remember rightly, with Andrée and had to lie in the open air during a cold night. He died in the same year as the cited letter was written."

It should be added that Gustaf Nordenskiöld did take part in one of Andrée's balloon ascents in Stockholm on April 30, 1894. This was an ascent with the balloon *Svea* fettered, and he served as photographer. But all ascents with the balloon free were carried out by Andrée alone (see p. 246).

When Gustaf Nordenskiöld died in 1895, he was travelling by rail with his parents and his wife to Mörsil in the mountain region of Sweden, where it was hoped that he would regain his health. He succumbed on board the train before reaching Mörsil. Sven Hedin writes further:

"After my return home in 1897 Nordenskiöld often talked to me about Gustaf. He never said a word about Gustaf's death; he talked about him as if he were still alive."

21. DARING TRAVELS WITH SMALL RESOURCES

JOHAN ALFRED BJÖRLING (1871-1892)

Many of the arctic travellers in the period following the "Nordenskiöld epoch" of 1864-1883 were young men. Some of them took up polar research for purely scientific reasons, but three—Gustaf Nordenskiöld (1868-95), Salomon August Andrée (1854-97) and Johan Alfred Björling (1871-92)—were developing their natural gifts in order to become expedition leaders as well.

This is particularly conspicuous in the case of Björling. He wanted to become a leader of men, notably of men engaged in polar travel and research. Axel Klinckowström, his expedition colleague in 1890, gives an outspoken and anything but respectful description of Björling, which seems a fairly correct assessment of his interesting personality. These impressions of Björling during the Spitsbergen expedition of 1890 come from Klinckowström's memoirs:

"In due time our new companion appeared and it turned out—with what feelings I leave to the reader to imagine—that Mr. Björling was not a man but simply a sixth-former, i.e. in our eyes very little better than a schoolboy, a fat and flourishing sixth-former, beaming with well-being, with round innocent eyes and a close crew-cut—at the sight of him both of us [Klinckowström and Gustaf Nordenskiöld] were thinking of the fat boy in Dickens' 'David Copperfield'. Rather soon, however, we realized that in the case of our fat friend, we had to do with a prize eccentric of less general standard. Johan Adam [should be Johan Alfred] was in a worse degree than anyone I have met, either sooner or later, afflicted with the most absolute polar craze—'bidt av en gal eskimo' [bitten by a mad Eskimo] as they say in Köbenhavn.

Jules Verne's Captain Hatteras and he would have suited each other excellently, and gradually we began to understand the witchcraft with which he had succeeded in winning the favour of the old professor [A.E. Nordenskiöld]: in spite of differences in age and position in society, the renowned *Vega* hero must have had a feeling of a kindred soul in the humble sixth-former. Our new friend was perfectly indifferent to *everything* except to the discovery of the North Pole and possibly in some degree to collecting plants. When it came to his most all-absorbing interest, he proved able to manifest an utterly unbeliev-

able will-power, an iron energy capable of overcoming any obstacle except death... After we had come to know his eccentricities we two older persons, Gustaf and I, found young Björling a capable and harmless, though not a very entertaining cabin companion..."

Klinckowström himself was a nobleman and a robust sportsman, full of vitality. Moreover he was, or rather became, an author gifted with a fluent pen. It should be added that, during the expedition of 1890, Björling had saved Klinckowström's life when the latter had become stuck on a bird-cliff at Isfjorden. Björling also possessed talents in mathematics and natural science, and was especially interested in botany and chemistry, but he had no concern for the arts.

In 1892, while preparing for the departure from St. John's, Newfoundland, Björling and Kallstenius got to know the Rev. Dr. Harvey, who gives a somewhat different picture of Björling:

"Björling was the young viking giant, six feet and two or three inches tall, with a strong chest, powerful arms and a beautiful posture. I have seldom seen a more beautiful face, fair-skinned, beautifully moulded mouth and nose in addition to large blue eyes. People here in town used to stop in the street to look after him in admiration."

Dr. Harvey notes further:

"What struck me most in conversations with him was the fact that fear seemed unknown to him. I suppose that this absence of forethought enticed him to this ill-considered expedition, which ended in such a disastrous way."

The three—Gustaf Nordenskiöld, S.A. Andrée and J.A. Björling—had one thing in common: the deciding role which A.E. Nordenskiöld played in their lives, notably in their becoming polar travellers and leaders of polar expeditions.

Gustaf Nordenskiöld had the experience, the human contacts and the authority of his father behind him. Andrée was poor but he possessed a magnetic charm, which helped him to get the assistance—including the financial help—that he needed. Björling was also poor and worked alone, with extremely meagre resources at his disposal. He had to economize which sometimes led him into difficulties. He compensated for these deficiencies with extraordinary will-power and a strong physique.

Björling belonged to an intellectual family, and his

cousin was a professor of mathematics at Lund University, Carl Fabian Emanuel Björling (1839–1910), who by the way indirectly inspired Andrée to take up balloon sailing and polar exploration (compare p. 243).

Gustaf Nordenskiöld had the best initial advantages of the three, but his health failed him. Andrée and Björling had to shape their own careers—with A.E. Nordenskiöld's help—yet their minds differed: Andrée knew how to wait in the course of fulfilling his dreams, and Björling apparently did not. The lives of all three were tragic in the end; Andrée and Björling were connected with great polar disasters.

MOUNTAINEER AND POLAR TRAVELLER:

A SUMMARY

Johan Alfred Björling prepared himself from early years to become a polar traveller, not least by leading an ascetic life during excursions and travels at home. He financed these enterprises by giving private lessons and by selling rarities from his herbarium. He was able to carry out his early journeys, but at the prize of scanty food and unsatisfactory equipment. He had much in common with Andrée here.

Björling may be said to have started his arctic career in 1889, when he and two schoolfellows—he was not quite 18 years old—visited the mountainous region of northern Sweden, well inside the Arctic Circle and with a polar climate. They climbed Kebnekaise, the highest mountain in the country.

After that sporting event, he spent each year in the Arctic until his death in 1892:

1890 In Spitsbergen as a member of Gustaf Nordenskiöld's expedition, where he worked as botanist and oceanographic observer.

1891 In north-western Greenland on an expedition of his own, travelling by boat from Upernavik to 74°32'N and back.

1892 With the zoologist Evald Kallstenius he sailed in a small ship, the *Ripple*, with the intention of investigating the south-east of Ellesmere Island in the Canadian Arctic. The ship was wrecked on one of the Cary Islands (77.5°N) at the southern approach to Smith's Sound. The ultimate fate of the expedition is still unknown, but all five members of the expedition perished.

THE CLIMBING OF KEBNEKAISE IN 1889

In 1883 the French geographer and mountaineer Charles Rabot (1856–1944) had carried out the first climb of the highest mountain in Sweden, the South Top of Kebnekaise (2123 m a.s.l.; lat. 67°54'N). In 1889, Björling and his two friends travelled across the Scandinavian peninsula from the Bothnian Gulf to

the Atlantic—via Kebnekaise in Swedish Lapland. Their aim was to climb the South Top of Kebnekaise. They did not then know that Rabot had anticipated them by six years.

The names of Björling's two companions were given by Björling as "H. and K." in his report, published in 1890 in the *Yearbook of the Swedish Tourist Association*. In an article in *Till Fjälls* in 1945, H.N. Pallin proved that the name of H. was Axel O. Hultman (1872–1921), who later became a Master of Engineering. The name of K. is still unknown; it should be noted that Björling at that time did not know Evald Kallstenius, his companion on the tragic expedition of 1892.

In 1889 the railway did not extend beyond Gällivare. To reach Kebnekaise, one had to travel about 90 km on foot to Kaalasluspa, some 20 km south-west of Kiruna, at the eastern end of a chain of lakes running east-west up to present-day Nikkaluokta about 45 km away. They covered this route by boat, bringing along a Finn, Hartvig Johansson Fjellborg from Kaalasluspa. He was to help them on the way, and accompany them on the following walk to Kebnekaise, a distance of 20–25 km. They met Lapps who allowed them to use a kâta (Lapp cot) on the slopes of Karmastjåkka (Tjäuratjåkko), a little above the tree-limit. From here it was some 5 km to the base of the Kebnekaise Massif, and another 5 km to the South Top.

The Finn proposed that they should march to the glaciers of Kebnekaise, facing east, and try to climb the mountain from there. The quartet started out at 11.00h on July 5. First they walked up along the slope to a plateau, which was bounded on the west by the Tarfaladalen. A river, Tarfala-jokken, was flowing in the deep valley, which they found difficult to cross. They mounted a glacier, probably Storglaciären (the large glacier of Kebnekaise), and had many problems with crevasses—especially Björling, who fell down into one but, luckily, landed on a piece of protruding ice. He later described this incident in a very matter-of-fact way, but it was caused by naive neglect of the men's need to rope themselves together. That neglect was set right during the march onward.

They met with fog at higher levels and had to return—at 1330 m a.s.l. according to Björling, although this seems wrong when studying his report. Thus the latter stage of the march of July 5 remains more or less up in the air, but it matters little, as they failed to reach their goal. The day's march lasted 16 hours.

The Lapps offered them a separate hut, since space had become cramped. They were also advised to attempt a climb along Kittelbäcken, then up along the slope towards the col between the mountains of

Tolpagorni (1662 m) and Vierramvare (1710 m). The route proceeds via the latter mountain and down into a valley north of it, after which the slope is smooth practically all the way up to the South Top (2123 m). This was later called the Western Route, and was used in the early days of tourist hiking in the Lapland mountains. It may be said that the route is safe, toilsome and rather unexciting.

They rested for two days in their camp, the weather being overcast with low clouds. The next attempt began at 19.00h on July 8. Clouds lingered, but had risen somewhat. This time, K. decided to stay and botanize near the camp. The march was uneventful, though the men became soaking wet in the Tarfala Jokken, and had to light a fire to dry their clothes and foot-gear. They also took the opportunity to make coffee. This and some chocolate was their only sustenance during the 23 hours the trip lasted.

The ascent turned out to be arduous, and was impeded by stone blocks on the slopes. The clouds dissolved as they progressed. They could see the surrounding country, and soon they had come so high that all the other mountains lay beneath them. In front loomed an ice-hillock, the South Top. Björling and Hultman climbed the top, cutting steps as they went, while the Finn awaited them below the summit. Its altitude was given as 2123 m a.s.l., but later measurements have yielded 2117 m, possibly due to a net ablation during the intervening years.

Björling and Hultman reached the top at 08.00h on July 9, 1889, after 13 hours of almost continuous walking and climbing. As mentioned above, they believed that they were the first to get there, but Charles Rabot had already climbed Kebnekaise in 1883. He had come from Norway and had chosen a route along the glacier which now bears his name. The latter route has never been much used. A glacier lying south-east of the top bears the name of Björling today.

On the return march, Björling and his companion preferred to follow a route along the brook in the valley north of Vierramvare. They must have been the first tourists to follow that route. It took them west, then south and, finally, east in the sharp valley between the mountains Tolpagorni and Singitjåkka, until they reached the wide and fairly flat valley of Ladtjovagge. What the ascent had lacked in excitement, they now experienced in ample measure.

They were back at the camp at 18.00h on July 9, and next day they left Kebnekaise. In the Finn's home village, Björling secured a testimonial from Fjellborg stating that the former had climbed the highest top of Kebnekaise and that the latter had been the guide. Remarkably enough, Hultman was not mentioned.

And unfortunately, neither Hultman nor Fjellborg left any report of their own about the ascent.

The three young mountaineers reached Lofoten-fjorden in Norway on July 21. Björling then travelled alone northward and visited Nordkapp; the other two went south and home.

Björling had thus made his first encounter with the arctic environment and the nature of travel in a mountainous arctic land. After these, his second great interest was botany. The climate in the Kebnekaise region is indeed a polar one, with a mainly arctic flora, and now Björling had become familiar with it. Kebnekaise had given him an arctic training at the age of only 17. In the following years, the Swedish high mountains—notably Kebnekaise and the Sarek region in Swedish Lapland—were to become a school for prospective arctic travellers and scientists.

THE SPITSBERGEN EXPEDITION OF 1890 UNDER GUSTAF NORDENSKIÖLD

The next step to take was a visit to the Arctic, preferably as a member of an expedition. Björling was favoured by fortune in that respect, probably in a higher degree than he could have hoped for. He had contacts with A.E. Nordenskiöld, and he corresponded with A.G. Nathorst and Fridtjof Nansen. As it happened, Gustaf Nordenskiöld's expedition needed a man to replace Henning Boheman, who had been taken ill. A.E. Nordenskiöld sent Björling to northern Norway, where the expedition was about to leave (compare p. 200). The road had thus been paved for Björling.

A HAZARDOUS AND TOILSOME BOAT-TOUR IN WESTERN GREENLAND IN 1891

Next Björling was tempted by Greenland. Part of its long coastline was more or less unknown territory:

1. The north coast from Cape Washington (83°35'N) and eastward, then southward to 77°N on the east coast;
2. The east coast between 66° and 70°N;
3. The Melville Bay coast between 74° and 76°N in west Greenland.

With only meagre means available, Björling could consider only the last alternative. He planned to sail with one of the ships of the Royal Greenland Trade. These ships used to visit the northernmost Danish colony, Upernavik at lat. 72.5°N, from where he intended to start a boat-tour northward along the coast—as far as time, weather and ice would permit. As oarsmen he intended to use Greenlanders from the local population. His aims were:

1. To survey as much of the coast as possible,

Johan Alfred Björling (1871–1892) botanist, "a man with an iron energy capable of overcoming any obstacle except death". (Kallstenius, A.: Tradgedin i Smiths Sund.)

Evald Kallstenius (1868–1892), zoologist, member of the expedition with the *Ripple* in 1892. (Kallstenius, A.: Tradgedin i Smiths Sund.)

Karl Kann (1871–1892), Danish, skipper of the *Ripple* in 1892. (Kallstenius, A.: Tradgedin i Smiths Sund.)

Björling's boat route along western Greenland in 1891. Solid line marks outward route, broken line homeward route. (Ymer 1891.)

The voyage of the *Ripple* in 1892. The shaded area marks ice-filled waters.

2. To carry out investigations in botany and hydrography (oceanography),
3. To gain experience for further travels in the polar regions.

From the Royal Greenland Trade, Björling obtained the permission to sail to Upernavik. He also obtained a traveller's letter of credit, requesting the officials in Greenland to give him all possible help for his expedition. But one qualification was imposed: on no condition whatsoever would he be allowed to winter in Greenland. Besides, he was informed that the ships generally did not stay for more than a total of one month at the two northernmost "colonies" Upernavik and Prøven. Apparently there would not be much time for a long northerly boat-tour.

The barque *Ceres*, with Björling on board, left København on May 17. She had a speedy crossing of only seven days across the North Atlantic, but from Cape Farewell delays occurred due to weather and ice.

Egedesminde was reached on June 14, and the ship stayed there for 10 days. Björling took the opportunity to study the surrounding country and neighbouring islands in the company with a young Dane, A. Holm. He botanized, climbed hillocks to get an idea of the distribution of the ice, and carried out boat excursions. Most Greenlanders were away hunting, so he was supplied with "three small Greenlanders, sixteen years of age" to be used as oarsmen. The experience was useful for a successful execution of the planned boat-tour from Upernavik. Björling writes:

"The Greenlanders were not always so pleasant to have as oarsmen; sometimes they ceased rowing for a while, sometimes they tried to dip the oars without rowing, etc. We had a good deal of trouble to make them obey, as we did not understand their language."

The *Ceres* left Egedesminde in the night towards June 24, passing west of Disko Island, and on the 27th they were near Upernavik. A few gunshots made the local officials and some ten Greenlanders come out to the ship, but with bad news: during the spring a fierce influenza epidemic had been raging in the two "colonies" of Upernavik and Prøven. The Greenlanders were therefore much weakened, and were possibly not in a state to help with the unloading of the ship, let alone being fit as oarsmen for a tour northward, when they would be driven hard because of the short time available.

There was very little cargo to carry home to Denmark, so the time during which the ship was to remain

in the area would be still further reduced. After some discussions with the captain, Björling managed to fix July 15 as the latest time of departure from Prøven. In other words, he would have to be back from his boat-tour after an absence of 17 days in order to avoid a wintering—for which he was not prepared and had no permission. On June 28, the weather changed from a period of fine conditions to one of dense fog and rain-showers, which lasted, except for one day, until July 11.

The head of the "colony", Mr. Beyer, managed to supply Björling with four of the best Greenlanders to serve as oarsmen. But he was careful to point out that, in spite of the presence of the catechist of Upernavik, who was among the four, he could not guarantee that the Greenlanders would come with him for more than a few days. Björling, for his part, was careful not to mention that he intended to go beyond lat. 74° 08' N—farther north than any Greenlander in historic times had ever travelled.

Björling had a store of provisions with him from Stockholm, intended for himself. For the Greenlanders, he bought provisions at Upernavik for 20 days, consisting of coffee, candy sugar, ship's biscuits and peas. He hired a rather small boat with a relatively large beam. The provisions were stored in locked boxes. Björling and the four Greenlanders left Upernavik on the evening of June 28. The weather was characterized by rain and strong winds "in a delightful combination".

The route followed by Björling is indicated in Fig. p. 214: a solid line shows the outward route, and a dashed line the homeward route. In 1887 the Danish lieutenant Carl Hartvig Ryder (b. 1858) had reached Wilcox Head, the outer tip of the peninsula Nuqssuaq at 74° 08' N, a latitude which Björling now wanted to pass beyond. At Upernavik, people were of the opinion that he might reach Tasiusak, about 90 km north of Upernavik.

Before proceeding north, Björling passed south of the island on which Upernavik is situated, in order to take advantage of a smooth sea. Where possible, he landed to study the flora—which in this area meant finding whether there was any vegetation at all. All he could see were bare rocks and masses of stones.

Just before passing into the narrow sound between the islands of Kagse and Niakornak, they observed an iceberg about 20 m high and very long, which blocked the entrance to the sound. When they were almost 100 m from the berg, a piece of ice, large as a modest house, fell down into the water. Consequently the whole iceberg collapsed, giving rise to tremendous surges, "and not without difficulty was the boat prevented from being thrown towards the shore". After another kilometre they met with another iceberg,

which had the form of an arch and nearly blocked the sound.

"It was not with any great pluck that I passed through this arch, but well beyond it I did not regret what we had done. Soaking wet from rain and heavy seas, we pitched the tent on the isle of Tartok. But it was not agreeable to lie in the wet tent and the soggy sleeping-bags; I therefore ordered departure after three hours of rest. As I did not understand the Greenlandish language, it was good luck that the Catechist understood a few Danish words; otherwise I would not have come far, because the others proved to be rather unwilling. The Greenlanders did not have any other clothes than those they had on. They were therefore in bad humour and wanted to turn back, as they suspected that they would be forced to have their wet clothes on for several days."

At 06.00h on June 29, they continued across Upernavik Isfjord, between floating icebergs from the fjord's interior and high breakers from the open sea. They had to turn back and try to find a new way through the ice masses. Several times the waves washed the boat and hurled it towards the icebergs. Only with difficulty could they avoid being bumped into the bergs. They found it necessary to seek shelter and rest at Saitok, where a family of Greenlanders lived.

"The gale raged worse than before, and snow was falling at a temperature of 0°C. It was only with the greatest dislike that I let the Greenlanders come to Saitok, for I was afraid that they would prefer to stay with their fellow-countrymen rather than continue the rowing in their wet clothes."

Having spent four hours at Saitok, they left and arrived at Tasiusak on June 30. At that time, Tasiusak (73°22'N) was the northernmost place on Earth permanently occupied by Europeans. It consisted of two houses and about 20 small cottages, low and filthy, the latter belonging to Greenlanders. Björling was obliged to stay here for a few hours, to let his Greenlanders rest and to give himself an opportunity to graduate a line, 600 m long. This was to be used for sounding the depth and for lowering his thermometer to fixed depths.

Since leaving Upernavik, his Greenlanders had eaten only a few biscuits. They had only made coffee once, as it had been impossible to light a fire with wet pieces of wood.

"Other travellers in Greenland have often complained about having been so dependent on the whims of the Greenlanders. My opinion is that

this whimsicality is due to the fact that one has let them live in a better way than they are used to. I considered that they would become more obedient if they had to work hard and, besides, be given little food; on my return from the boat-tour, I found that I had not made a mistake on that point."

The stay at Tasiusak was complicated by the presence of a large iceberg in the harbour. Several pieces of ice fell down from it, causing surges, so that the boats could not remain in the harbour and had to be transferred to a safe place at some distance.

Björling could find few plants in this area. After he had graduated his line, they left Tasiusak and rowed along the west side of the steep Anariartorfik Island, then between it and another island to the north, Nulok. Here Björling got his first temperature series, reaching 180 m. The weather was improving, and the inland ice was seen in sunshine for the first time during the trip. But soon they had to pass through the glacier ice coming out of the Giesecke Ice Fjord—where a dense fog prevailed.

The only possibility of coming northward was to pass between the two islands of Kavdlunait and Najanguak. The farther they came into the ice, the denser it grew, and soon they were stuck. The currents started to move about the blocks of ice, and for a couple of hours they were trapped in a most disagreeable way. However, the ice at last became more open, and on the evening of July 1 they managed to reach Kavdlunait, having taken 17 hours to cover 10 km.

Apart from the fog in the fjord, the weather was now fine with sunshine. Björling photographed the surroundings, including the island of Kook, which is the northernmost place where Greenlanders winter in western Greenland. In the summer, Greenlanders from the northern dwellings often visit the island of Kekertak (73°43'N) and stay there, as long as the auks and divers remain at the birdcliff of Cape Shackleton.

On the same day they reached Kekertak, which is a small island but rather rich in plants. They met two families of Greenlanders, 20 persons in all, with whom Björling bartered a couple of ship's biscuits for 15 boiled auk eggs.

"The first egg I cracked contained a young bird with a long neck and an evil-smelling greenish-yellow fluid. However, as the Greenlanders were standing in a circle around me, I was forced to eat it up. But I had satisfied my hunger with eggs for that day."

They next visited Cape Shackleton. Björling botanized

on the steep rocks, while his Greenlanders were shooting birds. He remarks:

"This birdcliff surpassed by far those I had previously seen in northern Norway, Spitsbergen and southern Greenland."

At midnight they entered the narrow Horne Sound to the east of Cape Shackleton. The boat was loaded with birds and eggs. The weather was fine, there was almost no ice, and a bright midnight sun was shining. This passage was among the most memorable events of the entire boat-tour. Yet on the homeward trip they had to pass the sound in a terrifying gale.

Björling decided to choose the passage between Kitorsak and Kugdlerkorsuit, but there was much winter-ice in the sound, and this almost threatened to thwart his plans. The whole of Sugar Loaf Bay was filled with ice, and only out at sea did it seem possible to proceed. As the Greenlanders constantly demanded to turn back, Björling would not pass into the open water south of Kitorsak. Instead they pushed through the ice and landed on Kitorsak. Now the Greenlanders flatly refused to go farther north.

"I knew that no persuasion whatsoever would now lead to anything, because they, like myself, were quite exhausted owing to the incessant rowing and poling.

I therefore let them rest for a few hours... I woke up after two hours and hurried to rouse the men, which was not easy even after I had got them into a sitting position. Only the Catechist was willing to come with me; the others urged an immediate return to Upernavik. The cause was not only that they had got so little rest; it was also a longing to come home and be spared from doing things. I, however, went into the boat together with the Catechist, determined not to give way to them, and I induced one of the others to come with us. After the Catechist and I had poled the boat some twenty metres from the shore, I had him tell them that I would gladly let them remain and starve to death on Kitorsak Island and that we would continue alone northward. As they had not eaten for several hours, and as they noticed that I intended to put my threat into practice, they became very frightened and entreated me to allow them to come with us. After a moment of feigned disinclination, I let them come with us; however, as a punishment for this third attempt at mutiny, I did not let them have any food until 24 hours had passed after their last meal."

Björling now wanted to climb the high and steep Sugar-Loaf Island, in order to ascertain the ice conditions to the north. He gave his Greenlanders a good rest, sat down alone at the tiller, and sailed among icebergs in beautiful weather.

Sugar-Loaf Island is 330 m high and resembles the crown of a hat. It was difficult to climb. Not even Kebnekaise—seven times as high—had been as hard to conquer, but the view from the top was grand and inspiring. To the north, they could see the mountainous island, Holms Ö, which Ryder had observed in 1887, but had not reached because of the ice. To the east lay the inland ice, and to the west was Baffin Bay with ice-fields as far as the eye could reach. But most important was the observation that a lane, 20 km broad and only partly covered with ice, stretched northward along the extreme headlands. Björling decided to follow this lead. On the summit grew the polar poppy and a few specimens of *Armeria sibirica*. Far to the south, they noticed some small dark clouds, indicating that a south-westerly gale with snow or rain was raging there.

They descended to the boat on the evening of July 2. Without getting any food or rest, they continued their tour northward; Björling wanted to reach Wilcox Head as soon as possible. On the way, he took a water temperature series down to 420 m. Only the outermost 7 km of the headland were free of winter ice. On the top of the peninsula, they found Eskimo cottages which, as usual, were covered with *Alepecurus alpinus*.

To let the Greenlanders regain their strength, Björling gave them a few hours of rest upon the rocks of the shore. From the incessant rowing, they had become so exhausted that they often fell asleep while rowing. On the other hand, Björling had such a short time at his disposal that it was necessary to row day and night with only a few hours of sleep at intervals. While the Greenlanders were sleeping, Björling had to attend to his plants and put them into his plant press. He hoped to get some sleep for a few hours during the long leg of 40 km to Holms Ö. The small clouds to the south were expanding, and Björling feared that they would hide the unknown coast to the north of Holms Ö.

They landed upon the island at 18.00h on July 3. Björling botanized, discovered Eskimo huts, and saw indications that reindeer were to be found in the neighbourhood. He loaded his cassettes with photographic plates—a disagreeable procedure, as he had to creep head-first into two sleeping-bags, one enclosing the other, and he was almost suffocated by the time the cassettes were loaded. Moreover, the Greenlanders had placed all available clothing on top

of the sleeping-bags in order to improve the darkness.

With the Catechist and another man, Björling then climbed the mountain (684 m a.s.l.) near the landing-place. On top of the dome-shaped plateau which constituted the summit, they got a wide northerly view over Melville Bugt. Far to the north they could see several high mountains, probably thanks to atmospheric refraction. At closer range they observed a great number of small nunataks, between which the inland ice protruded towards the sea in the form of huge glaciers. Their attention was drawn to a pillar-like mountain, Devils Thumb (840 m a.s.l.), well-known among generations of whalers. Ryder had given its latitude as 74°19'N, but Björling made a subsequent measurement of 74°41'N.

The ice did not permit Björling to penetrate farther north. He was forced to take photographs and to measure angles from another mountain peak, which was 732 m high and situated about 3.3 km from the first top. In this way he was able to map the region to the north of Holms Ö. The view from the latter peak was wider, and they got a better look at the northern side of Holms Ö.

The Greenlanders, at an early stage of the excursion, had become dissatisfied with the visit to the mountain.

"They were freezing and asked when I would be ready to go back. Owing to a superstitious fear of the inland ice and of large glaciers, a feeling which is prevalent among all Greenlanders, their courage declined considerably when I told them that I intended to cross a glacier in order to climb the mountain, 732 m high. If they had not known that I would easily overtake them, they would probably have left me alone and hurried back."

On the mountain-top was a low cairn, probably erected in memory of some arctic expedition which had landed at the island.

Björling dared not proceed farther north. The large floes of ice in Melville Bugt might become packed together and make a return journey impossible. He now had only 11 days to cover the 300 km back to Pröven. With the whole summer at his disposal, a march over the inland ice would have been of great value; several nunataks could be seen far inland. The northernmost position which Björling reached was 74°32'N.

On the way down to the boat he found, at a remarkably high altitude, several species of *Potentilla* and three-flowered specimens of *Arnica alpina*. Moreover, on a very steep slope at 250 m he observed species of *Salix* with trunks up to 6 cm thick, which

trailed around stones; several species of *Pedicularis*; a great many *Poa*, *Saxifraga*, *Potentilla*, *Hierochloa*, and other plants.

When they returned to the boat, they had been away for 15 hours without any food except water:

"...and even I felt satisfied to return to the boat. My kamiks had practically gone to pieces, and I had to march across several snow-fields, at first in my stockings and later, when these had disintegrated, with my bare feet."

Immediately after returning to the boat, they started the homeward tour, on July 4. Halfway to Wilcox Head, the foreshadowed south-westerly gale came over them, bringing a rough sea. It was not easy to row the boat, and 12 hours were needed to reach Wilcox Head—a distance of 30 km—but here they could not land; there was no shelter. They continued rowing towards Sugar-Loaf, often with a risk of having the boat broken to pieces against the bits of ice which danced among the waves. But Björling still used the opportunity to obtain a series of water temperatures, "though we did not find it very agreeable".

Near Sugar-Loaf they were able to land at an island, where they found shelter against the south-west wind.

"I first sent a Greenlander to pitch the tent on a slope, a short distance from the boat. As he was not seen for some time, I went to find out where he had gone. I found him sleeping on the slope, quite exhausted; one of the others, who was to carry up my plant press, was found some distance higher, also sleeping. I pitched the tent with the help of the two remaining men, and asked the former two if they would not rather lie within the tent than outside in the snowstorm, but they were too tired to get up, and I let them remain where they were. Since leaving Upernavik on June 28, I had myself not been able to sleep for more than 2 consecutive hours, and now it was already July 5. When I returned to the tent, I was so exhausted that I had to creep along the slope."

After a rest of six hours they continued their boat tour homeward (see dashed line on map p. 214). On July 7 they reached Tasiusak. They had company with an *umiak* (women's boat) rowed by six women, with three men as passengers. They had overtaken it, as the women were talkative and less diligent at the oars.

"I stayed [at Tasiusak] for more than 12 hours, so that they would not blame me for not letting the

Greenlanders rest when there was an opportunity to do so. People at Tasiusak were very much surprised that we had reached so far to the north in such a short time."

On July 11 they reached Upernavik, and Björling managed to get new oarsmen for the remaining leg to Prøven. There he arrived on July 14, twelve hours before the time agreed upon expired. On July 20 the Trade's ship, the *Ceres*, left Prøven for home, and on September 17 she was back in København. Björling summarized:

"The result of the expedition consisted mainly of some oceanographical studies and of a botanical collection. In addition, I drew a map of a part of Melville Bugt. *But most of all I valued the training which was a consequence of the boat-tour. I hope this training will be of benefit to me on future travels in the polar regions.*"

In total, 14 hydrographic series of water temperature measurements were taken. Of these, eight reached depths between 500 and 600 m. Near the surface, the temperature was a few degrees above 0°C. With increasing depth, it decreased to about -0.8°C at 100 m. At still greater depths, however, it *increased* to about +1.2°C between 500 and 600 m. (compare Chapt. 43 p. 490)

The boat-tour had been hard and in many cases very unpleasant. Nor did it become more attractive with the addition of stops for oceanographic measurements. It is remarkable that Björling managed to make the Greenlanders respect him so much that, together, they could carry through the enterprise. This tells a good deal about Björling's ability to lead men under the severest conditions—for better or worse.

It would be interesting to know how the four Greenlanders looked upon their long boat-tour in later years. They must have realized that they had performed a real achievement. Probably they were proud of what they had done, and the same should apply to Björling. However, his kind of leadership was such that it could result in triumphs and disasters alike—chance would decide. Björling's report on the Greenland boat-trip provides a nice insight into his personality and character. The report is clear, rich in information, and written in a matter-of-fact way as regards style and contents. It is an impressive piece of work by a person not yet 20 years old.

A POLAR TRAGEDY: THE VOYAGE OF THE RIPPLE IN 1892

The Swedish polar expeditions had worked mainly in

the Svalbard region and along the Siberian arctic coast. Valuable scientific research had also been conducted along the Yenisey River and in Greenland. But no expeditions had been dispatched to the Canadian Arctic. During Björling's preparatory travels—to Kebnekaise in Lapland in 1889, Spitsbergen in 1890, and Greenland in 1891—he had acquired good training in arctic travel technique. However, his experience was limited to summer conditions.

After Björling had returned from Greenland in the autumn of 1891, his interest centred upon the Canadian Arctic, and specifically on the southern parts of Ellesmere Island, lying to the north-west of Greenland. These regions of Ellesmere Island were less known than the more northerly portions which are situated along the sea-basins and channels of Smith Sound, Kane Basin, Kennedy Channel, Hall Basin and Robeson Channel—the latter constituting a "road" in connection with the attempts to reach a high northerly latitude, and even the North Pole.

Björling's new venture was necessarily going to be fairly inexpensive and, therefore, a summer expedition. In the present case, a forced wintering had to be considered, but there was a possibility of relying upon the Eskimos living on the Greenland coast. Whether an Eskimo population existed on Ellesmere Island was rather doubtful, yet some polar workers thought they knew.

Björling submitted an application for money from the Vega Fund. He also managed to obtain means from Oscar Dickson, and from other private sources. In his application to the Swedish Society of Anthropology and Geography, he gave an outline of his plans:

"My intention is to leave Stockholm in the beginning of May, and to travel along the West Greenland coast past Cape York, to some place on Ellesmere Island as near Cape Sabine as possible. The arrival in the area should under ordinary conditions suitably take place at Midsummer. During the following two months and a half, a tour by sledge and boat will be made along Ellesmere Island, and through Hayes Sound with the Victoria Archipelago or North Kent as a goal. This area, which is quite unknown in geographical respects, offers an extremely rich field for botanical research, as it constitutes the connecting link between arctic North America and Greenland.

If arctic North America has been reached by a whaler, the return voyage must start from Cape Warrender on Devon Island at Lancaster Sound or from a place on Ellesmere Island. As to the

prospect of carrying out this long tour of 1000 km in 75 days, without any great reduction, I should mention that, in 1891, I advanced along the West Greenland coast 600 km in 16 days, and under the most unfavourable conditions."

In a lecture on the Björling expedition at the Swedish Society of Anthropology and Geography on December 15, 1893, Gustaf Nordenskiöld commented on the expedition plan (compare p. 227):

"...Björling's plan does not impress me as anything that could not be carried out. To reach the coast of Ellesmere Island under ordinary conditions is not difficult. A tour inland to unknown territory might also be conducted without too much hardship, although possibly not to the extent that Björling believed."

Björling was primarily a botanist, with some knowledge of navigation, surveying and geography. He needed assistance in his scientific work, and there was some talk of a geologist, but nothing more was heard about the latter. Instead, Björling's schoolfellow Kurt Hanner, a Master of Engineering, was chosen to take part in the expedition, yet he was taken ill shortly before the start of the expedition.

Björling asked T.F.H. Tullberg (1842–1920), professor of zoology at Uppsala University, to help him obtain a zoologist for the scientific work on the expedition. The man chosen was *Evald Kallstenius*. Three years older than Björling, he too came from an intellectual and artistic family. Evald's elder brother Gottfrid (1861–1943) was a famous painter and teacher of painting at the Swedish Academy of Art. Evald had finished his studies for a B.Sc., although a formality remained at the time of departure.

Kallstenius did not know Björling personally when he became involved, but it required no persuasion from Professor Tullberg to get him interested. However, he was engaged in the nick of time, and is said to have had only about 20 days for planning and making arrangements before the start. He had no previous arctic experience to fall back upon.

Björling was used to practising strict economy, which is often considered an advantage. But in this case, it meant additional dangers. The expedition had to buy a ship of its own and hire a small crew. Moreover, as mentioned, Björling had to consider the risks of a forced wintering. Neither he nor anyone else on board had experience of a polar wintering.

The expedition turned out to become a great tragedy; none of the participants returned to tell the tale. However, the voyage to north-western Greenland

can be sketched with the help of letters from Björling and Kallstenius—and from messages left at their last known "station" in the high north, one of the Cary Islands in the southern approach to Smith Sound, although these messages are cryptic in several respects. There also exist statements from people whom the expedition met along the way. A summary of the messages will be given later (pp. 221–227), and we shall begin by describing the voyage.

To St. John's, Newfoundland: initial difficulties

Björling and Kallstenius, with 32 parcels, left Stockholm on May 12, 1892. They were waved off by just a few close relatives. Travelling in the cheapest possible way from Göteborg via Hull to Liverpool, they lived in dirty emigrant hotels, and in England they rode on an emigrant train with their parcels. They crossed the Atlantic on a filthy steamer, sharing a narrow cabin with six other passengers.

They arrived in St. John's on June 1. Björling called on the Governor of Newfoundland and Labrador, and was invited by him to dinner a few days later. Much discussion went on about the purchase of a suitable ship for the expedition. In a letter to A.E. Nordenskiöld, dated July 31 at Godhavn, Björling writes:

"I first approached the Governor at St. John's, who had been informed of my voyage both by Lord Salisbury and by the Secretary of the Colonies, Lord Knutsford, in order to be directed to someone who would best know how to help me. He recommended the Swedish-Norwegian consul, R.H. Prowse, who, after I had bought another ship than his own, tried in the most infamous manner to prevent my departure, and was successful insofar as I did not get people to my ship until June 22. He [the consul] tried to make all sailors at St. John's believe that my ship was quite useless and would sink just off Newfoundland. For that reason I did not succeed in getting more than 3 men, who were from Europe. I can prove that I have not been mistaken in the choice of the ship by the fact that I could pass through the extremely heavy pack-ice, which comes from East Greenland, in only 16 days. For the first time since one hundred years ago, this ice has filled the whole lower part of Davis Sound, and has only left a narrow lead along Baffin Land free."

It should be noted that Björling never exaggerated in his choice of words. Despite this, A.E. Nordenskiöld, in later messages to the press and to the Swedish

Society of Anthropology and Geography, censored the negative language in Björling's letter.

Already at the beginning of their stay at St. John's, Björling had come across a small schooner of 37 tons called the *Ripple* at a price of 665 dollars (2490 Sw.Cr.). A crew and captain were also being procured, but unsuccessfully for the reasons given above. The departure was provisionally fixed at June 6, but it was delayed till June 22. Thus valuable time slipped away, and this may have been a contributing cause of the tragedy.

At last Björling managed to obtain three men to join him as crew of the *Ripple*.

THE EXPEDITION MEMBERS WERE:

Johan Alfred Björling (1871-92), undergraduate, botanist, surveyor, leader.

Evald Gustaf Götrik Kallstenius (1868-92), B.Sc., zoologist.

Karl Kann (1871-92), Danish, skipper.

Gilbert Dunn, English, seaman.

Herbert McDonald, from Prince Edward Island, cook.

The names of the ship's crew were not given by Björling and Kallstenius in their letters and messages. They appeared instead in an article in the Canadian newspaper *The Evening Herald*. This is the only information on the matter, except that Gustaf Nordenskiöld gave the names in his lecture at the Swedish Society of Anthropology and Geography on December 15, 1893 (published in *Ymer* 1894), evidently with data from that newspaper. These sources provided the information given by Alfild Kallstenius in a related book of 1966. The official documents of the crew's signing on the *Ripple* were seemingly lost in the great fire at St. John's later in the year.

The time at St. John's was not wasted. Björling and Kallstenius made a number of excursions inland, returning with collections which were packed in a large box, to be fetched when they came back later in the autumn. However, this box too was destroyed in the great fire in the latter part of the summer. The two men were optimistic at the time, and were quite sure that their expedition would be a success.

*A hard voyage to Godhavn, Greenland,
June 24-July 28, 1892*

On June 24, all preparations were completed. With greetings from many of the local population, the *Ripple* put to sea. Two months later, much of St. John's would be burnt down—while up north, disaster was closing round the Björling expedition.

The next destination was Godhavn on Disko Island. This part of the voyage is fairly well known from letters, by Björling to A.E. Nordenskiöld and by

Kallstenius to his parents. Some details are also known from hearsay and from later publications in newspapers.

Already at this stage, Björling's remarkable reticence manifests itself. Kallstenius is more open, but even he is silent about important events and situations. From the ship's crew, no written information is at hand.

The route of the *Ripple* is seen from the map p. 214. The southern part of Davis Strait was filled with ice. In his letter to A.E. Nordenskiöld, Björling gave the approximate limits of the ice as (see also p. 214): lat. 67°N to north, lat. 60°N to south, long. 62°W to west, and—to the east—close upon the west Greenland coast. Only along the Baffin Island coast was there a lead of partly open water. These ice conditions would determine the route of the *Ripple*.

From Kallstenius' letters the following "fixed points" and dates are given, besides the starting point at St. John's:

July 1: lat. 59°N, long. 50°W (near Cape Farewell);
July 3: land sighted at a distance of about 100 km, mountain peaks of Greenland.

Until now, the weather had been fine, and the course had apparently been set more or less directly for Cape Farewell. The voyage had proceeded according to plan.

But after July 3, difficulties arose. They met with pack-ice, and the weather deteriorated. They were drifting about among the ice and/or surrounded by dense fog. On July 17, the position was about 64°N, probably near Baffin Island. Kallstenius notes:

"It's more than three weeks now without seeing land, except on July 3."

Kallstenius loved hard winds at sea, but was now tired of them. During the previous two days, the ship had been drifting in a severe gale, unable to sail.

Björling remarked in his letter to A.E. Nordenskiöld that there was no ice near Cape Walsingham on Baffin Island on July 24, when they passed the area. At 05.00h on July 28, the *Ripple* entered the harbour of Godhavn in a dense fog.

For the voyage from St. John's to Godhavn, the following "fixed points" thus exist:

June 24	St. John's, Newfoundland
July 1	59°N, 50°W, near Cape Farewell
July 3	Mountain peaks of Greenland sighted at a distance of about 100 km
July 17	64°N, probably near Baffin Island
July 24	Near Cape Walsingham, Baffin Island (66°N)
July 28	At Godhavn, Greenland (69°N)

It is remarkable that nothing is said about the crew, by either Björling or Kallstenius. It seems as if they had agreed upon not doing so. But Björling is satisfied with the ship, especially after her ordeal in Davis Strait. In a letter to his parents, dated July 31, Kallstenius pictures life on board:

“A voyage like this one cannot be compared with an ordinary sea-voyage; there are, especially, some conveniences which one must learn to do without. And that is possible; it is easier than one could imagine. To sleep in one’s clothes is something one gets used to. During the whole time, when we were on the way from St. John’s to Godhavn, I had not been out of my clothes more than once, when I had a cold rub-down—a very cold one. Worse is to adopt the practice of washing only two or three times a week in order to economize on our store of water... As for food we were comparatively well off; it was not very monotonous. Besides a number of different kinds of tinned meat and vegetables, which are really very good, and among which occur beefsteak, roast veal [there follows a long enumeration of 10 different sorts of tinned meat], asparagus and green peas, [they can cook fruit soup and clear soup, etc.]. And then we have supplies of birds and fish. And the cooking we see to ourselves, on a little spirit stove of our own. Apart from food in the proper sense of the word, we are also equipped with some sweets, such as figs, raisins, dates, prunes and chocolate in rather rich amounts.”

It seems as if the provisioning had been done with care and knowledge. However, one cannot help wondering why each man prepared his own food, since they had a cook among the ship’s company. There must have been something wrong with the cook. One of the Swedish friends of the expedition mentions that the cook had been drunk when the *Ripple* left St. John’s—but such a thing may happen to the best of men.

With regard to Björling and Kallstenius, the silence is complete. No letters from the former to his mother survive, if any ever existed. Björling’s father had died in the year of his birth.

Alfhild Kallstenius comments:

“It seems as if he [Björling] had broken all personal bonds now, when standing face to face with his great responsibility as leader, and with the mission which he felt he had in the service of science.”

Some more information does exist, but it is mere

hearsay. Björling is said to have described the hardships of the voyage to the Danish governor at Godhavn, who mentioned them to a member of the Peary relief expedition, who in turn told one of the editors of “Public Ledgers”, who told Dr. Harvey, who got it printed in *The Evening Herald* of St. John’s. According to this report, the cook had gone insane after a few days at sea, and soon the sailor showed symptoms of the same ailment. However, a few days of fine weather before reaching Godhavn were enough to cure them both. At all events, the men on board must have had a hard time in the ice.

The people of the *Ripple* were well treated at Godhavn. Björling was able to replenish the equipment. He bought ropes, provisions, fur clothes, a shotgun with 500 cartridges and other types of ammunition. As a loan he procured a sporting rifle, according to the chief of the “Colony” of Godhavn, Mr. Jørgensen. With the latter’s help, he also procured a very good sloop. The expedition was thus fairly well equipped when it left Godhavn, though it was not provisioned for a forced wintering, nor was the clothing ideal for such a purpose. With the addition of the rifle and the shotgun, the expedition now had access to four—or possibly five—firearms.

Examples of the misinformation which spread after the disaster became known will be given later. In this regard, the Swedish-Norwegian consul at St. John’s may have acted like a spider in its web.

A shipwreck at Cary Islands.

Messages from the expedition

The *Ripple* left Godhavn on August 3. Owing to the delay at St. John’s, it was rather late in the season. The vessel had behaved well until then, but there was still the risk of a forced wintering. Björling was quite aware of this and, in his letter to A.E. Nordenskiöld from Godhavn, he had written:

“If a wintering should be necessary, I will resort to the Eskimos in North Greenland or to the Danes on the west coast. If I cannot come home this year, I beg you to request the whalers of St. John’s to bring along with them the written messages which I hope to deposit on the top of the highest among the Cary Islands; usually they pass close to these islands.”

With that, the *Ripple* sailed into the unknown. The expedition vanished, but the wreck of the ship, as well as some meagre messages and relics, were found in June 1893 and later, on the so-called South-eastern Island among the Cary Islands, which lie in the southern approach to Smith Sound. The first finds

were made on June 17, 1893, by the Scottish whaler *Aurora* under Captain MacCay, near the wreck of the *Ripple*.

When the *Aurora* passed through the ice near Cary Islands, the look-out man in the crow's nest observed an object resembling a wreck on the shore at the south side of the island—which was then named the South-eastern Cary Island, and now bears the name *Björling Island*. The wreck was indeed the schooner *Ripple*. She was partly buried in ice, and it was not possible to come into her.

On November 14, 1893, a telegraphic report about the finds arrived in Stockholm, and some days later the written messages reached A.E. Nordenskiöld. With this information, Gustaf Nordenskiöld gave his lecture to the Swedish Society of Anthropology and Geography on December 15, 1893. The relics were few: some books, a flag, and a few articles of clothing.

A tragedy was evident, although hope at first clung to the chance that the expedition had found refuge with Eskimos. The written information which was delivered to A.E. Nordenskiöld consisted of three cards and one letter, all in English:

Card 1 (undated) contained a request to a member of the *Kite* expedition (Peary's expedition) to supply information on Björling to the Rev. Dr. Harvey at St. John's, Newfoundland.

Card 2 was dated August 17, 1892, and had the wording (translated here from the Swedish):

"Visited South-eastern Cary Island on August 16, 1892. Left Godhavn on the 2nd [should be on the 3rd] of this month and sailed along the ice in Baffin Bay until the 13th, after which I sailed in only one day across Melville Bay to Cape York. An easterly gale near the latter place drifted me westward, and at midday I was near Cape Parry, from which place I sailed to Cary Islands in order to provide myself with provisions from the English depot.¹⁾"

These lines are written in ink before the shipwreck of the *Ripple*. After the shipwreck, an addition was made with a pencil, dated August 17:

"After we had taken aboard the provisions from the Nares depot, the schooner *Ripple* ran ashore on the south side of this island, where you will find us in a small tent.

A new message will be left before we leave the island."

Card 3 bore the message:

"After I had lost the ship and thus had been forced to winter, I left this island on August 27 with the intention of reaching Foulke Fjord. If I should be forced to go to another place, further information will be given at Pandora Harbour. Including the stores from Nares' depot here, I hope to have provisions enough to sustain me and my four companions until the month of June 1893."

The letter, which was written in pencil, read:

"To visitors to southeastern Cary Island in 1893. As you can see from my messages, I have, after the loss of my ship, tried to reach Foulke Fjord in order to winter there; but after I had reached Northumberland Island, I had to give up this tour for several reasons and return to Cary Island. Forced by bad weather to linger on this island for a long time, I now set out on the tour to the Eskimos at Clarence Head or Cape Faraday on Ellesmere Island. As I hope that a whaler will visit Cary Island next summer to rescue me and my companions, I will try to reach this island again before July 1. If none has come here by July 15, I must, if possible, try to reach the Danish colonies. Therefore, if you visit this island later than July 1 and if you then do not find any message from me concerning my tour to the Danish colonies, I would be most obliged to you, if you would go to Clarence Head (50 statute miles from here), where I will leave a message in a cairn on the easternmost cape concerning our life during the winter.

Finally I beg you to send a message from me to Professor Baron A.E. Nordenskiöld in Stockholm or to the nearest Swedish consul, and to inform him on where and when this message was found.

Our stores will not last longer than January 1, if I cannot find any Eskimos or eke out our store from some depot.

We are now five men, of which one is dying. South-eastern Cary Island, October 12, 1892. J.A. Björling, Swedish Scientist."

Kallstenius wrote a letter to his father on August 16, 1892, when the *Ripple* was near Cape Parry at lat. 76°N, long. 71°W. A few passages from this letter will be cited here:

"...about halfway between Greenland and

¹⁾ This depot was established in 1875 by the British expedition under Captain George Nares in the *Alert*.

The wreck of the *Ripple* found on the southeastern shores of Cary Islands, later called Björling Island, in the approach to Smith's Sound. The discovery of the ship was made by the Scottish whaler *Aurora* on 17 June 1893. (Kallstenius, A.: *Tradgedin i Smiths Sund.*)

In 1894, the Swedish marine zoologist Axel Ohlin and the forester Elis Nilsson were separately sent to the Cary Islands to search for the Björling expedition. Sketch map from this visit, showing how Ohlin seems to have mixed up true north with magnetic north, compare Figs. on p. 229 (right). (Ohlin, A.: *På forskningsfärd efter Björling och Kallstenius.*)

Detail of aeronautical chart showing the approach to Thule airfield. To the right Björling Island. The magnetic deviation depicted by oblique lines (below).

Ellesmere Island you will find a small archipelago, named Cary Islands. We are now heading towards the south-eastern of these islands. Before we continue farther north to Cape Sabine (on Ellesmere Land at Smith and Hays Sounds)¹⁾ which are the original destinations of our voyage, we intend to deposit our mail in a cairn, which will serve as post office, viz. one telegram to *Aftonbladet* together with this letter; we will also take aboard provisions, which have been laid up there.

But it is not our intention to stay up there on Ellesmere Land longer than until September 15—at the very latest (in which case we hope to be in Godhavn one of the last days in September and to arrive in St. John's at the end of October, where we will stay for about two weeks). For the sake of security, as an early winter might make a wintering necessary, we intend to equip ourselves with provisions for at least one year (exclusive of the fresh meat in large quantities that we can procure from hunting). I mention this so that you and all our dear relatives will not be worried, even if still another year should intervene before we meet again.

I have no time at present to tell you about the voyage and what I have experienced and learnt, because we will now soon reach Cary Islands and we must prepare ourselves to accomplish what we have to do as quickly as possible, while the wind is still suitable for lying in the lee of the island."

Kallstenius does not express any doubts or pessimism. Apart from the delay in the first stages of their voyage, which necessitated some extra precautions, the voyage had proceeded almost according to plan. Kallstenius' letter to his father is the only personal letter, written by a member of the expedition to relatives or friends at home, which has been found. But it would be strange if none of the other expedition members had written any such letters—Björling to his mother, the crew to their families, and Kallstenius to his father with information on what had happened after August 16. It is all a mystery.

In his report, Captain MacCay of the *Aurora* mentioned a sealed item of mail addressed to Dr. Harvey at St. John's. The latter received it in due course, but it contained only two letters, both dated August 16: Kallstenius' letter to his father, and a letter from Björling to Dr. Harvey. The first letter was passed on

by Dr. Harvey to Kallstenius' father, with the following note added:

"The enclosed letter, which was carried here from Cary Island, Smith Sound by the whaling ship *Aurora*, reached me two days ago. The following is a copy of the letter which was enclosed with it:

'South-eastern Cary Island 16/8, 1892.

Dear Dr. Harvy,

I would be very grateful if you would send the enclosed letters to their respective addresses, and I would be particularly thankful if you would telegraph the following lines to Sweden, *Aftonbladet*, Stockholm: 'Passed across Melville Bay on August 13, after having been beset in the ice of Baffin Bay at 73°. Reached Cary Island on August 16.—Björling.'

I hope you will excuse the brevity of my report. Yours sincerely J.A. Björling."

Dr. Harvey continues:

"I did not telegraph to Sweden, as I knew that it would be meaningless, because tragic news of later date had been brought home by the *Aurora*. Mr. Björling talks of letters, but there was only one letter in the enclosure, which came to me and which I now send."

SUMMARY AND DISCUSSION

The *Ripple* had left Godhavn on August 3, 1892. From the written information found by the *Aurora* on June 17, 1893, it is possible to reconstruct the voyage of the *Ripple* and the ensuing events until October 12, 1892. However, Björling in his reticence left out information which must be considered as obviously essential. It seems as though he consciously wanted to prevent insight into important events during the expedition; not a word was said about the crew.

The *Ripple* sailed north along the ice in the east of Baffin Bay until the 13th. Then in one day she sailed across Melville Bay to Cape York. From there, she was carried westward by a gale to the neighbourhood of Cape Parry. As for the time and distance covered, the voyage from Godhavn had been satisfactory; but it was now late in the season, especially as they had scientific work to do up north. The ship, though, apparently behaved well.

On August 16, when they were near Cape Parry, they changed their course in order to visit the south-eastern island in the Cary archipelago. Here the leader of the British Navy expedition with the *Alert*

¹⁾ He meant Smith Sound and Hayes Fjord.

and *Discovery*, Captain George Nares, had established a large depot in 1875. Provisions from this depot might give the Björling expedition the extra security that was needed for a forced wintering.

They reached the south-eastern Cary Island safely on the 16th, and the necessary provisions were taken aboard from the depot. However, next day, the 17th, Björling wrote a message stating that the *Ripple* had run ashore on the south side of the island. He added that they were camped in a small tent nearby. But nothing was said about the cause of the stranding. Had ice come drifting unexpectedly, forcing the ship onto the shore? Or had an onshore wind made her drift ashore? The anchorages are mostly bad in the area, and there are no harbours at the island giving shelter.

One further question might be put: were the men exhausted after having taken aboard the provisions, and had they simply gone to sleep? Björling gives no indication, and does not even mention his companions.

This was a serious setback to the expedition, and almost a catastrophe for its programme. Nearly all their plans would have to be given up. But it was not yet a literal catastrophe, as the ship and equipment lay upon the shore. They could adapt to winter on the island, and hope that next summer a whaler might visit it to look for them—which in fact did happen on June 17, 1893. And their ship remained on the shore, at least until the latter date.

Björling's plans had suddenly been threatened, but it was not a hopeless situation. The expedition could proceed on a modified basis. Björling was extremely stubborn, as his Greenland expedition of 1891 so often illustrated. He could act regardless of the feelings, health or death of his companions: nothing would be allowed to stand in his way. It is doubtful whether his companions now wanted to go on under fundamentally changed conditions, and probably the crew would not do so. But would Kallstenius, who until then had been remarkably loyal? Perhaps he would.

One thing, though, seems certain: the *Ripple* was not to be blamed for the shipwreck. This could have happened to any ship of similar size.

Once the expedition had lost the ship, they would have to winter in the region. Björling had apparently decided that this would not be done on the island. On the Greenland coast lived Eskimos, and he chose to go north in the sloop, which evidently had not been damaged. Already on August 27, they left the island in order to reach Foulke Fjord, at the narrowest part of Smith Sound. They would then be within about 50 km of the region which had been chosen in their

original plans. If they should need to choose another place, Björling stated in his message on Cary Island that a new message would be left at Pandora Harbour near Foulke Fjord. He also stated that he hoped to have enough provisions to sustain them until June 1893. He did not mention, though, whether so much was loaded in the sloop to go with them.

However, they never got so far north. Already at Northumberland Island, after they had covered 4/10 of the distance to Foulke Fjord, Björling gave up this boat-tour "for several reasons and return to Cary Island". He is silent as to these reasons: were they stopped by the ice, or the weather? Did they land on the island?

Alfhild Kallstenius offers a theory in her book. To turn back must have been against Björling's wishes. Was a simple vote taken among the shipwrecked men, so that the crew had their way with three votes against two? In any case, a few days later—the exact date is not given by Björling—they were back at the Cary Islands, and were forced to stay there by unfavourable weather.

Björling now planned a new boat-tour, this time to Ellesmere Island, where he would try to reach Clarence Head or Cape Faraday to the west and the north-west respectively. This was within the proposed research area, and they might meet Eskimos here too. But knowledge about Eskimo settlements on Ellesmere Island was extremely scarce at the time, and may be regarded as mere supposition.

In his letter dated October 12, 1892, Björling outlined his further plans. He would try to reach Cary Islands before July 1, 1893, and would then await the arrival of a whaler until July 15. If no ship came, he would try to reach the Danish colonies. If the island was visited by a ship later than July 1, it was asked to land at Clarence Head and look for a cairn on the easternmost cape, where a message with information on the expedition would be found.

Björling also noted that his store of provisions would last only until January 1. But at the start of his boat-tour north on August 27, he had said until June 1893. Not a word was written to explain this severe reduction.

Björling's letter ended with a sentence as enigmatic as it was tragic: "We are now five men, of which one is dying." Why was he dying, and why did Björling not name him? Apparently he died before the start of the boat-tour, as his dead body was later found on the island. But why was his death not mentioned? From the state of his teeth, it appeared that he had been a pipe-smoker (see p. 231). Kallstenius was not a smoker; as for the others, nothing is known.

Considering these facts, the boat-tour to Ellesmere Island must have started on October 12 or somewhat

later. The winter was near; already from October 30 onward, the sun was due to stay below the horizon day and night, not to emerge again until February 13.

The departure for Ellesmere Island marks the beginning of the end of the drama. Nothing was ever heard of the four men after they left the Cary Islands. It is, however, doubtful that they ever reached Ellesmere Island. The great mystery is why they chose to go westward to Ellesmere Island, where practically nothing was known of Eskimo sites. Help was to be found in Greenland. Did Björling stubbornly adhere to the original plans? And why did the other three men follow him? Were the votes now in his favour after the death of one man of the crew, making it two against two—and with Björling, the commander, settling the outcome?

SEARCH EXPEDITIONS

Doubt and hesitation at home

As can be seen, much information was obtained from written documents and letters, despite Björling's silence about crucial events. Yet the likely disappearance of letters hinders a reconstruction of what happened after August 16, 1892. We thus turn to a summary of the measures which were taken at home in order to illuminate the drama or bring help to the expedition.

When nothing was heard from the expedition by the following autumn, some people got worried, but the disaster was not clear. Björling had mentioned an eventual forced wintering in his letter to A.E. Nordenskiöld. But rumours spread concerning the "floating coffin" they sailed in, unsuitable equipment, insufficient provisions, incompetent crew, and so on. Urgent requests "to do something" were heard. A.E. Nordenskiöld, who obviously played a central role in the matter at home, tried to subdue others' anxiety by referring to experience from his own expeditions. In a letter to the Kallstenius family, he expressed himself rather tactlessly, yet quite correctly:

"When young men go out in search of adventures, they will have to take the perilous consequences of their action."

Nordenskiöld had done so several times during his arctic career, but his wording gave rise to much criticism as being cynical and inhuman.

The last information from the expedition was, at that time, Björling's letter to Nordenskiöld (Godhavn, July 31, 1892). However, nothing could be done in the winter of 1892/93.

Professor Alfred Nathorst was the first to take initiatives for dispatching a relief expedition. He

contacted Consul Prowse at St. John's, and received the latter's negative views of the ship and equipment. Nathorst also recommended that the Swedish Foreign Office should officially inform the Royal Danish Greenland Trade on the matter. But not much practical work was done in the first winter.

Nordenskiöld corresponded with Lieutenant Edwin Peary, who had just returned home from Greenland after his gallant sledge tour across the inland ice in the north of Greenland. Peary repeated the current rumours about the ship, provisions and equipment. But he would see to it that American ships visiting the area were informed.

Both Nordenskiöld and Nathorst felt anxious about the Björling expedition. They had apparently encouraged Björling in the enterprise. However, at a meeting of the Swedish Society of Anthropology and Geography on May 17, 1893—with King Oscar present—Nordenskiöld tried to allay the fears of the Society; and the Minister for Foreign Affairs informed the Society that his office had sent telegrams to the Swedish consuls in Canada, St. John's, and Dundee (Scotland), as well as to the Danish Greenland Trade. Peary, too, had been approached for help.

The attitudes of Nathorst and A.E. Nordenskiöld were in sharp contrast: the former had asked for immediate action two months earlier, while the latter kept trying to subdue everyone's feelings.

On June 17, 1893, the Scottish whaler *Aurora* found documents and relics from the missing expedition on one of the Cary Islands. Not until November 14 did the news reach Stockholm; such were the communications in those days. Now all doubts of a tragedy were dispelled. It was only a month later, on December 15, that Gustaf Nordenskiöld, who had been Björling's expedition companion in 1890, gave his lecture on the Björling expedition to the Swedish Society of Anthropology and Geography.

Both A.E. and Gustaf Nordenskiöld tried to comfort the listeners by telling about the miraculous rescue of some arctic expeditions.

The search expeditions of Elis Nilsson and of Axel Ohlin

At last it was time for action. Gustaf Nordenskiöld suggested that a committee be established for the dispatch of a relief expedition. A.E. Nordenskiöld, insisting that there was hope, travelled to Köbenhavn to start preparing such an expedition. In order to get financial support, it was apparently important to uphold the belief that the members of the Björling expedition were still alive. In London the president of the Royal Geographical Society, Sir Clements Markham, also pleaded for a relief expedition.

Neither Nordenskiöld nor Markham succeeded. They could not procure enough money for expeditions, probably because the search seemed hopeless—time had run away. However, it was possible to dispatch two men during the summer of 1894: Johan *Elis* Nilsson (b. 1863), a forester, and *Axel* Gabriel Ohlin (1867–1903), B.Sc., a marine zoologist.

During April–July 1891, Ohlin had taken part in an expedition on a Norwegian whaler to conduct marine zoological studies. He had obtained economic aid from Oscar Dickson. Ohlin's research had mainly been restricted to the region 64°–72°N, 12°W–2°E, within the Jan Mayen region and also south of it, where the ship cruised between April 3 and July 10.

Elis Nilsson sailed on board the Scottish whaler *Eclipse* of Dundee. An agreement was reached that—at an extra charge of 100 pounds—Nilsson would be given the opportunity to visit the Cary Island where the *Ripple* had stranded, and for another 100 pounds Clarence Head would be visited in order to seek messages from Björling.

The *Eclipse* was delayed by ice, but Elis Nilsson managed to land at Cary Island on July 6, 1894, with a few men. The visit was short, and there was still much ice and snow on the ground. He visited the cairn on top of the island, where the *Aurora* had found the messages from Björling, but nothing was found now. He left a visiting-card, which was later retrieved by the American expedition on the *Falcon*, of which Axel Ohlin was a member (see below). The note ran:

“Carey islands, July 6, 1894.

Landed here to-day. I did not find anything that might give information about Björling and Kallstenius. We sail now directly to Lancaster Sound. Perhaps I may get an opportunity to come to Ellesmere Island in the beginning or in the middle of August.

Elis Nilsson”

Yet Nilsson never succeeded in visiting Ellesmere Island.

Axel Ohlin's search was based, to begin with, upon a proposed expedition under the geologist Robert Stein from Washington D.C. This expedition intended to winter at or near Clarence Head on the east coast of Ellesmere Island—within the area where Björling had intended to winter when he left Cary Island in October, 1892. The planned activities of Stein during the first year, 1894–95, seemed realistic enough, but his plans for a second year were closer to the realm of fairy tales.

Ohlin had obtained permission to go with the expedition. However, when about to leave Sweden

and join the expedition, he received a telegram from Stein suggesting that he postpone his departure from Sweden, as Stein had not been able to acquire a whaling ship. Both A.E. Nordenskiöld and Ohlin considered that he should go to New York, then to St. John's, and try to join a whaler there. Evidently Stein's expedition—like the man himself—was a great humbug.

In the end, though, Ohlin managed to become a member of the Peary Auxiliary Expedition of 1894, as a zoologist. He even obtained an agreement that granted careful searches for the Björling expedition, both at the Cary Islands and in the regions of Clarence Head and Cape Faraday. The expedition's leader, Henry G. Bryant, was accompanied by five scientists and a journalist.

The expedition was to start from St. John's on board the whaler *Falcon*, but the ship was one week late. Ohlin thus had plenty of time to collect information on the Björling expedition and its equipment. Ohlin did not know Björling and Kallstenius, but he displayed an arrogant tone when talking about Björling, although not in regard to Kallstenius. Alfhiel Kallstenius' book seriously criticises this attitude of Ohlin, which was due to mere hearsay.

The Swedish-Norwegian consul, Prowse, naturally belonged to Ohlin's most reliable sources of information. But Ohlin knew nothing about the consul's actions in connection with Björling's purchase of the *Ripple*. He was apparently not told by Nordenskiöld, although the latter had been informed on the matter in Björling's letter from Godhavn. Thus, Ohlin was biased with respect to the Björling expedition, from the very beginning of his mission.

A different opinion was held by the Swedish-Norwegian consul to the Dominion of Canada and the Colony of Newfoundland, W.A. Schwartz. He protested against some of the writing in newspapers at St. John's concerning the state of the *Ripple*, which was what the debate mainly was about.

Ohlin arrived with the *Falcon* at the Cary Islands on July 24, 1894. Three men of the scientific staff went ashore in a small bay of the southeastern island, where they saw barrels and other objects lying on the shore. This group then launched a reconnaissance of the area. The ship—with Ohlin and the rest on board—steamed slowly around the island, scanning the shores and the hill slopes, but no relics or the wreck of the *Ripple* were seen.

At 19.00h the scientific staff plus some 10 men went ashore. We may now follow Ohlin's report.

A little to the west of the barrels (now empty), inside a little bay and 15 m above the sea surface, they found a cleft which had apparently served as a camp-

Not shown in digital edition

Photograph of the western end of Björling Island, taken from helicopter by Dr. Weston Blake on 23 July 1976 (left).

Air photograph of Björling Island from true South on 23 July 1976 (right). Photo: Dr. Weston Blake.

Not shown in digital edition

Cary Islands (south-west, within circle) and the sounds and channels leading northwards between Greenland and Ellesmere Island. Map from 1892, published in Ohlin's book on the search for the Björling expedition in 1894 (below). (Ohlin, A.: På forskningsfärd efter Björling och Kallstenius.)

site during Björling's stay on the island. Under an old sail lay some scattered objects, such as a plant press, a surface bag-net, four handkerchiefs marked J.A.B., a bunch of keys, a rusty pocket watch, some loose leaves from books on arctic expeditions, and zoological notes. Quite nearby were some worn articles of clothing and the two lights of the *Ripple*.

After Ohlin had decided which of these articles was to be taken home, he and three others of the scientific staff visited the highest point in the south (west)¹⁾ of the island, where they had observed a cairn. Here they found Elis Nilsson's visiting-card (see above), and they added a report of their own. After a troublesome walk down the slopes, they joined the rest of the party.

One of the scientists had meanwhile found a heap of stones on the eastern (south) side of the island. Oddly, it revealed some waistcoats and other rags of clothing, of rather coarse quality. In a snow-drift nearby, they found a human skull and books, and a thighbone. Later Ohlin visited the grave without discovering anything of interest. The bones had apparently been mistreated by gulls.

These pieces of a skeleton were taken to Björling's campsite. A grave was prepared, and the leader of the expedition read some prayers. Where the skull and the bones were buried, a board was set up and inscribed:

"Here rests the body of an unknown man, who was buried at this place by members of the Peary Auxiliary Expedition. The remains were discovered at a distance of a quarter of a [statute] mile from this place in a north-easterly (south-eastern) direction and near a small cairn."

At the foot, another board was placed with the inscription:

"Here rests the body of a man from the crew of the schooner *Ripple*."

Ohlin, in his report of 1895, published a sketch map of Björling Island and the other islands in the Cary archipelago. For comparison, I show here a detail from an American aeronautical chart of the Thule region (USAF Aeronautical Approach Chart, 20 C 14, Thule, 1952). The two maps differ as to the general form of Björling Island. The discrepancies are, however, explained by two photographs taken from a helicopter by Dr. Weston Blake Jr. on July 23, 1976.

The general form of the island on the aeronautical chart agrees with the two photographs—as is to be

expected. But for some reason Ohlin's sketch map does not contain the characteristic southern promontory of low land. The Björling Island of Ohlin does show the general form of the *high* land—a fairly flat ridge—in the north of Björling Island; even the little hill with the cairn of Elis Nilsson is visible in the photographs. Yet curiously, Ohlin omitted the low land to the south of the ridge. The ridge actually extends about W–E, not S–N as on Ohlin's sketch map. This difference may be due to mixing up true and geomagnetic points of the compass. The geomagnetic declination in the area is as great as almost 90°W.

When they had come aboard the *Falcon*, Ohlin observed a cairn on one of the islands to the northwest (Table Island?). But on inspection, this cairn proved to be very old; it was covered with black lichens. They also found remains of Eskimo huts and graves on the western side of the island. None of the other islands in the archipelago was investigated.

The *Falcon* proceeded to visit the coast of Ellesmere Island, and landings were made at Cape Faraday and Clarence Head on August 7 and 8 respectively. Yet no traces of the Björling expedition were seen. The verdict of the search party was: "No places more desolate than these could ever have been chosen by Björling."

The finds of Peter Freuchen in 1916

In August 1916, Peter Freuchen, the manager of Knud Rasmussen's trading post Thule, and member of several of his so-called Thule expeditions, visited Björling Island. Freuchen had come by motor-boat from Thule, situated at North Star Bay, Wolstenholme Sound. On the eastern side of the island, he found the following relics from the Björling expedition:

Twelve empty 4.5-pound tins of boiled beef, remains of at least four wooden boxes, one small bottle of beer, seven collector glasses used for plankton studies, a few pieces of a striped textile, pieces of plants, gauze bandages, matches and nails, a table-knife, a white handkerchief marked E.K.12 at one corner, an empty raisin-box, a towel, a black felt hat, one shoe and pieces of a boot, a pair of dark-brown trousers, remains of barrels for meat, pieces of pottery, empty tins for preserved meat, a round wooden box, a large iron cauldron (not enamelled), a white blue-striped cotton shirt, a number of Swedish, English and French relics of books—among them Greely's "Three years of arctic service" and Hellwald's "I Höga Norden" (In the High North)—as well as two lids of a small stove, and ribs of oxen gnawed to the very bone as if by hungry men.

Freuchen also noted relics of books, wooden boxes,

¹⁾ Within parentheses are given directions obtained from our considerations.

pieces of rope, and so on, covered by frozen snow. His list was detailed and carefully made—in striking contrast to that of Ohlin, as has been pointed out by Alfild Kallstenius.

Information on the visit and the finds from the Björling expedition was published by the Swedish botanist Dr. Thorild Wulff in *Ymer* for 1917. Wulff, then a member of the Second Thule Expedition, died in the field from fatigue and hunger on the homeward march during a long sledge expedition to northernmost Greenland in the summer of 1917 (see end of the present chapter).

Another, and most valuable, find was:

“a grave covered with small stones—though large stones were to be found nearby. In the grave was a human skeleton, partly covered with earth, having a large well-shaped skull, a large nose, large beautiful teeth. In the upper jaw the right molar was missing of old; at the place of the left molar was still a stump of a tooth, and the jawbone was strongly affected by caries there. In the lower jaw all teeth remained. The person concerned had been in the habit of carrying his pipe in the left side of his mouth, as the front teeth were worn there in both the upper and the lower jaw.”

Had this man been a member of the Björling expedition? Probably so; but as mentioned above, he was not Kallstenius, who did not smoke. (compare p. 226)

The three groups of visitors—the *Falcon* expedition with Ohlin, the whaler *Eclipse* with Elis Nilsson, and Peter Freuchen—all had to leave the island in great

haste, although there is no report that the landing-group from the *Falcon* was actually forced to do so. Alfild Kallstenius is very critical on this point in her book. Why were the relics found by Freuchen not observed by the other groups? Was the find-place of 1916 buried in snow at the time of the other visits, or was the search by Ohlin's group with the *Falcon* slipshod?

THE END

Let us recall that after he left Björling Island—on October 12, 1892, if not a day or so later—nothing was ever heard from Björling and his three companions. The boat must have been heavily loaded, even though the cargo was relieved of all items that were not absolutely essential for sustaining life. The winter was approaching, the polar night was near, and the days had become colder. According to a report from Elis Nilsson to A.E. Nordenskiöld, persistent and severe gales had blown from the east and north-east in the area during the time of interest in the autumn of 1892.

There are many obscure points as to what really happened while the expedition stayed on the island, and still more as to what happened after they began their last boat tour. Most theories hold that the group never reached its destination but perished on the way. Besides the heavily laden boat and the gales, the low temperatures threatened to cover the boat with ice, if it did not fill with water. In the sea there was dense ice at some places; elsewhere small floes and pieces of ice danced on the waves and in the swell, ready to crush the little craft.

For all that, the four men's ultimate fate must remain unknown. The rest is silence.

22. SWEDISH INVESTIGATIONS IN THE NORTH-EAST OF THE CANADIAN ARCTIC ARCHIPELAGO AND IN NORTH-WEST GREENLAND

In the previous pages it was described how the expedition of Alfred Björling was overtaken by disaster in 1892, on its way to southern Ellesmere Island in the north-east of the Canadian Arctic Archipelago.

In 1898–1902, a Norwegian expedition wintered in the southern parts of Ellesmere Island. During long sledge-tours, a hitherto unknown archipelago of both large and small islands was discovered and investigated to the west of Ellesmere Island. The expedition was led by Otto Sverdrup, Nansen's previous travel companion, and Nansen's famous ship *Fram* was used by the expedition. A Swedish scientist, the botanist Herman Simmons, took part in this very successful expedition.

More recently two Swedish meteorologists, Björn Holmgren and Lars Dahlgren, carried out meteorological research on Devon Island—to the south of Ellesmere Island—during the summers of 1961–63. They were members of an expedition which had been dispatched by the Arctic Institute of North America.

Finally, in 1917, the Swedish botanist Thorild Wulff took part in Knud Rasmussen's long sledging tour from the Thule station in north-west Greenland, along the system of sounds between Greenland and Ellesmere Island and farther north-eastward. On the return tour, Wulff succumbed to the hardships of the journey. His fate will be related at the end of the present chapter.

The research work of Simmons, and of Holmgren and Dahlgren, concerns us to begin with. These scientists worked in the Jones Sound area—Simmons mainly on the north side of the Sound, Holmgren and Dahlgren on the south side, in regions which Björling had hoped to attain.

THE BOTANICAL WORK OF HERMAN SIMMONS DURING THE SECOND FRAM EXPEDITION 1898–1902

The expedition under Captain Otto Sverdrup had originally planned to explore the north-west, north and north-east coast of Greenland. It was to sail through Smith Sound and follow the sound complex northward to about 82°N. There a land party would

go ashore, establish quarters, and spend the winter of 1898–99. In the following spring, the party would sledge along the Greenland north coast, then along the east coast to Cape Bismarck at about 77°N. Here the sledgers were to be fetched by the *Fram* after her own wintering in west Greenland (compare p. 278).

However, fortune had much better things in store for the expedition. On the way north in 1898, the ship met with severe ice north of Smith Sound, and had to spend the winter of 1898–99 to the north-west of Pim Island, situated off the east coast of Ellesmere Island. In other words, the long sledge tour along the north coast of Greenland was prevented. But as a result, the expedition turned into vast unknown regions and—from a geographical viewpoint—became one of the most triumphant arctic ventures of all time.

The expedition comprised 16 members, of which only six persons will be mentioned here:

Otto Neumann Knoph Sverdrup (1855–1930), leader of the expedition, commander of the *Fram*.

Gunnerius (*Gunnar*) Ingvald Isachsen (1868–1939), topographic surveyor to the expedition.

Herman Georg Simmons (1866–1943), B.Sc., Swedish botanist.

Edward Bay (b. 1867), zoologist.

Per Schei (1875–1905), geologist.

Johan Svendsen (b. 1866), doctor to the expedition.

Sverdrup had been with Fridtjof Nansen on his march across the Greenland inland ice in 1888, and in 1893–96 he had been the commander of the *Fram* during her drift across the Polar Sea. Gunnar Isachsen was later to start the systematic Norwegian research in Svalbard—beginning in 1906 and still going on (see p. 401). He then led the Spitsbergen expeditions financed by Prince Albert I of Monaco in 1906 and 1907, as well as the Norwegian ones in 1909 and 1910. Herman Simmons had done botanical studies on the Faeroe Islands in 1895.

The ship, the *Fram*, had been modified before the start of the expedition, thanks to a grant from the Norwegian Storting (Parliament). Otherwise the expedition's financial sponsors were Axel Heiberg and the brothers Amund and Ellef Ringnes.

The expedition left Kristiania (Oslo) on Midsummer Day, 1898. On the way north along west Greenland, the dogs for the long sledge tours were taken aboard at some of the Danish colonies.

On August 7, having crossed Melville Bay, the *Fram* passed the Cary Islands, well known since Björling's visits in 1892. A visit was now paid to Foulke Fjord, situated on the Greenland side of Smith Sound. Here Simmons began his botanical studies.

However, the summer was drawing to a close, and

the ship's progress north was soon impeded by ice—already at the entrance to the system of sounds and basins beyond Smith Sound. The winter of 1898-99 was spent not far from Pim Island near the coast of Ellesmere Land. It may be recalled that the tragic Greely expedition of 1881-84 succumbed in "Death Camp" at Cape Sabine on the south side of Pim Island (see p. 186).

The vegetation was found to be rather meagre here. Not until June 1899 could Simmons pursue his studies, in connection with excursions to the fjords in the north-west, whose plant life proved to be fairly luxuriant.

The botanist M. Hart, of the British expedition under Sir George Nares, had found 63 species of vascular plants. Three of these were not found by Simmons, but in compensation he observed 27 which Hart had missed.

During the ship's stay at Smith Sound, two long sledging tours were taken to the western side of Ellesmere Island. In the summer of 1899, the ice conditions still prevented the ship from coming further north, so Sverdrup was forced to make a drastic change in the expedition plans—which was all to the good. He had free hands in his capacity of expedition leader, and this made the decision easier.

The *Fram* left Smith Sound and proceeded southward. Foulke Fjord with the Eskimo settlement of Etah was visited, and its vegetation was studied by Simmons. The ship then steered into Jones Sound between Ellesmere Island and Devon Island. She entered a fjord in the south of the former island, and found a harbour for the second winter, 1899-1900. The fjord was named Havnefjorden (see map p. 236). The expedition was to spend the next three years in this area of Ellesmere Island.

From the three winter quarters, long sledging tours were made into an unknown archipelago, along uncharted fjords and sounds—mainly within a sector between north and west, as seen from the winter quarters. In the north, the sledgers almost reached the westward extreme attained by P. Aldrich in 1876 during the British expedition under Sir George Nares. The sledgers of the *Fram* did an important and excellent "job", and Gunnar Isachsen, the cartographer, became in a sense the most prominent man on board. His status may thus be compared with that of P. Dusén during A.G. Nathorst's expedition to East Greenland in 1899 (see Chapt. 28).

A few days after the arrival in Havnefjorden, the ground became covered by snow, and practically no botanical work could be done. The winter was much like the previous winter, and only scattered observations could be made by Simmons. The winter and

spring were, however, remarkable for the great variations in temperature. Simmons' botanical excursions aimed at studying the flora in different parts of Havnefjorden, but one long excursion went westward to Moskusfjorden (at long. about 88°W). Simmons noted how the vegetation became poorer as he passed from the Archaean rocks in the east to the Silurian rocks in the west.

The summer of 1900 gave rich harvests of cryptogams. On August 9 the *Fram* left her winter quarters in Havnefjorden. After a short visit to Devon Island, she passed through the Cardigan Strait between Ellesmere and Devon Islands, and proceeded farther north-west. But soon she was beset by heavy ice and imprisoned there for a month, to the detriment of the scientific work which had been planned for that time. The *Fram* then managed to penetrate into the very narrow Goose Fjord, where she was doomed to stay for the next two years, in 1900-02, because of the ice which blocked the entrance to the fjord in the summer of 1901.

The winter of 1900-01 was spent at the bottom of the fjord, and the winter of 1901-02 about 15 km closer to the mouth. During the former winter, storm winds blew almost constantly, and often made landings from the anchored ship unpleasant or impossible. The vegetation in the neighbouring land was poor, and the botanist obtained few observations during the following winter.

The summer of 1901 was late in coming, and so were the plants. On June 21, Simmons and the zoologist Bay went on a boat excursion—which was planned to last a fortnight but, in effect, took a month. They travelled west, then north, and passed through the narrow sound of Hell Gate with its currents, until they came near Nordstrand on the west coast of Ellesmere Island at latitude 77°N. They landed at several places along the route, and carried out dredgings at several stations, but the harvests were less than Simmons had expected. On the north of North Kent Island—situated on the west side of Hell Gate—he collected 24 species of phanerogams and a number of cryptogams.

After returning to the ship on July 23, Simmons botanized in her neighbourhood and, among other things, visited a bird mountain in the inner part of the fjord. He found a phanerogamous flora, which was abundant but very poor in the number of species.

It proved impossible to force a way out of the fjord, so there was no choice but to spend a second winter, 1901-02, in the same fjord. In Simmons' words: "There is nothing to be said about this stay." At the end of May and beginning of June, he made a tour northward to Baumannfjorden. It was too early to

TEMPERATURES (°C), (MONTHLY MEAN, ANNUAL HIGHEST AND LOWEST)
DURING THE SECOND FRAM EXPEDITION, 1898–1902

	<i>At Pim Island</i> 78°46'N, 75°W 1898–99	<i>In Havnefjorden</i> 76°29'N, 84°25'W 1899–1900	<i>In Goose Fjord</i> 76°48'N ca 89°W 1900–01	<i>In Goose Fjord</i> 76°41'N, ca 89°W 1901–02
<i>Sept.</i>	-8.3	-3.4	—	-8.2
<i>Oct.</i>	-15.3	-18.4	-17.6	-19.8
<i>Nov.</i>	-28.3	-36.5	-26.9	-24.8
<i>Dec.</i>	-32.0	-28.0	-33.7	-29.8
<i>Jan.</i>	-33.6	-34.3	-38.5	-36.3
<i>Feb.</i>	-32.3	-22.1	-34.1	-29.5
<i>March</i>	-31.3	-27.5	-34.9	-34.1
<i>April</i>	-20.7	-21.4	-25.2	-34.3
<i>May</i>	- 8.5	- 8.2	-11.7	-11.9
<i>June</i>	+ 1.7	+ 1.8	- 1.6	+ 2.5
<i>July</i>	+ 3.1	+ 3.2	+ 2.9	+ 5.3
<i>Aug.</i>	—	—	+ 0.9	—
<i>Sept.</i>	—	—	- 8.2	—
ANNUAL. MAX.	+9.5	+12.2	+11.5	+13.3
ANNUAL. MIN.	-42.8	-48.7	-51.0	-44.9

Missing data indicate that the ship was on the move between winter quarters, during the whole month or part of it.

make botanical investigations, as the snow still covered the ground. However, he collected abundant Tertiary plant fossils in the upper reaches of the fjord. The summer was early and surprisingly mild in 1902; before the end of June, Simmons had noted 25 species of phanerogams coming into flower, much more than had been observed at the same date in the previous three years.

A boat excursion was taken to the Devon Island coastal area opposite Goose Fjord. Here at Cape Vera, the vegetation was found to be plentiful, but poor in species.

For the first time, Simmons observed red snow in great quantities, and procured samples of it. He got as far as the north part of Norfolk Island, yet became enclosed by the ice on a little islet—where he stayed more than a week before managing, with difficulty, to proceed to Ellesmere Island and reach the ship, which departed for home on August 6.

The *Fram* passed by Havnefjorden and lingered there for a day and a half. Simmons had just time to secure some plants for his herbarium, as well as a number of live plants for the Botanical Garden of Kristiania (Oslo). These plants were successfully transported across the Atlantic. On September 28, 1902, the *Fram* arrived in Kristiania after an absence of 4 years and 3 months.

SUMMARY

It was a virgin region that had been explored by the Second Fram Expedition. The sketch map (p. 236) gives an idea of the gigantic areas (marked with thick lines) which were discovered or investigated. On the whole, the work was pursued from the three winter bases on the north side of Jones Sound. Gunnar Isachsen was responsible for the surveying of the extensive land areas, which took place mostly during long sledge tours. At the same time, the local geology, flora and fauna were studied. Further activity included the following:

1. Meteorological observations made every two hours.
2. Tidal observations were carried out every hour during the greater part of three years.
3. The thickness of the sea ice was measured, as was the temperature of the sea water and the sea ice.
4. Botanical and zoological observations were conducted both on land and in the sea within the regions visited by the expedition. When possible, collections were brought together. It should be noted that the western side of Axel Heiberg Island was found to be the richest in animals and plants.

The temperature conditions at the four wintering stations are illustrated in the table. This also indicates the severity of winters in the region.

Herman Simmons released the principal results of his botanical studies in the Scientific Reports of the Second Fram Expedition, 1898–1902, as *The vascular plants in the flora of Ellesmere Land*, published by Videnskaps-Selskabet in Kristiania (Oslo) in 1906. He also used this treatise as a dissertation for his doctoral degree in the same year. In 1918, Simmons became professor at the agricultural college of Ultuna (now the Swedish University of Agricultural Sciences), and during 1928–32 he was its vice chancellor.

Research on Devon Island: the background

The Second Fram Expedition, 1898–1902, had spent three years on the northern side of Jones Sound, and its field investigations had occurred largely within a sector NNW–NW. The northern coast of Devon Island—situated on the southern side of Jones Sound—was also explored and delineated on the map.

The Baffin Bay region has frequently been visited by whalers and sealers as well as by scientific expeditions. There is often navigable water in Baffin Bay, and from it extend two mighty waterways. One leads northward between Ellesmere Island and north-western Greenland; the other penetrates westward into the Canadian Arctic Archipelago. The former lead has been used to reach far north, either by ship or by dog-sledges, but the ice conditions there are severe and highly unreliable. The latter lead continues through the Canadian Arctic Archipelago, and was repeatedly used since 1818 by the mainly British expeditions which aimed at finding and navigating the North-West Passage.

Visits were frequent after the disaster of the British expedition of 1845–48 with the ships *Erebus* and *Terror*, commanded by Captain John Franklin. The search for this missing expedition gave rise, until 1859, to a boom in polar activity in the Canadian Arctic. Franklin's wintering harbour in 1845–46 at Beechie Island, at the south-western corner of Devon Island, soon became a meeting-place for the many ships on the search. The southern and western coasts of Devon Island thus became well known, in contrast to the northern coast.

The Canadian Arctic Archipelago attracted few visitors subsequently, until after World War II when meteorological stations, radar stations and airfields were established in the region—such as the airbase Resolute on Cornwallis Island. This gave polar scientists easy access to the Archipelago. The meteorological stations now provided a good view of the meteorological and climatological conditions. If necessary, these could be supplemented by observations in the field, thanks to air connections which were possible with relatively small planes from the main airbases.

Marked characteristics of the climate in the central and northern parts of the Archipelago are the low winter temperature and the low annual precipitation—except in the east—with values of 100 mm per year or less. In the areas of Baffin Bay and further south, water vapour is transferred to the atmosphere from the open or partly open seas. Besides, the predominant cyclone tracks end in the same region, bringing rich precipitation to the land areas surrounding it, namely western Greenland and the eastern parts of the Canadian Arctic Archipelago, which are mountainous.

In sum, everything favours the formation and maintenance of land ice here. This is clear from a glance at a physical map of the American Arctic. Devon Island, for instance, possesses a marked ice-cap in its eastern part, while there is no ice-sheet further westward.

METEOROLOGICAL WORK IN THE SUMMERS OF 1961–1963

In 1961 the Arctic Institute of North America launched a long-term scientific investigation on Devon Island. As stated by Lars Dahlgren, one of the two Swedish scientists who took part in the expedition, the aim of this interdisciplinary research was:

“to investigate interrelationships between the ice-cap with its outlet glaciers, the ocean in Jones Sound and the atmosphere. To that end a multi-disciplinary program was designed, which involved meteorology, glaciology, oceanography, marine biology and geology.”

Two Swedish meteorologists from the Department of Meteorology of Uppsala University took part in the expedition:

Björn Erik Holmgren (b. 1930), B.Sc., worked on Devon Island in the summers of 1961–63.

Lars Erik Gunnar Dahlgren (b. 1930), B.Sc., worked on Devon Island in the summers of 1961–62.

The expedition travelled to the research area on a transport aircraft, which landed at Resolute on Cornwallis Island. A smaller craft then flew the members to the coastal plain north-west of the Devon Island ice-cap (see map p. 239). The party arrived in the middle or latter half of May during 1961–63.

A *Base Station (B)* was established on the coastal plain, about 3 km from the shore and at 15 m a.s.l. The geographical coordinates were 75°40'N, 84°32'W. Dahlgren measured the solar radiation here.

An *Ice-Cap Station (I)* was established on the north-western slope of the ice-cap, about 50 km from the base and at 1320 m a.s.l. This was Holmgren's principal place of work.

Herman Simmons (1866–1943), Swedish botanist, who took part in the Second Fram Expedition to the Canadian Arctic Archipelago in 1898–1902. Photo: Sveriges Lantbruksuniversitet, Ultuna.

Member of the Second Thule Expedition, 1916–1917. Knud Rasmussen (1879–1933), Danish polar explorer and ethnologist, leader of the expedition. (Elvin, A., ed.: Th. Wulffs grönländska dagböcker.)

Member of the Second Thule Expedition, Lauge Koch (1892–1964), Danish geologist and cartographer. (Elvin, A., ed.: Th. Wulffs grönländska dagböcker.)

Member of the Second Thule Expedition, Thorild Wulff (1877–1917), Swedish biologist and photographer. (Elvin, A., ed.: Th. Wulffs grönländska dagböcker.)

Regions indicated by thick coastlines, investigated by the Second Fram Expedition in 1898–1902. (Ymer 1902.)

A *Plateau Station (P)* was used temporarily by Holmgren in the summer of 1963. It was situated at 1797 m a.s.l. near the summit of the ice-cap (1885 m).

Further, a *Glacier Station (G)* was manned in July and August 1963 by the glaciologist C.M. Keeler. This station lay at 300 m a.s.l. on the Sverdrup Glacier, an outlet glacier from the ice-cap.

It was possible to study the meteorological conditions in different parts of the ice-cap by making observations at some supplementary stations, in connection with travels over the ice-cap by means of snow tractors.

In this way the influence of the topography of the ice-cap upon the meteorological conditions, and the influence of the atmospheric circulation upon the mass balance of the ice-cap, were studied.

The investigations were similar to those made in the Antarctic during the Norwegian-British-Swedish expedition of 1949-52. Basically, the energy exchange of the ice-cap was studied, a task which includes measurements of solar radiation and of terrestrial infrared radiation, reaching and leaving the snow surface; the penetration of the solar radiation into the snow; and the reflectivity, or albedo, of the snow surface. There also occurs a turbulent energy transfer, from the air to the snow surface or in the opposite direction. This can be determined by measuring the temperature, humidity and wind at a number of heights above the snow surface, using an observation mast some 5-10 m high.

From the many measurements of different variables, much valuable information was gained, besides the energy exchange—such as the development of a cold layer of air above the ice-cap, and the ensuing flow of cold air down the slopes of the ice-cap in so-called katabatic winds. The structure of these winds was ascertained.

The measurements of temperature, humidity and wind at different levels above the snow surface could be used to determine the flow of energy between air and surface.

The observations also revealed the climate over the ice-cap and in the coastal zone. Especially valuable were the data regarding climatic conditions in the low atmospheric layer—between the surface and about 10 m above it. The variation with height of the solar radiation climate was obtained from simultaneous measurements at the Base Station and at the Ice-Cap Station, the content of dust particles in the atmosphere being indicated by the so-called turbidity parameter.

Holmgren and Dahlgren collected very valuable

data during their three and two summer seasons, respectively, on Devon Island. They were both able to obtain a doctor's degree in meteorology at Uppsala University from their investigations on Devon Island. The area in which they worked was, moreover, extremely interesting.

THORILD WULFF AND THE SECOND THULE EXPEDITION IN 1916

The same region which had claimed the lives of Björling and Kallstenius was to witness the end of Thorild Wulff (1877-1917). Wulff was foremost a botanist and a collector but, besides, he had many other interests.

He possessed an adventurous and restless mind, he was depressed or exhilarated and he seemed to find no definite direction for his career.

This can be seen from the leading events in his life: 1899 Member of the Swedish Arc-of-Meridian expedition under E. Jäderin; he then carried out botanical research for his doctoral thesis. See p. 340

1902 Ph.D. at Lund University with the thesis *Botanische Beobachtungen aus Spitzbergen*.

Winter of 1902. Botanical research in India, resulting in two articles, *Indian horticulture* and *Indian architecture*.

1906-09 Assistant at the Institute of Experimental Works in Agriculture in Stockholm. These were the "quiet" years in the life of Wulff, to use an expression of his biographer, Selim Birger. It might be mentioned, though, that his "personal chemistry" did not suit that of his chief.

1909 Lecturer (docent) in botany at Stockholm University.

1911 Travels in Iceland with the Swedish author and artist Albert Engström (1869-1940). Wulff carried out botanical observations, besides making a film of the event. Engström published a book on the tour, *Ät Häcklefjäll*.

In the following year many different plans for the future passed through Wulff's mind, until in 1912 a task for collecting objects of art in China was entrusted to him by a museum for arts and crafts in Göteborg.

1912-14 Wulff travelled in China, Japan and Java, collecting items of art and ethnography.

Thus it appeared that Wulff had found an appropriate field of activity. Yet he returned to Sweden after the outbreak of World War I, and could not proceed to make interesting journeys. However, he was already planning new travels, this time to countries untouched by the war. His ambitions were to be realized in Greenland, but at the cost of his life.

The expedition's background and preparations

In 1910 the great Danish polar traveller and ethnologist Knud Rasmussen (1879–1933) had established a trading station called Thule (76°35'N; 68°W) at Wolstenholme Fjord in north-western Greenland, for the purpose of financing his planned investigations in northern and north-western Greenland. The station was also to serve as a base for the long sledge tours which were planned.

In 1912 Rasmussen, with Peter Freuchen (1886–1957) and two polar Eskimos, travelled across the inland ice to Independence Fjord and Denmark Fjord in the north-east of Greenland—the First Thule Expedition. Not all plans were realized, however, and it was found necessary to organize a second expedition for exploring the north coast of Greenland. An attempt at a start by Freuchen in 1914 failed, mainly because his theodolite was damaged soon after he and his party had left Thule, making it useless to go on.

In 1916, Rasmussen assembled a party for a Second Thule Expedition that summer. As travel companion he engaged a young student, Lauge Koch, who was to act as geologist and cartographer. Rasmussen himself would look for remains of old Eskimo winter huts, indicating whether an immigration of Eskimos had gone via the north of Greenland. Moreover, Rasmussen wanted to have biological research included in the expedition programme, though only in the neighbourhood of Thule. During a visit to Stockholm, his friend Albert Engström recommended Thorild Wulff for the task. Rasmussen was unsure, as he did not consider Wulff's constitution sufficiently robust for the purpose. Nonetheless, Wulff was attached to the expedition.

Knud Rasmussen and Lauge Koch left København on April 1, 1916, aboard the *Hans Egede* of the Greenland Administration. They reached Godthaab on April 18, but difficulties arose. The winter in Greenland had been mild and the spring early; when going north, they found neither good winter-ice nor open water. They had to do the best they could for travel: by motorboat, umiak (women's boat), kayak and dog sledge. It was now apparent that there would not be any time to carry out the planned research on the north coast of Greenland this summer. But Rasmussen had an alternative: an investigation of the coastal zone of Melville Bugt, a region which was poorly known.

On June 4 they reached Devil's Thumb, the marked mountain peak in the south of Melville Bugt. The weather was mostly fine in the following days, and they found many seals to eke out their store of provisions. During the 15 days of passage, Koch managed to map the entire Bugt, about 500 km, so that only some supplementary work had to be done in the

following months of October and November. Rasmussen found about 50 house ruins, which indicated that Melville Bugt had once been an important route during the ancient Eskimo immigrations into western Greenland. Considering the short time at their disposal, the outcome of the investigation was successful.

On June 17, Rasmussen and Koch reached Thule, in whose region they proceeded to conduct archaeological and geological work. It was now definitely too late to start the long sledge tour to the north coast, and Rasmussen was in favour of returning home with his own ship, the *Kap York*. She was expected to arrive later in the summer—but in fact she did not, as the ice conditions were severe.

There was also another expedition in the same region of Greenland waiting for a passage home: the American Crocker-Land Expedition. It had been staying at the Eskimo settlement Etah, some 200 km north-north-east of Thule, for three years; and it was doomed to stay for another year. The expedition had been looking for the "Crocker Land" which had been seen by R.E. Peary. Actually it was chasing an atmospheric optical phenomenon, which failed to materialize.

Thorild Wulff comes to Greenland

Wulff had not been in such a hurry as Rasmussen and Koch. He was not supposed to take part in the tour to the north coast, but was to leave Thule around September 15 by the *Kap York*. On June 1, he left København aboard the *Hans Egede*, with considerable luggage. In addition to his own 38 pieces of baggage, he brought a large quantity of articles for Rasmussen's trading station.

He reached Godhavn on the island of Disko on June 22. Here he stayed with his friend Morten P. Porsild (1872–1956) at "Den Danske Arktiske Station", which Porsild had founded in 1906 and was to direct until 1946.

Wulff stayed at the station for five weeks, occupied with botanical research in its little laboratory and making excursions in the neighbourhood. He also carried out oceanographic research from one of the motorboats of the station, in order to get initial data for his planned investigations on board the expedition ship *Danmark* during her passage north to Thule later in the summer. The ship was in the service of the American Crocker-Land expedition and was on her way to bring this expedition home.

Wulff left Godhavn on board the *Danmark* on August 1, on a voyage which became adventurous because of the ice. The ship's party almost had to spend the winter in the pack-ice in Melville Bugt. She

Research region of the Arctic Institute of North America in 1961-1963: eastern part of Devon Island.

B) Base station on the north coast. I) Ice cap station. P) Plateau station. G) Glacier station. Swedish members were Björn Holmgren and Lars Dahlgren (see p. 235). (Holmgren, B.: Climate and energy exchange on a sub-polar icecap in summer.)

The sledge route of the Second Thule Expedition in northern Greenland in 1917. Outward route, to Low Point, long 45°W, broken line. Homeward route, indicated by solid line. (Elvin, A., ed.: Th. Wulffs grönländska dagböcker.)

did reach Wolstenholme Fjord on September 23, but was forced to winter at Thule after it had been found impossible to reach the American base at Etah.

During the voyage from Godhavn to Thule, Wulff managed to obtain oceanographical observations from 25 stations along the route. These were measurements of the water temperature, besides water samples for determining the salinity at specific depths from the surface to the bottom or down to 500 m. Plankton was also collected at particular depths down to 500 m.

At Thule, Wulff became a boarder with Peter Freuchen, who served as "managing director" of the trading station.

Expedition members and plans

The participants in the research programme were now collected at Thule. Peter Freuchen was originally supposed to go with the sledge party, but at the beginning of the winter it was decided that Wulff would take his place. Consequently the latter was given good training in dog-driving during the rest of the winter.

THE PARTICIPANTS IN THE LONG SLEDGE TOUR WERE:

Knud Rasmussen (1879–1933), Danish ethnologist, leader of the expedition.

Lauge Koch (1892–1964), Danish geologist and cartographer.

Thorild Wulff (1877–1917), Swedish biologist, notably botanist, photographer.

In addition, the Greenlander Hendrik Olsen and three polar Eskimos were to take part.

Each man was to drive a team of his own, with 10–12 dogs. In fact they were to travel in Eskimo fashion. The men and dogs would have to live off the country—by hunting musk-oxen, polar bears, seals, walruses, arctic hares and birds—but they brought along tea, coffee, sugar and biscuits.

Their research was to concentrate mainly on the land areas at Nordenskiöld Fjord, Victoria Fjord, Sherard Osborn Fjord, and western Peary Land. The work would consist of mapping, geological and botanical research, and excavations of old Eskimo dwellings and settlements which they expected to find. At the end of July, they would have to return and take the route across the inland ice. From Thule they would go by ship or dog sledge in order to reach the last shipping opportunity of the year at Holstenborg, in the beginning of October. København would then be reached in November 1917.

Such were the plans, which were ambitious to the utmost. The party would need to travel about 1000 km by dog sledge before starting the research work.

Moreover, in spring the fjords on the north coast are nearly always covered with deep snow, impeding progress.

Sledging to the research area

The start from Thule took place on April 6, 1917. At first, the expedition was assisted by several teams of polar Eskimos, which mainly transported dog food. On May 1, they reached Polaris Harbour at about 81.5°N, where the last supporting parties of Eskimos were sent back. They had planned to rest at Greely's old base, Fort Conger on Ellesmere Island across the sound, but instead they proceeded directly towards the north-east, and on May 7 they reached their working-field at Dragon Point.

They had travelled over heavy pack-ice, but had not been impeded by open water. However, the long and cumbersome sledging without any rest had exhausted men as well as dogs. They established a depot at Dragon Point for their return journey, and continued with light sledges to Kap May, the north point of the large peninsula which was later named Wulff Land. In the neighbourhood they managed to shoot some musk-oxen. From now on, they would have to provide food for themselves and the 70 dogs by hunting with success.

On May 31, near Kap Salor, they divided the party into two groups: a *cartographic group* with Rasmussen, Koch and one polar Eskimo, and a *biological group* with Wulff, one Greenlander and two polar Eskimos. To a great extent, the men of the latter group would have to devote themselves to hunting.

Scientific research and hunting

They had now worked in the research area for three weeks, and had mapped Victoria Fjord and Sherard Osborn Fjord. They had secured musk-oxen in Wulff Land and Nares Land. But they had still not obtained everything that the men and dogs required. Thus far, 26 of the 70 dogs had been lost, and the remainder were exhausted. Still, the men were optimistic. The cartographic party intended to pass through the supposed Peary Channel—which in fact does not exist—to reach Independence Fjord, then go east and north around Peary Land to eventually meet the biological party at Kap Morris Jesup, the north point of Peary Land and of Greenland.

However, the cartographic party had to turn back already before reaching the inner part of Nordenskiöld Fjord—which at the time was supposed to be a part of the Peary Channel—since a great number of icebergs barred the way. The biological party was also forced to return. This group had been fighting heavy winds and could not secure any game. The inner part of

Independence Fjord was rich in game—according to the experiences of Rasmussen and Freuchen in 1912. Now they intended to try their luck in north-western Peary Land, which was alpine in character and proved to be poor in game.

The plans were thus changed. The *cartographic* party would make an attempt to reach and map De Long Fjord in western Peary Land, and the *biological* party was to travel towards Wulff Land. Only 24 dogs now remained. The two parties met again on June 28 at Kap Salor in Nordenskiöld Fjord. The cartographic party had at last found good hunting, and so had the biological party—with seals. Normally it is difficult to hunt seals during the snow-melt in May-June.

From June 30 until July 11, the two groups travelled to Wulff Land. The weather was fine. The snow was melting and the ice was becoming covered with pools and slushy snow. The daily marches were therefore short, which was an advantage only to the cartographer. The sledging became a combination of very hard work, wet clothing, wet shoes and hunger.

On the 17th they reached Dragon Point, where they hunted seals. A few days earlier, they had a successful hunt of musk-oxen. But on July 21 the Greenlander Hendrik Olsen disappeared during a hunting excursion south of Dragon Point. He was never found. Meanwhile they also had to struggle against bad weather, and their progress had been delayed.

A hunger-march homeward

It was their aim to follow St. George Fjord southward and, via the outlet glacier at its bottom, reach the inland ice. On August 4 they attained what they thought was the edge of the inland ice—but it was only a local ice-cap, and not until August 11 did they reach the inland ice. Only 14 dogs now remained. During the climb they had to pass overland on the eastern side of the glacier.

From then until August 24, they travelled across the inland ice towards the north-eastern part of Inglefield Land. Their provisions were finished, but they had the dogs to live on, the last dog being eaten on the 24th. They reached the land at Cape Agassiz near the southern side of the large Humboldt Gletscher. There remained 225 km to Etah and safety, but Wulff's strength was declining rapidly, so it was decided that Rasmussen and one of the polar Eskimos would cover the remaining distance in forced marches to ask for help. Wulff, with Koch and two Eskimos, would follow slowly.

They had shot some hares when they got down to the land, but Wulff could not eat anything. He had

apparently lost the will to live, and his heart pained him. On August 29, 1917, he lay down to await death, while the others continued the march. His last words to his departing companions were:

"In farewell I wish that you may reach your goal... remember that it now depends on you whether our results will be saved. I hope you will succeed. And now farewell."

Knud Rasmussen and his Eskimo companion reached Etah on August 30. A sledge party was sent out immediately. It joined Koch and the two Eskimos on September 4, but it was too late to help Thorild Wulff.

Exactly when he died is unknown, nor has his body been found. On September 10, the relief party and Koch and the two Eskimos were back in Etah.

During the so-called Jubilee expedition of 1920-23, Lauge Koch visited the place on June 30, 1922, but Wulff's body was not found. Koch writes:

"Late in the evening we reached the ravine where I had left him. Unfortunately there was now deep snow. However, I believed that I had found the boulder near which he lay, and we scraped away the snow, but we found nothing. When we left him, there had been a fog; consequently we had difficulties in orientating ourselves, and now I had to choose between three or four large stones. I am absolutely sure that we were in the ravine where he died, but I am not so sure that we found the same stone where he had lain down. After searching for a while, we had to return to our tent with no result. It is probable that I had come to the right place, but that his skeleton had become scattered and that the bones were now hidden in the snow."

The scientific notes and observations of the expedition reached safety, and the results were published, including Wulff's botanical work. His five Greenland diaries also reached civilization and were published in 1934.

In the winter of 1916-17, Thorild Wulff had written an article for the journal *Ymer* of the Swedish Society of Anthropology and Geography. It described the planned programme of the Second Thule Expedition, as well as Wulff's first time in Greenland until shortly before the start of the long sledge tour. Moreover, the article supplied a report on Peter Freuchen's visit to the Cary Islands, notably Björling Island, in August 1916—when remains from the Björling expedition of 1892 were found (see p.230).

A “BOOM” IN SWEDISH
POLAR ACTIVITY
1896–1910

23. THE BALLOON FLIGHT OF S.A. ANDRÉE IN 1897

For thirty-three years the balloon flight of Salomon August Andrée remained a mystery of the Arctic. The disclosure in 1930 of the expedition's fate revealed almost all of the secrets, and many in detail—but some linger on.

The leader of the expedition, S.A. Andrée (1854–97), was in many respects a man out of the ordinary. In order to understand the fate of his venture, we must closely review his personality and life, especially those aspects which led directly to this tragic enterprise.

The young Andrée

In 1876 Andrée undertook a study tour to the USA. He was then 22 years of age. Two years earlier he had graduated as Master of Engineering from the Technological Institute in Stockholm. His outlook upon life was dominated by technical science. He was intelligent, inquisitive and full of ideas. He was also characterized by many as presumptuous, stubborn and reckless. At Philadelphia a great exhibition was held. The young man wanted to study the technical fields there, as well as American institutions and industries.

During his passage across the Atlantic, Andrée studied a popular book written by the professor of mathematics of Lund University, C.F.E. Björling (1839–1910): *Om vindarnas lagar och försöken till väderleksförsägelser* (On the laws of the winds and attempts to forecast weather). This book acquainted Andrée with the trade winds, the westerlies and the monsoons. An obvious conclusion for him was that these wind systems might be used for communication purposes with the help of balloons. Andrée's interest in balloon sailing originated from this occasion.

At the Philadelphia Exhibition balloon ascents were undertaken from the exhibition ground. Andrée did not take part in any ascents, as he could not afford to pay the fees. Yet he made friends with the aeronaut and, to his heart's delight, could discuss practical balloon technique with the man. Andrée's interest in balloon sailing was then to remain latent for many years to come.

In 1882 the first Polar Year was launched. By international co-operation, 12 scientific stations were established in the Arctic and two in the Subantarctic. Sweden had chosen A.E. Nordenskiöld's hut at Mosselbukta on the north coast of Spitsbergen as the site of her station. As the north coast was blocked by pack-ice in the summer of 1882, Kapp Thordsen at Isfjorden was chosen as a base site (see p. 178). A house

had been built here in 1872 by a Swedish mining company (p. 73).

The leader of the station was the meteorologist Nils Ekholm, who was later to be closely connected with Andrée's balloon flight. The scientific staff consisted of six men, including Andrée. There were also six men to take care of the practical work at the station.

The one-year stay at Kapp Thordsen was definitely not a happy period in Andrée's life. He was dissatisfied with his status on the expedition, and his relations with some of its other members were not the best.

Andrée was not a scientist of true academic upbringing and, in addition, he had left school at an early stage before becoming a sixth-former. He now felt utterly out of his element. Despite his inquisitive mind in scientific and technical matters, he lacked a wide theoretical background, and often proposed ideas which aroused ridicule from his companions. Moreover, he did not become very popular when the stock of paraffin oil for the lamps at the base was found to be quite insufficient. Andrée had been responsible for the acquisition of this item of equipment; there were also some other articles which caused irritation. The fact is that Andrée possessed a most economical mind. This is generally not considered a vice, but in this case it was, as it dealt with vital supplies.

He confided to his diary all the sufferings he had to undergo at the station: the unfriendliness of his companions, his feeling of inferiority, the strain from night duties, the howling of the dogs. The polar night of four months' duration exercised a severe stress upon his nerves. This did not improve after he had taken part in a medical experiment. He also worried about his future.

After coming home in September 1883, Andrée was given an administrative post at the Technological Institute in Stockholm. This helped him economically, until in 1885 he obtained a position at the reorganized Patent Office, where he became head of the technical department. This post suited him well, but it involved some extra work for his chief. As usual, Andrée was contrary and stubborn. His chief used to say that, in order to convince Andrée of the simplest things, one had always to start from the very beginning—indeed from the creation of the Universe. But Andrée had an ardent interest in inventions, and a very high regard for inventors—as they did for him. During the years that followed, he made contributions to many branches of endeavour, above all in technology but also in local politics.

His dreams of long balloon flights were to all appearances now forgotten. But were they? It rather seems that he awaited a suitable time for their realization.

Andrée's first balloon ascents

Not until 1892 did he take his first steps towards a realization of his dreams. An Italian, Francesco Cetti, at that time undertook balloon ascents at pleasure-fields all over Europe. Andrée managed to become a passenger on two of these ascents at Stockholm. There was nothing sensational about the short flights, except that a civil servant of high social position was the passenger.

His next step would naturally be to obtain a balloon of his own, officially for the purpose of making scien-

tific observations. His practical experience was, however, insignificant and it is remarkable that, already in the same year of 1892, he managed to procure a large sum of money from funds and private patrons for such a venture. Thus, in the spring of 1893, Andrée was the happy owner of a balloon of about 1000 m³, which was supposed to reach a maximum height of 3000 m—in reality more than 4000 m.

From July 1893 to March 1895 Andrée carried out nine ascents with his balloon *Svea*, four from Stockholm and five from Göteborg (see Table below). His

ANDRÉE'S FLIGHTS WITH THE BALLOON SVEA IN 1893–1895

<i>Ascent no.</i>	<i>Year</i>	<i>Date</i>	<i>Startingplace time</i>	<i>Max. altitude m</i>	<i>Landingplace time</i>	<i>Distance covered km</i>
1	1893	July 15	Stockholm 03.34h	3400	Dalarö 05.52h	44
2		Aug. 9	Stockholm 08.46h	3600	near Norrtälje 15.34h	115 (first towards SSW, then NNE)
3		Oct. 19	Stockholm 08.43h	3000	Eskörn Islet S of Korpo Is., Turku (Åbo) Archipelago, Finland	284 (guide-rope) 202 km)
4	1894	Feb. 26	Göteborg 12.32h	3280	35 km S of Jönköping 15.09h	148
5		Apr. 7	Stockholm 13.08h	4390	near Alunda NE of Uppsala 16.50h	115
6		July 14	Göteborg 11.22h	2310	between Vara and Skara (NE of Göteborg) 15.31h	84
7		Aug. 4	Göteborg 11.44h	3750	6 km SW of Trollhättan 13.51h	63
8		Nov. 29	Göteborg 11.45h	2680	Fröjeln parish, south-western Gotland 16.45h	400
9	1895	March 17	Göteborg 12.57h	3550	7.5 km N of Lenhovda church (Småland) 15.54h	260

Notes: Ascent Oct. 19, 1893: Strong wind, dangerous flight over the Baltic.

July 14 1894: Attempts at deviating the drift of the balloon.

Nov. 29 1894: Strong wind, flight within or above clouds.

Andrée's preparatory flights with his balloon Svea, from 1893-1895.
See Table p. 244.

The balloon Örnén.

1. Calotte.
2. Net
3. Supporting rope for sail.
4. Bursting arrangement (for deflating the balloon rapidly when landing).
5. Manoeuvring valves.
6. Belly-band for protecting the gondola and the lower portions of the balloon from dripping water.
7. Side sails.
8. Middle sails.
9. Bottom valve (for automatic regulation of the gas pressure in the balloon).
10. Packet-pockets in carrying ring.
11. Carrying-ring (seen from the side).
12. Guide-rope holder.
13. Instrument-ring.
14. Gondola.
15. Guide-ropes.
16. Packing basket in carrying-ring
17. Bamboo for side sails.
18. Rope ladder between roof of gondola and carrying-ring.
19. Tackle for manoeuvring the guide-ropes (i.e. for regulating the orientation of sails, relative wind)
20. Skirt of canvas.
21. Packing basket in gondola.
22. Bunk in gondola.
23. Ballast rope.

scientific observations were "first-class", and his reports were printed in the publications of The Royal Swedish Academy of Sciences. They can still be studied with pleasure and profit. Some of the ascents were highly adventurous, and the newspapers brought fame to Andrée; but many people were irritated with him. On two occasions Andrée drifted out over the Baltic. Once he reached safety on a skerry in south-western Finland, and another time he drifted from Göteborg to the island of Gotland during a gale. A few flights were made on February 15, April 7 and 30, 1894, by using the *Svea* as a captive balloon with a line 430 m long. These ascents took place in Stockholm from the island of Kungsholmen. The passengers were, besides Andrée, officers of the Svea engineer battalion. In one flight, on April 30, 1894, Gustaf Nordenskiöld, the son of A.E. Nordenskiöld, took part as photographer. The officers were mainly occupied with photography and studies of the terrain. Andrée measured the air temperature and observed the behaviour of the balloon.

Andrée also tried to steer his balloon—to some extent—by letting so-called guide-ropes slide over the Earth's surface. These introduced a force which slowed the balloon's drift, so that the relative wind could act upon sails which were suitably orientated. The relative wind acted at right angles to the sails. With their help, Andrée was able to deviate the drift of his balloon about 27° from the wind-flow, on an average. However, only once, on July 14, 1894, did Andrée test this method, which was something almost new in balloon sailing. Generally guide-ropes were used by aeronauts to keep a balloon at a fairly constant height above the Earth's surface. With the balloon rising, more rope is lifted from the surface, and the upward motion is eventually stopped; with the balloon sinking, less rope is lifted to stop, or at least reduce, a downward motion.

Evidently these nine flights of Andrée had been only a preparation for a far more daring and spectacular enterprise. Among friends, Andrée had spoken already in 1893 of a polar flight.

Preparing the polar expedition

The 16th of March, 1894, was a decisive day in Andrée's life. After a meeting at the Swedish Society of Anthropology and Geography, Adolf Erik Nordenskiöld, the great polar explorer, had asked for some advice from him concerning the practicability of using a captive balloon on an Antarctic expedition (compare p. 199). Andrée gave his advice, and he also told Nordenskiöld of his own secret plans—a flight over the Polar Sea starting from Spitsbergen. "You can count on me," Nordenskiöld had said. One month

and a half later, Nordenskiöld's son Gustaf took part in a flight with a captive balloon under Andrée (see p. 210).

From then on, things happened in rapid succession. In fact, they happened much too fast.

On February 13, 1895, Andrée gave a lecture to The Royal Swedish Academy of Sciences, as Nordenskiöld had advised him to do. He publicly announced his plans for a balloon flight in the Arctic. Two days later, the same lecture was delivered at the Swedish Society of Anthropology and Geography. Andrée maintained that it would be little more than a technical problem to reach the North Pole.

He summarized the requirements which had to be fulfilled:

1. The balloon must be so large that it could carry three men with scientific instruments, provisions and other equipment, including ballast, which meant a total weight of about 3000 kg.
2. The balloon must be so tight that it would be able to float in the air for at least 30 days.
3. The balloon must be filled with gas at the base in the Arctic.
4. The balloon should be dirigible to some extent.

The first need was easily satisfied. Suitable balloons were constructed and could be purchased. As to the second requirement, Andrée asserted that balloons could be—and had been—constructed as tight as he demanded. Gas generators existed on the market or could be constructed. And finally, Andrée's own experiments had shown that balloons could be steered to some extent.

After his announcement, the soundness of his plan was debated. Many people were against it, but Nordenskiöld supported Andrée and so did Nils Ekholm, his previous chief in Spitsbergen. A few months after Andrée had presented his plans in Stockholm, he was visited at the Patent Office by Alfred Nobel (1833–96). The Nobel of the future Nobel Prizes was enthusiastic about Andrée's plans, and wanted to support the enterprise. After two weeks Andrée was informed that Nobel would pay half the costs, on the condition that other patrons were found within two months.

King Oscar II of Sweden and Norway, Baron Oscar Dickson and, to a minor extent, Professor Gustaf Retzius supplied the rest of the money—and they did so in time. At the beginning of June 1895, less than four months after Andrée had presented his plans, he had obtained all the financial support that he needed. A subscription had been planned by him and an appeal had been printed, but these copies could now be consigned to the ashcan (and a few to collectors). All

this is a good illustration of the remarkable powers of persuasion and inspiration which Andrée possessed.

Andrée had originally planned to begin his flight in 1897. But with money available, the start was scheduled already for 1896. A year remained for organizing the expedition. The Royal Swedish Academy of Sciences placed a few rooms at his disposal, but he attended to his ordinary duties at the Patent Office until April 1, 1896. To prepare the expedition, he thus had to make use of early mornings and late evenings and nights.

Four vital matters had to be settled as soon as possible: the choice of two men for the flight, the choice and ordering of the balloon, a gas generator (of iron and sulphuric acid), and a shelter for housing and protecting the balloon. Nils Ekholm decided to take part in the flight, although he was at first somewhat doubtful about the possibility of finding a balloon that could float for 30 days. Andrée managed to convince him.

The other expedition member, Nils Strindberg, was young: only 24 in 1896, against Andrée's 42 and Ekholm's 48 years. He worked at the Technological Institute as an assistant in physics. He belonged to the same family as the great Swedish author August Strindberg, who was a cousin of Nils' father. Nils Strindberg would act as physicist on the expedition, as well as being navigator and photographer. In the spring of 1896 he was given aeronautical training in France and took part in six ascents.

Andrée attended a great number of meetings and conferences, especially in France, England and Germany, for the specific purpose of discussing vital points in his aeronautical plans. The balloon was constructed in Paris at the beginning of 1896 by the firm H. Lachambre. On May 16, it was shipped to Göteborg a short time before the departure of the expedition for Spitsbergen.

No expedition member had been to Paris for a last official inspection of the balloon before delivery. Nor had there been any time for filling the balloon with hydrogen gas to test its tightness. The varnished silk cloth itself was, however, extremely tight. It was laid either double or, on the top of the balloon, triple. The critical point was the tightness of the balloon *seams*. The volume of the balloon was 4500 m³ in 1896, but was increased in 1897 to 4800 m³ by adding a zonal belt at the equator.

Great care had been devoted to creating facilities for storage of the comprehensive equipment. Here the carrying-ring played an important role. The ring was covered with a piece of canvas, which served as a floor for packing-baskets. Between the ropes connecting the net with the carrying-ring, packet-pock-

ets had been applied. In this way a sort of secondary gondola was provided, both as a storeroom and as a safeguard in case it should become necessary to let the ordinary gondola go in a critical situation. (See the drawings of the balloon, with text p. 245, and the photo showing the balloon immediately after the start on July 11, 1897 p. 249).

To steer the balloon and keep it at a nearly constant height, 150–250 metres, it was equipped with three guide-ropes, each about 350 m long, the lower two-thirds being coconut-fibre ropes impregnated with tallow and vaseline. The balloon was also equipped with eight ballast-ropes, each 70 m long. These were intended to serve as a safe-guard in case the balloon should lose height rapidly.

The coconut-fibre ropes were—in 1897—attached to hemp ropes via screwed joints, having threads of only 1.5 revolutions. Andrée had been prompted to this contraption in 1896 by people who envisaged how the ropes might be jammed by ice hummocks during the flight over the pack-ice. There were many novelties among the equipment, and a fatal flaw was that some of them were not tested practically.

At the end of the 19th century, the wind conditions over the Polar Sea were still unknown. But Andrée seems to have counted upon steady winds to carry him over the pole—or near it—and farther across the Polar Sea.

The winds in the Spitsbergen area are on the whole south-westerly in July. Yet they are highly variable, due mainly to the passage of cyclones which come up from the East Greenland Sea and pass in over the Polar Sea. The drift of Andrée's balloon in 1897 may therefore be considered as fairly "regular", and in fact it was led astray by a cyclone. The position of a trough in the pressure distribution near Spitsbergen in July indicates that north-westerly winds may also be fairly common (see the climatological map p. 249). In autumn, winter and spring, on the other hand, the winds come mostly from easterly directions, and a balloon would then very probably be carried towards Greenland.

The tightness of the balloon would be a matter of life or death, as would any accretion of ice and water upon the balloon cloth. Ice accretion in clouds and fogs was generally not considered by the aeronauts of those days. An accretion of snow on the top of the balloon was, however, considered by Andrée, and steps were taken against it by applying a calotte of balloon-cloth above the rope network.

In the summer, fogs and low stratus clouds are common over the ice-covered Polar Sea. With the temperatures which prevail—around 0°C—this may lead to an accretion of water or ice upon a balloon sailing at low levels, which means an increase of weight.

Using guide-ropes, the balloon will therefore sail at heights where the risk of icing and water accretion is great.

With a free balloon sailing above the fog and the low clouds, the hydrogen gas in the balloon will be heated by solar radiation—if there are no dense clouds above—and the atmospheric pressure will be lower than near the Earth's surface. Both of these circumstances promote an expansion of the gas in the balloon, which means a loss of gas, as the balloon cloth is not elastic. Any subsequent cooling of the gas, for example in the shadow from dense clouds at higher levels, will result in a contraction of the gas in the balloon—and a decrease in carrying power—whether or not outside air is sucked into the balloon.

The balloon expedition was planned to be more or less a direct flight, from the start to an ultimate destination. Possible new lands would be photographed from the air, and the films would be developed in the gondola. Even samples of the ground below the balloon might be collected from the air with the help of a special scraper. For cooking, they had a special container housing a spirit burner and a cooking pan above it. This apparatus could be lowered under the gondola, and the cooking done from above, thus eliminating the danger of fire.

*AT DANSKÖYA,
SPITSBERGEN, IN 1896 AND 1897
Expedition members*

On June 7, 1896, the steamship *Virgo* left Göteborg with Andrée's expedition on board. This was a cargo-steamer of steel; she could carry 550 tons and her crew counted 30 men. She had been strengthened additionally against ice. Her commander was Hugo Leopold Zachau, a captain in the merchant service.

THE BALLOON GROUP CONSISTED OF:

Salomon August Andrée (1854–97), Master of Engineering, leader of the expedition.

Nils Gustaf Ekholm (1848–1923), Ph.D., meteorologist and astronomer.

Nils Strindberg (1872–97), B.Sc., physicist, photographer, assistant technician.

Two Frenchmen took part in the expedition: M. Henri Lachambre, who had constructed the balloon, and the aeronaut M. Alexis Machuron. Further, there were technicians in different fields.

The public exhibited an enormous interest, and Andrée gave the journalists all the information they desired. Almost everyone believed that it would be simple to carry out the expedition's plans. In a letter written from Spitsbergen to one of the patrons of the enterprise, Andrée wrote:

“It does not seem to have occurred to anybody on board that any difficulties may arise. It is delightful to hypnotize on a grand scale.”

On June 23, a base site was found on the northern side of Dansköya in the north-western corner of Spitsbergen. The preparatory work was finished on July 23—landing the equipment, and mounting the balloon shelter and the gas generator. The filling of the balloon then began and was completed on the 27th. After that, there remained only to await suitable weather: a south wind, not too weak and not too strong. But the south wind never came, and a deadline existed in the timetable: the ship had to leave on August 21 at the latest. Such were the insurance stipulations.

On August 29, Andrée was back in Sweden. The disappointment in the country was great, and Andrée's critics were many. But his patrons remained loyal, and after a few weeks a new expedition was guaranteed for 1897. Alfred Nobel was even willing to supply a new balloon, but Andrée considered this unnecessary.

In the summer of 1896, the Nansen expedition with the *Fram* had returned from its three-year drift in the pack-ice in the Polar Sea. The ship—without Nansen on board—had visited Andrée's base in Spitsbergen. Later Andrée met Nansen in Tromsö and Stockholm, and was given advice on equipment. He also obtained fresh information about the conditions prevailing on and over the Polar Sea.

Nils Ekholm now joined the critics. In Spitsbergen he had measured the leakage of the balloon, and found that it corresponded to a decrease in carrying power of 60–100 kg per day. Furthermore, the friction of the guide-ropes had been found to be greater than assumed in Andrée's rough calculations. Consequently the speed of the balloon must be slower than according to Andrée's findings, or roughly half his value.

Ekholm insisted upon a greater “safety factor” than Andrée could guarantee. He therefore left the expedition and was replaced by Knut Fränkel, a civil engineer and a sportsman, 27 years old, who was to take care of the meteorological observations. Fränkel was also given aeronautic training in France. The carrying power of the balloon was increased somewhat by adding a belt at its equator.

In 1897 the expedition was transported to Spitsbergen on board two ships: the *Virgo* of the previous year and the gunboat *Svensksund* of the Swedish Navy.

THE BALLOON GROUP CONSISTED OF:

Salomon August Andrée (1854–97), leader.

Nils Strindberg (1872–97), B.Sc., physicist, astronomical observations.

Knut Hjalmar Ferdinand Fränkel (1870–97), civil

Knut Fraenkel (1870-1897), civil engineer, member of the *Örnen* expedition (Haglund, S. & Ångström, A.: *Andrée. Mannen med vilja och mod.*)

Salomon August (S.A.) Andrée (1854-1897), leader of the expedition. (Haglund, S. & Ångström, A.: *Andrée. Mannen med vilja och mod.*)

Nils Strindberg (1872-1897), physicist and photographer of the expedition. (Haglund, S. & Ångström, A.: *Andrée. Mannen med vilja och mod.*)

Immediately before the start of the polar balloon flight on 11 July 1897, Dansköya. Left Andrée, right Strindberg.

The balloon *Örnen* has started its disastrous flight. Photo: Andréemuséet.

The balloon crew in 1896: Andrée (seated), Ekholm (left), Strindberg (right). (Fataburen 1983.)

The currents in the Polar Sea, according to our most recent information. (Source: Anders Häggblom.)

engineer, meteorological observations. *Gustaf* Wilhelm Emanuel Svedenborg (1869–1943), lieutenant, Swedish Army. Substitute. The French aeronaut M. Alexis Machuron took part in the expedition also in 1897.

THE OFFICERS OF HMS *SVENSKSUND* WERE:

Captain *Carl-August* Ehrensvärd (b. 1858), commander.

Lieutenant *Carl Gustaf* Norselius (b. 1864).

Lieutenant *Gustaf* Robert Celsing (b. 1869).

THE COMMANDER OF THE *VIRGO* IN 1897 WAS:

Berndt Oscar Olsson (b. 1853), captain in the merchant service.

THE BALLOON ÖRZEN FLIES INTO OBLIVION
Dansköya was reached on May 30, 1897. The filling of the balloon was completed on June 22, more than a month earlier than in the previous year, and the south wind arrived on July 11. There was only a light breeze in the morning, but during the day it became fresh and rather gusty.

After some discussions, the start was decided upon and the preparations began. The balloon shelter was partly pulled down at its northern face, and the gondola was fastened to the carrying-ring. At last, with the aeronauts on board, the last ropes holding the balloon were cut through at 13.46 GMT.

The start was dramatic. Just after the balloon had come out of her shelter, a downwind pressed her towards the surface of the sea, and the gondola touched the water. At the same time, the balloon rotated half a revolution round a vertical axis. This was caused by the guide-ropes which were stretched out along the shore. These ropes must also have contributed to the downward motion. The rotation of the balloon unscrewed the joints between the coconut-fibre ropes and the hemp ropes.

All this meant a loss of ballast amounting to 530 kg. Besides, 207 kg of the ordinary ballast had been thrown out to make the balloon rise. The balloon—called *Örzen* (the Eagle)—was now a free balloon. All the careful planning for holding her at a height of 150–250 m, and at the same time making her somewhat dirigible, had been to no avail.

The balloon rose to a height of about 600 m. Naturally, gas was now pressed out through the bottom valve and was lost. The *Örzen* was observed from Dansköya as she drifted towards the north-east until, one hour after the start, she disappeared behind the islands in that direction.

The aeronauts had two means for sending messages: by carrier pigeons and by buoys. The former “postal service” was relatively fast, but unreliable; the

latter was extremely slow and depended upon chance. Only one pigeon returned. It was shot on July 15 by the skipper of a Norwegian sealer at Sjuöyane (Seven Islands) near Nordaustlandet. The pigeon carried a message reading:

“July 13 at 12.30 p.m. Lat. 82°2'W, Long. 15°E, good speed towards east 10° south. All well. This is the third pigeon post. Andrée.”

As we know now, the situation could not then be characterized as “all well” on board the *Örzen*. Five buoys were found in the following years, two of them containing messages from the expedition. These messages were remarkably poor in information.

The expedition base on Dansköya was visited in 1897 by a German expedition on board the small Norwegian steamer *Express*. The aim of the expedition was primarily hunting; its leader was Th. Lerner (compare p. 288). This expedition rendered good service to Andrée’s expedition at the special request of Andrée. The *Express* visited the base of A.E. Norden-skiöld at Mosselbukta in 1872–73, and verified that the store of provisions there were in good condition. Furthermore, a depot for the Andrée expedition was later (July 23) established on Rossöya, the northernmost of Sjuöyane, under the supervision of Lieutenant Svedenborg.

Other depots at Andrée’s disposal had been established at Cape Flora in Franz Josef Land and on one of the New Siberian Islands.

After—and even before—the start of the *Örzen*, reports about the balloon were received from many regions. According to them, it had been sighted in Norway, the USA, Canada, Greenland and Siberia. It had also been observed floating in the ocean.

However, Andrée and his companions did not come back.

Search expeditions

When nothing was heard from the aeronauts in the following autumn and winter, expeditions and other investigations were contemplated. Nansen gave his advice and recommended especially two regions where a search should be attempted: eastern and northern Greenland, and the Siberian coast from Cape Chelyuskin westward. Spitsbergen and Franz Josef Land were, of course, also recommended. In some regions the population was asked to be on the lookout.

In 1898 the Swedish journalist J. Stadling (1847–1935), with two companions, travelled through the Lena Delta and over the sea-ice westward, then overland and along rivers westward to the river Yenisey (see p. 257). Nothing was heard from Andrée.

In 1899, A.G. Nathorst (1850-1921) with his ship the *Antarctic* went to East Greenland for the specific purpose of finding Andrée (see p. 274). A grand and beautiful fjord system was discovered and investigated, but there was no trace of the aeronauts there. However, in the previous year, Nathorst had in fact landed on Kvitöya—situated to the east of Nordaustlandet—and came within just a few kilometres of Andrée's last camp, but did not notice it (see p. 272). The visit ashore was short, visibility was low, and ice threatened the ship.

The fate of the Andrée expedition seemed bound to remain a polar mystery forever. On August 6, 1930, the Norwegian sealer *Bratvaag* anchored off the south-western, ice-free tip of the ice-covered Kvitöya. The ship carried a group of scientists from the Norwegian Polar Institute (then called Norges Svalbard- og Ishavs-Undersøkelser) under the leadership of the geologist Gunnar Horn (1894-1946). Andrée's last camp was found about 200 m from the shore. All articles of equipment that were seen, and the bodily remains of Andrée and Strindberg, were taken aboard the ship and carried to Tromsø.

But there was still much snow on the ground. Later, during September 5-8, an expedition with the Norwegian sealer *Isbjörn* visited Kvitöya. Much of the snow had melted away, and many new relics were seen, including the remains of Fränkel. The leader of this expedition was the Swedish journalist Knut Stubbendorff (1893-1965).

The discovery of the Andrée camp was a world sensation. The most important finds were, of course, the diaries and the observation-books. They were all legible, except part of the entries in Andrée's second diary, which covered the last few days of the expedition. Perhaps most remarkable was the fact that about 20 printable negatives could be obtained from the photographic films of the expedition.

The Andrée polar flight was no longer a mystery of the Arctic.

THE FLIGHT OF THE ÖRZEN

The dramatic events after the start at 13.46h on July 11 were barely touched upon in the diaries of the aeronauts. Due to the loss of the guide-ropes, the balloon ascended to about 600 m. The sailing was pleasant in the sunlight and under the blue sky. The temperature was +1°C, and the balloon drifted with a speed of 9 m/s towards the north-east. The aeronauts relaxed after the stress of the preceding hours.

At 16.16h drift-ice appeared. At 17.36h, when at 240 m, the first pigeons were released. They were never heard of, and must have fallen prey to ivory gulls.

At 18h the *Örnen* sailed at 600 m with good speed towards the north-east. It was still warm in the sunshine. They were now over the ice. The flight had been uneventful, excluding, of course, the start. At 19h, fog or stratus clouds developed under the balloon and to the north. Andrée went down into the gondola to have a rest, while Strindberg and Fränkel took over the watch. The low clouds or fog had grown denser, but the balloon still sailed in sunshine at 700 m.

At 21.43h the balloon touched the top of the cloud/fog layer at 500 m. Ballast-sand and a buoy—was thrown out. The buoy, which contained a message, was found in northernmost Norway in 1900. At about 22.30h some more ballast was thrown out, and later another buoy with a short message written by Strindberg. This buoy was found in northern Iceland in 1899.

At about 23.15h they observed shadows from an altocumulus layer to the north-east. The uneventful passage was drawing to a close, and harder times were awaiting the aeronauts.

Soon after midnight between the 11th and 12th, the balloon entered the shadow of the altocumulus layer. It cooled down and lost height, and the shortened guide-ropes reached the ice. The fog grew denser, the wind decreased, and at 01.26h on the 12th the balloon stopped in a calm.

At 02.00h Andrée relieved his two companions. The wind was now light and backing from near south to almost due east, so they were heading back westwards along their previous track. The drift was, however, very slow at first. There was a light fog, and a light drizzle was falling. The temperature was 0°C. The drizzle added weight to the balloon, which lost height rapidly at 15.06h from about 65 m, until the gondola touched the ice. The men tried to make the balloon rise, but in vain. They threw out ballast: sand, ropes, one anchor and even their big polar buoy, which was intended to be thrown out at their northernmost point. There was a risk that the gondola would be smashed against the ice hummocks. The polar buoy—without a message—was found in 1899 on Kongsöya to the south-east of Nordaustlandet.

In the evening the fog became still denser, and more weight was added to the balloon. From about eight bumps against the ice every half hour, the number increased to one bump per one or two minutes. The ice surface now became, so to speak, marked by the car at intervals of some 50 m.

At 22.00h, the balloon once again became stationary. One of the (reduced) guide-ropes had become jammed under a block of ice. Everything was now dripping wet. One hour later Andrée took over the

Aerial view of the north coast of Spitsbergen as seen from the west. In front Amsterdamöya and part of Dansköya, with Danskegattet in between. Virgohamna with Andrée's base in front of the little headland at Dansköya's northeastern corner. Beyond Smeerenburgfjorden in part covered by banks of fog. The north coast of Spitsbergen with fjords and headlands can be followed to Hinlopenstretet. Beyond Nordaustlandet is seen like a dark streak. Photo: Norsk Polarinstitut, Oslo.

Virgohamna and Danskegattet seen from the east. The ship is the *Svensksund*, in the summer of 1897 in the service of the Andrée Expedition. The hut belonged to an Englishman, Arnold Pike, who was an enthusiastic Arctic explorer. In 1888–1889 he wintered in his hut. Photo: F. Goldberg Collection.

The flight of the *Örnen*, (solid line). The ensuing march and drift with the ice (broken line). The landing took place on 14 July 1897 and on 5 October 1897 the aeronauts went ashore on Kvitöya. (Andrée, S.A.: Med Örnen mot Polen.)

watch. He devoted his time to introspection and to writing in his diary. The entries give a good idea of his inner thoughts during this stage of the expedition:

"It is a strange feeling to float in the air over the Polar Sea. When will we have followers? Will people consider us mad or will they follow our example? I cannot deny that there is a proud feeling which commands us. We think that we can very well face death after doing what we have done now. Maybe this is due to an utterly strong feeling of individuality, which cannot accept that one should live and die like a man of the common herd, forgotten by coming generations. Is this a feeling of high ambition?"

The balloon stayed put for 13 hours, in spite of a light to moderate wind. Not until 11h on the 13th did she come free with a jerk. The clouds had become thinner, blue sky could be seen, and the carrying power of the balloon increased. The wind had turned westerly, so they were now heading east, again more or less along their previous track. But the clouds grew denser once more. The air had become somewhat colder, and the wet ropes froze.

At 12.00h four pigeons were released. One of these was shot near Sjuöyane two days later, as mentioned above. In the afternoon fog again formed and grew denser; ice stuck to the balloon, adding weight, so the bumping against the ice started again. The course was easterly, to become north-easterly. In the evening they threw out much ballast and were given a last good flight of a few hours' duration, before the bumping resumed.

The situation seemed hopeless. The landscape was depressing: fog, ice with pools on top, dark leads with open water. There was no land, no birds, no seals, no polar bears—just ice, dark water and fog.

The bumping continued during the night and early morning, and the ice accretion on the balloon increased. The men realized that the situation was beyond hope. The notes in their diaries are scarce, but Strindberg wrote that they anchored on an ice floe at 07.22h in the morning of July 14. The landing seems to have been successful. The position was 82°56'N, 29°52'E, not very far from Nordaustlandet.

On the drifting pack-ice

Their balloon had been in the air for 65.5 hours, which is not bad compared with previous long flights. But it was only a fraction of the 30 days which Andrée had contemplated. They had covered 830 km, but the direct distance to Dansköya was only 480 km. The flight track had been more or less in the region of

Edward Parry's ice-march with boats in 1827.

They now had to undertake a march over the ice to one of their depots. They chose the Cape Flora depot about 350 km to the south-east. However, they first had to make preparations for the march and to choose the most necessary things to take with them.

Finally on July 22 they left their landing-place, carrying the equipment on three small sledges. One of these held their light boat, a wooden framework covered with balloon cloth. They had a tent of balloon cloth, a three-man sleeping-bag, a Primus stove, and three guns. The provisions were supposed to last for three months, but in addition they hoped to live off the country. They had already been visited by polar bears. They saw many birds, including ivory gulls, which were found delicious for food. Later they even tried algae from the sea water as food. There did not seem to be any problem whatsoever in getting food from the surroundings. But the sledges were heavy in the rough pack-ice, so the loads had to be reduced after a few days, from 160–200 kg to about 130 kg per sledge.

For a sledger, the Arctic pack-ice is a true nightmare in the height of summer. Pools form on the floes, and sometimes become covered with a sharp crust of ice; leads or cracks open and close; the ice hummocks become dangerous when the snow melts away; large areas consist of deep slushy snow. The progress is slow and fatiguing, but worst of all is the fact that the traveller is often a victim of the ice drift. Andrée and his companions received an ample share of hardships.

On the 3rd of August, they decided to forget the Cape Flora depot and march towards the depot on Sjuöyane, which they optimistically expected to reach after one month and a half. The ice now carried them southward, although erratic deviations from that course occurred. The summer was coming to an end, it was getting slightly colder, and ice formed more often than previously on the pools and on the leads between the floes.

In the first half of September they could feel the approach of catastrophe. They were now very ill, especially Fränkel, who was the strongest of them. They had severe diarrhoea, their feet hurt, and they suffered from painful cramps. Fränkel could not drag his sledge and had to be helped. They were very tired all the time, and this was probably not due solely to exhaustion by hard work. The cause may have been deeper.

The entries in Andrée's diary became shorter, and ceased altogether between the 9th and 17th of September. Strindberg, however, wrote a few words every day in his almanac. Andrée now seldom men-

The *Örnen* after landing on the ice on 14 July 1897, S.A. Andrée (right), Knut Fraenkel (left). Photo: Nils Strindberg.

The *Örnen* after the landing on an ice-floe, 82°56'N, 29°52'E, not far from Nordaustlandet. (right). Photo: Nils Strindberg.

The camp in the pack-ice, 19 July 1897. Andrée is standing on the gondola of the balloon, scanning the horizon, to the left Fraenkel. Equipment for the ice-march is being assembled to the right. The boat is seen in the opening of the tent (left). Photo: Nils Strindberg.

tioned anything about their feelings. On the 13th they decided to stop marching and let the drifting ice take care of their transportation. They found an ice-floe which seemed suitable, and here, with Strindberg in charge, they soon started to build an ice hut.

The drift had been strong lately, and on the 16th of September they sighted Kvitöya. On the 18th they passed close to the north-eastern extremity of the island, and during the rest of September they drifted south-westward, near the island's icy coastline. On the 28th they moved into their ice hut, called "The Home". It contained a sleeping-room, living-room/kitchen and storeroom, all small.

In the early morning of October 2, however, their ice-floe broke up into several small floes, and a crack formed near the hut. Their own floe now had a diameter of only 24 m, and their equipment lay scattered upon several small floes all around. But the weather was fine, and despite the danger they spent the following night in the hut.

The tragedy on Kvitöya

The south-western extremity of Kvitöya was near. It is a spit of bare, low land, covered by gravel and shingle, with small outcrops of rock here and there. It must have been a desolate place to come to.

Strindberg's short notes in his almanac give a hint of what happened during the following days:

"October 3rd and 4th: exciting situation.

October 5th: moved ashore.

October 6th: snowstorm, reconnaissance.

October 7th: removal."

Then follows an enigmatic entry for October 17: "Home at 7.5 o'clock a.m."

The writing is different from that of the previous days, and it may have been entered much earlier, perhaps even before the start from Dansköya.

The fragmentary pages of Andrée's second diary can be interpreted in part, and provide some more details about these critical days, but probably his entries do not go beyond the first week of October either.

The aeronauts had found a slight shelter close to a low rock outcrop. Here they pitched their tent. They must have been exhausted from the strain during the past few days. When their camp was found, it indicated indifference: the equipment lay scattered, and important articles had been left on the sledges or in the boat, unprotected from attacks by polar bears and other animals.

There have been speculations as to the cause of death of the aeronauts. After the discovery of the camp in 1930, it was generally accepted that they had frozen to death, as their clothing was considered unfit

for the winter. But it was not yet winter when they died. Moreover, there was unused clothing in their possession; they had a good store of balloon cloth which could be used for windproofs; and they had the skins of two polar bears. No, the aeronauts did not freeze to death.

Their death has also been attributed to monoxide poisoning caused by the Primus stove. When the stove was found in 1930, there was still paraffin oil in its reservoir and it could be used, but nobody recorded whether the tap had been open or closed. If open, poisoning would seem less probable.

Another probable cause of death, trichinosis, was brought forward by the Danish physician E.A. Tryde in 1950. In the 1940s, it had been found in Greenland that many polar bears and also seals were infected by trichinae. Andrée's descriptions of the ailments of the aeronauts during their ice march indicate, according to Tryde, that they very probably had suffered repeatedly from such infections. Altogether 13 polar bears were shot. The cooking had been imperfect in order to spare paraffin oil, and they had even eaten one bear raw. It should also be noted that a microscopic investigation in Denmark had revealed capsules of trichinae in remains of meat from one of the polar bears which had been shot by the aeronauts at Kvitöya.

Strindberg was the first to go. His death may have been sudden; heart failure has been guessed at. He may even have been attacked by a polar bear. His body was placed in the space between two small rock outcrops. It was covered with stones as a protection against animals, but no cross was erected. Andrée and Fränkel died later in their tent, but not in their sleeping-bag.

It is remarkable that Andrée did not mention Strindberg's death in his diary, nor anything which happened later. Another surprise is the lack of a diary from Fränkel—we have only his meteorological log. It seems reasonable that he kept some sort of diary. Andrée and Fränkel may have suffered from trichinosis, and they may have dreaded the polar night which was edging closer: on October 20 the sun would be touching the horizon to the south. To be frank, one cannot help mentioning a further potential cause of death. Andrée and Fränkel may have resorted to a drug from the medicine chest in order to be relieved from the horrors which they anticipated.¹⁾

¹⁾ This was written in 1983 by the present author. In 1990 he came across an article in *Polarboken* of 1985-86, the Yearbook of Norsk Polarklubb, written by P.W. Zapffe. Here it is stated that morphine tablets were found in the camp during the visit of the *Isbjörn*, but were kept a secret. The tablets were found in a glass tube, but also scattered about.

On the way south.

Photo: Nils Strindberg.

The camp left by the aeronauts on 22 July 1897. The gondola and the balloon-cloth stretched out upon the snow, together with litter of different kinds. Photo: Nils Strindberg.

Journeys end; the last camp on Kvitöya, as found in August–September 1930 by the *Bratvaag* and *Isbjörn* expeditions. The tent had been pitched at B, close to a small rock outcrop about 200 m from the shore. Here the *Bratvaag* expedition built a cairn, at F. To the west of the tent the three sledges and the boat (upon one of the sledges) were found, together with a manifold of equipment. Skins of two polar bears were found. Within the tent space (marked by a log of driftwood and two whale bones) the bodily remains of Andrée and Fraenkel were found (B and B2). Strindberg had been buried at E, 35 m to the NNE of the *Bratvaag* cairn, F. At D logs of driftwood assembled by the aeronauts.

The ill-fated Andrée expedition was the first to use a free balloon for polar exploration; it was also the last expedition to do so. Andrée had started his expedition on the threshold of a new technological age. The balloon developed into the dirigible, and the American Walter Wellman was the first to use it in the Arctic—at Dansköya—a few years after Andrée's flight, but with little success. Not until 1926, 1928 and 1931 did dirigibles operate over the Polar Sea. At the same time, vehicles heavier than the air were already taking over; reliable aircraft engines had been invented and constructed.

24. A SEARCH FOR ANDRÉE IN SIBERIA.

JONAS STADLING'S EXPEDITION IN 1898

Plans and participants

The Swedish newspaper *Aftonbladet* had been very much interested in the polar flight of Andrée. It had also contributed some of the expedition's equipment, and one of its correspondents had been present at the start of the flight on July 11, 1897. This was Jonas Jonsson Stadling (1847-1935).

Stadling was an unusual man. Educated partly in places of non-conformist religion, he wrote for non-conformist papers and journals, besides being a correspondent to *Aftonbladet*. He was a popular lecturer and an author of books dealing with religion, history, sociology and travels. For three years he travelled in America, and during the famine in Russia in 1892-93 he was an assistant to Leo Tolstoy, the author, as well as representing American philanthropists. In sum, Stadling had many strings to his bow.

When nothing but groundless rumours was heard about the Andrée expedition in the autumn and winter after its flight, Stadling supported the insistence that searches be made for Andrée and his companions, especially along the Siberian coast. As a Russian expedition was said to be planned for a visit to the coast west of Cape Chelyuskin, the regions east of that cape should be chosen for a Swedish expedition.

No suitable leader for such a venture was available in Sweden at the time. Stadling was therefore more or less forced to take the matter in hand himself. After an application for money he obtained grants from the Vega Fund, (see p. 138) for the purpose. Moreover, he obtained grants from Stockholm University and from the Swedish Museum of Natural History. It was considered that scientific research should also be carried out in addition to a search, particularly since

the Stadling expedition was to travel through regions which had not been visited by the Vega expedition.

Herman Nilsson, a young B.Sc. of Lund University, was asked to carry out botanical studies along the Lena River. And at the very last moment before the start, Hans Fränkel was engaged for the expedition. He was a younger brother of Knut Fränkel, who had gone with Andrée on the polar flight.

THE EXPEDITION CONSISTED OF THE FOLLOWING PERSONS:

Jonas Jonsson Stadling (1847-1935), leader.

Herman Nilsson (1873-1949), B.Sc., botanist.

Hans Fränkel (b. 1875), engineer.

Nilsson, who in 1901 changed his family name to Nilsson-Ehle, was later to become a famous scientist in plant ecology and genetics.

The expedition left Stockholm on April 20, 1898, and stayed for a week in St. Petersburg. Here Stadling met the Russian polar explorer Baron E.V. Toll, who seems to have treated him somewhat curtly and thought that the projected expedition was of no use: it would be better to organize a search to the west of Cape Chelyuskin. Stadling also met Fridtjof Nansen in St. Petersburg. Nansen had advocated western Siberia and eastern Greenland as search regions.

The Russian authorities were extremely obliging towards the expedition. Transport within Russia and Siberia was offered free of charge as far as the Trans-Siberian Railway was built—to Tulun situated about 400 km from Irkutsk.

The plan was to travel down the Lena to the proximity of the Lena Delta. Thereafter the route would depend upon what was heard from the local population as to possible finds from the Andrée expedition.

From Stockholm to the Lena Delta

The expedition left St. Petersburg on May 1. They travelled by railway as far as they could go, and the last 400 km were covered by horse and carriage, which resulted in some damage to their instrumental equipment. After three days spent in Irkutsk for repairing the instruments, they continued overland to reach the Lena at Shigalova, where the river traffic down the Lena started. This traffic was conducted by about 20 shallow-draught steamers. A few of these carried mail from Yakutsk to the north, but the only seaworthy steamer was the Swedish-built *Lena*, which in 1878 had accompanied the *Vega* to the vicinity of the Lena Delta, from where the former ship had proceeded upstream to Yakutsk (see p. 140).

The expedition stayed for a week in Yakutsk, and was received with much benevolence by the governor.

A Cossack officer and a soldier were placed at the expedition's disposal as interpreters and attendants during the tour northwards. They travelled north with the steamer *Lena* on June 17, and arrived on the 28th at Bulkur, a tour of about 2000 km.

During much of its length, the Lena River has eroded itself into an undulating plain covered with woods and forests. As seen from the river, the surrounding country gives the impression of a mountainous landscape. After the river has received water from its four greatest tributaries—the most northerly being the Vilui—it looks more like a lake with low islands than a river, and in situations with strong winds a very rough sea may develop.

The land was covered in the verdure of spring, but ice and snow could be seen in narrow valleys, and large blocks of ice still remained along the shore since the break-up of the river ice. Herman Nilsson collected plants during each stop—eight stops altogether between Yakutsk and Bulun. From the ship, he observed continuously how the vegetation changed its character with the latitude.

At 64°N the pine disappeared, and at 67°N the spruce and soon also the birch faded away. After that the larch reigned supreme right up to the tree line. Most bushes, like the larch, reach farther north at the Lena than at the Yenisey, where the Swedish expeditions of 1875 and 1876 had carried out valuable observations (see Chapt. 15).

Bulun, situated about 220 km from the Lena Delta, was a centre of the trade and administration around the lower reaches of the Lena. Stadling was told here that the New Siberian Islands had been visited in 1897 as well as in 1898. Natives had also been contacted and questioned; some of them had come from regions as far away as the river Indigirka in the east and the river Anabar in the west. But nobody had seen any traces of the Andrée expedition.

Nor had the population in the Lena Delta reported anything, despite the fact that they had become interested in keeping a lookout for traces of the expedition—thanks to a Norwegian, Johan Torgersen (b. 1857), who had settled at Bulun after coming to Siberia in 1878 as a mate on board the steamer *Lena* in connection with the Vega expedition.

Since his arrival with the *Lena*, Torgersen had remained faithful to Siberia. To begin with, he served for several years as captain or mate on vessels which plied Lake Baikal and the river Vitim. From 1890 until the Russian revolution in 1917, he carried on trade in fishing and trapping in the Lena Delta. During the revolution all his resources were confiscated and he himself was sentenced to death, but the punishment was set aside.

Afterwards he lived at Bulun in very modest circumstances.

Torgersen was engaged by the expedition for the adventurous overland journey which lay ahead. His knowledge of the native population and of the conditions on the tundra was invaluable to the expedition.

Apparently it was of no use to visit the New Siberian Islands or the regions lying to the east. The expedition would have to travel west—first through the Lena Delta and along the coast, then overland and along rivers, across the Taymyr Peninsula to the Yenisey River. By means of discussions with the nomadizing Samoyed population, they hoped that it would be possible to obtain information on the Andrée expedition and whether it had reached these regions.

In St. Petersburg, Nansen had spoken with Stadling about the regions where a search should be concentrated. As mentioned (p. 257), he had advised that the Siberian coast to the west of Cape Chelyuskin be visited, because the islands of Svalbard and Franz Josef Land were visited by Norwegian sealers every year. East Greenland could, with regard to Stadling's plans, be left out of consideration. Stadling, in spite of this advice, had chosen the Lena Delta as a point of departure for his search, due to the information he had received in Russia—that a Russian expedition was going to travel along the west coast of the Taymyr Peninsula. However, this expedition did not materialize. In any case, Stadling did not aim at *finding* Andrée but at collecting eventual information on his expedition from the Samoyeds, and also asking them to be on the lookout for traces of the expedition.

The long overland journey which was planned could not be carried out until late autumn, after the ground had become frozen and snow-covered and the sea, lakes and watercourses had frozen over. The delay was utilized by making further contacts with the native population and getting people interested in "keeping their eyes open".

Nilsson's botanical observations

During this time, Herman Nilsson was assiduously occupied with his botanical work, collecting plants and studying their physiognomy and phytogeography. He spent almost three months in the region between Bulun (lat. 70° 43'N) and Titary (lat. 72°N), the latter being situated at about the southern limit of the Lena Delta. He judged that the most profitable method of working would be to make a careful and detailed investigation within a relatively limited region, especially as the region chosen had been very little investigated and held much of interest.

The flora, which Nilsson termed subarctic, was quite rich in species—about 400 phanerogams and

vascular cryptogams. It comprised a mixture of the species of the forest and of the tundra. The richness in species was determined by several factors. The character of the habitats was highly varied: mountains of limestone alternated with those of sandstone and shales; deeply eroded valleys gave rise to cold and warm, moist and dry habitats. The climate was continental with relatively warm summers, which are decisive for the flora; the region's extremely cold winters were less important. Southerly species therefore occurred far towards the north.

Herman Nilsson left his expedition companions on September 17 and, going south with the *Lena*, he reached Yakutsk on October 2. However, he had to remain at Yakutsk until November 19, when the river had frozen up and the ice had become safe for travel. Meanwhile he was invited to stay in the home of the governor, Mr. Skrypitsin, where he met with much hospitality.

On December 14 he reached Irkutsk, and was informed that Stadling and Fränkel had safely reached the Trans-Siberian Railway after their long and hazardous journey. On January 12, 1899, Nilsson and his collections reached Sweden.

The Lena Delta and the tundra

After parting from Herman Nilsson at Bulkur on September 17, Stadling's search expedition also left. The group now consisted of Stadling, Fränkel and Torgersen, with a few Yakuts.

They travelled down the Lena in an open boat, which was heavily loaded. The wind was in their favour, and the progress was rapid. Before making for the west, they took the opportunity to visit Chegil-Kaya—or Monument Mountain, as named by Americans.

On the top of the mountain, a large wooden cross stands with twelve names engraved in memory of the members of the American Jeannette expedition, who died from privations in October 1881, some 20 km north of Monument Mountain. The bodies had been temporarily buried at the mountain, awaiting transport to the USA.

Stadling's expedition then headed west through the labyrinth of the delta, until they became stuck on an island at its fringe, uninhabited although there were some yurtas (nomad tents). Here they remained for 17 days until the ice had become safe. Two Yakuts were sent 80–100 km back into the delta, to get dogs and dog drivers for transport to the Olenek River. Fränkel and another Yakut meanwhile walked westward to the mouth of the latter river—a distance of about 180 km, covered in four days.

The intention was to contact the nomads before

they moved to their winter yurtas at the forest limit in the south. On the journey west from the Olenek, reindeer were to be used.

All arrangements for the transport of the expedition turned out successfully. With eight sledges and more than 100 dogs, the expedition reached the Olenek after a speedy passage over the sea-ice.

From now on they were to travel on sledges, each pulled by 2–3 reindeer. They would cross the wide tundras of the immense Taymyr Peninsula, to Dudinskoye at the Yenisey, which meant a distance of 2500 km. They would then travel along the Yenisey on the river ice via Turuchansk to Krasnoyarsk, situated at the Trans-Siberian Railway.

During a good part of the route from the Lena Delta to Dudinskoye, it would be possible to spend the nights in yurtas or in "stations" at suitable intervals—the latter being rough cottages for the "comfort" of travellers, offering only a roof over their heads. During the first 500 km of the journey, as far as the Anabar, the route would cross an uninhabited tundra lacking characteristic "road signs". As it happened, visibility was very deceptive at times on this route: the light was quite diffuse and the surroundings looked white-on-white, due to the repeated reflections of the light between cloud base and snow surface.

They started the journey across the tundra on October 14. The Yakut chieftain Androssov and two other Yakuts went along, one of them serving as guide. The Yakuts proved to possess a well-developed sense of direction.

The tundra was dotted with ravines, depressions and lakes. In these depressions is a layer of earth (1–2 m thick), resting on ice which here takes the place of bedrock. In the earth layer are found, embedded, very old driftwood and relics of mammoth and other extinct animals. Birchwood also occurs, so fresh that axe-handles can be made from it. The area was situated at about 100 m a.s.l., 400 km north of the nearest forest, and 150 km from the sea. The expedition found only driftwood here, as the season was not right for seeking other relics.

Meetings with nomads

From the Anabar River they travelled in a north-westerly direction towards the estuary of the Khatanga and then, via the mouth itself, along the river and in the same direction to Khatangskoye. This was "a great station" with a few *simovies* (winter huts for travellers) and two old chapels. On the way they met several nomads, to whom they explained the purpose of their journey. They told the people about the balloon flight and asked them to keep a lookout for the aeronauts or for relics of the expedition. These con-

tacts with the native population were mainly conducted by Torgersen.

Sometimes unexpected situations arose. Once a nomad chieftain wanted to know who had sent Andrée and his companions upon this flight. Stadling answered:

"Our High White Sun (our Tsar) had done this." The face of the chieftain darkened, and his next question ran:

"Why has the High White Sun banished the three young men so far and forced them to embark upon such a dangerous journey?"

However, it seemed to him almost inconceivable that there existed another High White Sun in addition to the sovereign of the Tsarist Empire, that this "Sun Farther Away" had equipped the three men generously, and that these men of their own free will had undertaken the journey.

South of the "station" Rybnoye they passed the most northerly forest on earth. It was situated at lat. 72°50'N, and was just a number of scattered and dwarfed larch-trees.

The expedition was entirely dependent upon the nomads and their reindeer. The nomads had not yet gone to their winter yurtas near the forest limit, where they spend the winter. The expedition therefore needed to look for them in their camps on the open tundra—and the positions of these camps were only roughly known to the guides of the expedition. This suggested dangers ahead, for instance if the guides had to leave the expedition members upon the open tundra in order to travel far in their quest.

The route passed through a desolate and flat snow desert on the Taymyr Peninsula, in a region between the watersheds of rivers flowing to the north, east and west. They now travelled as fast as possible in order to avoid the gales with snowfall and drifting snow, which are common after the sun has disappeared in the winter.

Finally they reached Dudinskoye at the Yenisey. It is an important trade centre which, at that time, boasted two tradesmen, two clergymen and one representative of the law and police (compare pp. 106 and 113).

Several rumours about the Andrée expedition were circulating: the balloon had been seen in various parts of western and central Siberia, a message from the expedition had been found in a bottle, and so forth. But Stadling learned that the intended Russian expedition to western Taymyr had not visited Dudinskoye, and that only one English ship out of an intended flotilla had arrived during the summer.

Torgersen now left the expedition, having given excellent service. He travelled back to the Lena following the forest limit.

The nomads had settled in their winter yurtas and he could obtain lodgings on the way, also finding opportunities to tell the nomads about Andrée and the missing balloon.

Stadling and Fränkel left Dudinskoye on November 10, and travelled up the Yenisey. Via Turuchansk and Yeniseysk, they reached the Trans-Siberian Railway at Krasnoyarsk, and in December they were back in Sweden.

SOME COMMENTS

Stadling's journey had been very long and full of hardships, as well as occasional hazards. The result as regards the Andrée expedition was, of course, negative: Andrée and his two companions never came to Siberia. Since a year previously, they had lain in a bleak spot on Kvitöya to the east of Nordaustlandet.

Herman Nilsson's botanical work along the Lena, and especially his detailed observations in the region south of the Lena Delta, gave valuable information on the vegetation in areas having extreme types of climates.

His data also offered a good comparison with the conditions along the Yenisey River, notably the data collected by the Swedish Yenisey expeditions of 1875 and 1876.

Stadling's long journey would not have been possible without the help and benevolence of the Russian and Siberian authorities and tradesmen, the invaluable and self-sacrificing assistance of Johan Torgersen, and—not least—the help with lodgings and transports, which the expedition received from a loyal and reliable Samoyed and Yakut population.

25. BOTANICAL RESEARCH BY OTTO EKSTAM IN THE RUSSIAN ARCTIC AND IN SPITSBERGEN

Major Swedish investigations in the Russian and Siberian Arctic were virtually given up after the voyage of the *Vega* in 1878. However, two Swedish botanists carried out research here after 1878: Herman Nilsson along the Lena in 1898, notably in its lower reaches (p. 258), and Otto Ekstam (b. 1870). Ekstam studied the flora in the Russian Arctic and Subarctic, and in Spitsbergen, mainly during the 1890s.

Travelling across the Kola Peninsula in 1890

This was a journey with meagre resources, made by a young man 20 years of age. Ekstam started on July 9 from Kola in the north-western part of the Kola Peninsula, heading for Kuzomen at the White Sea. Initially the expedition consisted of four men, six reindeer and provisions for 60 days. The last leg of the journey went by boat along two rivers, the Pana and the Varsuga.

It was a fairly hard tour, mostly due to the rich occurrence of morasses. On August 29 the party reached Kuzomen, and four days later Ekstam, with two of his companions, took a fishing-vessel to Arkhangelsk, where the expedition broke up. Ekstam proceeded by steamer up the Dvina River, but the ship had to turn back after about 600 km; there was not enough water in the river. At Arkhangelsk, Ekstam managed to get passage to Lofoten on a British steamer.

Botanical studies in Novaya Zemlya: 1891 and 1895

Ekstam's botanical studies in Novaya Zemlya and Spitsbergen were published in the Tromsø Museum's *Aarshefter* (Yearbooks) and in *Översikt KVA Förbandl.* These papers give some information about his travels, but not much. In *Ymer* for 1891, Ekstam supplied the following details on the expedition of that year.

He travelled on board a Russian steamer from Arkhangelsk to Matochkin Shar, the narrow sound between the North and South Islands of Novaya Zemlya. His intention had been to proceed with a boat northward from the eastern mouth of the sound. This would have taken him along a very little known stretch of coast. In a letter of July 21 to the editor of *Ymer* he wrote:

"Not until today did I arrive at Matochkin Shar, having weathered a severe north-westerly storm for seven days, in combination with snow and hail. Ice has not been seen as yet, but the conditions have until now been very unfavourable, and snow covers the mountains and to a great extent also the lowland. In Matochkin Shar there is fast-ice over the last stretch of thirty kilometres towards the east, and if the ice conditions do not improve within a short time, it will be necessary to limit ourselves to making excursions in different directions from the wintering hut, built by the Russian government. On about August 27 we will be fetched again by the same ship as we came by. If an accident of some kind should prevent the ship from reaching us, we can very well winter here."

From Ekstam's botanical papers, it appears that he spent the summer of 1891 at Matochkin Shar—and the summer of 1895 at Matochkin Shar as well as Gribovaya Bay and Karmakul Bay, on the west coast to the south of Matochkin Shar. The work in 1895 mid-September. Vascular plants, mosses and lichens were collected and studied. Ekstam reported:

"The investigations include pictures of the vegetation, physiognomic notes, registers of plants, notes on wintering conditions and on the first appearance of the plants in the beginning of the vegetative period, and biological and morphological observations concerning most of the phanerogams found during the expeditions."

Botanical studies in Spitsbergen in 1897

In the summer of 1897, Ekstam made biological observations of the flowers in Spitsbergen. He enjoyed the easy way of travelling to Spitsbergen, thanks to the traffic of tourist steamers. Besides, it was possible to hire boats or even small steamers at a low cost for excursions in the area. And at Adventfjorden there was at the time a small tourist hotel, also keeping low prices. The facilities for travelling and working were thus excellent.

The scientific work included the following studies, which were similar to those he had conducted at Novaya Zemlya in 1891 and 1895: the flowering season of the different species, size, scent and colour of the flowers, notes on pollination, fruit and seed ripeness, shape of the fruits and means of spreading.

Ekstam carried out his studies in the Isfjorden region. Several botanists had studied the flora of this area, notably during visits of Swedish expeditions. We should here mention the names of S. Berggren, Th. Fries, F.R. Kjellman, A.J. Malmgren and A.G. Nathorst.

It would therefore seem unlikely that any "new" flowers could be added to the Spitsbergen list. As to the plant-biological investigations, Ekstam did concentrate on a relatively small region, but in compensation he stayed here from July 9 until August 24—from the beginning towards the end of the vegetative period.

In 1901, Ekstam was back in Novaya Zemlya with the intention of doing botanical research on the east coast. However, due to extremely severe ice conditions, his scientific work failed this time.

In 1902 he was going to make a new attempt, but the present author has failed to find any notes on that expedition. Ekstam received a B.Sc. in 1898 and a Ph.D. in 1899, both at Uppsala University.

The Siberian journey of Jonas Stadling in 1898, in search of information on the Andrée expedition. Stadling, a correspondent of the newspaper Aftonbladet, had taken a great interest in Andrée's polar flight. (Ymer 1899.)

Alfred Gabriel (A.G.) Nathorst (1850–1921), in the prime of life. (Andersson, J.G.: Antarctic.)

Relaxation during the passage north along River Lena on board the steamer *Lena*, 1898. The botanist of the Andrée search expedition Herman Nilsson (the man with the pipe) and below him the leader of the expedition Jonas Stadling. (Royal Swedish Academy of Sciences.)

26. A.G. NATHORST, PALAEONTOLOGIST AND POLAR TRAVELLER

Alfred Gabriel Nathorst (1850-1921) belongs to the great names in Swedish polar research. He was a descendant of an English family, which in the 18th century had come to Sweden via Germany. Both his father and his grandfather worked in agricultural sciences and teaching, and the former became a professor in 1861 at Alnarp Agricultural Institute. Here A.G. Nathorst was introduced to natural sciences in his early years, although at first by collecting plants and hunting.

In 1868, when Nathorst registered at Lund University, his primary aim was to study botany. But geological field work, in the company of a geologist during the preceding summer, made him change his plans and go in for geology, notably plant paleontology. Otto Torell, who was professor of zoology at the university, engaged himself voluntarily in teaching Nathorst geology. Yet Nathorst's interest in botany, as in hunting and healthy outdoor life, was to endure.

He passed his academic examinations rapidly, earning a B.Sc. in 1873 and a Ph.D. in 1874, when he became lecturer in geology at the university. However, he never became an academic teacher, which was probably fortunate for him as well as for Swedish polar research.

Otto Torell was appointed head of the Geological Survey of Sweden in 1870, and in 1873 Nathorst was made the assistant geologist there, becoming Torell's assistant in 1877. In 1884 he obtained a personal post as professor and head of the newly created department of archegoniates and fossil plants at the Swedish Museum of Natural History in Stockholm. He was to remain here until he retired in 1917, four years before his death.

Nathorst's scientific contributions cover several branches of natural science, but he was chiefly a paleobotanist. The study of fossil collections from the early Swedish polar expeditions had been conducted by foreign scientists, notably the Swiss Oswald Heer (1809-83). But after the latter's death, these tasks fell upon Nathorst, who was alone in this capacity in the country.

Nathorst was the born collector and field worker. He loved his scientific material, and he used to describe it in minute detail. His scientific publications are many, some of them wide-ranging, others dealing with observational aspects which he considered of value. His capacity for work was extraordinary.

He began his research in the polar regions in 1870, when he was not quite 20 years old. He took part in five arctic expeditions, three of which he led (see the summary below). He was a worthy successor to Adolf Erik Nordenskiöld. But Nathorst had to fight against one severe handicap: he was hard of hearing and had to use an ear-trumpet. This ailment grew worse as the years went by.

In 1897, Otto Torell retired from his post as head of the Geological Survey of Sweden. Nathorst had hoped to become Torell's successor, but in view of his handicap, the post was given to another competent geologist. It was a hard blow, but his fighting spirit was awakened and he decided to show the "high authorities" that even a man who had to use an ear-trumpet might make a good chief and leader. In consequence, Nathorst organized the two very successful arctic expeditions of 1898 and 1899. After A.E. Nordenskiöld's death in 1901, Nathorst was the "Nestor" of Swedish polar exploration.

NATHORST WAS A MEMBER OF THE FOLLOWING ARCTIC EXPEDITIONS:

1870 A geological expedition led by Hjalmar Wilander on board the sloop *Lydianna*, the aim being to ascertain the profitability of future mining of fertilizers from phosphorite layers at Kapp Thorsden. The first observation of dwarf birch in Spitsbergen was made by Nathorst. An indication was discovered by Nathorst on Björnöya to the effect that this island might have been covered by a vast ice-sheet. See p. 73.

1882 A geological expedition with Gerard De Geer to the west of Spitsbergen on board the yacht *Bjona*. Considerable collections of plant fossils were brought together; the rich Tertiary flora on Nordenskiöldfjellet was discovered by Nathorst. In the Liefde-bay series at Billefjorden and Dicksonfjorden, fossil relics of fish made a dating to the Devonian period possible. Nathorst led this expedition. See Chapt. 19.

1883 Second leader on Nordenskiöld's second Greenland expedition. Nathorst studied the very rich fossil flora along the sound of Vaigat (north of Disko Island). A push northward was made with the expedition ship *Sofia* to the neighbourhood of Cape York. See p. 164.

1898 An expedition with the polar ship *Antarctic* to Svalbard and its waters. Svalbard was circumnavigated; Kong Karls Land and Björnöya were mapped and investigated. A large scientific staff was on board. Nathorst led the expedition. See p. 264.

1899 A visit to East Greenland with the *Antarctic*, officially in search of the Andrée expedition,

which was not found. A vast system of fjords and sounds was discovered, mapped and investigated. Again a large scientific staff was on board. Nathorst led the expedition.

In 1903, Nathorst initiated the Swedish expedition of 1903–04 for the relief of Otto Nordenskiöld's antarctic expedition (see p. 375).

27. THE SVALBARD EXPEDITION OF 1898.

A CIRCUMNAVIGATION OF SVALBARD

Plans, participants, and ship

Ever since his boyhood years, Nathorst had been fascinated by a picture in the travel report of the Spitsbergen expedition of 1864. The picture showed a view eastward from Kvitberget in eastern Spitsbergen. At an estimated distance of 200 km, Nordenskiöld and Dunér had seen

"...a rather high land with two rounded domes. It was the westernmost part of a still almost unknown arctic continent, which, though forgotten and omitted on the newest charts, had been discovered already in 1707 by commander Giles."

This land was, though, not really Giles Land and it was not part of a large continent, as later observations by Norwegian sealers were to show. However, it had gained in importance after the discovery of Franz Josef Land in 1872–73 by the Tegetthoff expedition. In geological respects, it was expected to constitute a connecting link between Spitsbergen and Franz Josef Land, the geology of the latter being in many ways different from that of Spitsbergen.

In 1870 Nathorst and Wilander intended to visit this land, but when their task in Spitsbergen was completed, autumn had already set in and they gave up the attempt. Moreover, since the expedition of 1870, Nathorst was eager to investigate Björnöya, where he had found indications of a large ice-sheet, a small part of which had probably once covered the island. In 1882 an attempt was made to check the observations from 1870, but the weather and sea were against Nathorst. In 1883 he went to Greenland with Nordenskiöld, and was favoured with a very rich field for paleobotanic studies.

Thus time passed, until in the 1890s he began to contemplate an expedition to the Svalbard region. Here two research areas were defined: the land seen

by and Dunér in 1864 (present Kong Karls Land) and Björnöya. Weather and ice might prevent a visit to these parts, so Svalbard as a whole with its surrounding seas was officially given as the area of research.

Nathorst had worked out a plan for an expedition at the beginning of the 1890s. But in 1895, when the situation looked bright for arranging the finances of a proposed expedition, Andrée entered the field. Nathorst deemed it wise to postpone the announcement of his expedition until the autumn of 1896, when the financial situation of Andrée's second attempt had been resolved.

Nathorst announced his expedition plans in a lecture at a meeting of the Swedish Society of Anthropology and Geography on November 20, 1896, published that year in *Ymer*. The response from the Society was positive, and sponsors signed the subscription lists—among them Oscar II, the King of Sweden and Norway, and Oscar Dickson.

The expedition was intended to be a great interdisciplinary enterprise with a qualified scientific staff. A fairly large and strong expedition ship was therefore a "must", and her interior fittings should be suitable both for the social life on board and for the scientific work. It was found advantageous to buy the ship instead of hiring her. Such a ship was found at Tönsberg, Norway: a three-masted barque with a steam engine. Built in 1871, she had carried out sealing and bottle-nose hunting in Jan Mayen waters under the name of *Cap Nord*. But in 1893, when dispatched to Antarctic waters, she had received the name *Antarctic*. She was to become a famous expedition ship in Swedish service.

Nathorst chose his friend from the Greenland expedition of 1883, Emil Nilsson, to be the commander of the *Antarctic*.

THE SCIENTIFIC STAFF CONSISTED OF THE FOLLOWING PERSONS:

Alfred Gabriel Nathorst (1850–1921), Ph.D., professor, geologist, notably paleobotanist, botanist, leader of the expedition.

Carl Filip Gunnar Andersson (1865–1928), Ph.D., botanist.

Oscar August Henrik Vilhelm Hesselman (1874–1943), B.Sc., botanist.

Axel Hamberg (1863–1933), Ph.D. oceanographer, mineralogist, geologist, surveyor (using terrestrial photogrammetry), photographer.

Carl Johan Otto Kjellström (1855–1913), lieutenant in the Swedish Army, surveyor and photographer.

Gustaf Isak Kolthoff (1845–1913), taxidermist, zoologist.

Ernst Ivar Levin (1868–1934), M.D., physician, bacteriologist.

The Svalbard expedition 1898. The scientific staff and the captain of the *Antarctic*. Bottom row, from left: Captain Emil Nilsson, A.G. Nathorst, Gustaf Kolthoff, Axel Ohlin. Top row, from left: Johan Gunnar (J.G.) Andersson, Otto Kjellström, Gunnar Andersson, Henrik Hesselman, Axel Hamberg, Ernst Levin., (Nathorst, A.G.: Två somrar i Norra Ishavet.)

Not shown in digital edition

Map of Svalbard with the route of the *Antarctic* in 1898. (Andersson, J.G.: *Antarctic*.)

Axel Gabriel Ohlin (1867–1903), Ph.D., marine zoologist.

Johan Gunnar Andersson (1874–1960), undergraduate, assistant oceanographer and geologist.

Among the ship's company should be mentioned:

Emil Nilsson (1850–1921), captain in the merchant service, commander of the *Antarctic*.

Nils Jacob Forsblad (b. 1874), captain in the merchant service, first mate.

H.J. Haslum (b. 1856), Norwegian, second mate, ice pilot; this was his 24th voyage to the Arctic.

O. Kulseth (b. 1847), Norwegian, sailor. He had been a member of the Swedish Polar Year expedition in 1882–83, and was later to take part in Nathorst's Greenland expedition of 1899 and Kolthoff's zoological expedition of 1900.

The interior fittings of the ship were modified to suit the accommodation of the expedition members as well as the scientific work. A deck-house was built, containing an "observation cabin" for the captain and a laboratory for the scientists. In the laboratory, the zoologists and botanists worked, and the doctor had his bacteriological apparatus mounted here. The taxidermist had a special cabin for his work below deck, where birds and other animals were preserved. Opposite to this cabin was the photographic darkroom with appropriate utensils and chemicals.

A telephone wire connected the crow's nest with the bridge, and with the observation cabin of the captain. With the help of an electric signalling device, direct orders could be given from the crow's nest to the engine room.

For excursions and for connections with land, the expedition had two hunting boats, a jolly-boat, a steam launch, and a canoe which was light enough to be carried overland for investigations in lakes.

The oceanographical studies were carried out from the fore-deck. Here, on the port side, was a roll with 6000 m of wire-rope, to be used for the zoological dredgings at great depths. On the starboard side was another roll with a slender line of Italian hemp, 5500 m long, for the deep-sea soundings and for taking water samples.

A visit to Björnöya, June 13–20, 1898

The *Antarctic* left Göteborg on May 25, 1898, and reached Tromsö on June 5. She put to sea on the 8th, with Björnöya as her next destination.

Ever since 1870, Nathorst had wanted to come back to Björnöya, to check and to make detailed investigations of the island's glacial striae. The question was whether the island had once been covered by a local ice-cap or by a large ice-sheet. Its geology was

only superficially known, and previous surveys had been unsatisfactory. Weather and ice had prevented many expeditions from landing, or visits had been interrupted, because there were no harbours.

The northern and north-western part of the island is a flat plateau at 40–50 m a.s.l., ending with precipitous cliffs towards the sea. The plateau—a mere stone desert—is studded with innumerable, mostly small lakes, which are almost devoid of vegetation. The southern and south-eastern portions of the island are mountainous, with cliffs abundant in birds. The most notorious mountain is Miseryfjellet in the south-east, having the three summits of Urd, Verdande and Skuld, the former reaching 535 m a.s.l. The coasts of Björnöya give excellent examples of the denuding effects of the sea, with rock pillars and arches situated at or near the steep coast.

The climate is dreary. From the north-east comes a cold current, with ice, fogs and low clouds; from the south-west come cyclones with gales and unsettled weather. But the scientific problems were challenging. The expedition stayed for a week, June 13–20, and the scientists worked hard. They knew that a strong onshore wind might force them to give up their studies.

The two surveyors were able to map the whole island, except the countless lakes, for which there was no time. Kjellström and his assistants walked along the northern coastline with their plane-table. Hamberg concentrated on the mountainous area, using terrestrial photogrammetry. When the northern party returned to the base camp at Sörhamna, they were able to complete the mapping that still remained. Björnöya was found to be substantially smaller than the old maps indicated.

The geological investigation was successful. Three geological systems, unknown until then, were discovered. The pyramidal summits of Miseryfjellet were found to belong to the Triassic system; old strata in the south of the island were seen to contain orthoceratites and other fossils which probably indicate that they belong to the Silurian system; and finally, a mighty series of fossil-bearing rocks were observed to be of lower Carboniferous age. The island had been part of a large ancient continent.

Concerning the problem of glacial striae, Nathorst wrote:

"There are no longer any glaciers on Björnöya and, until now, nothing has been known with certainty of how the Ice Age turned out on the island. When in 1870 I made my first arctic voyage and spent a few hours here, I believed, though, that I had observed glacial striae on the

The coasts of Björnöya are highly affected by the ocean. (Nathorst, A.G.: *Två somrar i Norra Ishavet.*)

Draft of a map of Björnöya carried out by Nils Dunér during the Spitsbergen expedition in 1864 (right). (Dunér & Malmgren & Nordenskiöld & Quennerstedt: Svenska expeditioner till Spetsbergen och Jan Mayen 1863 och 1864.)

Relaxation on the deck of the *Antarctic*, Midsummer, 1898. From left: Axel Ohlin, Gustaf Kolthoff, Henrik Hesselman, Gunnar Andersson. Sitting: Otto Kjellström. (Andersson, J.G.: *Antarctic*.)

The first reliable map of Björnöya was compiled by Otto Kjellström and Axel Hamberg during a week's stay on the island during the Nathorst expedition in 1898. However, there was not time enough to map the many lakes on the plateau-land in the north of the island (right). (Nathorst, A.G.: *Två somrar i Norra Ishavet.*)

Mount Misery, Björnöya, as seen from the south. (Nathorst, A.G.: *Två somrar i Norra Ishavet*.)

east coast north of Miseryfjellet. I was then only nineteen years old and did not have any great geological experience; therefore I have later often wondered whether the observation were correct. Now, however, I succeeded not only in finding my old locality and being able to ascertain that I had seen right, but also in finding glacial striae at several other places, which prove that Björnöya during the Ice Age was completely covered by an ice-sheet. Yet strangely enough, this ice does not seem to have had its centre on the high portions of the island, but on the low sandstone ground west of Miseryfjellet. This would indicate an immense precipitation in that part of the island."

Botanical and zoological collections were assembled, and the bacteriological apparatus saw continuous action.

The Bellsund fjord system, June 27–July 16, 1898

On June 20 the course was set for the island of Hopen, which was sighted on June 22. However, the swell was too high to permit a safe landing. Thus a planned mapping and investigation of the island had to be given up. Instead the *Antarctic* passed round Hopen. As she went, the island was photographed and bearings were taken towards characteristic points.

They had been sailing in ice-free waters, but from the crow's nest ice had been sighted to the north-east, and the *Antarctic* now steered in this direction. The ship penetrated the ice on June 23. At first it was mere drift-ice, more or less scattered, but finally at lat. 77°25'N dense pack-ice was met with. From the crow's nest no openings were observed, and the ice-blink was intense.

The course was set for Sörkapp, but Nathorst was not dissatisfied. The ice was not very thick, and some weeks of sunshine and mild air might render it navigable. Besides, Kong Karls Land was probably still covered in snow, which would prevent an effective investigation on land. At Sörkapp there was still much snow, so the *Antarctic* followed the west coast of Spitsbergen northward to Bellsund. There the ship anchored in Recherchefjorden on June 27, and stayed for three weeks.

Much of the scientific work on the expedition would be done to the east of Spitsbergen. But these waters are often blocked by ice in the early part of the summer, while the west coast is open or at least navigable. Nathorst considered that nothing better could be done now than mapping and investigating the Bellsund fjord system.

Kjellström surveyed the northern fjord branch,

Van Mijenfjorden, with his plane-table on the scale 1:100 000. This fjord proved to be twice as long as shown on existing maps. Hamberg used the photogrammetric method to obtain a map of the southern fjord branch, Van Keulenfjorden.

On these excursions geological, botanical, zoological and bacteriological research was also carried out, and rich collections were obtained. Nathorst was able to verify that the Tertiary flora, which he had discovered in 1882 on Nordenskiöldfjellet at Isfjorden, also prevailed here at Bellsund. He writes:

"Where these strata occur, one literally 'wades' in fossils, such as magnificent impressions of leaves from marsh cypresses, alders, limes, magnolias, etc., the leaves of which have a most exceptional size. The geologist revels in this abundance, but at the same time he suffers the torments of Tantalus, for he cannot carry with him all that he would like to have."

Nathorst was enthusiastic at hunting, but it lost appeal for him in Van Mijenfjorden, as the reindeer were too tame. At first, he and his men stole upon the animals according to the rules of the game.

"After a few days, however, we noticed that one had only to appear to make the animals come within range from sheer curiosity, and with that all pleasure from the hunt was gone... We shot just as many as we absolutely needed."

*Via Isfjorden to Kong Karls Land,
July 16–August 4, 1898*

The expedition left Bellsund on July 16 and anchored next day in Adventfjorden, which was now somewhat civilized. Large touring steamers paid visits in the summer and, on Hotellneset at the mouth of Adventfjorden, even a small tourist hotel had been built. Here they received two bags of mail, which led to a deep silence on board the *Antarctic*.

The stay in Isfjorden lasted only some days, and they visited few habitats, but still important finds were made. Already in 1882 Nathorst had discovered the first coleoptera, a staphylinid, but unfortunately it escaped. At Colesbukta the same species of coleoptera was now found, and a curculionid was discovered under the dwarf birches there. Thus two new species of beetles were added to the fauna of Spitsbergen.

On the 24th, they were in the mouth of Isfjorden with a westerly course. It had originally been planned to carry out survey work in Storfjorden, in the south-east of Spitsbergen. However, the Swedish-Russian

Arc-of-Meridian expeditions had been organized, and these would find ample opportunities to do the surveying in the Storfjorden area. Instead, Nathorst decided upon oceanographic studies to the west of Spitsbergen. Here, at the edge of the Greenland ice, the expedition with the *Sofia* in 1868 (see Chapt. 9). had measured a depth of 4850 m. Nathorst wanted to check this figure with better equipment, besides conducting ordinary oceanographic observations.

Already at the entrance to Isfjorden a remarkable discovery was made: the warm water of the North Atlantic current, the Gulf Stream, was found to extend from the surface to the bottom at 400 m. In 1890 Gustaf Nordenskiöld's expedition had only found the Gulf Stream water in the surface layers, with cold water below it. Great changes had apparently taken place, promising favourable ice conditions in the Svalbard waters.

After a short visit to Prins Karls Foreland, the ship steered westward and soundings were taken. The measurements of the depth indicated a flat bottom at about 2700 m, with a maximum of 3150 m near the Greenwich meridian. Thus, the depths within the "Swedish Depth" were on the whole about 2000 m less than measured in 1868. Hamberg had marked the line and noted the time between the marks; after the bottom had been reached, the line clearly slowed down, and Hamberg did not make mistakes.

Simultaneously, water samples were taken at chosen depths—from the bottom upward—and the water temperature was measured. On the other side of the ship, the zoologists worked with the trawl when the soundings had been carried out. Excitement was always great when the trawl came up with its catch from the great depths. The last soundings were made at the edge of the Greenland ice at longitude 3°W.

On July 30 the *Antarctic* left the West Ice, and set course for Sörkapp to round it, then proceed north-east in order to reach Kong Karls Land. She passed ice at the mouth of Storfjorden and to the south of Edgeöya, but it was mainly open and did not cause much trouble. At 01.00h on August 4, the ship entered open water to the east of Edgeöya. At 09.00h, Kongsöya was sighted; some time later, Svensköya in the west appeared, and finally Johnsenberget far to the east. At 14.00h on August 4, they anchored—with the flags hoisted—near the southern side of Svensköya.

Kong Karls Land, August 4-17, 1898

From a Swedish point of view, the interest of Kong Karls Land originates from the ascent of Kvitberget by Nordenskiöld and Dunér on August 22, 1864. To the east they had observed in the distance a rather

high land, which they believed to be Giles Land—discovered by a Dutchman, Captain Cornelis Giles. As we know, their assumption was wrong, as that land lay farther north and corresponds to present Kvitöya. The "Giles Land" of Nordenskiöld corresponds instead to the land(s) probably discovered by the English whaler Thomas Edge in 1617 and then named Wiches Land.

Both before and after the observation of Nordenskiöld and Dunér, Norwegian sealers had seen the same land from different directions; even landings had been made. The first observations were by E. Eriksen in 1853. In 1859, he sailed east of Edgeöya, discovered the present Svensköya, and came ashore for the first time on that island. He also sighted Kongsöya to the north-east. In the 1870s, the Norwegian professor of meteorology Henrik Mohn (1835-1916) scrutinized the observations of Norwegian sealers and constructed a preliminary map.

The *Antarctic* had been favoured by a fine ice situation and fine weather, but it was necessary to map and investigate the islands as fast as possible, because the waters were foul, good harbours were non-existent and the anchorages unreliable. For 28 years Nathorst had dreamt of reaching Kong Karls Land, and now he had done so, easily and without any fight against the ice.

For three days everybody worked hard at their respective occupations and sciences. But on the fourth day there prevailed a severe swell, which interfered with the communications between ship and land. Kjellström had walked round Svensköya with his plane-table. The whole of the island had been surveyed and the map was constructed on the scale 1:100 000. The geological research went on hand in hand with the surveying and the geographical studies. As mentioned, the geology of the area was of special interest as a connecting link between Spitsbergen and Franz Josef Land.

Svensköya was found to be a plateau-land reaching almost 200 m a.s.l., with lower ground at its sides. The Jurassic strata were covered with basalt, which everywhere constitutes the top of the plateaus. This basalt was once a lava stream which spread across the underlying layers of sand and clay. In the Jurassic strata below the basalt, the geologists collected both animal and plant fossils. The basalt is sometimes isolated into pillars, for example at Kapp Weissenfels in the south-east. Here Kolthoff visited the breeding-place of the ivory gull (*Pagophila eburnea*), which had been discovered here in 1897. An interesting observation was that the whole of Svensköya had once been situated below sea level, and that the change in level had been greater than on the Spitsbergen mainland; coastlines and

driftwood were found high above the present seaboard, attesting a higher ancient water-level.

The vegetation was scanty, though the mountain poppy (*Papaver radicatum*) was luxurious, and a field of shifting sand near the shore exhibited forms of plants which promised interesting studies to the botanists.

The visitors ashore were struck by the abundance of polar bear tracks—in the sand, in the clay, in the snow, even on top of the plateaus. Bear caves were observed in the snowdrifts that sloped down from the plateau crest. Marks were seen in the snow where bears had slid downward. Judging from their visceral contents, the bears which live on land seem to feed on grass or other vegetable food.

On August 8, the *Antarctic* left Svensköya and anchored to the east of a long and narrow spit of land, which projects southward from the south-western part of Kongsöya, Kapp Altmann. They had two days of fine and sunny weather here, but on August 11 they were attacked by a severe gale, which threatened to hurl the ship ashore. They were forced to weigh anchor and seek shelter on the west side of Kapp Altmann, but the strong swell and breakers still prevented them from landing even on the 12th.

The 13th was a fine day, but on the 14th, when they intended to move to the eastern part of Kongsöya, they had instead to stand out to sea and lie hove-to, awaiting the decrease of the gale which had arisen. On August 16 they again reached Kongsöya, and the next day brought good weather, so they could finish their work on the island. By the time all groups came aboard the *Antarctic*, the mapping and the investigation of the island were completed.

In its western part, Kongsöya is made up of plateau mountains, like Svensköya—with basalt on top of Cretaceous and Jurassic strata. The two highest mountains of Kong Karls Land are situated here: Retziusfjellet (320 m) and Hårfagrehaugen (306 m). To the east of this plateau, the land extends at lower levels, mostly with coastlines of basalt rubble stones in the form of terraces. The driftwood is found here on these old coastlines up to about 40 m a.s.l., still unweathered.

Still farther east is another plateau mountain, Johnsenberget (230 m), with the same geological structure as the other mountains. On the plateau mountains of Svensköya and western Kongsöya, there occurs petrified wood, sometimes as tree-trunks half a metre wide, due to the spreading of the basalt on top of the Jurassic and Cretaceous strata.

The vegetation was like that of Svensköya. Samples of red and green snow were collected in order to study the microscopic algae from which the colour of the snow is derived.

The mapping was carried out with the same distribution of work between Kjellström and Hamberg as had been used previously. Kjellström surveyed the mountainous regions in the west and east of the island with his plane-table, while Hamberg used terrestrial photogrammetry in the lowland.

While they stayed at Kong Karls Land, the sea had been free of ice, but on August 17 they observed from the highest parts of Kongsöya a thin strip of ice along the horizon to the north-east.

Originally Nathorst had intended to visit Franz Josef Land, to search for the Andrée expedition—though also with the motive of studying the geology of this recently discovered land. However, on August 12 the Norwegian sealer *Frithjof* arrived from that archipelago and her commander, Captain Johan Kjeldsen, reported that he had searched for the Andrée expedition in the whole southern part of the archipelago as far north as the ice permitted. He had visited the huts of Leigh Smith and of Jackson. Nowhere had he seen any traces of the aeronauts. Hence there was nothing for Nathorst to do in Franz Josef Land.

Passing north of Svalbard, August 18–26, 1898

In the night towards August 18, the *Antarctic* left Kong Karls Land. The scientists were satisfied to have successfully completed their work and the mapping of the islands. But they were also glad to leave the land, because the waters were foul, the weather had become unsettled and there was always the risk of ice. The course was set for Kvitöya, the enigmatic land discovered by Cornelis Giles in 1707 and later sighted by two sealing captains from Tromsø—Johan Kjeldsen in 1876 and E.H. Johannesen in 1887.

In the morning of August 18, they observed a strange domeshaped whitish surface through the hazy air. Later in the forenoon, it brightened and began to look like land, especially as the ice cliff at its foot was visible. The air became hazier and soon the ice cliff resembled real land, above which the bright surface resembled a cloud. But the visibility improved, and for a while Kvitöya lay dazzling white in front of them.

The weather was wintry with snow showers. In the evening they landed briefly at the north-eastern end of the island, where the ice cap did not quite reach the water. The sea-ice was approaching, and on the point of catching the ship. Next morning—on the 19th—Nathorst, Kolthoff and J.G. Andersson were landed on the island's south-western spit of ice-free land. The land is low here and the ground consists of primary rocks, granite and gneiss. A great number of ivory gulls had their nests on the ground, but no young ones were seen.

Driftwood occurred on old coastlines. No phanero-

The leader of the Svalbard expedition A.G. Nathorst on the deck of the *Antarctic*, July 30, 1898 (above). Photo: O. Kjellström.

The maps of the van Mijen- and van Keulenford were improved by Otto Kjellström and Axel Hamberg during the Svalbard expedition of 1898 (top right). (Nathorst, A.G.: *Två somrar i Norra Ishavet.*)

Temperature and salinity of the Svalbard waters were determined 1898 by Axel Hamberg and his assistants (middle right). (Andersson, J.G.: *Antarctic*)

With bag net and dredge the marine zoologist A. Ohlin with assistants studied the life in the ocean, Svalbard 1898 (below right). (Royal Swedish Academy of Sciences.)

Scientists relaxing in the gunroom of the *Antarctic*, 5 September 1898. (Andersson, J.G.: *Antarctic*)

gams were seen, but the ground was covered with newly fallen snow, so the men may have missed them. However, lichens and mosses were seen, and mosses were found lining the nests of the ivory gulls. Andersson wrote 44 years later:

"Nathorst collected specimens of the scanty vegetation, which consisted of mosses and lichens. Kolthoff tried in vain to find young birds of the ivory gull which occurred in great numbers. I myself walked rapidly into the coastal land of small hillocks. I wanted to obtain a general view of the bedrock during the short time I had at my disposal. A short distance inland I caught a glimpse of the slope of the ice-cap through the snow-haze.

Then sounded, also this time, the warning signal from the ship. Soon we were all leaving Kvitöya. But without suspecting it, we had left behind us, a few kilometres from our landing-place, the traces of one of the most remarkable among the many tragedies of polar exploration. There lay unknown, for many years, the death-camp of the Andrée expedition, which was first discovered by the men on board the Norwegian ship *Bratvaag*."

Once the *Antarctic* had circumnavigated Kvitöya on August 19, she steered north. But the ice became more severe, and she had to follow the ice edge towards the north-west. Next morning—on the 20th—she reached Karl XII Öyane. These two islands, Karl XII Öya "proper" and Drabanten, are now connected by a bar, but apparently they were not so in 1898.

Karl XII Öyane are, together with Sjuöyane, the extreme outposts of Svalbard towards the north. Karl XII Öya is beautiful with steep sides and a flat top. Both it and Drabanten were studied; their bedrock was found to consist of primary rocks.

With the investigation of the islands completed, the *Antarctic* proceeded north-west until lat. $81^{\circ}14'N$ was attained in the evening. Here they met with dense pack-ice. This position was to be their most northerly; but if they had come a few weeks earlier, they might have reached further north. Owing to the persistent northerly winds during the preceding days, the ice had drifted southward.

They determined the depth, then continued south-west, passing Sjuöyane—and Heclahamna in Sorgfjorden, where they cleaned the boiler of the ship—to reach Gråhuken on August 25. A push northward was made, but the pack-ice was encountered fairly soon, and they got no farther north than lat. $80^{\circ}18'N$.

They returned to Gråhuken and followed the north

coast rather closely, until on August 26 they reached Virgohamna and Dansköya. From there, Andrée had started his fatal balloon flight one year previously. The balloon shelter was found blown down by the winds.

After a sounding to the north-west of Amsterdamöya, it was time to steer south. On August 28 they crossed their outbound course of July 25, which meant that the *Antarctic* had now completed the circumnavigation of Svalbard, being the first Swedish ship to do so.

Next day they were attacked by a severe gale, which was followed by others, so that a projected visit to Storfjorden for geological studies had to be given up. On September 3 they passed close to Björnöya; and on September 7 they were back in Tromsø, having carried out oceanographic research along the way.

COMMENTS AND SUMMARY OF THE SCIENTIFIC WORK

The voyage of the *Antarctic* in 1898 had been a successful expedition—well planned, excellently realized, and favoured by fortune, the ice and the weather. The enigmatic Kong Karls Land had been mapped and investigated, Björnöya had been mapped and its geology had been studied. Nathorst was at long last able to verify his observations of glacial striae in 1870.

The Svalbard waters had been studied down to a maximum depth of 3150 m: depths, thermal conditions, salinity, and the marine flora and fauna. The layer of warm North Atlantic water was found to be thicker than previously measured, to both the west and south of Svalbard; and the ice conditions were consequently favourable. The Swedish Depth, where the *Sofia* expedition of Sept. 23, 1868 measured 4850 m, was reduced to 3150 m. Great care was exercised to obtain reliable depth measurements.

Of special interest were the bacteriological investigations, carried out by the expedition's doctor. He filtered the outside air at about 20 stations situated on Björnöya, Spitsbergen and Kong Karls Land, but he found no bacteria and very few mould fungi. Bacteriological studies were also conducted with water, snow and ice, as well as sea water from different depths down to 2700 m. The water was found to be extremely poor in bacteria—about 1 bacterium per 11 cm^3 —although the number increased somewhat with depth in sea water. The visceral content of bacteria was also studied in different animals.

A few words should be said about the botanical and zoological activity. The botanical collections from Kong Karls Land are of special interest, as the conditions here were quite unknown. Noteworthy, too, were the collections of red and green snow, and the

samples of earth and of seed. The garden, Bergianska trädgården, in Stockholm obtained 52 specimens of living plants, which all reached their destination in good condition. Biological investigations of flowers were carried out, as were studies of the plants' reaction to the air temperature and the humidity, the light intensity, and so on. A rich collection of driftwood samples was also carried home.

The zoological collections of birds and mammals were intended to become components of a projected arctic biological museum. The habits of some birds were studied.

Samples of the marine fauna were obtained with the help of scraper and trawl, at 42 stations and at depths from the surface to 3150 m. Of particular interest are the 150 samples of plankton, mostly from the surface layers but also from depths between 500 and 2100 m. The latter were the first samples of plankton ever obtained from such a great depth in the polar regions.

Finally, measurements of the geomagnetic declination were made at about 10 stations. Meteorological

data were obtained from recordings of pressure and temperature.

THREE MEMBERS OF THE SCIENTIFIC STAFF WERE TO BE HEARD OF AGAIN IN THE FOLLOWING YEARS:

J.G. Andersson had acquired much information and training as assistant to Nathorst during the expedition. In 1899 he led a small expedition of his own to Björnöya. These geological investigations were followed in 1903 by his epoch-making discoveries on the Antarctic Peninsula of fossil plants from the Jurassic period (see p. 372).

Axel Hamberg had already in 1895 begun his cartographic and glaciological work in the Sarek region of mountains and wilderness in Swedish Lapland. This pioneering work was to develop into a great interdisciplinary investigation, with several research workers (see p. 310).

Gustaf Koltthoff was in 1900 the leader of a zoological expedition to Spitsbergen and north-eastern Greenland, as part of the plans to create a biological museum in Stockholm (see p. 291).

Ivory gulls at the southwestern end of Kvitöya, Svalbard 1898. (Andersson, J.G.: Antarctic.)

28. A SEARCH FOR ANDRÉE IN EAST GREENLAND. NATHORST'S EXPEDITION OF 1899

Scientific programme and members

In the autumn of 1898 after sealers, arctic expeditions and other search tours had returned home, it appeared that the Andrée expedition—or traces of it—could not be found. Even in Svalbard the aeronauts had been sought, in vain although, as we now know, Nathorst's expedition of 1898 with the *Antarctic* had come within a few kilometres of Andrée's last camp on south-western Kvitöya.

During the same summer, the Norwegian sealer *Frithjof* had been to the southern part of Franz Josef Land, visiting the huts of Leigh Smith and Frederick Jackson on Bell Island and at Cape Flora of Northbrook Island respectively (see p. 270). But no sign of the Andrée expedition was seen. The Stadling expedition returned from the Siberian tundras and the coastal zone along the Laptev Sea, with the same negative result. Yet rumours flowed freely.

Nansen had recommended that eastern and northern Greenland should be searched. The currents in the Siberian and European sectors of the Polar Sea were westgoing, and much of the polar pack-ice drifted southward along the East Greenland coast. The aeronauts might have been carried towards and along East Greenland, if they had landed on the ice in the Polar Sea. These regions, between 70° and 76°N, were rich in game, and an expedition might be able to survive here for several years.

No search for Andrée had been carried out here, and Nathorst considered that Sweden was duty-bound to make one. Besides, the situation was favourable for organizing such an expedition. The *Antarctic* was still in Nathorst's possession, although her hull needed some strengthening. There was also unused money for the Andrée expedition, and it could be transferred to the new expedition.

On February 9, 1899, an appeal for money was addressed to the Swedish people, with successful results. The state added further funds, and Nathorst placed the *Antarctic* at the disposal of the expedition. But time was running short. From the date of the appeal to the planned date of departure, May 20, there were only 3 months and 10 days.

THE CORE OF THE SHIP'S PARTY WAS LARGELY THE SAME AS IN 1898:

Nils Jacob Forsblad (b. 1874), captain in the merchant service, commander of the *Antarctic*.

H.J. Haslum (b. 1856), Norwegian, first mate; this was his 25th visit to the Arctic.

J. Menander (b. 1877), second mate.

I. Peterson (b. 1872), chief engineer.

C.J. Flemming (b. 1877), second engineer.

O. Kulseth (b. 1847), Norwegian, sailor, carpenter and hunter.

The chances of finding the Andrée expedition were, however, rather slim. If the expedition was solely a search, it would fail entirely in the event of not finding the aeronauts. But even with that failure, it could claim success if given a scientific character, by including a competent scientific staff. Such were the plans of Nathorst.

THE STAFF CONSISTED OF FOLLOWING PERSONS:

Alfred Gabriel Nathorst (1850-1921), Ph.D., professor, geologist (notably paleobotanist), botanist, leader of the expedition.

Per Karl Hjalmar Dusén (1855-1920), engineer, botanist, surveyor, photographer.

Johan *Elis* Nilsson (b. 1863), certified forester.

Filip Åkerblom (1869-1942), Ph.D., meteorologist, oceanographer and physicist to the expedition.

Ivar Arwidsson (b. 1873), B.Sc., zoologist.

Josef Hammar (b. 1868), M.D., doctor to the expedition; responsible for ethnological studies and collecting driftwood.

H. Skoog (b. 1870), taxidermist, assistant to the zoologist.

Elis Nilsson had gone in 1894 with the Scottish whaler *Eclipse* to seek traces of the ill-fated expedition by Björling and Kallstenius in 1892 (see p. 228). *Per* Dusén had undertaken botanical research in Africa and South America.

Only Nathorst and *Elis* Nilsson in the scientific staff had previously visited the Arctic.

The total number of persons on board was 26.

Jan Mayen

The *Antarctic* left Stockholm on May 20 according to plan. At Helsingborg the coal store was eked out. During the voyage to Greenland, oceanographic observations were made on the slope of the North Sea Plateau and in the Norwegian Deep. There was a very heavy swell, which impeded the measurements and led to the loss of the sounding wire, 5000 m long, with instruments. However, it was possible to work with the wire-rope 6000 m long, so the loss did not imply a catastrophe.

On the morning of June 10, they met with the ice at lat. 70°48'N, long. 15°30'W, i.e. west of Jan Mayen. The ice was dense, packed, and impenetrable with the

Nils Forsblad (b. 1874), Captain of the *Antarctic*, 1899. (Nathorst, A.G.: Två somrar i Norra Ishavet.)

Per Dusén (1855-1920), surveyor to the East Greenland expedition 1899. (Andersson, J.G.: Antarctic.)

The expedition-ship *Antarctic* was used by A.G. Nathorst when searching for Andrée in East Greenland 1899 (top above). (Nathorst, A.G.: Två somrar i Norra Ishavet.)

The volcanic island of Jan Mayen was visited for the first time by a Swedish expedition during the Nathorst Greenland expedition of 1899. The volcano Beerenberg (2277 m a.s.l.) dominates the landscape (above). (Nathorst, A.G.: Två somrar i Norra Ishavet.)

The *Antarctic* in Franz Josef Fjord 1899. The sky was clear, there was no wind and practically no ice—and the land was virgin and unmapped (left). (Andersson, J.G.: Antarctic.)

ship; it was still too early in the season. Tongues of ice extended east-west; finally the ice-edge took the same direction, forcing the ship to steer east towards Jan Mayen, which was reached on June 12.

The *Antarctic* anchored in Rekvedbukta at the south-eastern side of the island. No Swedish expedition had ever visited Jan Mayen.

In 1863 the zoologist August Quennerstedt, on the Norwegian sealer *Jan Mayen*, had worked in the area, but his hope of coming to the island had not been realized (see Chapt. 6).

The first documented discovery of Jan Mayen took place at the beginning of the 17th century. English and Dutch whalers were then hunting in the area. The discovery was made according to some sources by the Englishman Henry Hudson in 1607, but according to others by the Dutch whaler Jan Jacobsz May van Schellinkhout in 1614. From the latter candidate, the island received its name. Whaling was done around the island in the first half of the 17th century, mainly by the Dutch.

During the Polar Year of 1882–83, Austria had a scientific station on Jan Mayen, which then became properly mapped and investigated. In 1921 a meteorological station was established on the island by Norway, since when it has been a scene of official Norwegian activity. In 1922, Jan Mayen was annexed for Norway by the Norwegian Meteorological Institute; but not until February 27, 1930, did it become a part of Norway by law.

The island is volcanic, and is dominated by the partly ice-covered volcano Beerenberg (2277 m a.s.l. according to the latest Norwegian measurements), which lies in its north-eastern part. The south-western part is also mountainous, but less broad and lower. Between these two areas are the most accessible parts of the island, though heavy swell often renders a landing dangerous or impossible. Human activity has therefore been restricted to these parts of the island. But no harbours exist.

The expedition remained at Jan Mayen during June 12–24, so the members had a good opportunity to become familiar with the specific weather conditions prevailing at the island: sudden increases of the wind to gale force or more; excellent visibility and a cloudless sky deteriorating to an overcast of low clouds or a dense fog, often in combination with strong winds; a rough sea and heavy breakers, which often occur, preventing communication between land and ship in situations with an onshore wind.

To begin with, the men had no suspicions about the whims and malice of the Jan Mayen weather gods. On the first day, Nathorst and Nilsson attempted to land with a small boat, but had to give up and return to the

ship. Dusén and Hammar were more successful and spent the day at Rekvedbukta, the former occupied with botanical work.

Next day Nathorst, Forsblad and Nilsson landed at the south-eastern part of the island. A short walk was taken in the surrounding country, and the grand view near Beeren Gat was admired. The long boat trip back to the ship became adventurous, the wind having freshened in combination with a dense fog and a rough sea.

Those on board had been very anxious over the absence of Nathorst, and soon he himself would find cause for alarm. The doctor had disappeared, paddling alone in the canoe towards Jamesonbukta east of Eggöya. However, a relief boat-party found him the next day, took him aboard and towed the canoe back to the ship. The doctor's night had not been agreeable. He had intended to go overland to the Austrian station but was discouraged by the dense fog—perhaps luckily, as matters could have turned out even worse. Nathorst writes:

"I do not know that I have ever been to a place where the weather has been subject to such rapid changes as at Jan Mayen. In the morning of the 15th we had strong winds with nasty weather and a temperature at or only a little above freezing. But then the wind died down and at the same time it began clearing up and Beerenberg appeared, at first only partly and then altogether. One admires the mighty volcano anew each time it is unveiled, and one never gets tired of seeing it. How magnificent beyond description it must have appeared in full volcanic activity. It is twice as high as Vesuvius."

Nathorst comments on the situation later that day, June 15:

"The swell was, however, on this day still heavier than before, so a landing was out of the question. The young members were, of course, very impatient, when they saw the land so near without being able to go there. On arctic expeditions one is not allowed to miss opportunities which are offered, nor to be enticed into undertakings at the wrong moment from mere impatience. One must have the patience to await the right moment and then without delay take advantage of it. I expected southerly wind in order to proceed to the northern side of the island, where we would find shelter. Where we were now, we had to busy ourselves with a little of everything while waiting: zoological scrapings can always be carried

out, and create further work with sorting and preparation of the material."

The day had been clear, but in the afternoon they became encircled by fog. Nathorst expected southerly wind, and orders had been given to weigh anchor at 04.00h next morning.

The ship rounded Northeast Cape, and during the passage they enjoyed the magnificent views of Beerenberg as seen from different directions. To the north, the drift-ice was seen from the crow's nest. The southerly wind had increased, enabling them to study and enjoy the flight of the fulmars.

In the afternoon they anchored off the Austrian Polar Year station from 1882-83. The swell was now inconsiderable, as an offshore wind prevailed, though strong. There were no longer any problems with communication between the ship and the land. But the wind had risen to a severe gale, with heavy gusts in between. All scientists took the chance to come ashore.

The purpose of landing was not only to carry out scientific research. They also wanted to search for traces of Andrée, not least the buoys thrown out from his balloon. Nilsson and Hammar investigated the low beaches on both the southern and northern sides of the island. But no signs of the Andrée expedition were found.

The Austrian station, near the landing-place, consisted of two large houses, besides observation huts and storehouses. The two dwelling-houses were rather oddly constructed. They looked like ship hulls, turned upside down and cut off vertically fore and aft, in order to prevent snow from collecting upon the roof. The houses had now begun to fall into decay. This type of hut was to become common during World War II.

Most of the scientists enjoyed the outdoor life, and preferred to remain ashore under the primitive and humid conditions in one of the Austrian huts. They spent two days here in misty air, strong winds and rain. The nearest surroundings were investigated as carefully as conditions allowed. When Nathorst visited them on the 17th, he still found them happy and satisfied, but when the weather did not improve next day, they were called back to the ship.

On the 19th there was still fog, but otherwise the weather had improved, and some of the scientists went ashore again. Dusén botanized, and Nathorst and Nilsson were able to make an excursion from the Austrian station, even if there was not much use walking around without getting any general view of the neighbourhood. Nathorst comments:

"Anyway with luck we managed to mount one of

the most regularly shaped volcanoes, viz. Hochstetter Crater, with a fine, ice-free little lake in the bottom of the crater, so the wandering was not wanting in interest."

Another excursion party, though in a canoe, returned to the ship with the information that the conditions were better in Walrus Gat, a part of English Bay. There were interesting and beautiful mountain formations, and on the sandy beach lay tremendous amounts of driftwood. They also noted remains of Dutch train-oil "factories". Great quantities of whale bones on the beach, too, attested the activity of the Dutch in the 17th century. Most remarkable were the steep rocks and the display of colour—black, red, green, yellowish green and white—exhibited by the volcanic rocks, the vegetation below the breeding-places of the birds, the mosses, the white snow patches and the waterfalls.

Dusén was busy botanizing here. Somewhat surprisingly, the mountain poppy (*Papaver radicatum*) was not found. Jan Mayen is perhaps the only arctic land where this flower does not grow. Dusén also found two or three species of phanerogams, and many species of mosses, which had not previously been recorded from Jan Mayen.

Through the East Greenland ice

The expedition was to leave Jan Mayen on the morning of June 24, Midsummer Day. Midsummer Eve was devoted to celebrations and activities on board the *Antarctic*—and the weather was fine. At 06.00h on Midsummer Day, the ship weighed anchor and stood out to sea on a north-north-westerly course, in order to find out the position of the edge of the pack-ice.

The East Greenland pack-ice is rightly feared by arctic travellers, and many are the shipwrecks which have been suffered here. But conditions vary from one year, or even month, to the next. Between latitudes 73° and 75°N, however, the chances are fairly good of penetrating the ice and reaching Greenland, at least in most years if a strong steamer is used.

On the evening of June 24, the *Antarctic* reached the edge of the ice and followed it eastward, then north-east and north. The captain was looking for a place where the ship could enter the ice, but everywhere it was too densely packed. Finally on June 27, at lat. 73°12'N, long. 5°10'W, the ice looked promising and its outer margin was penetrated, after which more open ice was reached. The course was set towards the north-west. Roughly 400 km now separated the ship from the Greenland coast at Pendulum Island. The ice floes were very dirty, and Nathorst remarks:

"This state of things is no accidental occurrence; it is common. The dirt consists of clayey mud, driftwood is common here, and if one examines these floes closely, one will also find small twigs, probably of arctic species of willow, mosses, etc., which indicate that the ice originates from some coast. Past investigations have all confirmed the opinion of Nansen, that this ice comes from the icy seas of northern Siberia."

For five days the ship was able to proceed westward through more or less open ice, though now and again she had to lie still owing to fog. It had not been necessary to ram the ice until June 30. However, the character of the ice had changed during this time, from floes having a diameter of 50–100 m to floes with a diameter of several kilometres. The floes were not flat, but looked like slightly broken ground covered by snow due to the pressure ridges.

On June 30 they met the whaler *Balaena* of Dundee, under Captain Robertson, who had already been near the coast and now gave the *Antarctic* people good hopes of reaching it. But they encountered heavier ice, at first in combination with reduced visibility. In the night towards July 2, the visibility improved. Before them lay Pendulum Island and the Greenland coast between 74° and 75°N. There was heavy ice ahead, calling for much ramming and hard work, until on July 2 the ship entered an ice-free sea. The sky was clear and visibility was good. Pendulum and Sabine Islands were in front of them, and apparently they had now got free of the ice. Farther north, the southern part of Shannon Island seemed to be free of ice.

Scouting along the East Greenland coast

They had reached east Greenland earlier than any expedition before. Captain Robertson had mentioned that July 10 was the earliest approach he had ever heard of. But they did not get to the land so soon. With about half an hour to go, the fog swallowed them and a fresh onshore wind arose. Nothing remained but lying hove-to, and so they stayed until July 5, with the rig enveloped in hoar-frost.

Visibility improved and they got a view of the surroundings. They steered towards the southern part of Shannon Island, but found coastal fast-ice along its shore. They now followed the ice edge towards Pendulum Island, yet the fog returned. In the evening they moored to the ice-edge off the eastern side of Pendulum Island. Next morning—July 6—Nathorst, with Nilsson and two of the hunters, started towards the island with the intention of passing across it and meeting the ship at the southern side of the island.

From a distance, Pendulum Island appeared utterly sterile, with its dark basalt mountains and blocks of stone. But when they landed, the men were astonished by the rich vegetation. Nathorst noted 48 phanerogams. Large hairy caterpillars, crane-flies, small butterflies, and flies occurred in sizeable numbers; even a few bumblebees were seen. The men were rather tired when they returned to the ship.

The most valuable work was anticipated near the large Franz Josef Fjord. It had been discovered by the Second German Polar expedition under Captain Carl Koldewey and Julius Payer in 1869–70. The coastal zone in the same area had been roughly mapped from ships sailing some distance away from the land—by William Scoresby Jr. in 1822, and by Douglas Clavering on an expedition in 1823 to make pendulum observations in Norway, Spitsbergen and north-eastern Greenland, and in lower latitudes. These measurements were carried out by the great British geophysicist Edward Sabine (1788–1883) (compare p. 26).

A remarkable event during the latter expedition had been the discovery of a group of twelve Eskimos at a site. The Eskimos fled, but returned to make friends with the British party. The Eskimo site was situated on the northern side of Gael Hamke Bugt. Nearly 50 years were to pass before a ship next visited the area. The Eskimos had by then disappeared, but tent rings and traces of winter huts were found along the coast. The remarkable thing was that—as far as anyone knew at the time—there were no other Eskimos in the whole of East Greenland; the inhabitants of south-eastern Greenland were practically unknown as yet. As was found by the end of the 19th century, Eskimos lived from Angmagsalik southwards.

It was too early to make an attempt to penetrate into the fjords. At first it would be necessary to keep to the coastal zone, not least because they were looking for signs of Andrée. Nathorst had also promised Nansen to establish a depot for the Second Fram expedition under Otto Sverdrup (compare p. 232). This very comprehensive depot was established on July 9 at the western side of Walrus Island, near Sabine Island.

Two regions on the east coast had been well mapped: the one near Pendulum Island, where the German expedition under Koldewey had wintered in 1869–70, and Scoresby Sound to the south, where the Danish expedition under Lieutenant Carl Ryder had worked in 1891–92.

From the depot established on Walrus Island, the wintering harbour—Germaniahafen—of the German expedition on Sabine Island could be seen. Nathorst paid a visit to the place. Apparently nobody had visited

The second German Polar Expedition of 1869-1870 under Karl Koldewey was a predecessor to Nathorst's expedition of 1899. Note the visits of the German expeditions to Franz Josef Fjord. (Payer, J.: Upptäcktsresor i Norra Polarhavet.)

The southern side of Franz Josef Fjord from a photo by P. Dusén, 1899. To the left the snow-covered Payer Spitz (2100 m a.s.l.) which was climbed by the Austrian member of the German expedition, Julius Payer in 1870. (Nathorst, A.G.: Två somrar i Norra Ishavet.)

the place since the Germans left in 1870. Nor had the Andrée expedition, although it would have done so if it had reached these regions. Nathorst also visited some old Eskimo huts here.

On July 14 the *Antarctic* steered south from Flache Bugt, south of Walrus Island, in order to reach Gael Hamke Bugt, but a north-easterly gale drifted the ice into the bay. They experienced a severe gale here, together with three Norwegian sealing vessels. At times the wind reached hurricane force. After the weather had improved, the *Antarctic* headed for Cape Mary, the eastern headland of Clavering Island. Here they found several Eskimo graves, which provided them with human skulls and ethnographical objects. The vegetation was rich, and the mosquitoes were many.

On July 17 they were able to push westward along the southern shore of Clavering Island. They hunted musk-oxen, as they had done on several of the previous days. Nathorst, the sportsman, was to be enthusiastic in his tales of these hunting expeditions.

In the evening they steered towards Franz Josef Fjord. Payer's descriptions are vivid when dealing with the fauna and flora of this fjord. The area would be excellent for an expedition trying to sustain life. If Andrée had come so far, it is highly probable that he would have visited the fjord. However, the coastal ice now prevented a visit. They stayed here till July 22.

Nathorst had come to the conclusion that Franz Josef Fjord demanded an investigation, both with regard to the fate of the Andrée expedition and from scientific considerations. As he could not yet enter the fjord, he decided to wait and meanwhile follow the Greenland coast southward to Scoresby Sound. After scientific investigations there, he would return north and make a new attempt.

The passage south supplied opportunities for polar bear hunting. On July 28 they reached the Liverpool Coast and followed it in ice-free water. They enjoyed the alpine character of the mountains and the many glaciers. They saw masses of little auks. The great number of stately icebergs still had the charm of novelty. Red snow was seen everywhere.

They spent the night in Holloway Bugt and next day, July 29, they continued the passage towards the south. It had been snowing in the morning, but it cleared up gradually, and this fine weather was to remain during the rest of their voyage. In the evening they anchored at Cape Stewart on the northern side of Scoresby Sound, just off the ruins of Eskimo huts, which had been described by Scoresby. In 1891 and 1892 Carl Ryder had established a depot here, which might have been used by Andrée if he had reached so far south. But there was no message from him. Thus

it would not pay to seek him and his companions farther inside the fjord.

While waiting for Franz Josef Fjord to become ice-free, Nathorst decided to investigate the inner portions of Hurry Inlet, which had never been visited by a scientific expedition. They stayed here until August 7. Studies in geology, zoology, botany and ethnography were conducted, and Dusén mapped the inner part of the fjord. They observed two white wolves, proving beyond doubt that Greenland had been invaded by these animals from Arctic Canada.

The valley opening northward along the large river, which debouched into the inlet, turned out to be a real desert landscape with shifting sand, sand-polished flat rocks and stones. Violent winds often arise here and form clouds of dust. Sand dunes occur on the western side of the river.

They were visited by Captain Robertson of the *Balaena* and—as he was going to Iceland for bunkering—the expedition got a welcome opportunity to send letters home. On August 7, they steered out of Hurry Inlet for a new attempt to enter Franz Josef Fjord.

An unknown region of mountains, glaciers, sounds and fjords

This time they encountered no significant difficulties. The *Antarctic* steamed into Franz Josef Fjord on the morning of August 9. It was with high expectations that they now began to explore this fjord and its many branches. The German expedition of 1869–70 had given enthusiastic descriptions of its beauty and its flora and fauna. The Germans, though, had not reached its bottom. About halfway, they were forced to turn back by the bad state of the ship's boiler. After 1870 the fjord had not been visited.

The high mountains surrounding the fjord exhibited different colours—red, brown, grey—and in the fjord majestic icebergs were swimming. From these, sounds were heard like the thunder of guns as new crevasses opened.

In the night, the *Antarctic* passed the Teufelschloss (Devil's Castle) of the German expedition. This is a grand, many-coloured mountain, at a narrow passage of the fjord, which was now almost blocked by icebergs. On the morning of August 10, they reached the point where the Germans had turned back.

The *Antarctic* was now steaming in waters where no ship had ever been. The fjord became more narrow, contrary to what the German map indicated. Looking at the almost vertical mountain sides, 1200–1800 m high, one had to turn one's head backwards, and the mountainsides seemed to be overhanging.

The fjord's westward extension was shorter than

given on the German map. The report of Payer on the landscape at the innermost portions of the fjord is somewhat exaggerated, though the landscape is imposing enough. To the west lay Petermann Spitze, which is not as high as Payer's estimate of 3500 to 4270 m a.s.l. To the north were lofty mountains with hanging glaciers; to the east steep rock-faces; and to the south Kjerulf Fjord, narrow and enclosed by majestic mountains, its inner parts packed with stranded icebergs.

The *Antarctic* anchored at the mouth of Kjerulf Fjord, in such shallow water that the drifting icebergs could not reach her. This place was not without danger from ice and winds, but fortunately the days were calm and the glacier in the fjord bottom did not calve. The men had opportunities to see the luxuriant vegetation of the Greenland fjords, and ethnographical finds were obtained from some old Eskimo huts. They also observed reindeer and shot some.

But the most important task ahead was to construct a map of the wonderful fjord region they had entered. This task gradually emerged as much more important and comprehensive than they had ever imagined. Per Dusén, the surveyor and botanist to the expedition, was becoming the most valuable man on board.

During the planning of the expedition, it had been thought that surveying should be done photogrammetrically. But it was already evident that this method would be less practical here, because of the narrow fjords and the absence of beaches at many places. Dusén had maintained that the mapping should start from the bottom of the fjord, once the conditions became known and the most practical method could be chosen.

It was apparent that the innermost portions of the fjord could be surveyed by the ordinary method, using a plane-table and measuring a base-line. The innermost part of Kjerulf Fjord could not be reached overland, but Dr. Hammar travelled by canoe along this entire fjord branch and was able to produce a sketch map.

By far the greatest part of the surveying had to be done from the ship, proceeding with constant speed along chosen courses. These were read from the ship's compass and fixed with distant objects, such as mountain peaks or a marked patch of snow. From the ship's speed and the time, her position would be known at any moment. By using a plane-table, the bearings to different objects could be entered in the usual manner, and the points of observation were also known on the map. A table of time versus distance was drawn up in advance.

The speed of the *Antarctic* was 6 knots with full steam pressure, but this was valid—and was checked—

in a calm and with no currents in the water. Fortunately, the entire period of surveying was characterized by a calm and clear sky, except on three occasions. To correct the positions on the map of the points in the landscape, astronomical determinations of latitude and longitude were carried out by Filip Åkerblom, requiring stops for some hours at suitable places. These stops were greedily exploited by the other scientists on board.

The *Antarctic* stayed at Kjerulf Fjord during August 10-13, while the surveying here went on. On the last day, she proceeded out along Franz Josef Fjord to the anchorage of the *Germania*, east of the mountain Payerspitze. There on the 14th, a fjord branch opened towards the south-east. To begin with, they expected that the branch would be short; but soon they found that they were in a sound—Antarctic Sound. This gradually widened and opened into a larger water, where an island of conical shape was situated. It was named Ruth Island on the same day.

Now it seemed essential to give priority to the mapping. Yet Nathorst, the leader and scientist, would have to decide. He describes his situation:

"After seeing how extensive King Oscar Fjord with all its branches really was, I found myself in a rather awkward position. I realized that it would be necessary to choose between mapping the fjord and fully investigating it in scientific respects; there was no time for doing both during the short part of the summer that still remained. To choose the mapping was natural, as it would not do to have made all these geographical discoveries without being able to show what they really were. We now had permanent sunshine, the summits of the mountains were not hidden by clouds, and the calm weather supported this work in every way. But as the mapping had to be carried out from the ship, the consequence would be that we would come ashore only on the occasions when the *Antarctic* had to lie still in the evenings, or when astronomical observations were made. With aching hearts we often had to pass the most tempting places in geological, botanical, zoological and ethnographical terms, and leave the bulk of the scientific research to those who were to come after us. But this ruthlessness was necessary, and it paid off, for the map did become completed, in spite of the fact that geographical discoveries were being made at the same time."

They were now in unknown territory; no ship had been here and no European had ever seen the region.

Map of Jan Mayen (above). Barr, S.: Kulturminner på Jan Mayen.

East Greenland, where the Nathorst expedition worked in 1899. (left). (Andersson, J.G.: Antarctic.)

Pointed mountains—Syltopparne, 1570 m a.s.l., from a photo by F. Åkerblom, 1899. (Nathorst, A.G.: Två somrar i Norra Ishavet.)

A wide expanse of water opened to the south, where the view was limited by glaciers and high pointed mountains. This was King Oscar Fjord, the most important discovery of the expedition. Towards the east a waterway opened, which they presumed to lead to the ocean. This lead, later named Sofia Sound, was entered first of all. During the following days they entered all the branches of King Oscar Fjord, and the weather remained excellent—calm with a clear sky. Once, on August 16, there was fog, but this day could be used for bringing stones as ballast to the ship.

South of Sofia Sound, they found another waterway leading east to the ocean, Vega Sound. Towards the west opened two fjords with branches in their inner portions, Kempe Fjord and Segelsällskapets Fjord. The waters were treacherous. In some areas lay small islands and underwater shoals, so great care had to be exercised in the handling of the ship.

The people on the *Antarctic* were pioneers, and they travelled through a landscape of exquisite beauty and grandeur. Besides, the weather was ideal. The men must have been gripped by a feeling of adventure and exhilaration as the days passed on. Nathorst writes:

"We enjoyed the grand surroundings to the full during these days. The eastern sides of the fjords are built up of red and greenish-grey sandstones and schists of Devonian age, and present many magnificent mountains, especially Kungaborgen (Royal Castle). The south-western side of the fjord towards Davy Sound is a grandiose alpine landscape, with tremendous peaked summits, Syltopparne, and many glaciers. Ella Island has on its western side almost vertical walls, and Bastionen is particularly majestic... In sum, we enjoyed one surprising, spectacular scene after the other. And it was strange to imagine that we were the first white men who had been granted the privilege to behold these regions. I say white men, because the Eskimos have in times past lived here; we found evidence of this at several places."

On August 24 they passed through Antarctic Sound in order to reach Franz Josef Fjord—the ice still barred the entrances to the sounds further south. To begin with, they visited the fjord branch to the north of Payerspitze. Nathorst was most impressed by the icebergs:

"I doubt that larger icebergs are to be found anywhere in the north polar regions than here and in Scoresby Sound."

They now continued the mapping of Franz Josef Fjord eastward, and passed the mountain Teufelschloss to reach Cape Weber at the entrance to Geologfjorden. Here they obtained rich ethnographical harvests from some old Eskimo huts. They entered the narrow Geologfjorden and then Nordfjorden, at whose bottom they discovered the long and narrow Myskoxefjorden. Farther east, near the mouth of Franz Josef Fjord, they entered and mapped Duséns Fjord. Finally the mapping was completed at Cape Franklin, where they built a cairn. In it was placed a report on the expedition and discoveries, as a safeguard in case the *Antarctic* were to meet with disaster on her voyage home.

On August 30 the *Antarctic* stood out to sea, taking a south-easterly course. She became enveloped in fog, but passed the ice rapidly and, already on September 1 with improving visibility, passed through the belt of heavy ice which bordered upon the open sea. On September 17, the *Antarctic* arrived in Stockholm with 70 tons of coal left in her bunkers.

It had been an extremely successful and happy expedition, favoured by fortune. But Andrée and his two companions had not been found. These had reached their journey's end two years earlier at Kvitöya. Nevertheless, to Nathorst and his colleagues, the search had fulfilled a duty.

A SUMMARY OF THE SCIENTIFIC WORK

The scientific results of Nathorst's Greenland expedition of 1899 were briefly as follows:

In cartography, the large complex of fjords and sounds lying between latitudes 72°–74° N in north-eastern Greenland had been mapped in detail. The principal part of the region had been discovered, notably King Oscar Fjord with its adjoining fjord arms and sounds. The inner part of Hurry Inlet at the mouth of Scoresby Sound had also been mapped. Hand in hand with the surveying went astronomical determinations of latitude and longitude. The mapping became, by force of circumstances, the most important part of the expedition's work in the field.

Geological studies mainly elucidated the geological structure of the fjord system. The previously unknown Silurian and Devonian systems in East Greenland were discovered.

Botanical collections were gathered in Greenland and on Jan Mayen. Samples of driftwood were collected in both regions.

Zoological work consisted of preparations of musk-oxen, collections of insects, marine and other animals. Throughout the voyage samples of plankton were collected.

Hydrographic series were taken during the voyage.

Meteorological observations were made regularly and, at some places, geomagnetic observations were carried out.

Ethnographic collections were brought home.

29. GEOLOGICAL AND BIOLOGICAL STUDIES ON BJÖRNÖYA

J. G. ANDERSSON'S EXPEDITION IN 1899

Björnöya (Beeren Eiland, Bear Island, Cherrie Island) was discovered in 1596 by a Dutch expedition of two ships, which had been sent to discover a North-East Passage to the Far East. Willem Barents was officially chief pilot of the enterprise, but is generally termed its leader. After the discovery of Beeren Eiland (Björnöya), the expedition sailed to Spitsbergen, which was likewise now discovered. From there, one of the ships, with Barents on board, passed via Björnöya—to the north of Novaya Zemlya, where the party had to winter in a house built on the land. Barents died in the following summer, when the party was returning to civilization in two boats.

In 1603 an English expedition visited Björnöya. Dispatched by Sir Francis Cherrie, it was led by Stephen Bennet on board the *Grace*. The English did not know about Barents' discovery seven years earlier, and named the island Cherrie Island, which was later sometimes turned into Cherry Island. In the following years the island was often referred to as Cherry Island or Cherrie Island, alternating with Bear Island and Beeren Eiland—the latter name being given in

remembrance of a fight with a polar bear, which had troubled the Dutch discoverers.

Björnöya was subsequently visited by various hunting and fishing expeditions. The first scientific studies of Björnöya were undertaken by the Norwegian geologist Baltazar Mathias Keilhau (1797–1858) in connection with his visit to Spitsbergen in the summer of 1827 (see pp. 18 and 54). The Swedish Spitsbergen expeditions in the latter half of the 19th century made repeated attempts to land on the island, but sometimes failed because of strong winds with heavy breakers along the shores, fog for long periods, and ice. The table gives an idea of the successful attempts.

Among non-Swedish visitors to the island should be mentioned the Norwegian Sivert Tobiesen, who in 1865–66 wintered here for hunting purposes. The first series of meteorological observations from Björnöya was made by Tobiesen and his men during their stay.

The Swedish Svalbard expedition of 1898 under A. G. Nathorst spent one week on Björnöya. During this time the first reliable map of the island was produced and scientific research was carried out, notably geological investigations by Nathorst and his young assistant Johan Gunnar Andersson (1874–1960). Thanks to the interesting geological results, Nathorst proposed that Andersson should organize and lead a small expedition to Björnöya. It was to stay for a summer on the island without risking interruption by poor weather, ice or fog, or by conflict with the wishes of other expedition members.

Plans and members

In connection with the geological field work during the cruise of the *Antarctic* in 1898, J. G. Andersson had been instructed and trained very efficiently by Nathorst. After his return home, Andersson began

VISITS TO BJÖRNÖYA BY SWEDISH EXPEDITIONS

<i>Time</i>	<i>Leader</i>	<i>Ship</i>	<i>Stay on the island</i>
1864	A. E. Nordenskiöld	<i>Axel Thordsen</i>	18–19 June
1868	A. E. Nordenskiöld	<i>Sofia</i>	22–27 July
1870	Hj. M. Wilander and A. G. Nathorst	<i>Lydianna</i>	12 July
1892	A. Hamberg	<i>Gjöa</i>	18–19 June
1898	A. G. Nathorst	<i>Antarctic</i>	13–20 June
1899	J. G. Andersson	<i>Skytten</i>	23 June–19 August
	Haalogaland, Terschelling		
1965	Stockholm University expedition, leader S.-R. Ekman	<i>Nordssyssel</i>	May–June

planning his own expedition. It was modest in scale, with two scientists, as well as two Norwegian assistants for the practical tasks. Later on, Andersson added further studies to the geological survey of the island.

THE SCIENTIFIC PROGRAMME WAS FINALLY ESTABLISHED AS FOLLOWS:

1. A geological survey of Björnöya.
2. Meteorological observations to complete Tobiesen's series covering July 29, 1865-June 19, 1866; the interval June 20-July 28 was missing to obtain a full annual series.
3. Biological studies, notably concerning the development of the flora and fauna during the arctic summer; experiments with cultivation were to be made in order to learn the influence of the permanent daylight upon plant life.

This expanded programme required that a biologist be engaged on the expedition.

THE MEMBERS OF THE EXPEDITION WERE:

Johan *Gunnar* (J.G.) Andersson (1874-1960), B.Sc. (Ph.D. in 1901), geologist, leader.

Carl *August* Forsberg (1877-1901), undergraduate, responsible for the meteorological observations and the complementary mapping; he also assisted in the geological survey.

Carl *Gustaf* Swenander (1874-1953), B.Sc. (Ph.D. 1903 in zoology), zoological and botanical studies. Assistants (Norw.: "altmuligmen"): H. Jacobsen and P. Jørgensen, both from Tromsø.

The expedition was financed by grants from the Vega Fund, the Lars Hierta memorial fund, and private sponsors.

Coming to Björnöya

J.G. Andersson left Stockholm alone in order to make arrangements for the passage from Norway to Björnöya. He also wished to inform himself on the ice conditions. At Trondheim he met the chief of the Vesteraalske Dampskibsselskab, with whom he made a contract about the return passage from Björnöya to Norway on the tourist steamship *Lofoten* in the latter part of August.

Most important was that Andersson, later at Tromsø, met the whaling captain M. Ingebrigtsen, who used to extend his hunting cruises as far north as Björnöya. They had already negotiated concerning the expedition's passage north, and Andersson was now invited to go north with Ingebrigtsen and study the ice situation.

Northern Norway was still covered in snow, and during the reconnaissance, May 26-30, they got an idea of the capriciousness of spring. Gales and snow-

fall alternated with calms and sunshine, over ice-fields which were dazzling white.

The ice-edge was situated 70-80 nautical miles to the south of Björnöya, and about 30 nautical miles to the west. It was impossible to navigate through the ice, and Ingebrigtsen did not think it worthwhile to make a new attempt until the middle of June. There was nothing to do but return to Tromsø and wait. Meanwhile Andersson telegraphed to the head of the Russian section of the Swedish-Russian Arc-of-Meridian expedition in Spitsbergen, and asked for a passage north—but these transports were also delayed.

On June 13, Swenander and Forsberg arrived in Tromsø to join the expedition. The same ship carried the well-known Russian arctic traveller Eduard von Toll (1858-1903), who tried to arrange a passage north on the large Russian icebreaker *Yermak*. But she did not visit Tromsø, and von Toll had to board her at Hekkingen lighthouse, at the mouth of Malangen south-west of Tromsø.

Finally, on June 18, the members of the Björnöya expedition left Tromsø and travelled north, to board the two ships of Ingebrigtsen at his whaling station in Troldfjorden north of Hammerfest. The ships were the whaling steamer *Skytten*, on which Andersson became a passenger, and the steamer *Haalogaland* with the rest of the expedition including the equipment. The latter steamer was hired for the specific purpose of towing killed whales.

The two ships stood out to sea on June 21. Next day, when dead reckoning placed them about 30 nautical miles from Björnöya, they became enveloped by the "normal" fog of the region in summer. They wandered about, on this and the following day, without knowing exactly where they were—although the depths were low, 25-30 m, indicating that they must be on the Björnöya bank. The fog was dense in horizontal directions, but the blue sky was visible near the zenith. The two ships had to navigate cautiously, to avoid colliding with each other or losing contact.

After they had proceeded east some distance, the visibility improved and the island appeared about 30 nautical miles away. Soon the ships anchored off the mouth of Russeelva. The harbour here was named Russehamna; it was the Sydhamn of Nordenskiöld and Dunér. The weather was excellent for landing equipment. Their stores were soon on the beach, and at 21h on June 23 the ships left Björnöya.

Life and weather on Björnöya

The place had all necessary advantages. They could pitch their two tents on a terrace of river gravel, the site was dry and rather sheltered from heavy winds, and Russehamna offered a safe boat-haven. One of

The Björnöya expedition of J.G. Andersson in 1899 established its camp at Russehamna in the southeast of Björnöya (above). (Andersson, J.G.: Kineser och pingviner.)

Björnöya was discovered by Willem Barents in 1596 and given its Dutch name Beeren Eiland. From Björnöya Barents sailed to Spitsbergen, and then via Björnöya to Novaya Zemlya (below). See also Chapter 15, p.94. (From Barents map of 1598.)

During the expedition of 1864 A.E. Nordenskiöld photographed a rock outcrop with a marked "gate", which he named Borgmesterporten, after the many glaucous gulls (*Larus glaucus*), popularly called borgmester (photo see p. 49). Borgmesterporten was later observed by the Sofiaexpedition in 1868 and by Wilander and Nathorst in 1870. But in 1898, Nathorst could not locate the "gate" in spite of several visits to Russehamna. However, in 1899, the expedition of J.G. Andersson brought home a photograph showing proof that the Borgmesterporten had collapsed (below).

(Andersson J.G.: Kineser och pingviner.)

Today there are no glaciers on Björnöya, but observations since 1870 (Nathorst) and later by Swedes and Norwegians indicate an ice-flow outwards from the centre of the island. Observations also indicate a vast ice-sheet between northern Europe and Svalbard. The ice-flow found in Björnöya may represent the conditions at a later stage, i.e. with the Björnöya ice more or less isolated from the main ice (above). (Horn & Orvin: Geology of Bear Island.)

the tents served as a home, the other being used for scientific work and for housing the collections. At the campsite, they also set up a hotbed, where Swenander would start with cultivation experiments. On top of a hillock nearby, overlooking the camp, they mounted a meteorological mast to show the wind speed and direction. Here too, other meteorological variables were measured or recorded. Observations were carried out only twice a day, at 08.00h and 20.00h, since the observers mostly worked in the field by day.

The observations included air temperature and humidity, air pressure, direction and speed of the wind, cloudiness and so on; two of these variables were also recorded, the temperature and pressure. Precipitation was measured at the base camp, which was more sheltered than the hillock.

During the expedition with the *Axel Thorsen* in 1864, a landing was made at Sörhamna or Sydhamnen in the south-eastern part of Björnöya. The correspondence of this place to the present Russehamna is illustrated in a photograph taken by Nordenskiöld. It shows an archway, Borgmesterporten, through a rock outcrop where huge numbers of glaucous gulls (*Larus glaucus* or *hyperboreus*, often called Borgmester in Norwegian) had their nests. In 1899 Forsberg photographed the same outcrop, where the archway had now collapsed (see Figs. pp. 49 and 286).

The weather on Björnöya is far from ideal for scientific field work. July 1899 was characterized by periods with fog, which prevented some work—especially mapping and, to some extent, geological studies. The summits of Miseryfjellet, north of the camp, appeared only a few times.

The weather improved on July 30: the fog lifted and they could ascend Miseryfjellet. Forsberg took a series of photogrammetric pictures and measured the bearings to marked points in the landscape, such as mountains and headlands. Andersson collected fossils from the Triassic strata covering the mountain. The three peaks of Miseryfjellet obtained their names: Urd (536 m a.s.l.), Verdande (462 m) and Skuld (454 m).

In a cairn, a minimum thermometer was enclosed; future visitors were asked to read it and inform the Meteorological Department, Uppsala.

The period after July 30 was, however, not blessed with *fine* weather. Even now the expedition was sometimes troubled by fogs, though not for long intervals. Instead there were strong winds—sometimes rising to full gale force, more than 25 m/s, particularly at night—which tended to sweep away the fogs. They also experienced rains, some of which were heavy.

But the last 18 days of their stay on the island could be utilized most effectively for scientific work. Even

the cartographic programme was fulfilled in its essentials, resulting in a geological map of the island.

Scientific work

Most of the research consisted of field work during excursions over the island. For that purpose, two light tents were pitched in different parts of Björnöya as secondary base camps.

The *meteorological observations* were, however, made daily at the base camp at Russehamna, but only at 08.00h and 20.00h to prevent them from colliding with the field work.

The *tidal observations* were still more restricted. They were made every 15 or 30 minutes, and only when fog prevented other activities. Despite these restrictions, useful values were obtained, such as the mean water level. Bolts were fastened at some places to serve as fixed points for determining a possible variation of the land in relation to mean sea level. Such variations occur both in Spitsbergen and in Scandinavia, but the isolated Björnöya does not seem to exhibit any such variation (compare p. 561).

The *cartographic work* was limited to producing a map of Russehamna with surrounding land, and to making corrections and additions to the map of Kjellström and Hamberg, obtained during Nathorst's expedition of 1898. This map had been drawn by means of plane-table and divided staff, and by photogrammetry; but there had been no time to do a triangulation. In order to examine whether a deformation of the map had been introduced, Forsberg measured a base-line and thereby determined the distance between one of the peaks of Miseryfjellet and one peak of Antarcticfjellet in the south of the island. By measuring the bearings from those peaks to all headlands round the coast, he was able to construct a map of the coastline round the island. It was found that this map did agree almost perfectly with the map of 1898.

Geology: The main object of the expedition was to make a detailed investigation of the geology of Björnöya on the basis of Nathorst's important discoveries in 1898. J.G. Andersson found *Fusulina* limestone—an interesting type of fascies within the Carboniferous system, which had been found in Spitsbergen by Nathorst already in 1882 (see p. 192).

Of the fossil collections brought home, most interesting are the plant fossils in the ura sandstone—from the upper Devonian period—and the animal fossils from the Triassic. The latter fossils contain some 60 species of mostly new varieties.

In 1898 Nathorst had made important stratigraphic discoveries. He had also found a number of dislocations and discordances, which in several cases were

attributed to the Carboniferous period. However, a more complete idea of the tectonics was gained during the expedition of 1899. It was then found that the mountainous southern regions of the island are traversed by rift valleys with a north-south orientation. In these cases, strata of relatively young rocks—which are less resistant to denudation—are situated between ridges of the hard and resistant rocks of the lower Heclaheek series. The present topography has developed from these tectonic conditions.

The main part of Björnöya, its northern two thirds, consists of a low plain which ends at the shore in an abrasion cliff 25–30 m high. Inland and towards the south, the plain rises slowly to about 100 m a.s.l. The plain, which is dotted with small lakes, was once formed by abrasion of the relatively young strata, but it was stopped in the south by the old and hard strata of the present mountains.

The glaciation of Björnöya. In 1870 Nathorst had found glacial striae in the north-east of the island; in 1898 he was able to verify these observations, and to find striae in other parts of the island as well. It became evident that the glaciation had not been local and that it had been centred in the southern part of the Björnöya plain (compare p.266). In 1899 these observations were continued.

Furthermore, the geological structure of erratic blocks indicated that the displacement of these blocks agreed with the direction of the ice flow as shown by the striae. Later Norwegian studies have added still more observational data, and so have the Swedish observations of 1965 (see p. 561).

It should also be mentioned that there do not exist any signs of a postglacial rise of Björnöya, quite opposite to the case in Spitsbergen and in Scandinavia. Nathorst did not find any strandlines or shore terraces in 1898. Nor did Andersson observe any such indications in 1899, but he was careful to note that the flow of loose detritus masses along the mountain slopes may have destroyed such indications.

The present abrasion is well illustrated by the vertical cliffs of the coast and by the many rocky pillars in front of it at some places.

Biological studies. Björnöya is situated about halfway between the regions of Scandinavia and Spitsbergen, which are very mild in view of the high latitudes. The island might therefore be expected to have a luxuriant vegetation composed of a mixture of high arctic and southern species. Such is not the case. The vegetation is extremely sparse. Except for the bird life, the fauna too is scanty.

The flora of vascular plants counts only 45 species, against 125 in Spitsbergen. In spite of this poverty, there occur two southern species on Björnöya—*Rhodiola*

rosea and *Salix herbacea*—which are not found in Spitsbergen. The small size of Björnöya and the poverty in good habitats are probably decisive factors. In Spitsbergen the high flora is concentrated in the inner portions of the large fjords. Such geographical features do not exist on Björnöya. The temperature conditions of summer have, in the Arctic, a crucial influence on the vegetation.

The *climate* of Björnöya is maritime with small differences between winter and summer temperatures. In other words, the winter is fairly mild and the summer is cool (see Table below). The weather is stormy and, in the summer, also foggy; the island lies near the principal cyclone tracks.

The first *meteorological* observations were, as mentioned, carried out in 1865–66 by the Norwegian sealer S. Tobiesen; only the summer data were partly missing. The expedition of 1899 supplemented this not quite complete annual series.

The Norwegian company Björnöya A.S. started to mine Devonian coal on Björnöya in 1915, and this went on till 1925. In 1915 the company claimed the island—and on August 14, 1925, Norwegian sovereignty was claimed according to a treaty signed in Paris on February 9, 1920.

A wireless station was maintained by Björnöen A.S. and, in connection with it, a meteorological station by the Norwegian Government. The meteorological observations have continued on the island even after the mining ceased.

The monthly mean temperatures for the periods 1931–40 and 1951–60 are given in the table below; they exhibit a maritime polar climate of tundra type.

MEAN TEMPERATURES (°C) AT BJÖRNÖYA

Observation period 1931–1940 and 1951–1960

Jan.	Feb.	March	April	May	June
-5.3	-6.2	-7.0	-5.2	-0.8	+2.4
July	Aug.	Sept.	Oct.	Nov.	Dec.
+4.5	+5.2	+3.0	+0.6	-1.6	-3.6
Year					
-1.2					

A “political” farce on Björnöya

While the expedition stayed on Björnöya in the summer of , there occurred a series of events which were due to the rival interests of two German groups: Theodor Lerner (1866–1931) and his three associ-

ates, and the Deutsche Seefischerei-Verein (the German Deep-Sea Fishery Association).

In 1896 Lerner had visited Spitsbergen for the first time, and visited the base of Andrée's balloon expedition on Dansköya. Next year he returned as leader of a German hunting expedition, on the small Norwegian steamer *Express*. Again visiting the Andrée base, he helped this expedition by establishing a depot on Sjuöyane and by inspecting the store of provisions at Mosselbukta (see p. 250).

In 1898 he led a group of German tourists to Spitsbergen, on the German trawler *Rüdiger*. Björnöya was visited first, and here Lerner seized the opportunity to claim a small area in the south-east of the island, including the two harbours of Sörhamna and Kvalrossbukta and the approaches to the interior of the island. This was a private claim.

The German Deep-Sea Fishery Association wanted to expand its activities with trials at deep-sea fishing, whaling and coal mining in the Björnöya region. In 1898 the Association had made a reconnaissance northward, and in the following winter an expedition with three ships was being prepared in secrecy to leave for Björnöya in the spring of 1899, the aim being to make claims to certain parts of the island.

Thanks to the severe ice conditions, and to rapid action by Lerner when he heard of the project, he managed to organize an expedition of his own and to reach Björnöya three weeks in advance of the Association's expedition. This time was effectively used by Lerner to mark further claims, including the region where coal mining would be practical. The area was marked and the claims were notified on posters. When the expedition of the Association finally arrived, they had to be content with an area in the north and north-west of the island.

Lerner's group consisted of himself, three other Germans and a Norwegian. The Association group counted 38 men and the crew of the transport ship. With his intelligence and more militant behaviour, Lerner got the upper hand.

The events that ensued during the summer are beyond the scope of the present book. They might well be viewed as acts in a farce, played against an arctic background.

On July 21, the Russian cruiser *Svetlana* arrived with the specific purpose of claiming some areas of the island, where Russian hunters had once built their huts. Lerner's militancy served him well on this occasion too.

Yet he never returned to Björnöya, and the history of the island was later determined by political decisions among nations, which led to the occupation by Norway in 1925 (compare p. 397).

When J.G. Andersson and his companions landed on Björnöya, they found Lerner's occupation posts. Soon the Lerner group appeared—well armed—to inform the Swedes about the new order which existed on the island. However, the two groups were to get along nicely with one another. This may in part have been a consequence of the cheerful and disrespectful manners of the Swedish expedition members, and to the fact that Lerner had once been an undergraduate too.

Homeward

The home transport of the Swedish expedition met with some difficulties, caused by a lack of passengers for the tourist steamers and by dense fog. Instead Lerner invited the Swedish members to go with his ship, the *Terschelling*.

She left Björnöya on August 19, and entered the harbour of Hammerfest on the 21st. Andersson and his companions had thus completed a highly successful venture.

Biographical notes on J.G. Andersson (1874-1960)

Johan Gunnar Andersson was a highly talented man, intellectually, practically and temperamentally. In fact he was a most dynamic individual, and thanks to his extreme versatility he made contributions in many fields. Polar research was only one of these, however important it may have been to him.

His investigation of the geology of Björnöya in 1899, at an age of 25 years, was a fine piece of work. The Norwegian geologist Anders Orvin regarded Andersson's contribution "as the first exhaustive work on the geology of the island [Björnöya]". Andersson disputed for his doctor's degree in 1902, with a thesis entitled "Über die Stratigraphie und Tektonik der Bären Insel" (On the stratigraphy and tectonics of Björnöya).

J.G. ANDERSSON WAS A MEMBER OF THE FOLLOWING POLAR EXPEDITIONS:

1898 A.G. Nathorst's expedition with the ship *Antarctic* to Svalbard and Svalbard waters (p. 266).

Here he acted as geological assistant to Nathorst.

1899 The expedition to Björnöya (p. 284), where he acted as geologist and leader of the expedition.

1901-1903 The Swedish antarctic expedition under Otto Nordenskjöld (p. 363). Here he was geologist and second leader. He acted as leader on board the ship *Antarctic* during Nordenskjöld's stay on the winter station Snow Hill. He was one of three men, who were forced to winter in a small stone hut at the tip of the Antarctic Peninsula after an unsuccessful attempt to sledge to Snow Hill and inform Otto Nordenskiöld of the

severe ice conditions which until then had prevented the ship from reaching the wintering party. J.G. Andersson discovered here a "real herbarium" of Jurassic plants, a pioneering discovery with far-reaching consequences.

After his return home, he became head of the Geological Survey of Sweden, where he remained till 1914. During this period he served, among other things, as secretary general to the International Geological Congress in Stockholm in 1910 (see p. 324). In 1912–14, he and Louis Palander (the commander of the *Vega* in 1878–80) planned an Anglo-Swedish expedition to the tip of the Antarctic Peninsula. These plans, which had been introduced by Otto Norden-skiöld, had to be given up owing to the outbreak of World War I in 1914 (p. 376).

That same year—1914—Andersson was offered the post of advisor to the Chinese government on matters of mining. He accepted this offer, first taking a leave from his post at the Geological Survey of Sweden, and resigning in 1916.

A fascinating and exciting career had now opened to him, and he made the most of it. His versatility and energy carried him ever farther into branches of sciences which had been unfamiliar to him. He received the nickname "China Gunnar", which would cling to him for the rest of his life.

From mining, he turned to studies of extant loess formations, which could be used in his research on the Quaternary and Tertiary formations. He was a good collector, and his assemblages of plant and animal

fossils also enriched Swedish museums. This work led up to the discovery of traces of prehistoric man, and Andersson's archaeological contributions earned him world fame. These activities are, however, outside the scope of the present book.

After eleven years in China, Andersson returned to Sweden. He was first a professor of geology at the University of Stockholm, but already in 1926 he received a personal professorial chair in East Asiatic Archaeology, attached to the National Historical Museum in Stockholm. In 1939 he retired.

J.G. Andersson possessed a fluent pen, and after his return from China he published twelve books. They dealt mainly with the polar regions and China, and his activities in those regions; but later his interests turned to war and peace, religion, politics, and the critical situation of primitive peoples among colonial powers. His concern with polar exploration returned during World War II.

He wrote two books to make the Swedish people revive its role in polar research: *Antarctic* (the biography of a polar ship) and *Männen kring Sydpolen* (The Men of the South Pole), published in 1944 and 1945 respectively.

These books were followed in 1953 by a monumental work: *Hur vi erövrade världen. De geografiska upptäckterna genom tidsåldrarna* (How we conquered the world—geographical discoveries through the ages). Andersson's last book was published in 1956: *Mitt liv och min tro* (My Life and Faith). He died in 1960 at the age of 86.

The northerly two thirds of Björnöya is fairly flat and lowland. It is poor in colour—only grey, but rich in stones and small lakes and ponds. (Horn & Orvin: *Geology of Bear Island*.)

30. GUSTAF KOLTHOFF'S ZOOLOGICAL EXPEDITION TO SPITSBERGEN AND EAST GREENLAND IN 1900

GUSTAF KOLTHOFF: BIOGRAPHICAL NOTES

In Sweden, *Gustaf Isak Kolthoff* (1845-1913) held a highly respected position in natural history, primarily the study of birds and mammals. From 1878 he was a taxidermist at the zoological museum of Uppsala University. He was a sportsman in the best sense of the word, and an expert shot. Thanks to these qualities, he was able to provide zoological museums with birds and mammals for their collections. He was also a good author, who provided both experts and laymen with vivid and valuable descriptions of animals and their ways of life.

As Kolthoff was familiar with animals in their natural environments, he upheld the value of establishing museums, which would give the onlooker a clear picture of animals in the wild. He was personally acquainted with the famous Swedish painter of animal life, Bruno Liljefors (1860-1939), who later helped him to obtain landscape paintings for the backgrounds at the Biological Museum in Stockholm. The stuffed animals were mounted among trees, on the beach, or on the shelves of bird-cliffs.

In 1893 the Biological Museum had obtained a new building for the collections. It was constructed of wood and had the outward appearance of an ancient Norwegian stave church. The Swedes had at this time become interested in their history, and the Biological Museum was placed at Djurgården in Stockholm—between the open-air museum of *Skansen* and the monumental *Nordiska Museet* (Nordic Museum), the latter two institutions illustrating how the peoples of Scandinavia—notably Sweden—lived and worked in bygone days. *Skansen* and the Biological Museum also illustrate the northern animals in their natural surrounding.

Kolthoff was to be responsible for the design of the landscape and for supplying stuffed animals. The landscape of trees, bushes, mosses, stones and rock formations, would exhibit a smooth transition towards the background pictures painted by Bruno Liljefors upon a cyclorama. The museum would contain arctic species of birds and mammals, and Kolthoff was to provide the material for these sections.

Kolthoff was familiar with the fauna of the Arctic and also with the fauna in northern regions having less severe climates.

SOME IMPORTANT YEARS:

- 1872 Visits to Iceland and the Faeroe Islands.
- 1883 Taxidermist and zoologist on Nordenskiöld's Greenland expedition with the *Sofia* (see p. 153).
- 1887 A visit to the coastal regions of northernmost Norway.
- 1898 Taxidermist and zoologist on Nathorst's expedition with the *Antarctic* to the Svalbard region (see p. 264).

On the expeditions of 1883 and 1898 he made friends with A.G. Nathorst and Axel Hamberg. His friendship with Nathorst was to prove especially important to him in connection with the realization of his own zoological expedition in 1900. The reason for making a specific zoological expedition was his experience from the previous expeditions: many good opportunities had been sacrificed because they collided with the interests of other expedition members.

These circumstances led up to Kolthoff's zoological expedition to Spitsbergen and North-East Greenland in the summer of 1900. In 1907 he became *doctor honoris causa* of Uppsala University, and in 1910 he established a biological museum in Uppsala.

The expedition's plans, equipment and men

During Nathorst's Greenland expedition of 1899, musk-oxen had been observed and studied as much as conditions permitted. Most of the time, however, had been devoted to surveying the unknown region that the expedition had discovered. Nathorst had maintained that musk-oxen could be advantageously introduced in the mountainous regions of Scandinavia. An attempt in that direction might be carried out during the planned expedition for 1900.

Kolthoff himself wanted to continue his investigations of arctic birds and mammals. He also intended to supply the Biological Museum and other zoological museums with contributions to their collections. During the voyage, arctic marine animals should be collected at least to the same extent as during the largest of the previous Swedish expeditions.

Kolthoff discussed his aims with Nathorst, and a rudimentary expedition plan developed at an early stage. In order to make the best use of the arctic summer and the prevailing ice conditions, the expedition would first visit western Spitsbergen, perhaps as early as the end of May. Kolthoff knew this region since 1898, but now he wanted to experience the breeding season. The month of June was to be spent here.

About July 1, the expedition was to steer towards north-eastern Greenland.

In 1899 Nathorst had been able to penetrate the

pack-ice, and reach the Greenland coast beyond it, already in the beginning of July—probably the earliest approach ever made at the time (see p. 278). It would, though, be more realistic to count on arriving in Greenland at the end of July. Hence, about three weeks could be spent on the passage to Greenland from Spitsbergen, and devoted to a thorough study of the marine fauna in the layers from the bottom to the surface.

It would also be possible to study the birds and the mammals which live in the drift-ice, and to obtain specimens of the different species for the collections in certain museums. Finally, one month might be used for catching musk-oxen and for zoological studies in the coastal regions of East Greenland.

Nordenskiöld had been sponsored by Oscar Dickson. Kolthoff had the good fortune to obtain means for his expedition from the industrialist Consul Gustaf Emil Broms (1849–1903). In fact, the latter was the sole sponsor of the expedition, and he paid all costs, even when the programme was enlarged and the personnel increased. He took a particular interest in the plans for procuring musk-oxen.

Thus Kolthoff was immediately liberated from the nightmare of expedition finances. Besides, he obtained some equipment free of cost from many firms and private persons. Most fortunately, the zoological equipment could be procured new, and Kolthoff was not forced to bother zoological institutions and museums. A deciding factor with regard to the investigations in marine zoology was that "Petersen trawls" could be obtained from their constructor, C.G.J. Petersen, the head of the biological station of Denmark.

The expedition staff grew out of a core of two: Kolthoff himself and the marine zoologist Hjalmar Östergren. The latter had been approached by Kolthoff at an early stage, in connection with the planning of the marine zoological works and equipment.

THE EXPEDITION MEMBERS, NOT INCLUDING THE SHIP'S PARTY, WERE:

Gustaf Isak Kolthoff (1845–1913), zoologist and taxidermist, leader of the expedition.

Artur Hjalmar Östergren (b. 1869), Ph.D., zoologist, responsible for the marine zoological investigations; he was an assistant at the Kristineberg Marine Biological Station on the Swedish west coast.

Nils Johan Teodor Odhner (1879–1927), B.Sc., taking part in the marine zoological investigations, specialist in intestinal parasites.

Ernst Ivar Levin (1868–1934), M.D., the doctor of the expedition, responsible for bacteriological investigations, photographer, and "master of the kitchen".

Kjell Gustaf Adolf Henrik Kolthoff (1871–1947), zoologist (entomologist), charged with making paintings in nature for the planned arctic department of the Biological Museum, an expert shot, the son of Gustaf Kolthoff.

K.A.G. Gredin, supervisor of the preservation of the zoological collections, botanist.

Sigge Pettersson, *E. Eklund*, *Cyrus Widell*, and *John Pettersson*, responsible for preservation of the collections of mammals and birds.

E. Eriksson, steward.

Sigge Pettersson had been in Kolthoff's service for 20 years, accompanying him on travels, and had acquired great skill as a collector and taxidermist. *Ernst Levin* had taken part in Nathorst's expedition of 1898.

Kolthoff managed to hire the Norwegian sealing ship *Frithjof* for his expedition. She was a three-masted barque with a steam engine. Her owner was the consul *Johannes Gjæver*, who had rendered many services to previous Swedish arctic expeditions. The ship's commander was Captain *Johan Kjeldsen* (b. 1840), and she had an excellent crew, entirely Norwegian.

Noteworthy here is the harpooner *O. Kulseth* from Tromsø, who had taken part in several previous Swedish expeditions (see p. 266).

The voyage north

The members of the expedition embarked the *Frithjof* at Kristiania (Oslo) and at Trondheim. The last articles of cargo were loaded at Tromsø and at Store Skoröya, where the ship's owner, *Gjæver*, ran a whaling station. Until then, the voyage had been slow and troublesome because of persistent headwinds.

The *Frithjof* stood out to sea on the evening of June 4, favoured by fine weather and a light northerly breeze. On the 6th, the first ice was met with. On this zoological expedition to supply animals for museums, the anatomy of the animals was also to be studied, and fresh meat was to eke out the standard ship's provisions—all of which called for much shooting. The two Kolthoffs, father and son, were crack shots, and several others on board were good shots as well. There was no lack of interest; the joy of hunting gripped most of the men. The first hunt occurred when hundreds of seals were observed on the ice. Kolthoff writes:

"This was our first opportunity for hunting. Well knowing that caution is necessary above all on such an expedition as ours, I had already from the start forbidden all shooting without my permission. From then on, it was decided who was

to shoot, and the shots were given their determined places."

The hunt was successful, reaping thirteen Greenland seals,

"...and now we had work to do on board. The seal-skins were taken off and were washed and salted. The entrails of the animals were examined, the animals were preserved, gall was taken for chemical analysis, and Odhner dug into the bodies of the animals for intestinal worms and other parasites. Most of the seals had empty stomachs, but in some cases there were remains of crustaceans, living at or near the sea surface."

These notes give some idea of one aspect of the routine which was to be followed on the expedition. When reading the subsequent report, one cannot help taking sides with the animals; yet the fact remains that such actions are necessary on this type of expedition.

Attempts were made to reach Björnöya, but the ice prevented them, so on June 7th the course was set for south-western Spitsbergen. Two ships belonging to the Russian group of the Arc-of-Meridian expedition passed the *Frithjof*. Hornsund, with the Russian base, lay on their route and it was decided to pay a visit there on the way north (compare p. 347).

On June 8, they had come far into the ice and the hunt had begun in earnest; seals and birds were shot. Several snow buntings came on board, apparently still migrating, and one was so exhausted that it could be caught by hand.

"We tried to save his life, but the strength of the little bird was gone and he died after a few minutes. When seeing the great number of exhausted birds which come on board in spring and autumn, one understands that there must be a considerable number of birds which during the migration find a grave in the sea."

In the evening Spitsbergen was sighted, and next day, the 9th, the *Frithjof* entered Hornsund. The land was covered in snow, and the fjord was filled with ice. They saw a few seals on the ice. Otherwise, nothing could be done with all the snow still covering the land.

Zoological work along the west coast of Spitsbergen

After a short visit to the Russian station, they steered north—though not far. Between Hornsund and Bellsund, there are two groups of small islands, Dunöyane and Isöyane, harbouring many birds in the

summer. Kolthoff had visited the latter islets in 1898, so now the Dunöyane were chosen for a visit.

The largest island was visited. It was covered with snow, and only a few birds had started nesting at some places. Many eiders swam along the shore; some flew hither and thither, while others sat on the snowy fields. Groups of brent geese waded in the snow, and the little red phalarope (*Phalaropus fulicarius*) flew twittering to and fro along the shore or swam in small groups in the sea. Where rock outcrops protruded the snow, the geese and eiders had started to lay their eggs.

On June 10, the *Frithjof* steamed into Isfjorden with the intention of visiting Adventfjorden. But Isfjorden was found to be densely packed with ice, which the ship could not penetrate. They steered towards Grönfjorden, but it, too, was covered with fast-ice. The ship was moored along the ice-edge at the mouth of Grönfjorden, where they planned to wait for the ice situation to improve.

The season was not right for excursions on land. Snow lay a metre deep between the shore and the mountains. Kolthoff comments:

"There did not exist a bare patch where I could have satisfied my longing for the dry land."

Instead they had to enjoy themselves by studying the behaviour of the storm petrels or arctic fulmars which surrounded the ship. The crew of the ship, by tying pieces of blubber to strings, could angle for storm petrels and take them with their hands. When the birds were let go, the procedure was repeated and the same birds might be caught again.

"The storm petrel has no other worry than procuring food for himself. He is always hungry, and if he has just food to eat, nothing else matters. With the prospect of getting a piece of food he submits to the risk of becoming caught, and even if his fellow birds beside him are shot he does not pay the slightest attention if he can only get food for himself."

On the fast-ice were a great many seals, resting near their holes in the ice. They were very shy, in contrast to their indifference when resting upon a small piece of ice, where they could escape into the water in any direction.

On June 11 the men started to make short excursions. Kolthoff shot a number of seabirds, some for the collections, some for the cook. A skiing party observed traces of polar bears. Some Spitsbergen grouse (*Lagopus hyperboreus*), still in winter plumage,

were observed and shot. Snow buntings were also seen, but no other species of birds, and reindeer were sought in vain. Östergren was occupied with getting the trawls in order, and Odhner dug for intestinal worms in birds. It was apparently early in the season, but the snow buntings were twittering and flocks of geese were flying over the snow fields.

Next day, the 12th, an excursion was made to Colesbukta, using the steam launch with a boat in tow. The snow had been blown away here by the strong winds of the winter, and now a fresh green moss occupied the bare areas, a real comfort to the eye. They also noted the early flower of Spitsbergen, the scarlet *Saxifraga oppositifolia*. They saw traces of reindeer, followed these, and met with one reindeer. It trotted rapidly towards a member of the party, so he had to shoot it. The harpooner Kulseth took care of the meat and carried it on his strong shoulders down to the boat. Kolthoff comments:

"However excellent preserved food may be nowadays, one gets tired of it, and there will always be enthusiasm on board when such a splendid quarry as a reindeer is brought home. The great value one attaches to animals in the wild state enormously increases, in my opinion, the pleasure of a hunt. The knowledge of having killed the animal for a high purpose brings a feeling of satisfaction, and a high purpose it is when the meat of the animal contributes to one's livelihood—at the same time as the internal parts of the body, the hide and the skull are of value to science."

They observed several Spitsbergen grouse. It was apparent that the hens had taken on summer dress, while the cocks were still white. The dark dress of the hens merged with the mossy ground, and the birds were conscious of this fact. The cock almost always sat on the snow, while the hen preferred the bare patches of the ground.

In sum, the expedition members did not lack work when dead animals were taken aboard by different groups.

On June 14 the ship went to Colesbukta, where it was possible to walk on land. For the passage to Greenland they needed fresh meat, so seal hunting was now essential. Besides, the doctor needed samples of bacteria from reindeer—as many of them as possible. At the same time, geese and grouse were obtained by the hunters—for food and for science.

On June 15, Kolthoff was roused in his tent ashore by Östergren, who came from the ship to inform him of a fire on board. It had been serious, and might force

them to give up the whole expedition and go home. Apparently the fire started in the upper engine room, where the doctor had his laboratory. A lamp, which had been burning under his thermostat, exploded and the oil leaked out. Before anybody noticed it, the room was on fire. The engineers had to rush through the flames and the captain, roused at the last moment, was nearly asphyxiated. But the fire had been extinguished effectively, and—most important—the engine was not damaged. However, the ship did not look very good, and there was much work to set her in order again.

Scientific work went on undeterred by the accident. The collections were expanded steadily during excursions, and by trawling and dredging in the sea. The marine zoological work provided the kitchen with great amounts of shrimps (*Sclerocrangon boreas*), a real delicacy, "though they were not so good as crayfish" according to Kolthoff.

On Midsummer Eve a traditional feast was arranged on deck with everyone present. It was also an expression of gratitude to all on board for good work, as well as a farewell to Isfjorden. Next morning—Midsummer Day—they weighed anchor and steered across the fjord to Bohemanneset, where Kolthoff wanted to visit the small lakes and ponds on the plain, which unfortunately was found covered with deep snow. In 1898 large numbers of eiders had been there.

Östergren intended to make trawlings in the mouth of Isfjorden. Previously the trawling had been done from the steam launch, but now it was to be done from the *Frithjof* herself—and here the crew lacked experience. Nobody thought of stopping the engine while the trawl was let out. Consequently the propeller of the ship gripped the net and entangled it round the propeller axis, including the iron-shod boards of the trawl. The engine could not be used, so the only alternative was to set sail and proceed into Grönfjorden. Serious repairs followed, but the damage to the trawl was easily fixed, and next day the trawling in the mouth of Isfjorden was carried out with most satisfactory results. Östergren and Odhner had to spend a day and night preserving the animals in different solutions. A whole cauldron of shrimps was prepared for a "banquet".

Next Kolthoff wished to visit a group of small islands or islets situated off the south-western coast of Prins Karls Forland. They were not entered on the maps of that time. Probably no scientific expedition had ever visited these islets. The sealers, however, knew of them. The waters were thus unfamiliar and with some excitement the *Frithjof*, which had a draught of 4.5 m, was steered into the sheltered water between the islets, with depths between 6 and 7 metres.

A group paid a visit to one of the islets, which was found to be partly free of snow. Thousands of eider nests lay everywhere; brent geese, also sitting on eggs, were common. All the birds were fearless. Kolthoff remarked on the eiders in the Arctic that the males stay with the females while they sit on eggs, and do not leave them until the eggs are hatched. In Scandinavia, on the contrary, the male eiders leave the breeding-place as soon as the eggs have been laid. Kolthoff was enthusiastic:

"It was impressive to see these swarming crowds of birds. I stood there for a long while in the midst of thousands of eiders and listened to the trumpet-blasts of the geese, which reminded me of the call of the crane. Above me there circled arctic skuas and glaucous gulls (*Larus glaucus*); in the distance over the sea, auks and common kittiwakes (*Rissa tridactyla*) were flying along; a snow bunting was singing from his green tuft and, now and again, divers passed across the island with a whistling speed. The divers often descended on the still ice-covered swamps, and sometimes settled in the small pools of water which formed at the edge of the large snow fields."

On June 27 a group of three men visited the Forland to the east. They went ashore on a small islet which had no vegetation, yet was still inhabited by a colony of eiders. These lacked moss or earth for building nests, and could not make any hollows for their eggs. Instead, they had resorted to small chips of stone which covered the islet, enabling them to construct rather fine nests.

The group could not do much on Forlandet. The lowland was covered with deep snow, into which they sank waist-deep, and on the bottom there was water. The vegetation was late in coming. *Saxifraga oppositifolia* looked like just a small green spot on the ground.

The wind was increasing, and when Kolthoff returned a full gale was blowing. Strong winds had come to stay. The *Frithjof* left the harbour on June 28, during a lull in the wind and while the water was low. In case they ran aground, they would probably later be lifted free by the high tide. The passage out to sea was exciting, and the bottom could be seen clearly through the water.

The following night was somewhat gruesome. The wind rose to full gale, and in order to spare their store of coal, they set sails and tacked out to sea. Kolthoff had hoped to visit Fuglehuken, the north point of Prins Karls Forland, but on the morning of June 29

they found that they had been driven south by the wind during the night, and their position was now more southerly than on the previous evening. The wind calmed down before noon, but they preferred to set course for Kongsfjorden, and in the afternoon they anchored in a good harbour on the south side of the fjord.

Not until July 2 did the gale abate, but only a light swell rolled into the fjord, an indication that the ice was not very far away. Like all visitors to Kongsfjorden, the members of the expedition enjoyed the scenery of mountains and glaciers here.

The fresh meat on board was now consumed, calling for a hunt in the fjord. The best marksmen—Kolthoff senior and junior, and Levin—went by boat towards the inner portions of the fjord and got many a bird for food. But fast-ice still lay on the innermost part of the fjord, preventing them from reaching the small islands there. The animal life was poor.

In the afternoon the *Frithjof* weighed anchor, the intention being to proceed north to the island of Fuglesang at the north-west corner of Spitsbergen. Three trawlings were made in the open sea during the evening and the following night. The collections of marine animals were markedly enriched; among other things, they got several species of fish.

In the middle of the night a very large walrus was sighted on the ice. He was asleep, lying upon his back with his tusks pointing upwards. Once obtained as booty, he was found to be 4 m long, and so heavy that levers were necessary to turn him round. Kolthoff writes:

"After the hide had been removed, samples were taken from the inside. Odhner dug into the bowels for intestinal worms, the entomologist gathered the rare walrus lice from the hide, and I opened the stomach to investigate its contents. There I found to my astonishment a seal, half grown-up and cut into pieces. It was thus established that the walrus really catches and devours seals. The hide and blubber of the seal had been cut up into long strips, 10-15 cm broad and 1/2-2/3 m long. So it is obvious that the tusks have been used for cutting up the seal."

The plans to visit Fuglesang, and possibly also to reach Wijdefjorden, had to be given up because of the ice. Also the Swedish Arc-of-Meridian expedition had troubles with the ice on the north coast, as Kolthoff was told by a Norwegian sealer. Instead, they now visited Kobbekbukta on the western side of Dansköya, where they did some shooting of marine birds.

The visit to Spitsbergen had not turned out as

The scientists and their captain on the expedition to Spitsbergen and East Greenland in 1900. Sitting from left: Captain Johan Kjeldsen, Gustaf Kolthoff, Hjalmar Östergren. Standing from left: K.A.G. Gredin, Ernst Levin, Teodor Odhner, Kjell Kolthoff. (above left). (Kolthoff, G.: Till Spetsbergen och Östra Grönland år 1900.)

The big seal is hoisted on board (above right). (Kolthoff, G.: Till Spetsbergen och Östra Grönland år 1900.)

The expedition ship *Frithjof*. A three-masted barque with steam engine (left). (Kolthoff, G.: Till Spetsbergen och Östra Grönland år 1900.)

Colesbukta as seen from Isfjorden on 12 June 1900. (Kolthoff, G.: Till Spetsbergen och Östra Grönland år 1900.)

Kolthoff had hoped. Snow had cut them off from the land, and lakes and swamps were frozen. Even the fjords had been partly blocked by the ice, and the north coast was unattainable. But the collections were rich, in spite of these drawbacks: 1200 birds were preserved, and three species of birds which were new to Spitsbergen had been discovered. The marine zoologists were satisfied and so was Levin, the bacteriologist. He had found many opportunities to study the bacterial fauna in the intestinal canal of several arctic animals.

*From Spitsbergen to East Greenland:
observations in the pack-ice*

In the evening of July 4, they weighed anchor to start on the second leg of the voyage: the passage from north-western Spitsbergen to the fjord region of East Greenland. But first they did some trawlings and went up to the ice edge to the north. Then, in the evening of July 5, the engine was stopped and all sails were hoisted in order to spare the store of coal. The course was set for north-east Greenland.

The captain was asked to avoid entering heavy ice and, if such was met with, to proceed southward. However, next morning Kolthoff was surprised to find that they had in fact entered heavy ice during the night, and there were wide ice fields to the south. They were now forced to follow the route which at the moment was passable, namely towards the west and south-west. Visibility was fairly low, and it was impossible to observe the sun for position. The noon position on July 7, according to dead reckoning, was 77°15'N, 1°30'W.

Towards evening the passage became obstructed. A narrow lead was, however, seen to the south-east and the *Frithjof* worked hard to reach it—a toilsome and slow procedure, which was finally stopped by fog. The *Frithjof* was moored to a floe, and Östergren had an opportunity to take a hydrographic series at 77°11'N, 0°55'W, raising water samples and measuring the temperature at different depths. Professor Otto Pettersson (1848-1941), the pioneer in Swedish oceanography, had supplied the expedition with water samplers and thermometers for the purpose. The line, though, was not longer than 3100 m and the bottom was not reached. At 100-300 m the temperature was above 0°C, its maximum being +3.5°C; otherwise the readings were below 0°C. It should be recalled that ordinary ocean water freezes at about -2°C.

Next day, the 8th, the ship passed through extremely heavy pack-ice. From the masthead, no open water was seen except to the south-east. In this direction a narrow lead extended, and the ship followed it all day long. The captain was worried, and he often

repeated: "I have never seen ice before." Actually he had sailed in the Arctic for 30 years, and he understood that the fate of the *Frithjof* would be sealed if the narrow lead closed. Kolthoff writes:

"The *Frithjof*, the fine high-rigged ship, here seemed to me like a mosquito, which the forces of nature might crush at any moment. When looking at this ice, it gave the impression of a broken landscape of snow or rather a gigantic white city, here and there interspersed with lakes and plains. Blocks of ice lay scattered between large ruins, churches and towers, and everything was covered in the whitest of snow, and in between deep-blue lakes extended their crystal-clear surfaces, which were connected by brooks and rivers."

No doubt, the *Frithjof* had come deep into the polar pack-ice. Indeed, so far into it that no animal dared to visit the area. Kolthoff comments:

"We saw scarcely a bird, not even any traces from living creatures."

In the night towards July 9 the lead opened, and the ship was able to continue on an east-north-easterly course. As she proceeded, other narrow leads opened gradually, and finally much open water was seen to the south and south-south-west. They were able to resume the original course, setting sails to give the engine a rest. The animal life now indicated that they had emerged from the heavy polar pack-ice. Storm petrels and a few auks appeared; the seals also increased in number.

On July 10 they were surrounded by fog, but the weather was otherwise fine, the temperature being +2° to +3°C. At noon their position was 76°33'N, 2°E according to dead reckoning. They made a deep-sea sounding, yet the bottom was not reached with their 3100-m line.

The polar pack had interfered with Kolthoff's plan: his intention had been to proceed in open water along the ice edge, where it would be possible to make trawlings at great depths, and their 5000-m steel wire had been brought for such work.

In the forenoon the fog lifted, so they proceeded on a south-westerly course through a sea now containing only open ice. There were many Greenland seals, and the opportunity was seized to procure fresh meat for everyone on board, as well as scientific material to the zoologists. The marine zoologists got rich collections from the surface layer, including a great number of crustaceans and several large amphipods.

On July 11 the wind became westerly. During the voyage, the wind direction had otherwise been invariably northerly. At noon the temperature was up to +6°C—real summer warmth. The position was now obtained from measurements of the solar altitude and was found to be 75°21'N, 1°32'W. The ice was now dense to the west, so they had to steer south. They were roughly 500 km from the nearest land, and found it rather remarkable that the bird life was so rich in this season. They observed many storm petrels, the white variety increasing with the distance from Spitsbergen. Farther than 2000 km from Spitsbergen, it was found that the birds in question had not bred during the year—they were either immature or sterile. Moreover, these birds still partly wore winter plumage, a proof that they were incapable of breeding.

Besides storm petrels, they saw auks, little auks, common kittiwakes, a few Spitsbergen black guillemots, glaucous gulls, ivory gulls, arctic terns, and a few arctic skuas. The hooded seal (*Cystophora cristata*) was most common and was often seen resting on high blocks of ice, quite contrary to other seals. In appearance, too, it differed from other seals. Its food was found to consist mainly of cephalopods. Greenland seals (*Phoca groenlandica*) and ringed seals (*Phoca fetida*) were also observed. Kolthoff's investigations showed that these two species lived on crustaceans, mainly amphipods, which live in the surface layers.

On July 13 they could steer a more westerly course than previously, but at noon the fog settled around them, so they moored the ship along an ice floe. Although they could not trawl here in the ice, Östergren had constructed a large scoop-net to make up in part for this disadvantage. When the net was lowered to 1000 m or more, it caught many kinds of animals which were not obtained near the surface—such as crustaceans, medusae and jellyfish. It should also be noted that none of these animals were obtained when the net was lowered through the upper 500 m.

Until that time, several scientists had maintained that the animal life in the sea was limited to the layers near the surface and near the bottom; in the intermediate layers, living animals were supposed to be missing. The investigations from the *Frithjof* now showed that rich animal life also existed in these intermediate layers, agreeing with results from other scientific expeditions at the turn of the century.

Fog persisted next day, the 14th, and so it remained until the 20th. The ship stayed mostly moored to an ice-floe, but the marine zoologists could do their work with scoop-nets. The depths were becoming smaller, and on the 16th they reached the bottom by scoop-net. A deep-sea sounding nearby with the same

line (3100 m) gave the depth 2700 m. The position was 72°50'N, 3°08'W.

On July 17 they met with denser ice, and it seemed as if they were becoming "beset". But after a very hard and incessant fight, the ship came into an area with more open ice, and a slight swell from the east was noticed. On the 19th the wind increased to a gale from the north. They hoisted sails, and with fairly good speed the ship proceeded west, until after a few hours the ice barred the way. On the 20th their troubles ended, the sun was shining and the weather was fine. They were in the ice, yet a swell was coming from the east.

The time for trawling had come at last, and soon they reached open water at 72°01'N, 8°33'W. The depth was measured as 2400 m, and at this depth the trawling was to be carried out, a long and somewhat uncertain operation. The first trawling took half a day, and failed: the trawl got tangled in the line and was empty. But the second attempt contained mud from the bottom, besides rare sea-cucumbers, sea urchins and starfish.

They were now only about 100 km to the north-west of Jan Mayen. After the trawling was completed, Kolthoff decided to visit the island. On the morning of July 21, the ship lay close upon the land, at the north side of Jan Mayen. The wind was northerly, and the swell prevented a landing here. But after passing south of the north-eastern point, they found shelter in a small bay and could anchor. The coast was a steep cliff where thousands of birds were breeding, mostly auks and storm petrels. A party went ashore. Auks with their young were standing close together on the precipitous mountainside, and in every hole lived an Atlantic puffin or a little auk.

Kolthoff noticed that the southerly variety of puffins (*Fratercula arctica*) was the most common. This variety was first observed on Jan Mayen by Nathorst in 1899. Downy young of the little auk were caught for museums. In the steep mountain walls below Beerenberg, thousands of storm petrels were breeding. They all belonged to the white variety with bluish-grey mantle. Kolthoff remarks that he had previously observed that the storm petrels were also white in the Faeroes and Iceland, whereas they belonged to the grey variety in west Greenland, Spitsbergen and Björnöya. As noted previously, the small variety of the puffin was most common at Jan Mayen. Nathorst in 1899 found oyster-catchers and whimbrels, which are abundant in Iceland. The Austrian Polar Year expedition in 1882–83 saw many Icelandic birds which occasionally passed Jan Mayen, indicating quite a long flight across the ocean.

Kolthoff and his men also looked for remains of the

Andrée expedition at the request of Nathorst. Nothing was found. For that purpose, the ship was taken to Rekvedbukta on the south side of the island. They also used the visit here for trawling and scraping at rather small depths. Next day, the 23rd, an excursion was made on the island: Sörlagunen was studied and they crossed the island to the Austrian station.

The strong northerly wind was still blowing, and Kolthoff wanted to waste no more time at Jan Mayen. After some birds were shot for food, on July 24, they began the last leg of the voyage from Spitsbergen to Greenland. The sky was cloudless and the beautiful Beerenberg was seen all day, glittering in the sunlight.

They trawled over depths of about 2000 m, but the bottom was not reached although 4000 m of line was out, perhaps due to prevailing currents. However, they instead obtained animals from intermediate layers—among others a large purple nemertin (*Pelagoneustes*), a rarity which paid for all their troubles. On July 25 they entered the ice, and from now on they would have to expect fog.

The bird life on the ice was found to be fairly rich. Kolthoff noticed that the birds from Jan Mayen and Greenland, as well as from Spitsbergen, fly as much as 200 km out to sea for fishing. All birds which were shot at that distance from land had bred and sat on eggs. As mentioned earlier (p. 298), breeding birds were not found at greater distances from land. The observations also raise the question how the low-flying birds can find their way back to the nests, considering that fog is so common in the region.

The ice was not very thick or dense, but the ship's speed westward was slowed by the fog.

Meeting the fauna of East Greenland

On the evening of July 30, the ice opened markedly, and soon open water lay ahead as far as they could see in the fog. With good speed the ship steered for the Greenland coast. Late in the night towards July 31, visibility improved and, far to the west, the summit of a mountain was rising above the horizon—Kap Broer Ruys, as they found later when they got closer to the Greenland coast. The bird life at sea became more poor, and in some places they observed only an occasional glaucous gull or arctic skua.

At noon they were near land. It was vital to find a good anchorage, as the boiler of the ship had to be cleaned before they proceeded north. They saw traces of two wolves on a snow field, and high up on the mountain slope they noticed, to their delight, a herd of musk-oxen. Besides, the *Frithjof* had escaped from the fog. They celebrated the occasion: they had reached Greenland, and the sun shone invitingly on the land they had eagerly longed for.

They were near Kap Broer Ruys. From there they followed the southern coast of the land—Hold with Hope—and in the evening they steered into Mackenzie Bay. An islet and a few stranded icebergs would give shelter to the ship, so they anchored. They yearned for solid ground under their feet, and shortly afterwards a landing party left the ship. A vast lowland lay before them; beyond it, the mountains rose ever higher towards Hold with Hope, becoming blue in the distance.

Their impression of the area was definitely positive. Kolthoff wrote:

"The ground on the lowland was covered with green mosses; the yellow *Papaver radicum*, fair *Saxifrages*, *Ranunculuses*, the large violet *Spilobium latifolium* and many other flowers made a fine show on the tufts. Bumblebees were buzzing in the air, and butterflies were flying from one flower to the other. In whatever direction I turned my eyes, I could see long-tailed skuas with their long spears in the tail, and several of these birds, which had their young ones in the immediate neighbourhood, came anxiously shrieking close above my head. After I had walked some distance across the moist ground, I saw everywhere passages in the ground dug out by the rare Greenland lemming. The sanderling was common, with full-grown young...and along the shore, turnstones and ringed plovers were flying.

On the moist ground many traces of musk-oxen, and also winter-wool from them, were seen. Further, skulls of old bulls were found. These bulls had died long ago, and the skulls had evidently come from very old animals, because the points of the horns were worn off in a way which indicated a high age. Some old reindeer antlers lay there too.

Night was drawing near. It was not my intention to make an excursion. We sat down among the flowers and the butterflies. We toasted our doctor with a brandy and soda [it was his birthday] and then returned aboard at midnight."

Next day, August 1, they acquired their first practical experience of the musk-ox. The weather was not the very best for studying insects—as had been Kolthoff's original intention—but it was good enough for hunting musk-oxen. They were now hungry for fresh meat. A hunting-party left the ship, consisting of the three marksmen of the expedition: Kolthoff senior and junior, and Dr. Levin. They took four strong men from the ship's crew to carry the meat.

The first two musk-oxen they came across were rather frightened, quite contrary to what they had heard from members of the Nathorst expedition. However, they got the musk-oxen 5 km from the shore. The hunters left the carriers there and continued farther inland. They saw many remains and traces of musk-oxen, and soon they perceived thirteen animals. With binoculars they could tell that two of the animals were calves, and at some distance from this group they saw another two musk-oxen, probably males; the rest were females.

They reached a highland plain which extended roughly 10 km in a north-easterly direction. Here were numerous remains from both musk-oxen and reindeer. In the ground were passages made by lemmings, and nests of lemmings built from grass bitten into pieces.

They came to a ridge on the plain, and beyond it was a valley in which they saw 25 musk-oxen. The hunters sat down to study the animals, which were grazing peacefully and looked like a herd of cattle at home. The herd consisted of two bulls, the rest being cows; there were no calves. Kolthoff was struck by the idea of this place being a habitat where old sterile animals gathered to live and die. He suspected, too, that the lack of calves might be due to the fact that wolves had come to East Greenland from the north and north-west. Kolthoff wrote:

"The grazing musk-oxen did not see us where we sat on the hillock ridge. We therefore had the opportunity to study them in their undisturbed home life. The animals were rather playful. Often they ran for fun after each other; they moved easily and gracefully, grazed for a while, and lay down at times to rest."

In the evening, the hunters returned to the lowland and met the biological assistants, who had been studying the lemmings and had caught many of them, some alive.

"During our stay at this interesting habitat, the habits of this extremely rare Greenland lemming were so carefully studied, that it can be said to be now much better known than the way of life of our own Swedish lemming."

Östergren and Odhner, the marine zoologists, had also been busy during the day. They had obtained so many animals from the sea bottom that all the tubs on board were full, and now—after midnight—they were occupied with preserving their rarities. They received a real feast on the musk-ox meat, although not every-

body was delighted, as the meat of the two old bulls had a taste of musk—the mating season had begun. But when they later shot cows and calves, everybody on board was happy.

On August 2 the weather was fine. The three marksmen went on a new excursion, accompanied by a few men of the ship's company. This time, however, they intended to separate and work alone in different areas: the doctor would hunt, Kolthoff junior wanted to collect insects, and Kolthoff senior—the ornithologist—would study the bird life.

Kolthoff senior followed, to begin with, the shore in a northerly to north-westerly direction. Here were the ordinary Greenland wading birds; on the water lay long-tailed ducks, and females of king eider; in the air above, there were arctic skuas and terns.

"Rubbish from the *Frithjof* had drifted ashore, and some ravens had gathered to find out what was fit for food. Tins of sardines, pieces of bread, heads of auks, etc., seemed to surprise these wise birds, which were not used to such a fine breakfast. They were so surprised that they did not pay any attention to me, until I had come so close to them that three of the black fellows had to lose their lives."

From the shore Kolthoff walked inland, past thousands of small shallow pools. There he made an ornithological discovery of great interest. Great masses of king eiders occur along the Greenland coasts, and the bird was also common in Spitsbergen; yet it had seldom been seen breeding, and its breeding-places had not been located. Kolthoff now found that the king eider breeds at pools and small lakes inland, where human visitors almost never come. He also acquired samples of the young for Swedish museums. In Spitsbergen, king eiders are abundant near Bohemanneset in Isfjorden. No doubt they had their breeding-places analogously on this lowland promontory.

A few examples of Kolthoff's observations during his walk may be mentioned. First, the old phalaropes migrate southward long before their young leave; this was a finding which he had also made in Spitsbergen in 1898. Secondly, antlers and old remains of reindeer indicated that the animal had once been common here. The German expedition of 1869–70 saw large herds, but Nathorst in 1899 had noticed relatively few reindeer in the inner parts of Franz Josef Fjord, and had attributed the fact to invasions of wolves from the north.

The lemmings and their way of life were studied. Besides, 14 lemmings were taken home to Sweden.

Kolthoff had a good opportunity to study these animals "at close range". They were wise little creatures, with a pronounced feeling for order. This lemming does not hibernate, as is proved by its passion for collecting food and by the fact that it has a special winter pelt, which is lacking in animals that hibernate. The lemmings taken home to Sweden also wore their winter dress.

Kolthoff junior carried out entomological studies. The insect life was, however, found to be extremely poor. He was on the lookout for coleopteræ, but he never found any, or even remains of them. The season was fairly late; on the other hand, there do occur good and bad insect years. In the previous year, and in 1883 in western Greenland, Nathorst had found many insects. The entomological harvest was thus considerable in 1900.

When the excursion-party returned to the ship in the middle of the night, they were informed by the captain that the boiler had been cleaned, and that they could leave Mackenzie Bay on the morning of August 3.

The *Frithjof* steamed out of the bay early that morning, in fine weather. The course was set northward, with the intention of studying the bird life along the coast, and of trawling as far north as Pendulum and Sabine Islands. As they passed Hold with Hope, they met a small Norwegian yacht—the same ship and men that Nathorst had encountered in 1899.

The sea surface was extremely poor in life: no seals were seen, and only a few glaucous gulls and arctic skuas. They steamed in almost ice-free waters, and on the morning of August 4 they were close to Sabine Island and Walrus Island. The depot which Nathorst had established for the Sverdrup expedition was found in a good state, and they could deliver the post for Sverdrup which they had carried with them. They continued north along the eastern side of Pendulum Island, but at its northern side stretched a broad band of ice, which was not worth attacking in order to get farther north. Their aim was to study the fauna in Franz Josef Fjord, and time was short.

A visit to Sabine Island was, attempted, however, and on August 5 the ship entered the sound between Pendulum Island and Sabine Island. But they were surprised by a northerly gale, reaching hurricane force, and found some shelter behind a rocky islet, where they anchored. The ship was drifting and it seemed desirable to stand out to sea, yet she remained at the place during the night.

On the morning of August 6, the wind rose further and the ship drifted out of the "harbour". It was possible to anchor to the south of Sabine Island, where an anchorage was known to exist and where

they would be in the lee of the high mountains.

In the evening the gale abated, and a visit was paid to Sabine Island. A party walked some distance inland; they found the land desolate, and saw no living creatures. In a brook they observed salmon trout, but were unable to catch any, lacking suitable nets. The wind was so low that Kolthoff decided to weigh anchor in the early part of the night towards August 7. However, the wind became easterly and the ice drifted towards land, threatening to push the ship against the rocky shore. Thanks to fast manœuvring with the sails, it was possible to get free and stand out to sea. In the morning the weather was fine, and the wind had died down to a calm.

They were now in the ice and observed seals (*Phoca barbata*) on the floes. As they required several, a hunt was ordered and carried out from a boat. Then they steamed south towards Franz Josef Fjord. Here the ice was densely packed, so it was found necessary to revisit Mackenzie Bay and to await improvements in the ice situation.

On the way, trawlings were made at a depth of about 250 m. The catch was good; for instance, they obtained many specimens of two species of *Astrophyton* (*Astrophyton eucnemis* and *A. agassizii*)—"snake stars" with richly branched arms, which these animals use to catch smaller creatures in the water. The zoologists had brought up such animals previously, but the specimens here were unusually large: the arms were about 60 cm long, giving the animal a diameter of some 120 cm.

More musk-oxen

Soon they met the small yacht which they had seen during the voyage to Mackenzie Bay. The skipper came aboard the *Frithjof*, and reported that his crew had hunted a great number of musk-oxen at the same bay. Kolthoff's reaction to this information was, in his own words:

"I had felt great pleasure in sparing the musk-oxen at Mackenzie Bay. I felled only two of the more than 40 animals which we saw there; and now Captain Næsö told us that he and his men had been there and had shot no fewer than 30 musk-oxen. His men regretted that they did not succeed in shooting *all* musk-oxen they had seen, and said that they would stay another few days to get more of them. These hunters cause terrible massacres, and no wonder. They have no idea of sparing; ever since childhood they have only heard praise for those who have been able to lay down most animals, and what matters to them is to get as rich a quarry as possible."

The crew of the *Frithjof* was now planning a musk-ox hunt, and it was a great setback to hear of the hunting by the yacht's crew. They saw one musk-ox when they returned to Mackenzie Bay, and Kolthoff considered that

"this musk-ox would no doubt be shot by the sealers, so I thought that we might shoot him just as well."

Thus it came to pass. But Kolthoff also wanted to capture some musk-oxen and take them back to Sweden. By then, the musk-oxen in the area had either been shot or terrified.

Next day an attempt was made to capture a musk-ox. Kolthoff resorted to two methods for the purpose: driving musk-oxen towards a net, and making a musk-ox unconscious by shooting it with small arrows poisoned with curare. Both methods meant that it was necessary to approach the animals very closely. In addition, the topography of the land had to be suitable. The net must be placed in such a way that the animals could be driven towards it.

In order to obtain a musk-ox with the help of poisoned arrows, a suitable dose of the poison had to be applied, along with a correct amount of powder for driving the arrow towards its goal. Nothing in these respects was known to the expedition. The method had to be worked out in the field by the doctor, and it was time to go home when the experiments had been carried out.

These attempts with curare-arrows were made during August 9–12. A number of musk-oxen were also shot in the normal manner, despite the fright of those which remained after the Norwegian hunt. The doctor's experiments were not successful: the first arrow did not reach far enough to hit an animal; a second arrow temporarily crippled another animal, which had to be shot with a gun; the third musk-ox was hit, but the curare only made it furious, and the following arrow failed to hit it. The third arrow reached it but, instead of falling, the musk-ox ran away uphill with great speed. The next animal was not hit, though the arrow carried away a tuft of hair from its back.

However, the collections from Mackenzie Bay were in other respects rich and most valuable. They included 83 specimens of the rare Greenland lemming. The most precious results were the large collections of lower species of animals, which the two marine zoologists had obtained from the sea bottom—near the shore and out towards the deep sea.

The expedition left Mackenzie Bay on the evening of August 13. The next area of research was Franz

Josef Fjord, notably Musk-Ox Fjord, where further attempts to catch musk-oxen would be made. A day later, the *Frithjof* reached the mouth of Franz Josef Fjord, which was free of ice as far as the eye could reach. Soon they were passing between impressive icebergs.

Before the ship steamed into the fjord, trawling was carried out. Östergren had, from experience, high expectations of rich harvests at the fjord mouth, thanks to the intense exchange of water which occurs there. This trawling, in fact, was the most successful of the whole expedition.

Franz Josef Fjord and its lateral fjords and sounds were no longer unknown territory, since Nathorst's expedition of 1899. The *Frithjof* steered directly towards Musk-Ox Fjord on the northern side of Franz Josef Fjord, where Nathorst had observed several musk-oxen in 1899.

On August 15 the ship entered Musk-Ox Fjord in fine weather. Musk-oxen were visible on both its northern and southern sides. Kolthoff wanted to make a reconnaissance along the entire fjord—from west to east—before starting the catch. A good result depended greatly on the local topography.

However, at an early stage they observed six musk-oxen with two calves. As only a few calves had been seen until then, and as Nathorst likewise had seen few in 1899, Kolthoff decided to begin the catch immediately. The calves were the most valuable animals in the herd. The topography was not ideal for a catch with nets, and it was obvious that all the old musk-oxen would have to be shot in order to get the calves. Besides, some old animals were needed for the collections. At the first attempt, all the old animals were shot, but the calves ran away uphill. When they came back down, nets were used to catch them, yet failed; the calves slipped through and ran uphill again.

The reconnaissance along the fjord was continued, while new nets with smaller meshes were prepared. Many musk-oxen were seen from the ship—about 70, of which 16 were calves. The individual herds consisted of 5–14 animals, led by one or two bulls.

Later they observed a herd of musk-oxen on the southern side of the fjord—with one bull, twelve cows and one calf. Here the terrain was suitable. Two boats carried the equipment and as many men as the captain could spare from the ship. They landed some 2000 m to the east of the herd. The net was suspended on poles, from the fjord to a distance of 1200 m uphill, for which one hour was needed. Eight men formed a chain from the shore uphill, intending to drive the animals towards the net.

The animals, however, formed a line of defence with the bull at its head. They simply refused to move,

until the bull was shot. Then the cows and the calf moved towards the net in one united front, which the net, of course, could not stand. Nonetheless, four cows were caught. Four men were on guard, but they could not bind the legs of three cows, so these escaped. The remaining cow was very strong, and the four men mastered her only because she became entangled in the net.

They managed to get this cow aboard the *Frithjof*—after much work. She was very much frightened, and later she died. The doctor examined her and found that her back had been injured. Further, she was found to be sterile; a long time had passed since she had calved last. The same condition was found in many of the cows they shot while in Greenland. Kolthoff inferred that many of the musk-oxen in the region were overaged and had ceased to propagate. The animals which were to be taken to Sweden must, therefore, be calves.

The *Frithjof* reached the interior of Musk-Ox Fjord. On the way they shot a large wolf. They found the bird life relatively rich. Here the fjord was continued by a lowland, which connects with Mackenzie Bay, where they had previously been. The lowland was poor in animals, but traces of two wolves were observed.

The nets were now repaired, and Kolthoff gave orders to steam towards the mouth of the fjord. On August 18, in fine weather, they saw six musk-oxen with two calves. It proved impossible to separate the old animals from the two calves. So the old animals were shot—and by accident, one of the calves.

The remaining calf was captured and taken aboard the ship, with some trouble. It was very angry, but after some time it grew almost tame. The second calf which they obtained—a female—was caught a few days later.

These two calves, named Hjalmar and Lotta, soon got used to their new environment, and later, in northern Sweden, they felt quite at home.

While the hunting was going on in Musk-Ox Fjord, the two marine zoologists were busy collecting samples of the marine fauna in the fjord, with rich and interesting harvests. The weather had now deteriorated, amounting to strong winds and rain. The ship ran aground on a sandbank, and could not be liberated until the ballast was unloaded, as high water had arrived. Despite much work with the cable, anchor and ship's engine, there were many failures before the ship came free.

Homeward

The visit to Musk-Ox Fjord ended with high winds reaching hurricane force. It was also necessary to leave Franz Josef Fjord, and the ship was driven away

without sails, once the engine had been stopped. On August 24 they were back in Mackenzie Bay, to load stones for ballast.

The captain proposed going home, as winter was approaching rapidly. Kolthoff was disappointed at having to leave, but old ice was arriving and new ice was forming. On August 25 the *Frithjof* started her return voyage.

In the night towards August 26, the ship had to break a path through recently formed ice, which at places was more than 7.5 cm thick. Even Kolthoff had to concede that the winter was nigh, and that it was time to leave Greenland. Towards evening on the 26th, the ice opened and the large floes became few; next morning the *Frithjof* steamed in almost open water.

There was still some work to do. Kolthoff wanted to study how far the young of the storm petrels had developed. They grow slowly, and not until late autumn are they found on the open sea. Since they live on islands which are generally not visited by ships at that time of the year, little was known of this stage of their life. Other birds of the bird-cliffs were also of interest. A visit to Jan Mayen was called for, and the sea lay open.

Jan Mayen was reached on August 29. They came close upon the northern coast, but the northerly wind was strong and the breakers along the shore were furious, preventing a boat landing. The ship continued to the south coast, but it was icy, and nothing remained but to sail home. During the passage to Jan Mayen, the marine zoologists had been occupied with trawling and had obtained good results, but the equipment caused trouble.

Early in the morning of September 3, after a speedy passage of four days from Jan Mayen, the *Frithjof* anchored at Trondheim, Norway.

COMMENTS ON THE EXPEDITION AND ITS RESULTS

The expedition had met with some setbacks. Spitsbergen had been too wintry; they had encountered much ice on the passage to Greenland, which had prevented trawling. But the harvest in Greenland waters had been very rich, notably due to the good marine-zoological equipment. The entomological studies had been influenced negatively by the cold summer weather.

In all, 226 mammals and 1100 birds had been preserved. Parasites had been collected, and the doctor had taken 1200 samples for studying the bacteria in the intestinal canal of arctic mammals and birds. The habits of seals were studied and, by investigating their stomach contents, the diets of different species

were learned. Theories about the periodic migrations of hooded seals (*Cystophora cristata*), which prevailed in the zoological literature, were found to be wrong.

At Franz Josef Fjord, observations of the biology of the musk-ox were made. The Greenland lemming and its habits of life were studied carefully, both in Greenland and later at home in Sweden.

The life of the breeding birds was studied both in Spitsbergen and in Greenland. It was found that the birds used to fly as far as 200 km over the sea to get food for their young. At greater distances from land, the birds were found to be either young, sterile or non-breeding.

By using bag-nets, the vertical distribution of the marine animal life was studied. It was discovered that

a rich fauna prevailed at all depths from the bottom to the surface. The fauna to the east of Greenland was very little known at that time. In combination with the zoological studies of the Nathorst expedition of 1899, the expedition of 1900 added considerable new knowledge.

The zoological collections were distributed chiefly among the three universities of Uppsala, Lund and Stockholm, and the Biological Museum in Stockholm. Gustaf Kolthoff's zoological expedition represented a new type of scientific polar venture, by its concentration upon biological problems and upon collecting. This legacy certainly enhanced its clear success.

Hjalmar and Lotta, two young musk-oxen captured in East Greenland in 1900. The photo is taken one year after they had been moved from East Greenland to northern Sweden. (Kolthoff G.: Till Spetsbergen och Östra Grönland år 1900.)

31. AXEL HAMBERG AND THE SAREK INVESTIGATIONS

Axel Hamberg (1863-1933) belongs to the jacks-of-all-trades in Swedish polar research. He was a master of several scientific disciplines, and he was also a practical man, all of which made him an ideal field-worker.

He was born in Stockholm, where his father, Professor Nils Peter Hamberg, was a chemist working in forensic chemistry. Axel Hamberg began his higher studies in 1881 at Stockholm University which had been founded only three years previously.

This institution did not yet possess any examination rights; the students had to go to Uppsala or Lund to be examined.

It is natural that Axel Hamberg turned his interest towards chemistry and physics, and these subjects were included in his B.Sc., which he obtained in 1888. Otto Pettersson (1848-1941), professor of chemistry at the University, was at the same time a pioneer of physical oceanography in Sweden (see p. 405), and had worked on the oceanographic observations from the Vega expedition.

Already in 1883—at an age of 20 years—Hamberg became a member of Nordenskiöld's second Greenland expedition. Among other things, he was responsible for the investigations in physical and chemical oceanography. Otto Pettersson helped Hamberg with instruments for the expedition, and it is safe to assume that Pettersson also inspired Hamberg to go with the expedition and helped him to do so. Hamberg also took part in the paleontological field work under A.G. Nathorst.

In Stockholm a Norwegian, W.C. Brögger, was professor of mineralogy and geology, and Hamberg became one of his pupils. As a result Hamberg devoted a decade to studies in crystallography and mineralogy. In 1893 he became—without a doctor's disputation—lecturer in these disciplines at the University. The mineralogist Gregori Aminoff (1883-1947), in his biography of Hamberg, judged as follows:

"Hamberg was the foremost Swedish mineralogist of his time, and also in international competition he must have occupied one of the foremost places. From a mineralogical point of view one must deplore that, owing to external circumstances, he did not continue his mineralogical work."

By 1904, Hamberg's scientific work had on the whole changed towards geographical and geophysical problems. He took his doctorate in 1901, and the subject was no longer purely in mineralogy or crystallography; the title of his thesis was *Geological and physical geographical investigations in the Sarek mountains*. Of great importance to his subsequent research was a large fortune which he inherited upon the death of his father in 1902.

In 1907 he became professor of geography at Uppsala University. This discipline was to remain his principal interest during the rest of his life. Geography contains several specialties—not least cartography and photogrammetry, geology and glaciology, meteorology and climatology and oceanography—and all were central to Hamberg's sphere of interest. His practical interests were also many: travel technique, mountaineering, clothes and equipment for field use in cold regions, design and construction of scientific instruments, and the building of huts for scientific studies in mountainous and cold regions.

Hamberg visited the arctic regions three times:

- 1883 As a member of Nordenskiöld's second Greenland expedition; he was then only 20, but was responsible for the work in physical and chemical oceanography (see p. 153).
- 1892 Visit to Svalbard on board the Norwegian sealing yacht *Gjöa* (see p. 306).
- 1898 As a member of A.G. Nathorst's Svalbard expedition with the *Antarctic*. Hamberg's duties were manifold: physical oceanography, mineralogy, geology, cartography with terrestrial photogrammetry; he was also a photographer (see p. 264).

The scientific data which Hamberg collected during the expedition of 1883 were studied by him and published already in the following year in *Ymer*. Professor Hilding Köhler writes about this work:

"Hamberg had prepared himself carefully for the expedition, and after coming home he enthusiastically investigated his scientific material... He determined the CO₂ content, alkalinity, chlorine content, salinity and density of the sea water, and the temperature at different depths in the Greenland current. The quantity of results which Hamberg presents is imposing, but still more impressive on a young generation of geophysicists is how the young scientist was able to apply the modern developments in physics and chemistry to his problem."

Hamberg's own expedition to Svalbard in 1892 was in

his own opinion a failure, mainly due to an antagonism between him and the captain of the ship, Hans Christian Johannesen (1846–1920). However, the experience of ice—both on land and in the sea—which he gained during this cruise was to be of great value in his subsequent research work in the Sarek region of Swedish Lapland. He also acquired experience in using a plane-table camera for surveying, a contraption which had been devised by Hamberg himself.

During the Svalbard expedition of 1898 he was busily engaged. The cruise of the *Antarctic* round Svalbard gave Hamberg opportunities to work in more or less “virgin” waters. Ashore, he could devote himself to surveying with his plane-table camera, to astronomical determinations of position, geomagnetic measurements, and studies of glaciers and geological structures. Together with the cartographer C.J.O. Kjellström, he supplied the first reliable maps of Björnöya and Kong Karls Land. Hamberg also produced maps of Van Keulenfjorden and Recherche-fjorden.

Indeed, he had carried out first-class work, which must have been a consolation to him after the failure—again in his opinion—of the expedition of 1892. His polar travels and research were now completed. But instead he had, already a few years earlier, embarked upon a new scientific venture which was to last during the rest of his life: the investigation of the Sarek region in Swedish Lapland.

The expeditions of 1883 and 1898 have already been described. It remains to describe Hamberg’s Spitsbergen tour in 1892.

A VOYAGE OF RECONNAISSANCE TO SPITSBERGEN IN 1892

The lone scientist on a sealing vessel

Hamberg’s visit to Spitsbergen in the summer of 1892 was a rather preliminary venture. His interest in the Arctic was still lively, nine years after he had taken part in Nordenskiöld’s Greenland expedition in the *Sofia*. He applied for money from the Vega fund and obtained all that he wanted. In his report on the new expedition, Hamberg wrote:

“...it was my intention to make a preliminary reconnaissance for studying the ice conditions at Spitsbergen, the Norwegian hunters and their use in the service of science and, if possible, to gain an idea of this arctic land founded upon my own experience. I cannot deny that my intention was to return again to these regions, in one way or the other and with better equipment... However, I cherished hopes of obtaining some scientific results already during this first voyage. I did

realize that it would not be possible for me to hire a ship of my own, but I thought that at least some opportunities for making scientific observations would arise, even if I travelled as a passenger in one of the vessels which carry on hunting in the regions I wished to visit.”

In the following winter, 1891/92, Hamberg had an offer from Captain Hans Christian Johannesen (1846–1920) of Tromsø, who informed him that he intended to visit the West Ice along East Greenland. Johannesen pledged himself to visit the north coast of Spitsbergen, if ice conditions would permit. Otherwise he reserved the right to decide upon the course of the ship. No contract was set up. Hamberg had not been formally informed by the Swedish Society of Anthropology and Geography, whether he would be given any funds. When he received this information, it was too late for any formalities to be taken. In terms of time, Tromsø lay very far from Stockholm in those days!

Hans Christian Johannesen boasted a well-known name in polar history. He had been the commander of the *Lena*, which accompanied the *Vega* along the North-East Passage in 1878 to the Lena River, and then went upstream to Yakutsk. Johannesen’s yacht, the *Gjøa* of 62 tons, is no less renowned. In 1903–06, Roald Amundsen passed through the entire length of the North-West Passage on board this ship.

The crew of the *Gjøa*—not including her captain and cook—counted 12 men, most of whom were so-called “fisher Lapps”. After some delays, the ship left Tromsø on May 11, but not until the 24th did she stand out to sea. Hamberg found the days which followed extremely monotonous, and his time was mostly spent in his bunk. He seems to have already been somewhat irritated with the crew—or rather with the Lapps—and he characterized them as childish and capricious, except in connection with hunting and trapping.

“Unfortunately I was also looked upon as a catch, which should be flensed as carefully as possible. Their claims to rewards, even for very small services, were really magnificent and often degenerated into begging.”

This was definitely not the best way to start a long voyage in cramped quarters. Nor did the situation improve when animosity arose between Hamberg and the captain.

On May 28, Björnöya was seen to the north. In the following night the ship passed close along the western side of the island. In vain Hamberg asked the captain to lend him a boat and a few men for visiting the island.

The next day they met with the first ice, and during the following few weeks they cruised between Björnöya and Sörkapp, hunting seals. The state of mind on board now took a remarkable change for the better, as the catches were good. When the boats were away hunting, the ship had to lie hove-to, and therefore opportunities arose for making oceanographic observations. However, many chances were missed because of the captain's obstinacy. For such observations it was, of course, necessary to know the position of the ship, but the captain seldom took any astronomical observations for position, nor did he carry out a dead reckoning.

"Very soon I got the impression that he simply tried to hinder me from all scientific results, and the situation was often rather irritating. No doubt much depended here upon the fact that I was a lone stranger on board."

Hamberg therefore turned to studies of the sea-ice, namely its structure, gas and fluid enclosures, and so on. Yet to begin with, the people on board imagined that Hamberg was joking with them: obviously no scientific results could be obtained from mere pieces of ice. But when they understood that it *was* possible, they tried to stop him even here.

Several other hunting vessels were met. One was the *Cecilie Malene*, under Captain Magnus Arnesen. He is known as the commander of the schooner *Nordland*, which sailed with the steamer *Oscar Dickson* in 1880, destined for the Yenisey but reaching Gyda Bay instead (see p. 143).

"Meeting other sealers meant a badly needed change in the monotonous life on board the *Gjöa*; besides, my skipper and his crew exhibited a much milder disposition when other ships were near."

On June 17, when the *Gjöa* was near Björnöya, Hamberg received permission from the captain to be landed next day on the island together with two men—for a small sum of money. After one day's stay, they would be fetched by the ship.

At midday on the 18th, Hamberg and the two men were landed on the east side of Björnöya, just north of Miseryfjellet—at a place where it proved easy to come up to the plateau land, constituting the northern part of the island. They marched north-west along the steep precipitous cliff towards Engelskelva, where coal seams and fossils were said to exist.

At last they reached a valley in which a small brook was flowing, though mostly hidden from view by

masses of snow. They remained here, at Engelskelva, for some hours collecting fossils among pieces of rock, which had fallen or slid down from the sides of the valley.

Hamberg had hoped to reach Sivert Tobiesen's hut from 1864-65 on the north side of the island. But after marching for three hours, his two companions were tired of the journey. After a pause Hamberg was forced to return; one of the men was worn out. On the morning of June 19, they were back aboard the *Gjöa* after an absence of 17 hours.

The relations between Hamberg and the skipper had now improved. The course was set towards the north and west, apparently in order to reach the north coast of Spitsbergen. On June 23 the coast between Sörkapp and Hornsund was sighted. Flenching of the catch was to be done, and Hamberg asked the captain to do this in Isfjorden. However, the flenching took place on June 24-25 in the open sea, favoured by calm weather.

"These days did not increase the comfort and well-being on board; everything became covered with blubber, which—once there—will remain forever; and as everything was impregnated with blubber, the men themselves soon became impregnated with this substance. They lived in an atmosphere of blubber and 'pump odour'. The latter, the greatest scourge of the arctic yachts, consists mainly of hydrogen sulphide (H_2S) and arises from the decomposition of blood and meat, which sticks to the blubber and the skins after the flenching. This disgusting smell was, now and also later on some occasions, so intense that all metal objects in the cabin were blackened, even photographic paper and plates, if not carefully wrapped up."

On June 26 the *Gjöa* entered Isfjorden, but it was soon found that only the outer parts were free of ice. The ice-edge ran from Colesbukta to Trygghamna. The *Gjöa* anchored near the southern shore of Isfjorden, between Colesbukta and Grönfjorden. There was not much to do here, and already on the 28th they proceeded northward along the west coast of Prins Karls Foreland. That day, they came as far north as the middle (fourth) glacier of Dei Sju Isfjella. Then they suffered a calm, which lasted two days. Drift-ice was seen to the north, but the southerly swell was so high that it would have been dangerous to go into the ice for seal hunting.

Instead, Hamberg was given a boat with three men to study the glaciers, while the *Gjöa* was taken into Kongsfjorden, where they were to meet later. It

proved impossible to land along the coast of Dei Sju Isfjella because of the high swell. However, one could row fairly close along the glaciers, and Hamberg was given a good opportunity to study their general structure and different kinds of moraines—among other things the *internal* moraines, about which very little was known at the time. On the morning of July 1, they boarded the *Gjøa* in the mouth of Kongsfjorden. Next day they steered into the fjord, together with another sealer, and anchored in the lee of a tongue of land on the south side.

They stayed in Kongsfjorden for five days, until July 6. On the first day three polar bears were shot, but nothing happened after that. The crew could stand the inactivity for three days, and then began to grumble because nothing was done.

Hamberg, on the other hand, was at last able to concentrate on scientific work. He paid special attention to a few small glaciers with fronts ending on land, 1–2 km from the southern shore of Kongsfjorden. They were called “Lovén’s nevées” by Hamberg after Sven Lovén, who in 1837 had visited the same part of Kongsfjorden. Their present name is Lovénbreane.

He used his plane-table camera to construct a map of these glaciers, and studied the structure of their fronts, with internal moraines and terminal moraines. The glaciers filled the valleys between several small mountain ridges, and spread from there across the lowland to about 1 km from the southern shore. Their fronts consisted of either a steep ice-cliff or a smoother slope. Hamberg could now study internal moraines at close quarters to his heart’s delight.

On July 6 the anchor was weighed—in a calm—and they did not come out of the fjord until the 8th, when a northerly fresh breeze started to blow. Tacking northward, they came as far north as off Magdalenefjorden, where strips of rather heavy ice were met with. The captain did not want to sail farther north; he now intended to go south and, via Sörkapp, reach the waters to the east of Spitsbergen.

However, there existed an agreement between the captain and Hamberg to the effect that Spitsbergen’s north coast was to be visited. Hamberg asked for the disposition of a manned boat for two days, while the ship remained at her present position. He wanted to study the sea-ice conditions for one day and, during the other day, to map the small Hamburgbukta to the south of Magdalenefjorden. The former had not yet been investigated by any scientific expedition.

He was granted three men, but these had been out hunting during the previous day and night, and were not in the best condition; nor had they been told by the captain about his agreements with Hamberg. However, they did reach the eastern entrance to

Danskegattet between Danskøya and Amsterdamøya. A visit to Pike’s house from 1888—situated near the place where Andrée later had his balloon shelter—was out of the question. But observations on the distribution of the ice were made, as well as measurements of the ice thickness with the help of a “giant” set-square.

Coming aboard the *Gjøa* on July 9, Hamberg went to have some sleep. When he woke up, the *Gjøa* was proceeding south and had the southernmost of Dei Sju Isfjella to port. There was nothing that he could do about that.

Sailing and sealing to the east of Spitsbergen

The *Gjøa* sailed along the west coast of Spitsbergen, rounded Sörkapp, and arrived on July 15 in the neighbourhood of the island of Hopen. There they ran into fog and bad weather for some days.

“In this connection I got the bright idea of trying a bottom-scraper, which I had borrowed from Sparre-Schneider, a taxidermist of Tromsø. The crew at once took a great fancy to this occupation, and studied with interest the strange shapes which were taken up from the bottom of the sea. This was indeed much more interesting than my dull temperature observations and my water samples. During the next few days they were scraping to their hearts’ delight whenever there was an opportunity, either by day or at night, and independently of my presence, until one day the line broke and the scraper stayed in the depth of the sea. Such was the end of their pleasure.”

On July 17 the *Gjøa* proceeded west, then north into Storfjorden, passing through rather dense ice. They stayed for eight days, July 19–27, some ten nautical miles to the south-west of Kvalpynten, the south-west point of Edgeøya. The catch of seals had been rather low lately, but here in Storfjorden conditions improved. In fact the area between Storfjorden and Hopen, and between Hopen and Edgeøya, is considered the best hunting “ground” for big seals. During the stay near Kvalpynten the weather was “glorious”.

“It was really trying to be obliged to walk about the narrow deck of the *Gjøa* almost like a prisoner, by day and by night, able only to gaze upon the splendid mountains of Kvalpyntfjellet and Negerfjellet, the heights at the inner portions of Tjuvfjorden, still little investigated, and the eastern coast of Spitsbergen, most of which was an utter Terra Incognita to science. The ice conditions this year were extremely favourable in Storfjorden, and an expedition with a ship of its

Axel Hamberg, 1863-1933 a practical and learned man, here demonstrating his own design of dress and equipment for field use in the Scandinavian mountains during the summer season. (Hamberg, A: Sarekfjällen.)

Hamberg had many interests of which one was surveying. He preferred to use a photo-theodolite of his own design for the purpose. Note the hairlines in the picture, one horizontal and the other vertical (right). (Hoppe, G.: Minnesteckning över Axel Hamberg, 1980.)

The Norwegian yacht *Gjööa*. In 1892, Hamberg undertook a study tour in Svalbard and Svalbard waters on board the *Gjööa*. It was not an entirely happy tour, but Hamberg gained experience and knowledge and the ship as well as her captain and her passengers were to gain distinction (above left). (Hoppe, G.: Minnesteckning över Axel Hamberg, 1980.)

The investigations of Hamberg in Sarek, Swedish Lapland, were taken up in 1895 and went on till about 1931. They involved pioneering climbing tours and hard exercise. The photo shows geodetic measurements on the high mountains in central Sarek (above right). (Hoppe, G.: Minnesteckning över Axel Hamberg, 1980.)

Axel Hamberg's tour with the *Gjööa* in 1892. (left).

own would not have met with any great difficulties in substantially supplementing our meagre knowledge of the geology and geography of this region, which is generally so difficult of access. In vain I offered my skipper small sums for the disposition of a manned boat for a few days or a week."

Dissatisfaction

On July 27 the *Gjöa* steered south, then east, and passed north of Tusenöyane, although to the south of Kong Ludvigöyane. In the evening they came by Negerfjellet with its horizontal strata of the Triassic formation, and on July 29 they were near Ryke Yseöyane to the east of Edgeöya. Here they met the yacht *Cecilie Malene*, captained by Magnus Arnesen. In the night towards the 30th, Hamberg went aboard to negotiate with the captain for a transfer to his ship.

The relations between Hamberg and Johannesen had once again become very strained. In order to do any useful work, Hamberg wanted to hire Arnesen's ship for the rest of the season, or at least to obtain passage to Norway. The latter request could be accepted, but Arnesen intended to stay for another 8–10 days in the area. He promised to take Hamberg aboard his ship afterwards. Meanwhile the *Gjöa* went south to Hopen, then back towards Edgeöya and south towards Hopen again. Hamberg got an opportunity to study some icebergs, apparently coming from Nordaustlandet or from Kong Johans Bre on the east of Edgeöya.

On August 9 they were revisited by Magnus Arnesen, who announced that he would now sail home to Tromsö. The captain of the *Gjöa* was informed that Hamberg was leaving, and under a northerly breeze the *Cecilie Malene* steered south. Tromsö was reached on August 15, and on September 22 Hamberg arrived in Stockholm, having first spent some time in Norway occupied with glacier studies.

Hamberg regarded his tour in the *Gjöa* as a definite failure. His feelings of embitterment and disappointment were directed towards the captain of the *Gjöa*. In his direct way of expressing things, Hamberg wrote in a letter to Nathorst and E.W. Dahlgren—the latter a close friend of Nordenskiöld—as given in a rough draft:

"I wish I had him hanging by a gallows on top of an active volcano or at some other devilish place."

He intended to start a lawsuit against Johannesen. However, the two parties came to terms in April the following year. No doubt this was due to strong

pressure, which was brought to bear upon Hamberg by the "arctic establishment" in Stockholm.

And the voyage with the *Gjöa* had not really been a failure. Hamberg had observed many things, and he had gained experience which would be of value when, in 1895, he began his greatest venture: the investigation of the Sarek region in Swedish Lapland. The *Gjöa*, in turn, was to gain distinction as the first ship to sail entirely through the North-West Passage in 1903–06.

THE SAREK REGION IN SWEDISH LAPLAND *A wild environment*

The mountainous Sarek was declared a National Park in 1910, and is therefore still a wilderness as well as being fairly inaccessible. Far from the routes of man, it has an area of about 2000 km²; this roughly corresponds to a square 45x45 km², although the region is somewhat oblong from south-east to north-west.

Within the National Park boundary, the Sarek contains 200 mountain peaks higher than 1800 m a.s.l.—and 6 peaks higher than 2000 m, out of a total of 13 in Sweden. Until 1879, the Sulitelma (1874 m a.s.l.), situated to the south-west of the Sarek, was believed to be the highest mountain in Sweden. During that year, however, the Sarektjåkkå (2090 m) in the Sarek was found to be higher. Two years later, a still higher mountain was found about 60 km to the north-east, namely Kebnekaise (2123 m, present figure 2117 m).

There are about 100 glaciers in the region, and the precipitation is the highest in Sweden. The region lies approximately between latitudes 67° and 67.5°N, wholly within the Arctic Circle. The climate is subpolar or polar, depending upon the height a.s.l. The Sarek remained an almost unknown region until the turn of the century. It lacked possibilities for economic development, and its map was at best unreliable. In a word, the Sarek was—and remains—virgin territory.

Hamberg's first years in the Sarek

In the summer of 1895, Hamberg visited the Sarek for the first time. Already interested in the structure and behaviour of glaciers, he had come to love the free outdoor life in the north; the mapping and scientific study of virgin lands fascinated him. The Swedish member of the newly formed international glacier commission, Fredrik Svenonius (1852–1928), invited Hamberg to carry out a detailed mapping of glaciers in the Sarek. In July 1895, Hamberg commenced the task: with a veritable caravan of reindeer and men and heavy loads, he travelled into the last unknown region which lay wholly within Sweden.

This was certainly not to be Hamberg's last visit to the Sarek. From 1895 until 1931, he visited the region

every year except in 1898 and 1917. In 1898 he was a member of Nathorst's Svalbard expedition; and in 1917, taken ill with pulmonary tuberculosis, he stayed at the sanatorium of Romanäs in southern Sweden. The inventory of glaciers in the Sarek was the beginning of a great interdisciplinary investigation of the region, which would last till Hamberg's death in 1933. The research developed logically from the start, and one scientist after the other joined the project.

Hamberg very soon found that the topographic map of the region was so unreliable that it could scarcely serve his purposes. He therefore decided to map a central part of the Sarek. The resultant map was built upon a graphical triangulation and a few measurements of base-lines. The topographic features were then obtained by using a photogrammetric camera.

The mapping of the mountainous area necessitated the climbing of several peaks—including Sarektjåkkå (2090 m a.s.l.), the second highest of Swedish mountains. Hamberg's ascent of Sarektjåkkå was the third to be made. In the following years, numerous other high peaks were climbed, many of them for the first time (see Table below). With the exception of Pärtetjåkkå, the peaks given in the table are situated on both sides of the valley system of Rapavagge–Ruotesvagge, stretching SE–NW from Lake Laitaure in the south-east to the mountain named Akka in the north-west.

As the table shows, nearly all first climbs were made in the summer of 1896.

After the reconnaissance in 1895, Hamberg made up his mind

"to investigate topographically the entire region of high mountains between Kvikkjokk and Stora Sjöfallet [in the south and north respectively]."

Ultimately he wanted to construct a new and accurate map over the entire Sarek. The framework of this map would be derived from a network with six high peaks serving as triangulation points, among them Sarektjåkkå (2090 m).

"To carry out these six measurements meant a continual fight against difficulties."

To begin with, Hamberg lacked a sufficiently accurate theodolite and had to make triangulation measurements of a low order. Not until 1899, when he had obtained a more exact instrument, was he able to embark upon measurements of a higher order. In the first two years, 1896 and 1897, he carried out measurements from 130 points, and in the summer of 1896 he climbed about 20 mountain peaks higher than 1800 m a.s.l. (compare Table below).

In the following years, although Hamberg had a suitable instrument, luck was not in his favour. In 1899 and 1900 the weather was unsuitable, and he obtained measurements from only one of the six triangulation points. Not until 1902 did he get data from the remaining five points. Errors crept into the observation material, and new measurements had to

FIRST CLIMBS OF PEAKS IN THE SAREK HIGHER THAN 1900 M A.S.L.
THE CLIMBS WERE CARRIED OUT BY AXEL HAMBERG.

Peak	Height m a.s.l.	Date
1. Pärtetjåkkå	2005	Aug. 31 1896
"	2005	Apr. 7 1902
2. Kåtokkaskatjåkkå	1978	July 30 1896
3. Akkatjåkkå	1974	July 5 1896
4. Vuoinestjåkkå	1952	Aug. 18 1902
5. Kanalberget	1937	July 9 1896
6. Stuur Niak	1922	July 14 1896
7. Ruopsoktjåkkå	1914	Aug. 6 1896
8. Äpartjåkkå	1914	Aug. 4 1896
9. Sarvatjåkkå	1909	Aug. 18 1896

Source: G. Borenus in *Till Fjälls*, 1977. Note: The ascent of Pärtetjåkkå in 1896 was a "third climb", that of 1902 was a "first winter climb". All these peaks except Pärtetjåkkå are situated near the valley complex which extends SE–NW through central Sarek, from Rapavagge–Ruotesvagge to Akka Mountain.

be carried out in 1905, 1906 and 1910, but without full success; remaining errors had to be smoothed out from computations. The base-line for the triangulation network was measured in 1906, making it possible to connect Hamberg's geodetic network with that of the Swedish State.

It should be added that Hamberg took 1800 photographs with his photogrammetric camera, from about 500 stations. With the help of collaborators, levellings were carried out for fixing the heights of lake surfaces, passes and the mouths of brooks and rivers. Hamberg aimed at producing a map on the scale 1:50 000, containing contours to represent the topography. Correct names were obtained by co-operation with the professor of Finno-Ugric languages at Uppsala University, K.B. Wiklund.

Hamberg had set his ambitions too high, considering the means at his disposal—money and men—and the erratic weather conditions in the region. However, in 1922 he published a map on the scale 1:300 000, with correct Lapp names and with the topographical features shown in a simplified way. This map of the Sarek was the best on the market until official maps became available, constructed by air photogrammetry on the scale of 1:100 000.

Research activity increases

In 1895 the Sarek investigation was intended to go on for two years; but as we have seen, unexpected difficulties delayed the work in the field. The studies dealt at first with the glaciers and the topography and geology of the Sarek, but after some years interest turned towards meteorology and hydrology, zoology and botany. Hamberg succeeded in finding young scientists to help him—initially a geologist, a botanist and a zoologist. He also got competent people to help with his cartographic work.

The Sarek investigations developed into an interdisciplinary enterprise with several scientists involved, above all botanists and zoologists. In 1907 Hamberg started a scientific publication series of his own dealing with the Sarek research: *Naturwissenschaftliche Untersuchungen des Sarekgebirges in Schwedisch-Lapland, geleitet von Dr. Axel Hamberg* (Scientific Investigations in the Sarek mountains of Swedish Lapland under the leadership of Dr. Axel Hamberg). When Hamberg died in 1933, the series was made up of five volumes with a total of about 2400 pages. The number of contributions was about 40, and roughly three quarters of these were botanical and zoological inventories; the rest concerned meteorology, hydrology and glaciology.

Many prominent scientists worked in the Sarek and later published their results in the series.

SOME OF THE BEST-KNOWN SWEDISH CONTRIBUTORS WERE:

Gunnar Olof Alm (1889–1962), zoology, limnology.

Hampus Vilhelm Arnell (1848–1932), botany.

Tore Gudmund Adolf Ekblom (1896–1954), zoology.

Sven Petrus Ekman (1876–1964), zoology.

Axel Hamberg (1863–1933), geoscience and cartography.

Nils Gustaf Erland von Hofsten (1881–1967), zoology.

Hilding Köhler (1888–1982), meteorology.

Nils Hjalmar Odhner (1884–1973), zoology.

Ivar Oscar Herman Trägårdh (1878–1951), zoology.

Einar Otto Wahlgren (1874–1963), zoology (entomology).

During the international geological congress in Stockholm in 1910, Hamberg summarized his geological and geomorphological results. Among other things, he had discovered that the last remnants of the melting inland ice were not found to the east of the mountains but in the Sarek.

The melting inland ice thus “moved” westward towards the high mountains.

Hamberg also confirmed ideas which had been proposed by the Swedish geologist Alfred Törnebohm (1838–1911) regarding large mass transfers, to explain the fact that crystalline rocks in the Swedish mountains occur on top of the sedimentary rocks of the Cambro-Silurian periods. These ideas were forerunners to the conception of plate tectonics.

During the geological congress of 1910, a visit was paid to the Sarek and another excursion was undertaken to Spitsbergen under the leadership of Gerard De Geer (compare p. 326).

Geophysics takes the lead

The year 1910 marked a watershed in the programme of scientific research in the Sarek. The morphological and geological investigations were now more or less completed, and Hamberg turned to studies in meteorology, hydrology and glaciology, while the botanical and zoological investigations went on as before. These changes were connected with practical problems which had already been apparent earlier.

The investigation of the Sarek demanded the organization of veritable expeditions, having reindeer and assistants (carriers) loaded with equipment. There existed no paths or huts in the region, and none would be built after the Sarek became a National Park in 1910. Reindeer and assistants had to be hired; provisions, instruments, and everything else had to be carried; the scientists had to do part of their scientific work in tents; the organization of each summer's

investigations demanded much work and money—and the costs rose as the years passed.

Hamberg had been playing with the idea of building a few huts in the region, to serve as bases and scientific stations. Equipment could be laid up here, when transport conditions were the best. The idea became highly relevant when studies in meteorology, climatology, hydrology and glaciology were being

only temperature, was left on September 3, 1901, and was then functioning well.

Hamberg returned on April 7, 1902, but was at first unable to find the meteorograph, which had a height of 3.3 m. It had simply disappeared—but he observed some fantastic "snow monsters" and, digging in one of them, he found his instrument buried in snow. More exactly, it was encased in rime, built up from super-

MINIMUM WINTER TEMPERATURES (°C)

	1895/96	1896/97	1897/99	1899/1900
Sarektjåkkå (2090 m)	-19.0	-27.0	-27.8	-28.0
Kvikkjokk (330 m)	-27.0	-38.5	-38.0	-39.0

contemplated. In this connection it would also be important to know the meteorological and climatological conditions in the upper parts of the mountains.

The meteorological studies may be said to have begun in the high mountains from the very start, in 1895. A minimum thermometer enclosed in a metal casing was then left on the top of the Sarektjåkkå (2090 m a.s.l.). The thermometer was read and adjusted in the summers of 1896, 1897, 1899 and 1900; it should thus indicate the lowest temperature on the peak of Sarektjåkkå in the winters 1895/96, 1896/97, 1897/99 and 1899/90. The results, given below, have been compared with the corresponding values from Kvikkjokk (330 m a.s.l.) to the south-east of the Sarek region.

The minimum winter temperature thus proved to be roughly 10°C higher on the top of Sarektjåkkå than at Kvikkjokk in the lowland. This was contrary to what had been expected by Hamberg, and also by F. Svenonius, who had requested him to do the measurements. The marked temperature inversions, which develop above snow-covered ground in fine-weather situations in the winter, were not so well known in those days.

At the beginning of 1900, Hamberg planned to study the meteorological conditions in the high mountains by setting up recording instruments, so-called meteorographs, having a run of one year. Two stations for the recording were chosen, one on the summit of Pårtetjåkkå (2005 m) in the south of the Sarek region—33 km from the nearest settlement, which was the small village of Kvikkjokk. In terms of Sarek conditions, the Pårtetjåkkå was thus easily accessible. The other station, at a lower level, would follow later on.

In the summer of 1901, Hamberg set up his recording apparatus on the top of the Pårtetjåkkå. The wind recording unit was, however, not mounted because of the occurrence of severe gales; it was supposed not to endure a winter. The meteorograph, now recording

cooled fog or cloud droplets in situations with fresh to strong winds, the droplets freezing to ice when hitting objects—such as a meteorograph or the ground.

These rime formations were tremendous: the sides and top of the meteorograph held a layer 1–1.5 m thick, and the thickness was about 2 m on the ground near the instrument, where the cover probably consisted of a mixture of rime and snow. No "complete" meteorograph would function here. However, Hamberg noted that this intense rime formation was limited to the uppermost parts of the mountain. At 250 m below the top, no rime could be seen; and on a small plateau at 165 m below the peak, rather little rime had formed.

Here at 1835 m a.s.l., the meteorograph was mounted in the summer of 1902. Next year it was still covered in rime, but only partly so, and the rime was assumed to date from severe gales in the previous autumn. A few years afterward, Hamberg had the meteorograph cleaned of snow in late autumn, and it was found to be fairly free from rime in the following spring.

When Hamberg began his investigations in the Sarek, little was known about the conditions prevailing on the high peaks; in particular, the severe rime formation was quite unknown. The obvious conclusion was that a special hut had to be built—in the present case, on the Pårtetjåkkå plateau—and the instruments would have to be attended by meteorological observers. At the same time a hut would suitably be built at some intermediate level, to serve as both a meteorological observatory and a safety "device" for the man who was to routinely carry supplies up to the Pårtetjåkkå hut. Furthermore, a few huts might be built in the valleys leading into central Sarek. Hamberg had already pondered over such an outcome.

The huts in the Sarek

The Sarek had been declared a National Park, and from June 25, 1909, it was forbidden to build any huts

in the region. But a year later Hamberg was permitted by the Government to do so. He now became a builder and architect, although the problem was mainly one of transport.

The hut for the Pärtetjåkkå had to be transported from Kvikkjokk by reindeer and sledges, taking loads of 100 kg per sledge and reindeer. The best time for transport would be a relatively short period in spring, when the surface layer of the snow melts in daytime and becomes covered with a film of water, which freezes to form a crust of ice in the night—a surface of low friction. In this way it would be possible to reach the foot of the mountain, at roughly 800 m a.s.l. From here the building material would have to be carried by men to the observatory plateau (at 1 835 m a.s.l.). Even the transport from Stockholm to Kvikkjokk was time-consuming: 1 200 km by railway and 200 km by horse-sledges. Half of the latter leg passed over the ice of certain lakes. We shall consider this transport later.

It was evident from the beginning that the hut for Pärtetjåkkå had to be a fairly small and strong building, well insulated but also light, in order to meet the transport conditions. Hamberg decided that the hut should consist of a strong wooden framework with galvanized iron plates fastened to it on the outside and inside; in the space (10 cm) between the inner and the outer plates, heat-insulating mats of cotton wool were to be applied. With partitions, similarly constructed although less robust and only half as thickly insulated, four rooms were obtained: two with an area of 2.20 x 2.20 m², and the others 1.62 x 2.20 m².

The use of iron plates and cotton wool reduced the weight of the hut considerably, compared with using planks alone, but

“a newly built hut of galvanized iron plates does not present a pleasant appearance. Seen from the outside it looks like a battleship, from the inside like the Leads of Venice. This disagreeable impression could, of course, be eliminated by painting the plates.”

A few data regarding the transport of building material may be given here. The material reached Kvikkjokk in April 1911. By the beginning of May, the snow had attained a suitable consistency for the sledge transports; 2300 kg had to be brought, and as each reindeer could drag only 100 kg at a maximum, 23 animals would be needed. However, only 19 reindeer and 3 Lapps arrived to work, so 400 kg had to be left at Kvikkjokk and fetched later on. The caravan left Kvikkjokk in the night towards May 13.

In the night towards May 17, they had come within about 2 km from the foot of the mountain. Here the

material was left, while the Lapps with their reindeer returned to their camp, a blizzard having started. But they failed to appear again. The material was then carried to the Pärtetjåkkå plateau by two Lapps, taking from June 22 until July 5. One might well contrast the struggles and hardships of these transports with the ease of analogous helicopter transports today.

Hamberg arrived on July 5, and three days later he and four Lapps moved to the plateau to start the construction. Twice they had to leave the place because of blizzards, and seek shelter in a small cottage built some years previously of wood from Hamberg's instrument casings. This hut, situated near the forest limit, was called “Hotel Säkojokk”.

By July 18 the building work had proceeded far enough to enable them to find shelter in the new hut during high winds. On August 1, 1911, the hut on Pärtetjåkkå was so nearly completed that they could leave it and make the interior fittings later on. The other Sarek huts were built subsequently, somewhat weaker in construction than the mountain observatory.

FOLLOWING HUTS WERE SET UP 1912–1914:

1. The *Pårek hut* situated below Pärtetjåkkå at the birch forest limit, at 710 m a.s.l. This hut was to serve as an intermediate station between Pärtetjåkkå observatory and Kvikkjokk, besides being a meteorological station. The following huts were set up along the valley system which extends SE–NW through the Sarek (compare p. 311).
2. The *Litnok hut* (510 m a.s.l.), in the lower part of Rapa valley; it was intended for studies of the discharge in the most important river of the Sarek.
3. The *Tjågnoris hut* (675 m a.s.l.), near the birch forest limit in the upper parts of the valley system and centrally in the Sarek region; it was a suitable base for glacier studies in the surrounding massifs. (This hut was destined to be transferred, in April 1967, to the open-air museum at Jokkmokk.)
4. The *Skårkas hut* (595 m a.s.l.), in the middle part of the Rapa Valley and about halfway between the Litnok and Tjågnoris huts; this was a suitable central base for travels within the Sarek.

*The meteorological observatory on Pärtetjåkkå
(1835 m a.s.l.)*

In 1913 a grant for carrying out the meteorological observations had been obtained. A committee was established, to be responsible for the observation activity on Pärtetjåkkå. It consisted of Nils Ekholm (see pp. 176 and 248), Filip Åkerblom (see p. 274) and Axel Hamberg. Personnel were obtained, and instruments and other equipment were procured.

For the first investigations in Sarek, Hamberg had to organize veritable caravans of scientists, Lapp assistants, reindeer, instruments, food, camping equipment, etc. Later huts were built. These could be used as dwellings, as depots and as observatories. (Ymer 1901.)

A meteorological observatory was established in 1916 at Pårek, 710 m a.s.l., at the forest line. Left: Bror Hedemo, observer at Pårek. Right: Manne Hofling, assistant at Pärtetjåkkå (left below). (Hoppe, G.: Minnes-teckning över Axel Hamberg, 1980.)

The meteorological observatory on Pärtetjåkkå in southern Sarek, 1835 m a.s.l., was in use from 1914 to 1918 (below right). Photo: Bengt Erik Rydén, 1960.

The observatory on Pärtetjåkkå, 1835 m a.s.l., in winter. Photo: Manne Hofling, December 1916.

The observations were to be made by two young university graduates, preferably B.Sc.'s in physics, chemistry and mathematics. One was to be the chief, with the title of observer, and the other merely an observer with the title of assistant.

Food and fuel (paraffin oil), mail and other items would be brought up to the observatory rather regularly from Kvikkjokk—33 km distant but, from 1916 onward, with the Pärekk hut on the way. One carrier was to be responsible for this hard and sometimes dangerous task. The observation activity would depend upon this man being reliable, strong, and able to find his way even in fairly bad weather.

The routine meteorological observations were to be conducted every full hour, 24 times daily. Recording instruments were also mounted at Pärtetjåkkå; but since exactness was aimed at, the temperature and humidity were obtained from direct readings of Assmann psychrometers, and pressure was of course measured with a mercury barometer. In this way the observations were independent of variable corrections of the recording instruments. But it also meant that the two observers became "chained" to the observatory.

Later, when observations were begun at the Pärekk hut, one of the mountain observers could pay him a visit for a day or two, while the remaining man performed observations every full hour throughout the day and night. There were additional observations, not quite so regular—such as measurements of density and thickness of the snow-cover, observations

of rime and its formations, measurements of atmospheric electricity, studies of clouds and of cloud formations.

The observations began at Pärtetjåkkå on July 1, 1914, and at Pärekk on July 1, 1916, continuing at both stations until September 15, 1918. The latter station, being near the forest limit, was more sheltered and the observations were made in the more common way, with direct readings a few times per day, supplemented by data from recording instruments. Only one observer was stationed here. The temperature and wind conditions in 1914–15 at Pärtetjåkkå are given on p. 318.

The observation activity started at a somewhat unsuitable time: World War I broke out one month afterward. Gaps in the observation series were caused by military conscription of the observers, although exemption from service was later granted. And communications with the mountaintop were slow, which increased the gaps. Later, when rationing of food and paraffin oil set in, problems often arose; at times the way of life on the mountain then became ascetic, to say the least.

The low rations and the unexpected times, when they set in, caused Hamberg much worry and a good deal of paper work.

To this was added problems which had to do with the engagements of reliable carriers for sustaining the observers with food and fuel. Difficulties in this respect were to lead to an accidental death among the observers.

*THE FOLLOWING PERSONS WORKED AT PÄRTETJÄKKÅ AND PÄREK:
Observers (O) and Assistants (A) on Pärtetjåkkå (1835 m a.s.l.) and at Pärekk (710 m a.s.l.)*

<i>Period *</i>	<i>Pärtetjåkkå</i>	<i>Pärekk</i>
1914–1915	Axel Jönsson (O) Hilding Köhler (A)	—
1915–1916	Hilding Köhler (O) Axel Johansson (A)	—
1916–1917	Oskar Edlund (O) Manne Hofling (A)	Bror Hedemo (O) **
1917–1918	Manne Hofling (O) Finn Malmgren (A) <i>After Hofling's death (Sept. 29, 1917):</i> Finn Malmgren (O) Bertil Viberg (A), from Oct. 10, 1917 <i>Extended observations</i> <i>(July 1, 1918 to Sept. 9, 1918):</i> Bertil Viberg (O) John Eugen Nyström (A)	Sigurd Åstrand (O)

* Each period ran from July 1 of the first year until June 30 of the next.

** The "official" title at Pärekk was *meteorologist*.

Two of the observers at Pårtetjåkkå were later to become well-known for their meteorological research in cold regions:

Hilding Köhler (1888–1982) became professor of meteorology at Uppsala University. His stay on Pårtetjåkkå introduced and inspired him to a successful study of the condensation process in the atmosphere. In 1918–26 he was head of the geomagnetic and meteorological observatory on Halldé (900 m a.s.l., lat. 70°N) near Altafjorden in Norwegian Finnmark. Here he also gained rich opportunities for studying the water in the atmosphere.

Finn Malmgren (1895–1928) devoted his active life to meteorological and oceanographical research in the Arctic, where he died in connection with the crash in 1928 of the dirigible *Italia* (see p. 419). His stay on the Pårtetjåkkå gave him good training for his future arctic career.

A tragedy

Life on the Pårtetjåkkå was mostly monotonous. However, the atmosphere offered ever-changing scenery. The men lived among the phenomena they were studying, had time to think, and were not disturbed by the outside world. To some people, such a life appeals in the highest degree. Such a man was Hilding Köhler.

Sometimes it was cold in the hut, when the carrier was prevented from coming by periods of bad weather or by mere neglect. At times the indoor cold was due to the rationing of paraffin oil during the war. Similarly, the store of provisions varied.

Two main events were the hurricane winds on February 14, 1917, and the disappearance of the observer Manfred (*Manne*) Hofling (b. 1888) on September 25, 1917. The hurricane had a relatively short career of three hours, but it was very intense. Hofling himself described the hurricane winds at the time of maximum development:

"At 09.00h and 10.00h it was impossible to make any observations, the mercury in the barometer jumped up and down, and we could not open the window. Nothing remained but to wait and consider what might happen. The wind gusts gave rise to a drumfire as if coming from hundreds of guns, so that during the worst period (09.15–10.00h) we had to shout into each other's ears as loudly as we could."

Outdoor instruments and equipment blew away, and some were never found again.

The disappearance and death of Manne Hofling

(1888–1917) was a direct consequence of the neglect of a carrier. The previous carrier had become indispensable. He had attended to his hard transport work for 1.5 years, but finally, at 59 years of age, he wanted to be released from his task. After May 9, 1917, the communications with the "outside world" became unreliable and ceased for long periods, resulting in a gradual decrease or even disappearance of reserves, which had been laid up at the observatory.

The men on Pårtetjåkkå were informed that the provisions would arrive on September 20. Nothing came, and Hofling decided on the 22nd to go down to the Pårék observatory to obtain some food, as only provisions for one day remained on Pårtetjåkkå. He left, however, as late as 17.00–18.00h, meeting with snowfall and low visibility on the way. He had to spend the night outdoors without protection, but next morning he discovered that the "Säkok Hotel" was close at hand.

Only 3–4 km then lay between him and safety at Pårék. He got there, but with the greatest exertion. Becoming feverish, he went to bed, and his wet clothes had to dry. On the 25th, he left Pårék with 13–15 kg of provisions. He was ill and a headwind was blowing, 10 m/s at Pårék, rising to 29 m/s at Pårtetjåkkå. Hofling never reached the observatory, where Malmgren had awaited him with food for less than one day.

The gale lasted till the evening of September 26, and the wind was still fairly strong on the 27th, when Malmgren decided to go down to Pårék. He started in the evening and had, like Hofling, to spend the night outdoors; not until the morning of the 28th did he reach Pårék. With the observer at Pårék, Sigurd Åstrand, Malmgren then went to Kvikkjokk to organize search operations; the weather was still unsuitable at Pårék, with a gale blowing. Hamberg was informed and people from Kvikkjokk came to help in the search. But nothing has ever been heard of Hofling.

A guess has been brought forward that Hofling did reach the Pårtetjåkkå plateau, close to a precipice where the trail passed. A wind gust or reduced visibility may then have made him tumble down upon the glacier below, where he would have become encased in the snow and ice. This can explain why his bodily remains never have been found.

Hamberg was ill at the time, staying in a sanatorium. He now had to find a new observer, Bertil Viberg, and arrange the search. Subsequently Hamberg was much criticized in regard to this event; but from his correspondence with and instructions to Hofling, it appears that the criticism was unfair. In any case, a result of the tragedy was that the observation activity on Pårtetjåkkå and at Pårék had to be

METEOROLOGICAL OBSERVATIONS (JULY 1914–JUNE 1915) FROM PÅRTETJÄKKÅ, SAREK, SWEDISH LAPLAND

Position: 67°9'23"N, 17°37'57"E; 1835 m a.s.l.

Anemometer: 6.5 m above ground.

Temperature in °C, wind speed in m/s, cloudiness in tenths.

1914	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean temp.	+6.2	+1.3	-3.4	-5.1	-9.7	-12.6
Max. temp.	+17.6	+10.2	+3.7	+3.0	+0.6	-6.0
Min. temp.	-4.2	-7.1	-13.0	-12.8	-16.4	-19.8
Mean wind speed	6.0	5.3*	7.9	9.4	8.3	8.2
Mean cloudiness	5.6	(6.4)**	7.7	4.0	5.5	5.7
1915	Jan.	Feb.	March	April	May	June
Mean temp.	-15.7	-14.6	-17.5	-11.5	-9.7	-4.1
Max. temp.	-8.1	-5.0	-6.8	-3.6	-1.0	+3.1
Min. temp.	-23.0	-27.4	-26.1	-19.0	-18.8	-10.6
Mean wind speed	7.1	6.8	8.4	8.8	8.3	7.3
Mean cloudiness	5.2	6.0	5.6	7.0	6.2	6.5

ANNUAL VALUES JULY 1914–JUNE 1915

Mean temp.	-8.0
Max. temp.	+17.6
Min. temp.	-27.4
Mean wind speed	7.6 m/s
Mean cloudiness	6.0 tenths

* Observations covered 25 days.

** Observations covered 11 days.

Data taken from Hamberg, A. and Jönsson, A.: *Meteorologische Beobachtungen auf dem Pärtetjäkkå während des Beobachtungsjabres 1. Juli 1914 bis 30. Juni 1915*, Naturwiss. Unters. d. Sarekgeb., Vol. V, 1933, pp. 105–210.

discontinued at the end of the fourth year. It proved impossible to find personnel for the observations.

Hamberg continued to investigate in Sarek, spending the summers there until 1931, and died in 1933.

A FEW COMMENTS

Despite all this work, the Sarek investigations were never quite completed. The topographic map of the region was not published; the field measurements led only to a preliminary map on the scale 1:300,000 which was originally produced to indicate the Lapp place-names, although it was far better than the existing official map at the time. Nor were several research projects fulfilled. Many were carried out, as is clear from the series of scientific publications with its 2400 pages in five volumes.

Citing Gunnar Hoppe in his biography of Hamberg:

“The flow of enterprising young scientists was now directed less towards the Arctic than towards the Sarek of Hamberg.”

The huts in the Sarek are still used for scientific purposes.

32. GERARD DE GEER

RESEARCH ON LAND ICE AND ON ICE AGE

Gerard Jakob De Geer (1858–1943) is perhaps best known for his research on the latest Ice Age—notably its latest 20 000 years. However, he was also an arctic traveller, a geologist, a glaciologist and a cartographer. He visited Svalbard six times between the years 1882 and 1910, and was especially fascinated by the land ice in the region.

From his observations and studies here, he was able to interpret deposits from the Ice Age which are found in north-western Europe, but far away from any land ice existing today.

De Geer specialised in glacial geology and attained high positions in science, but his career differed from

The Sarek National Park in northern Sweden, shown in dark shading on the map, to separate it from the surrounding land.

(Statens Naturvårdsverk: Sveriges Nationalparker, 1983.)

During his Spitsbergen expeditions De Geer was—among other things—a keen observer of the extension and variation of the Spitsbergen glaciers. De Geer was above all an expert on the Isfjorden region. The map shows the extension and the edge of the Wahlenberg glacier at Ekmanfjorden (below).

(Ahlman, H. W:son: Gerard De Geer,
Minnesteckning.)

Gerard De Geer (1858–1943), geologist, notably within disciplines dealing with glaciers and the Ice-Age problems. He was also a cartographer. (Lundqvist, G.: Gerard Jakob De Geer, Minnes-teckning.)

the normal kind. His father was the Swedish statesman and author *Louis* Gerard De Geer (1818–96). He pursued only two years of academic studies, earning his B.Sc. in 1879. This was in fact the only academic degree which he sought; higher degrees and positions were awarded to him as a consequence of his scientific contributions.

As early as 1878—one year before his B.Sc. examination—he obtained a post at the Geological Survey of Sweden, whose chief was Otto Torell. He stayed there for almost 20 years: in 1878–81 as extra geologist, in 1882–85 as assistant geologist, and finally in 1885–97 as geologist of the permanent staff. Meanwhile, in 1893, he obtained an honorary Ph.D. at Uppsala University.

After leaving the Geological Survey he embarked upon an academic career, in 1897–1924 as professor of geology at Stockholm University, being its vice chancellor in 1902–10 and provice chancellor in 1910–24.

He also had several public functions, and in 1900–05 he was a member of the Swedish Parliament. Retiring in 1924, he was still the head of the *Geochronological Institute*, founded by himself. Here he remained until his death in 1943. He was ably assisted by his wife, Ebba Hult De Geer (b. 1882), to whom he had been married since 1908.

In 1882 the Royal Swedish Academy of Sciences invited De Geer to take part in a geological expedition to Spitsbergen under A.G. Nathorst (1850–1921). No doubt his recommendation came from Otto Torell (1828–1900), who was a pioneer student of the Ice Age problem and, like De Geer, had soon understood the advantage of studying the present-day land ice and its deposits to acquire basic knowledge in Ice Age research (compare Chapt. 4). De Geer never visited other regions in the far north or south than Svalbard. He became primarily an expert on the Isfjorden region.

De Geer had much to do on his expeditions, and also later at home. His expeditions are therefore badly documented in general; often he described them in short notes of 2–3 pages, usually in *Ymer* of the Swedish Society of Anthropology and Geography. At times he supplied information in notes which should have been published some ten years earlier.

De Geer's expertise in cartography served him well from the outset. In 1882 he employed photography both for mapping and for documenting geological features and structures in the landscape. His cartographic work, notably in the Isfjorden region, is a vital part of his contributions to our knowledge of Spitsbergen. However, he supplied very little information on the methods which he used. In 1896 he was

more engaged in mapping than on any of his other expeditions. In a lecture in 1890, he gave some practical hints on

“...the advantage of determining the positions of all the points which can be identified on photographic plates, which have been exposed in series from the ends of a base-line; besides, the landscape pictures facilitate the connecting of the points”.

Concerning the mapping of Isfjorden in 1896, De Geer stated in 1912 that he

“...adopted the plan of making a great number of maps independently of each other and thus founded on as many separate base-lines. Signals were also erected, and a considerable number of angles were measured for the connection of the special maps.”

On this topic Hans W:son Ahlmann remarks:

“He [De Geer] is well aware of the difficulties which are inherent in this procedure, but considers that it, combined with the photogrammetric technique, was the only possible one for using the hours with a clear sky and good visibility; otherwise the expedition would not have attained its aims. The number of such component maps amounted to about 30, and the base-lines, 500–600 m long, were measured with a steel tape on flat ground along the shore...”

On the whole, the expedition of 1896 lived up to the expectations of De Geer: it supplied the first comprehensive map of the entire Isfjorden. The first edition of this map was published in 1910; it was at the time a most praiseworthy piece of work.”

De Geer had started his scientific observations already at the age of 20. He was a good observer, although never a theorist. In 1882, during the expedition to Isfjorden under A.G. Nathorst, he began to meditate upon his observations in the field. During the following years, his thoughts ripened for harvesting in his works on the Ice Age.

De Geer is best known for his research on *varved clay*—the annual sedimentations of glacial rivers, with dark strata from the winters and light strata from the warmer seasons. By connecting diagrams of the varves from nearby places, he found a method of dating the retreat of the melting inland ice. These ideas originated as early as 1879, and his

final great work on the subject appeared in 1940–*Geochronologia Suecia: Principles* (see Bibliography of the present chapter).

But he had studied much more of Quaternary geology, such as strandlines and strand terraces. Their altitude above the present sea level, and their contents of subfossils, revealed changes in the height of the land relative to the actual sea level, and in the climate, during postglacial times. He also studied the eskers and explained their formation. With the help of his diagrams of varved clay, he was able for instance to follow in detail, and to date, the retreat of the inland ice in north-western Europe.

Much of this work built upon what the young geologist De Geer had observed in the field during the late 1870s and early 1880s. His ideas had only to mature and be combined with later observations. Hence, the Spitsbergen expeditions of De Geer played an important role in his development as a scientist.

His arctic expeditions and travels are summarized below:

- 1882 Geological expedition, mainly to the Isfjorden region of Spitsbergen, together with A.G. Nathorst who was the leader (Chapt. 19).
- 1896 Geological and cartographical expedition to the Isfjorden region. The expedition—9 men and 2 boats—was taken to Spitsbergen with the *Virgo* of the Andrée expedition. Isfjorden was investigated using the two boats, which had Adventfjorden as a base. (see p. 322). De Geer led this expedition.
- 1899 Invited by the Russian Committee of the Arc-of-Meridian expedition, De Geer and his topographer—Lieutenant Otto von Knorring of the expedition of 1896—joined the Russian expedition at its base at Hornsund, to take part in its field activity. De Geer now acquired opportunities to study *southern* and *south-eastern* Spitsbergen. (See p. 347).
- 1901 E. Jäderin, who had been the leader of the Swedish Arc-of-Meridian expedition for three summers and one winter, had asked to be freed from the leadership in the summer of 1901. De Geer was appointed leader in his place, and was then able to study the geology of *north-western* Spitsbergen. (See p. 352).
- 1908 Leader of a large interdisciplinary expedition to investigate the Isfjorden region in great detail as regards geology, zoology and oceanography. A detailed map of the region was also constructed, including topographical features on land and in the sea. (See p. 323).
- 1910 Leader of a geological excursion to the Isfjorden region for attendants at the 11th International

Conference on Geology in Stockholm. (See p. 326).

De Geer's visits to Spitsbergen in 1899 and 1901 are treated in connection with the Arc-of-Meridian expeditions (see references above).

DE GEER'S SPITSBERGEN EXPEDITION OF 1896

Plans and expedition members

After De Geer's first visit to Spitsbergen in 1882, fourteen years passed until his next visit. In Spitsbergen he gained knowledge of the glaciers and their deposits, which was of great value to his work on the glacial deposits from the latest Ice Age in Scandinavia.

By 1896, interest in polar exploration had increased in Sweden, due to the daring plans of the Andrée expedition. It was therefore easier to obtain economic support for polar research than earlier. When, in the same year, De Geer presented his plans for a geological study and detailed mapping of the Isfjorden region, he met with positive response from King Oscar II, Oscar Dickson and the wholesaler Fredrik Bünsow. Moreover, he was offered free passage to Spitsbergen on the steamship *Virgo*, which had been hired by the Andrée expedition.

De Geer's main task was to carry out a detailed mapping in order to obtain cartographic material as a basis for a complete study of the arctic environment. The mapping was to be done by the photogrammetric method which De Geer had tried already in 1882.

Nine persons were to take part in his expedition:

SCIENTIFIC STAFF

Gerhard Jakob De Geer (1858–1943), Ph.D.(h.c.), geologist, topographer, photographer, leader of the expedition.

Otto Wilhelm von Knorring (b. 1863), lieutenant in the Swedish Army, topographer, photographer.

C.A. Hansson, taxidermist at the Museum of Strömstad (Sweden), responsible for the meteorological observations and the collections of the expedition.

ASSISTANTS FOR PRACTICAL WORK

P. Björvig	H. Myhre
K. Iversen	D. Johannesen
H. Iversen	C. Jakobsen

The latter six men came from Tromsö or its neighbourhood. In the equipment were included two boats, 7 m long, and three tents.

Arrival and field work in Spitsbergen

The *Virgo*, carrying the expedition, reached the mouth of Isfjorden on June 20. Here she met the Norwegian steamer *Raftsund* belonging to Vesteraalens Damp-

skibsselskap, bound for Adventfjorden with material for a tourist hotel. A British expedition under Sir Martin Conway was also on board—as was the Swedish journalist J. Stadling, who intended to witness the start of Andrée's balloon expedition for his newspaper, *Aftonbladet*.

De Geer's expedition was invited to go with the *Raftsund* to Adventfjorden, where a depot of provisions would be laid up near the prospective tourist hotel on Hotellneset (which now obtained its name) at the mouth of Adventfjorden. De Geer's expedition was then ready to begin scientific work.

The inner portions of Isfjorden were still icy, so the expedition commenced work in the outer portions, from the west. The depot of provisions had, at Adventfjorden, a central position within the Isfjorden fjord complex. The boat excursions of the expeditions would have Hotellneset as base and starting-point. At intervals of one or two weeks, the boats would return to the base and fetch a new load of provisions. In this way it was hoped that the whole of the Isfjorden region would be covered during the summer. And each week the Norwegian steamer *Lofoten* called at Hotellneset. Mail and extra provisions were then obtained. Spitsbergen had become a goal of tourist excursions.

The De Geer expedition had the experience of previous Swedish ventures to build upon, and was equipped in advance with everything needed for life and work. De Geer expressed the situation in a nutshell:

"It has thus been proved that an expedition which is thrown back upon its own resources of open boats, tents and other equipment, is able to carry out all the work necessary for a detailed mapping in the mild season of three months."

The days passed while exact and effective scientific tasks were routinely performed. The geological investigation was conducted by De Geer, who also did most of the topographical work and a good deal of the photographic documentation.

Lieutenant von Knorring was responsible for most of the photographic work; he joined, too, in the topographic measurements, and took care of the stores and other expedition equipment. C.A. Hansson, as mentioned, saw to the meteorological observations indicated by thick coastlines and to the collections which were made. De Geer writes:

"Our expedition is the first which has visited Spitsbergen for the specific purpose of undertaking a systematic large-scale mapping of a

connected region in order to acquire a necessary cartographic basis for a more full survey of the arctic environment."

The scientific results

Among the expedition's achievements should primarily be mentioned a skeleton map on the scale of 1:100 000 covering almost the entire Isfjorden area, which extends roughly 100 km in length and breadth. For this purpose a great number of measurements were made with theodolite, plane-table, telescopic ruler, and other instruments. Further, from a great number of triangulation points, 500–600 orientated photographs were taken with the camera in a horizontal position. These photos were to be used for working out the topographical details with the help of photogrammetry.

Of the photographs, 100–200 were taken for purposes of geology or to show interesting details. So the total number of exposed negatives was about 700. As the position of many of the points on the map had been determined in several different ways, they would give a good indication of the reliability of the photogrammetric methods used. De Geer remarked that his map of the Isfjorden region was probably the most detailed map which, at that time, had ever been produced over a fairly large area within the polar regions.

He also pointed out that the photographs with a horizontal camera would make it possible to enclose many new altitude figures on the map—besides contour lines—to indicate the topography. It would even be possible to indicate the height and slope of different strata in the mountains. Few regions on Earth are better suited for such a detailed study of the structure of the Earth's crust. Along all of the lateral fjords and valleys which open into Isfjorden, nature herself has produced the most outstanding sections through mighty series of rock strata.

De Geer pointed out that

"...the large Isfjorden with its many lateral branches and coastal plains constitutes a sunken portion of the Earth's crust, bounded in all directions towards the surrounding frame by old rifts and considerable faults. Many of the smaller lateral valleys have, on the other hand, apparently been formed from later excavation or so-called land sculpture; and here, where no earth layers hide the character of the bedrock, it was of great interest to notice the diverse phenomena which characterize the sculptural work of streaming water and inland ice."

In Oscar II Land, at the time an almost unknown peninsula to the north-west of Isfjorden, the expedition studied a series of grand foldings, which seemed to be connected with the raised and folded strata along the Spitsbergen west coast. But the timetable did not allow any detailed investigations in this interesting region, and only a part of the folded area was examined.

"It seemed as if these foldings had occurred as late as the beginning of the Tertiary, probably in connection with a considerable rise of the land, which in these regions had preceded the Ice Age."

During the survey work, great attention was paid to the glacial formations. These observations indicated that the extent and thickness of the glaciers had once been much greater than now. Isfjorden and its lateral valleys were then filled with large streams of ice.

The expedition also studied strandline formations, which were due to the land being more depressed below the sea surface towards the end of the Ice Age than it is today. The highest of these were found at 130 m above the present sea level. Postglacial shell-banks were studied, containing shellfish which are no longer found in Spitsbergen waters, an indication that the climate was then milder. A question of great interest, from a climatological viewpoint, was how the extent and thickness of the glaciers vary in present times.

The eight glaciers which reach, or almost reach, Isfjorden from the north-west were named the Holmström, Sefström, Svea, Wahlenberg, Bore, Nansen, Esmark and Kjerulf glaciers, in order from north to south. Two of them, the Wahlenberg and Sefström glaciers, were given special attention by the expedition: they were mapped on the scale 1:20 000, as were the Nordenskiöld and Von Post glaciers in the north-eastern part of the Isfjorden region. Moreover, the fjords were sounded off these four glaciers, making it possible to get an idea of the thickness of the glaciers, which protruded into the sea.

Series of photographs were taken from well-defined camera positions, in order to indicate the extent and state of the glaciers in 1896. With similar photographs taken in the future, it will be possible to determine the variations of the glaciers and enter these changes on maps. In 1882—during the expedition with Nathorst (Chapt. 19)—De Geer had photographed the same glaciers from the same camera positions. The changes which had occurred in the interval of 1882-1896 were very intriguing. The large Sefströmbreen, with a vertical front, had protruded

about 4 km into Ekmanfjorden, although a retreat caused by melting seemed to have commenced. The glacier had reached the islet of Coraholmen, and only about 1 km remained to the eastern shore of the fjord. In other words, the inner part of Ekmanfjorden had been on the point of becoming secluded from Isfjorden (on p. 319).

The lands of Dickson, Bünsow and Nordenskiöld in the north-east and south were not covered by any inland ice; only local glaciers existed there. The limit between the two former lands and the inland ice was largely ascertained, and the respective lands' ice-free valleys of Mimerdalen, Gipsdalen and Sassendalen were mapped in part—like the lowlands, mountains and glaciers in Oscar II Land, which had been little known until then. Consequently the map of Isfjorden was revised in many ways. For example, Bohemanneset proved to be a plain some 10 km wide, instead of a narrow spit of land. North of Bohemanneset there opened a bay, Yoldiabukta, which was more than half the size of Tempelfjorden. The forms on the map of Ekmanfjorden and Kapp Waern, too, had changed.

"Svenskehuset" at Kapp Thorsen was visited and was found in fairly good order. Besides the expedition's main aims of mapping the Isfjorden region and documenting it photographically, other types of scientific activity were carried out. Collections of zoofossils were brought home, mainly from the Permo-Carboniferous, Triassic, Jurassic and Quaternary periods.

A rich collection of recent molluscs and other marine animals was obtained by bottom-scraper. Phanerogamic plants and seeds were collected. Hydrographic observations were made—giving water samples, water temperature and plankton forms at different depths—and meteorological observations were recorded.

The expedition was thus assured of success. On September 5, when the planned work had been completed, a Norwegian hunting cutter, the *Malygen*, arrived and the men were offered a passage home with her. They reached Tromsø on September 15.

In 1899 and 1901, De Geer was attached to the Arc-of-Meridian measurements, which were carried out in Spitsbergen by Swedes and Russians in 1898-1902. In 1899 he was a guest scientist with the Russian group, and in 1901 he was the leader of the Swedish group (see pp. 347 and 352).

THE SPITSBERGEN EXPEDITION OF 1908 *Plans and men*

The largest arctic enterprise led by De Geer was also his last expedition, although in 1910 he was to return as leader of a geological excursion (p. 326). On the

whole, the scientific programme in 1908 was the same as that of the expedition of 1896, viz. a detailed mapping and an interdisciplinary scientific study of the Isfjorden region.

Now, however, cartography did not play a dominant role as it had done in 1896. Instead, marine zoological investigations were added, while systematic hydrographic series and depth soundings were carried out in order to supply information on the environment of marine animals. The intention was also to build upon the scientific work of 1896. The glaciers and their extent and thickness would be studied, and new data would be obtained on their variations with time.

In 1910, the 11th International Conference on Geology was to be held in Stockholm. Swedish contributions in geology would be presented, both as regards the conditions in Sweden and in the polar regions, notably in Svalbard. De Geer was chosen as president of the conference, and J.G. Andersson as its secretary-general. Guides for the delegates at the conference were to be published, including a guide entitled "A Geological Excursion to Central Spitsbergen".

An excursion to Spitsbergen—the Isfjorden region—was planned, and the participants were to be given details on the region in question. Other guides dealt with the Swedish research in Spitsbergen, and with the stratigraphy of the Svalbard archipelago, written by A.G. Nathorst. It was imperative that the very best and latest information be supplied to the conference members, who numbered about 500. The Spitsbergen expedition of 1908 was to supply this information. At the same time, the excursion to Isfjorden could be planned directly and ideally in the field.

THE EXPEDITION'S SCIENTIFIC STAFF CONSISTED OF THE FOLLOWING PERSONS:

Gerard Jakob De Geer (1858–1943), Ph.D.(h.c.), geologist and cartographer, leader of the expedition.

Carl Johan Josef Ernst Wiman (1867–1944), Ph.D., palaeontologist.

Nils Gustaf Erland von Hofsten (1881–1967), Ph.D., responsible for the marine zoological and hydrographical work.

Oscar Hallin, professional photographer, responsible for the photographic documentation.

Sten De Geer (1886–1933), B.Sc., geologist and cartographer; son of Gerard De Geer.

Einar Johan Valdemar Jansson (b. 1889), undergraduate, geologist, cartographer.

Arvid Bertil Högbom (1888–1962), undergraduate, geologist, collector.

Karl Alfred Sixten Bock (1884–1946), B.Sc., assistant zoologist, hydrographic observer.

Folke Henschen (1881–1977), M.B., doctor to the expedition, assistant zoologist.

V. Söderberg, observer in physical oceanography.

H. Henriksson, assistant in the zoological work.

The Swedish Navy placed the gunboat *Svensksund* at the disposal of the expedition. Private persons contributed about two thirds of the costs, and the state one third. Among the officers on board the *Svensksund* may be mentioned:

Carl Gustaf Norselius (b. 1864), captain in the Swedish Navy, commander of the *Svensksund*, leader of the hydrographical surveying.

Carl Bengt (C.B.) Erikson (b. 1880), lieutenant in the Swedish Navy.

Ernst Gustaf Wilhelm Axelsson von Schoultz (b. 1881), lieutenant in the Swedish Navy.

The tasks of the expedition were to be distributed among different groups. Two land parties, each provided with two boats and tents, would carry out the geographical and geological investigations on the land adjoining Isfjorden, while a ship's group with two steam launches was to investigate the fjord itself.

THE PROGRAMME FOR THE TWO LAND PARTIES WAS:

1. Completion of the map of the Isfjorden region, for instance with missing shorelines, certain forms of terrain, and geological boundaries.
2. Studies of various aspects of the physical geography of the region, which were supposed to help explain the Ice Age formations in Sweden—such as measurements and photographs of the extent and structure of the glaciers.
3. A careful survey and recording of the sequence of strata, several thousands of metres thick. This work should preferably be carried out by measuring along the grand natural sections through the rock strata on the south-eastern side of the main fjord and of Billefjorden, where the finest geological section is exposed.
4. A collection of photos of geological interest, taken by a professional photographer, O. Hallin.
5. The task of the ship's group would be to conduct the best possible investigation in detail of a characteristic polar-sea environment. A statement by De Geer is worth dwelling upon:

"Isfjorden with its deep and broad major part and its many collateral branches, diverse in nature, and with its northern side rich in glaciers and its southern side free from them, lends itself extremely well to such an investigation—which ought to include depth soundings as well as hydrographic and zoogeographical studies, to aim at

elucidating the open question regarding the manner of formation of the fjords, and to supply badly needed information on the conditions under which the different groups of organisms found in the Swedish shell-banks once lived."

Working in Spitsbergen

The expedition aboard the *Svensksund* reached Hornsund on July 10. Gåshamna was visited, previous measurements and photographs were supplemented, and a collection of Silurian rocks was brought together. During a walk up the Gåsbreen (Goës glacier), its interesting ice-dammed lake was visited. De Geer and von Knorring had found this lake in 1899; the glacier had now declined and the lake had increased in extent.

A short visit was next paid to Bellsund, where the Tertiary strata south of its mouth were studied. These proved to be affected by the large dislocation system of western Spitsbergen, and not by any local faults.

On July 14 the investigation of the Isfjorden region was begun at Grönfjorden (Green Harbour or Bay). The work-groups obtained their equipment and instructions, before setting out upon their respective tasks.

These groups consisted of the following scientists and officers:

DE GEER'S LAND GROUP (WITH ONE BOAT)

G. De Geer, geologist, cartographer, leader.

O. Hallin, photographer.

S. De Geer, geologist and cartographer.

WIMAN'S LAND GROUP (WITH ONE BOAT)

C. Wiman, palaeontologist, leader of the group.

E. Jansson, geologist and cartographer.

B. Högbom, geologist and collector.

THE SVENSKSUND GROUP (WITH TWO STEAM LAUNCHES)

N. von Hofsten, zoologist, leader of zoological and hydrographic work.

K. Bock, assistant zoologist, hydrographic observations.

F. Henschen, doctor and assistant zoologist.

V. Söderberg, hydrographic observations.

H. Henriksson, assistant to zoologists.

Captain E. Norselius, leader of the hydrographic surveying.

Lieutenant C.B. Erikson, hydrographic surveying.

Lieutenant W. von Schoultz, hydrographic surveying.

The De Geer group

De Geer's group investigated, to begin with, the folded strata between Grönfjorden and a longitudinal valley, Linnédalen, to the west, not mapped until

now. This valley contained a fairly large lake by Spitsbergen standards, named Linnévatnet.

The group then moved across the fjord mouth and directed its attention to Oscar II Land, north-west of Isfjorden. The folded strata, discovered in 1896, were now investigated more closely, and their boundary with the horizontal strata which build up the low tundra headlands was entered on the map. The coast between Trygghamna and Bohemanneset was surveyed, and two lateral branches to Isfjorden were found here. The expedition of 1882 of Nathorst and De Geer had been prevented from doing this because of unsuitable weather.

Special attention was devoted to the large glaciers which fill the valleys on this side of the fjord. Almost all the glaciers seem to be on the retreat due to melting. From the surveying, the retreat was now ascertained for the glaciers which had been mapped here in 1896.

"The decline of Sefströmbreen was especially marked after 1896, when it still rose to 100 m at the point where the *Svensksund* now anchored, a couple of kilometres behind the front in 1896. On the other hand, one of the glaciers, Wahlenberg-breen, had grown in thickness and had protruded 2-4 km. Its previously smooth surface was now broken up into a mess of sharp peaks."

The map of Ekmanfjorden was also improved. At Dicksonfjorden and Ekmanfjorden, as well as at the northern part of Billefjorden, the altitude of the wide pre-Carboniferous abrasion surface was measured. It can be traced all the way to Kongsfjorden, where its altitude was later measured by De Geer in 1901. Measurements of the altitude of other guide horizons at Isfjorden were also made as an aid to determining the tectonics in the Isfjorden region.

The large glaciers at the bottom of Tempelfjorden and Billefjorden were investigated, and the grand dislocations here were studied. On all tours the photographer, Oscar Hallin, captured interesting sceneries and phenomena; altogether about 1000 photographs were taken by him.

Sten De Geer constructed maps on large scales of strandlines, terraces, erosion furrows and talus mantles. He measured base-lines for the map work of the group, and determined the silt content of the fjord water.

The Wiman group

The Wiman group worked mainly in the eastern and southern parts of Grönfjorden, at Colesbukta, Advent-

fjorden, the southern side of Sassenfjorden, the eastern side of Billefjorden, at Mimerbukta and at the mouth of Dicksonfjorden.

Wiman investigated the stratigraphy of the different formations, especially the fossil-bearing horizons. He was assisted by Bertil Högbom, who in particular was given the task of visiting distant and high localities. Among the palaeontological collections should be mentioned series of carbon brachiopods transformed into silicon, the inner structures of which were extremely well preserved.

E. Jansson carried out the surveying and measured parts of the large valleys, in the areas where investigations were conducted. In this way a foundation was obtained for the geological mapping of the middle part of the large geosynclinal of Isfjorden.

The Svenskund group

The marine zoological investigations were carried out under the leadership of N. von Hofsteen, assisted by S. Bock. Marine animals were collected and preserved from about 130 stations in all parts of Isfjorden; about 2500 different species were thus obtained from carefully determined positions and depths. The very rich material was intended to be a zoogeographic investigation in detail of a well-defined arctic environment.

Together with the zoological work, hydrographic series were taken—giving water temperature, salinity and so on—in different parts of the fjord and along a section off the fjord mouth to a depth of 750 m. This work was carried out by V. Söderberg, from the Bornö oceanographical station on the Swedish west coast. He also assisted when large depths were sounded, as did H. Henriksson from the Kristineberg zoological station in connection with zoological scrapings at great depths.

A careful determination of the bottom topography was performed by officers of the *Svenskund*, notably by the commander of the ship, Captain C.G. Norselius, and the lieutenants C.B. Erikson and W. von Schoultz. The whole fjord and its branches were sounded, with depth measurements at 3600 points. The greatest depth was found in the mouth of fjord, at a little more than 400 m. *No fjord threshold was found.*

The bottom topography is interesting, as it depends upon the geological mountain structures as well as upon the sculpturing and deposits by the glaciers of the Ice Age. The determining lines in the topography of the fjord seem to be rifts and dislocations in the bedrock; but the minor fjord branches are "hanging valleys", with certain exceptions probably due to submarine beds of diabase.

We should also mention the underwater precipice

of 200 m, which separates the shallow water off the low tundra headlands from the deep waters of the main fjord.

The expedition of 1908 had indeed done perfect work. De Geer was satisfied:

"After the close of the summer's work, there will surely not exist a fjord of corresponding size which can compete with Isfjorden in regard to the comprehensive and diverse material collected here for elucidating the fjord problem which has been in dispute for so long."

In his note in *Ymer* dealing with the expedition and its preliminary results, however, De Geer omitted to give the time of the voyage home.

THE GEOLOGICAL EXCURSION TO SPITSBERGEN IN 1910

The programme for the 11th International Geological Conference in Stockholm included a visit to the Isfjorden region of Spitsbergen. Naturally only a fraction of the approximately 500 persons who attended the conference would be able to take part in this excursion—about 70 in all.

As conference president, De Geer did much to prepare the visit, in regard to both scientific information and practical arrangements. The Isfjorden region was the part of Spitsbergen which he knew best. Naturally he was to be the leader of the excursion. Another energetic man in the leadership of the conference was Johan Gunnar Andersson, then head of the Geological Survey of Sweden.

The participants in the excursion left Stockholm by special train on July 25, and after a few stops on the way, Narvik was reached on the 28th. Here a hired passenger steamer, the *Aeolus* of the Swedish shipping company *Sveabolaget*, commanded by Captain S. af Klinteberg, was awaiting them. At Tromsø information was obtained about the ice situation in Spitsbergen waters: there had been a very early break-up in the Barents Sea, and ice was said to block the coasts of south-western Spitsbergen.

In the night towards July 3, the *Aeolus* passed close along Björnöya, whose different strata were easily visible. Next day the ice-edge was reached. It was followed north-west to the latitude of Isfjorden. Here all ice disappeared, and in quite open water the ship entered Isfjorden. A visit was paid to Trygghamna (Safe Bay), where the upright Silurian strata and the large glacier were studied.

The ship then steered south across Isfjorden towards the magnificent southern coastline with its grand natural section through the Tertiary strata,

dominated by Nordenskiöldfjellet. The American coal mine (present-day Longyearbyen) in the south of Adventfjorden was visited. Here Bertil Högbom (see p. 379) met the excursion participants to help in guiding some of the excursions in the neighbourhood.

A group under Högbom ascended Nordenskiöldfjellet, with its wonderful views and rich occurrence of Tertiary plant fossils. The rest of the excursion participants went across Adventfjorden to study the Jurassic strata with plant fossils.

The whole party continued to Sassenfjorden, in order to study the Triassic strata on the south side and on the north side the Carboniferous strata at Bjonahamna, rich in fossils. The palaeontologists stayed while the rest of the group was taken to the bottom of Tempelfjorden, where the majestic Von Postbreen was studied and rock samples were collected from its moraines.

Here a German training expedition, under Lieutenant Wilhelm Filchner, left the ship to prepare for the antarctic expedition of 1911–12 to the Weddell Sea. Nordenskiöldbreen and the interesting fault tectonics at the bottom of Billefjorden were studied. The ship then steamed to Longyear City in order to bunker, after which Ekmanfjorden was visited. The

participants collected gravel made of shells which had been washed out by waves from the terminal moraines.

The palaeontologists were next landed at the Triassic strata with saurian fossils. South of the mouth of Dicksonfjorden, their aim was to investigate the stratification and to collect fossils, while the ship proceeded to the inner portion of the magnificent fjord. Visits followed to the Svea and Wahlenberg glaciers, the folded zones along the western side of Isfjorden, and the faults to the west of Grönfjorden.

The voyage home started on August 9. Via Lyngenfjorden north of Tromsø, the route passed inside the islands and skerries along the Norwegian coast all the way to Trondheim, where the participants boarded the Stockholm train. On August 17 they arrived in Stockholm after an absence of 24 days.

This had been a daring enterprise, not only because of potential dangers, but chiefly due to the risk of unsuitable weather during the week spent in Isfjorden, which might have been entirely ruined by fog, rain and severe gales. But everything was in De Geer's favour, and the excursion to Spitsbergen proved a success in all respects.

It was a fitting conclusion to De Geer's visits to the Arctic.

In 1908, De Geer was the leader of a large Spitsbergen expedition and had great resources at his disposal for studying the natural environments of Isfjorden. The detailed measurements of the depth of Isfjorden were an important part of these investigations. The map shows deep water in the mouth of Isfjorden, opposite to what could be expected, considering that Isfjorden had been filled with ice during the Ice-Age. Another typical feature is the steep slopes of the bottom which occur in the zone of transition between deep and shallow waters near land. (Ahlmann, H., Wison: Gerard De Geer, Minnesteckning.)

33. ARC MEASUREMENTS IN HIGH LATITUDES

SOME THEORETICAL CONSIDERATIONS

In a first approximation, the Earth may be regarded as a rotating sphere floating in space. The planet's size may then be roughly determined by measuring the length (δs) of an arc along its surface, and the angular extent ($\delta\alpha$) of this arc as seen from the centre of the Earth. The angle can be determined by astronomical means. The radius (R) of the Earth is thereby obtained from the equation $R = \frac{\delta s}{\delta\alpha}$ (with $\delta\alpha$ expressed in radians).

On a homogeneous non-rotating planet, the only general force acting would be the force of gravity g directed towards the centre O . The force would be constant everywhere on the Earth's surface, and directed at right angles to the surface, since otherwise it would push the water in the seas horizontally until this state became fulfilled.

The Earth's rotation causes a smaller additional influence, the centrifugal force f , directed at right angles to and away from the axis of rotation. The size of f depends upon the speed of rotation and the distance r from the axis of rotation. The resultant of the two forces g and f yields an apparent gravitational force g' (see the accompanying figure on p. 353). This force is not directed towards the Earth's centre, except at the equator and at the poles. Nor is it constant over the globe, but increases as one goes from the equator toward the poles. However, it does act at right angles to the sea surface.

Considering the Earth roughly as a homogeneous fluid, the surface thus has an oblate spheroidal shape, as if formed by an ellipse rotating around its minor axis b . This surface, called a "geoid", levels out the Earth's irregular topographical features and mass distribution. Measurements of gravity are a practical method of tracing the geoid, and therefore of enabling us to approximately determine the shape and size of the entire Earth.

If, for instance, an arc is measured along a seashore from north to south, its angle at the centre of the Earth can be obtained from the latitude difference between the arc ends—or equivalently, as the difference of the zenith distances observed for one and the same star when passing the meridian at the endpoints of the considered arc, compare p. 331. On the geoid, one may also measure along the meridian, but the resultant values of the Earth's radius are shorter near the poles than at the equator. What we measure is the radius of curvature in the meridian plane of the geoid surface.

With a rough topography or over long distances, the arc can be obtained by triangulation—joining the two end points with a chain or network of triangles, whose corners are at chosen points in the landscape, such as mountaintops or towers. The angles of the triangles are measured with a theodolite. Knowing one side of a triangle, the whole chain of triangles can then be computed. Generally a base-line is measured, where the conditions are most favourable for measuring distances accurately, as on a flat plain or on sea ice. This base-line can be connected to the triangulation network, and the length of the arc between the end points is thus determined.

These geodetic measurements are generally called arc measurements, and arc-of-meridian measurements if they are made in a north-south direction along the meridian. In 1799, using contemporary arc measurements, the standard unit length of a metre was defined as one ten-millionth of the arc between the equator and the pole.

Here we shall describe two Arc-of-Meridian expeditions for ascertaining the size and shape of the Earth: the French measurements of 1736–37 in the Tornedalen in northern Sweden/Finland, and the Swedish-Russian measurements of 1898–1902 in Svalbard. Sweden was also actively involved in the former enterprise.

THE FRENCH ARC MEASUREMENTS IN 1736–1737

The first arc measurement was carried out in classical times by the Greek Eratosthenes (276–195 BC). He was able to determine both the distance and the latitude difference between two places on the Earth's surface, lying approximately on the same meridian—the towns of Syene and Alexandria. Thus he obtained a value for the Earth's radius which was only about 10% in error, a remarkable feat in view of his primitive methods.

By such means, fairly correct dimensions were assigned to the Earth, which was known already in antiquity to be spherical and floating in space. But no further understanding of the Earth's geometry was possible, until science discovered adequate theoretical tools for the purpose. These tools were the laws of gravity and motion, supplied by Newton in his great *Principia* of 1687. Assuming the Earth to be homogeneous and spherical, he showed that its rotation adds a centrifugal force to that of gravity.

The Earth's shape was then identified as an ellipsoid of revolution, turning about its minor axis. In common terms, it was said to resemble an orange—elongated at the equator and flattened at the poles. Its surface was thus expected to have a greater curvature

near the equator than near the poles, due to the variation of the centrifugal force with latitude.

However, scientists were also aware that the Earth is not homogeneous, but becomes increasingly dense towards the centre. In 1743, the French mathematician Clairaut argued that the Earth should therefore be less "flat" than if it were homogeneous. He also showed that the amount of curvature could be determined by measuring the force of gravity at two different latitudes.

In addition, other types of rotating planets were proved to be theoretically possible—notably one which would be elongated in the direction of its axis of revolution, similar to a lemon rather than an orange. The Newtonian type of planet, an ellipsoid flattened towards the poles, was embraced in France mainly by a number of young astronomers and mathematicians. Their leader, Pierre-Louis Moreau de Maupertuis, had spent some time in England and been influenced by Newtonian ideas.

Expedition members, plans and preparations

To test the two conceptions of "lemon" and "orange", two expeditions were dispatched from France: one in 1735 to the equator, and the other in 1736 to a high latitude. They travelled, respectively, to present-day Ecuador in South America and to the Tornedalen in northern Sweden/Finland. Both expeditions were to carry out arc-of-meridian measurements, determining the distance along the meridian which corresponded to a latitude difference of 1°. If this distance was found to be greater at the high latitude than at the equator, Newton's ideas would be considered correct.

The latter expedition—working in the Tornedalen—consisted of the following persons:

Pierre-Louis Moreau de Maupertuis (1698–1759), astronomer and geodesist, leader of the expedition.
Alexis Claude Clairaut (1713–65), astronomer and mathematician.

Pierre Charles Le Monnier (1715–99), astronomer and physicist.

Charles Etienne Louis Camus (1699–1768), mathematician.

Anders Celsius (1701–44), Swedish, professor of astronomy at Uppsala University.

Celsius is nowadays best known for his thermometer scale (°C). He and Maupertuis had become acquainted at an early stage, and Celsius had advocated the coastal zone along the Gulf of Bothnia as a suitable area for research.

Among the expedition members were a secretary named De Sommereux and the draughtsman d'Herbelot. Abbé Reginald Outhier (1694–1774) ac-

ted as clergyman and observer, and later wrote a narrative on the expedition.

The expedition—including Celsius—left Dunkerque on the French naval ship *Prudent* on May 2, 1736, and arrived in Stockholm on May 21. A ship had been hired for transporting the equipment from Stockholm to Torneå, but only a few of the expedition members travelled by her; most of them journeyed overland in two coaches.

It soon emerged that the Swedish Bothnian coast was unsuitable for an arc measurement. There remained the Tornedalen and the Bothnian coast on the Finnish side. Already before the transport vessel reached Torneå, Maupertuis took an opportunity to inspect the Tornedalen in company with the county governor. When he returned from the trip on June 21, the transport vessel had arrived; and after a reconnaissance along the Finnish coast with negative results, the Tornedalen was chosen.

An arc measurement programme has to be preceded by a careful reconnaissance of the area to be used. Signals must be erected on suitable hills, mountains or towers: the signals should be seen from at least two other stations to allow a triangulation network to be built up. The establishment of the vertical line is influenced by the topography of the surrounding country and by its geological structure. A knowledge of the topography and geology must therefore be included in the programme; with the help of pendulum observations, the local variations of the force of gravity can be studied. Good maps of the region are almost indispensable. The French, though, had to carry out their reconnaissance in the Tornedalen practically without any maps.

The reconnaissance of the triangulation network was conducted from the town of Torneå, which was to be the southernmost geodetic station (P in Fig. p. 333). The scientific staff of the expedition comprised the eight men mentioned above; there were also five servants, two of whom stayed at Torneå. Further, there was a Swedish-Finnish-French interpreter, Anders Hellant (1717–89), who proved to be a remarkable man in many ways.

Present-day Sweden and Finland are independent nations with a common frontier along the river Torne älv. But at the time of the French arc measurements, Finland was a part of Sweden, and the Torne River region belonged to the Swedish county of Västerbotten, whose government had its seat in the town of Umeå. The population in the Torne region was, then as now, mainly Finnish-speaking.

The reconnaissance for the triangulation network was planned on arrival in Torneå, and it began already on July 6. It was to employ boats for the transport of

men and equipment upstream. The military chief in Torneå, Lieutenant Colonel C.M. Du Rietz, placed military personnel at the disposal of the expedition. These men served as oarsmen and assistants.

The reconnaissance expedition itself consisted of the eight expedition members, five servants and an interpreter. It travelled north along the Torne River in seven boats, with three oarsmen in each boat. Its route and work are well documented from the narrative of Maupertuis, the journal of Abbé Outhier and the observation book of Celsius.

A primary task of the reconnaissance was to choose suitable station points for the triangulation network. The men would have to set up signals on these points and check that they could be observed from relevant points, to obtain the best possible network. The points were located chiefly on hills rather close to the Torne River, in order to minimize land transports during the period of measurement.

The reconnaissance proceeded very efficiently during the first five days, July 6–10, when as many as six points were successfully established. These and other points are given by the following table, and Fig. p. 333 shows their locations in the network.

THE GEODETIC POINTS OF THE TRIANGULATION CHAIN IN THE TORNEDALEN, 1736–1737

T	Torneå, church spire
n	Nivavaara
K	Kaakamavaara
C	Huitaperi
A	Aavasaksa
P	Pullinkivaara
Q	Kittisvaara
N	Niemivaara
H	Horrilankero
b	Northern end of the base-line
B	Southern end of the base-line
QM	meridian through Q (Kittisvaara)

The pace then slowed down. Starting on July 12, the seventh point P (Pullinkivaara) took ten more days to reconnoitre, and the northernmost point Q (Kittisvaara, near Pello) another fourteen days. Four days later the triangulation network was connected with point N (Niemivaara). The reconnaissance of the network was completed on August 5, from Torneå (T) in the south at a latitude of about 65°51'N to Kittisvaara (Q) at about 66°48'N.

Maupertuis was satisfied with the outcome of the reconnaissance. In his own English, he wrote:

“It looked as if the placing of these Montains had been at our disposal.”

The angular measurements

Next came the measurement of the angles of the triangles in the network. The main instrument for this purpose was a quadrant with a radius of about 70 cm. It allowed direct measurement of angles less than 90°. Larger angles had to be measured by stages, using a distant object near the horizon, such as a treetop. The expedition also possessed a somewhat smaller quadrant with a radius of about 49 cm. Both instruments were equipped with micrometers for reading the angles.

All scientifically schooled members of the expedition took part in measuring the angles: Maupertuis, Clairaut, Camus, Le Monnier, Outhier and Celsius. The measurements were started about three weeks before the triangulation network had become fully reconnoitred. Always at least two, and often more, observers worked at the same time. They finished the angular measurements on September 2, 1736, or—if a supplementary series of measurements is included—on September 6, after about one month.

At the end of August, the expedition had been informed that the sector, an instrument for measuring zenith distances, had arrived in Torneå. The next stage in the measurements could then have begun, except that the nights were still light. As it was necessary to sight on fixed stars passing near the zenith, dark nights were required. By using near-zenith stars, astronomical refraction was minimized.

The astronomical observations were to be made at the two extreme points of the triangulation chain—Kittisvaara (Q) in the north, and Torneå (T) in the south. To eliminate astronomical aberration, the measurements at Q and T should be made almost simultaneously, yet this was impossible because the expedition had only one instrument for the purpose. The next best thing would be to make the measurements at one of the two extreme points, and then travel to the other point as fast as possible, minimizing the difference in time between the two measurements. A practical solution would be to carry out the measurements at the northernmost point Q first, and travel downstream by boat to the southernmost station at T. The river should therefore be free of ice, so the winter was excluded.

On September 4 the expedition travelled north, with a considerable amount of equipment—using 15

boats to begin with. Pello was reached on the 9th. Before the measurements could begin, it was necessary to build a small observatory at the triangulation point on Kittisvaara (Q), to determine the north-south meridian through Q, and from there to determine the azimuth to the points Niemivaara (N) and Pullinki (P). In this way the triangulation network would be fixed in relation to the meridian through Q.

A somewhat larger observatory was built 7.3 m to the north of the triangulation point (Q). Here the sector was mounted for measuring the zenith distances. Everything was ready on September 16, but unsuitable weather delayed the measurements. Not until October 4, 5, 6, 8 and 10 was it possible to proceed, using the star *Draconis*. The measurements were carried out by three observers, who alternately performed different tasks. The zenith distance of *Draconis* was obtained as $2^{\circ}36'20''.5$.

The weather now became unfavourable and there was a risk that the river might freeze over, which would have delayed the measurements for a year. On October 23 they started for Torneå, where the expedition assembled on the 28th.

The observations were next made from an observatory 143.7 m to the south of the triangulation point (T) during five consecutive days, starting on November 1. The same star, *Draconis*, was used, and the zenith distance here was obtained as $1^{\circ}38'54''.25$. The meridian arc between (Q) and (T) was thus found to be $2^{\circ}36'20''.5 - 1^{\circ}38'54''.25 = 57'26''.25$. After some corrections, a value of $57'28''.67$ was established—nearly 1° .

Measuring the base-line

It remained to find an adequate place for arranging and measuring a base-line, and to include it in the triangulation network. Then the length of the sides of the individual triangles could be obtained in sequence, starting from a triangle containing the base. In this way it would also be possible to compute the length of the meridional arc between the parallel circles passing through the extreme points—in the present case, the points Q and T. It would be just a matter of projecting suitably chosen sides of triangles along a meridian—in Fig. p. 333 along the meridian passing through Q, according to the simplified scheme shown here.

The base-line, whose length was to be measured with great accuracy, had to be placed in a fairly flat region. While the reconnaissance of the network of triangles was still going on in the summer, Clairaut and Camus had been given the task of finding, marking and investigating such a base-line.

The search began on July 30. It was decided that a proper base-line could be laid out near the village of

Övertorneå, between a northerly point (b), situated on the eastern side of the river below Aavasaksa (A) mountain, and a southerly point (B) on the western side. The base-line *Bb* passed obliquely across the river, and was about 14 km long. Clairaut and Camus had solved their problem by August 13. The base-line would be measured in the winter, after the river had become ice-covered.

By November 5, the men had measured the angles of all the triangles in the network, and had completed the necessary astronomical determinations. The base-line measurement was now essential, in order to proceed with computational work. They were advised by people in Torneå to make these observations in the latter part of the winter, with a relatively long period of daylight and with a crust on the snow-cover.

However, Erik Brunnus, who helped them with material for the measurements, counselled them on December 7 to carry out the measurements in the height of the winter, since later periods of thaw might prevent the measurements on the ice. This suggestion appealed to Maupertuis, as it would avoid an interval of inactivity.

The decision to measure as soon as possible was taken on December 13, after a short visit to the base-line. Already next day, sledge parties with equipment and personnel left Torneå for Över-Torneå, arriving that evening.

While Le Monnier marked out the base-line, Camus and Outhier were busy producing poles of wood, with which the line was to be measured. The expedition had brought an iron pole with the length of 1 *toise* (the French fathom = 1949 m), and also a standard of 1 *toise*, both adjusted for a temperature of $+14^{\circ}$ Réaumur ($+17.5^{\circ}\text{C}$). Against these standards, wooden poles were produced with lengths of 1 *toise* and 5 *toises*, in a room heated to $+17.5^{\circ}\text{C}$. The poles were provided with a handle at each end, for easy transport by two men. A large nail was driven into each pole end. When measuring, the poles were laid on the snow, nail-end to nail-end.

The measurements were carried out by two separate groups, each of four men. Each man used, and was responsible for, one specific pole all the time, and no pole was handed "to a peasant, not even to any of our servants". Beginning on December 21, Midwinter Day, the measurements were finished on the 28th. A check was made on the two following days, using a rope, to ascertain that there had been no large error in counting the times each pole was laid down on the snow.

The mean value of the results from the two measuring groups gave the length of the base-line as 14 436.1 metres. The results obtained by the groups

differed by only one decimetre, which is remarkable considering the cold weather, the snow and the primitive means at their disposal.

The length of the meridian degree

All the required measurements were now in hand. But as a safeguard, a second series of astronomical observations was carried out in the spring of 1737. These were made at Torneå (T) on March 17–19, and at Kittisvaara (Q) near Pello on April 4–6. Now the star *Draconis* was used for the measurements, and the meridional arc between T and Q was found to be 57'26".5—almost the same value as that found in the previous autumn using the star *Draconis*, namely 57'26".25.

After applying some corrections, Maupertuis arrived at 57'28".67 as the definitive value of the meridian arc between Torneå and Kittisvaara.

With the base-line known and incorporated in the triangular network, the sides and angles of all the triangles were known or computable. By projecting suitable sides on the meridian through Kittisvaara, the meridian arc between the two parallels passing through Torneå and Kittisvaara was found—again after a few corrections—to be 107.24 km. This distance corresponded to the meridian arc obtained above.

It could then be calculated, with satisfactory accuracy, that the meridian degree—the length of the arc along the meridian corresponding to 1°—was 111.94 km. This result may be taken as valid at the Arctic Circle, which passed through the northern half of the triangulation network. The distance on the Earth's surface occupied by one degree was thus found to be longer here than in France (111.2 km) and, as was later realized, still longer than at the equator in present-day Ecuador. Consequently, the results indicated that the Earth's shape agreed with Newton's idea: the Earth was flattened at the poles like an orange.

However, Maupertuis worried that his value was larger than what might be expected. He and his companions discussed the matter thoroughly, and concluded that there could not be any errors in the measurements of the angles of the triangles, or of the base-line, to cause such a deviation in the final result. This was why, as mentioned above, new measurements of the zenith distances were carried out in the following spring.

The expedition made other observations as well: gravity measurements by pendulum, studies of astronomical refraction, latitude and longitude determinations for Torneå and the longitude of Pello, and daily recording of the air temperature and pressure. The draughtsman, d'Herbelot, prepared sketches for

the illustrations, which were subsequently printed in Outhier's journal on the expedition.

Lingering doubts and later arc measurements

Around June 9 the expedition left Torneå. The equipment and some of the members went by a sailing vessel. But most of the party travelled overland by different routes, and took the opportunity of meeting "important" persons on the way, in Uppsala and Stockholm. On August 20, 1737, the expedition reached Paris.

From its very beginning, the venture had become well-known even in non-scientific circles. This must be ascribed to the public appearances of the witty Maupertuis, who delivered vivid lectures on the events during the one-year stay in the faraway Tornedalen: the cold, the travels by boat in the Torne River rapids, the beautiful landscape, the aurora, the light summer nights and the winter darkness, the charmingly "exotic" names of places, the scientific work and the hardships experienced.

Already in April 1738, Maupertuis published his report on the expedition: *La Figure de la Terre*. That same year, it was followed by editions in English and Swedish—the former translated by Maupertuis himself, the latter by the Swedish-Finnish interpreter of the expedition, Anders Hellant. A German edition followed in 1741 and a Latin edition in 1742. Along with the last came Outhier's *Journal from a Journey in the North*. Celsius never published a report of the expedition; after coming home, he had his hands full with the arrangements for a new astronomical observatory at Uppsala.

There was also great enthusiasm over the expedition's discovery that the shape of the Earth agreed with Newtonian ideas. But Jacques Cassini (1677–1756), a famous astronomer who had measured the meridian arc in France and had written a book on the subject, advocated the opposite opinion. He was especially critical about the measurements of the zenith distances.

Doubts also lingered in the mind of Maupertuis: his meridian degree seemed too long. He discussed the problem with Celsius, who recommended a new measurement in Sweden. This was to be done on the Lake Vättern, which is long and narrow in a north-south direction. It would be possible to avoid a triangulation and measure the arc length directly on the ice in winter. If the ice conditions proved unsuitable, a value for the meridian degree could be obtained by making a triangulation with stations on both sides of the lake. But the project was never realized.

Many arc measurements were carried out in the years after 1740—in Europe, Egypt, North and South

Pierre Louis Moreau de Maupertuis, leader of the French Arc-of-Meridian Expedition 1736-1737 to the Torne Valley, northern Sweden. (Copperplate from a portrait by R. Tournière.)

Anders Celsius, professor of Astronomy at Uppsala University, Swedish member of the French Arc-of-Meridian Expedition. (Nordenmark: Anders Celsius, professor i Uppsala.)

Contemporaneous map of the lower Torne Valley, embracing the French geodetic chain (right). (Tobé, E.: Fransk visit i Tornedalen 1736-1737.)

Simplified version of the French geodetic chain, with Torne River included as a line of reference. Note the spelling of Finnish names, as given by Maupertuis (below). (Tobé, E.: Fransk visit i Tornedalen 1736-1737.)

The northernmost geodetic station Kittisvaara; the Qittis of Maupertui. The station is seen in the upper left corner: Below to the right are the quarters of the expedition (bottom right). (Outhier, R.: Journal från en resa i Norden år 1736-1737.)

America. They indicated that there must be a fundamental error in the Tornedalen result: its meridian degree *was* too long. Ultimately The Royal Swedish Academy of Sciences was inspired to look into the matter. The Academy's vice secretary, the astronomer Jöns Svanberg, was familiar with the Tornedalen since childhood. In 1799, he made a reconnaissance of the area.

Svanberg was unable to find any of the signals used by Maupertuis except, of course, the church tower in Torneå and the first station north of it, at Niemivaara. In any case, his triangulation network extended beyond the extreme stations of Maupertuis. He marked a base-line approximately where that of Maupertuis had been, and found it to be somewhat longer. Svanberg's measurements were completed in the winter of 1802/03. The arc (reduced to 1°) was found to be 407.3 m shorter than that of Maupertuis. At the same time, it was 214 m longer than had been found from an arc measurement in England and France during 1784–90. *The flattening of the Earth towards the pole, therefore, still held true.*

Svanberg's measurements fitted in well with those from other regions, but he was criticized because he had not found the sites of the French signals. Hence it was impossible to compare the measurements of the two expeditions in detail.

In 1845–52, there occurred an extensive project of arc measurements in the Tornedalen and farther north. It was part of a triangulation network which passed from the Black Sea via Torneå to Fuglenes, near Hammerfest in Norwegian Finnmark. No studies of differences between these measurements and those of Maupertuis and Svanberg seem to have been made.

Not until 1928 was a detailed investigation conducted, on the initiative of the Geodetic Institute of Finland, by the geodesist Yrjö Leinberg and Dr. Ölander. The arc measured by Maupertuis was now found to be 350 m too large. It emerged that the greatest error lay in the *astronomical* observations of the French expedition. Other differences were due to atmospheric refraction (which Maupertuis had not considered), deviations of the vertical line, and errors inherent in the measured length of the meridional arc—the geodetic error.

As was the case with the arc measurements during the 18th and early 19th centuries, the determination of the zenith distance—or the latitude—is the weak point in the series of measurements.

Considering the crude instruments of former times, it is surprising that the measurements could be as accurate as they were.

In sum, the flattening of the Earth's surface to-

wards the North Pole was established by Maupertuis, but his value of the meridian degree did not tally with measurements in other parts of the globe, and it took many decades before his value was shown to be about 0.35% too long. For comparison, the meridian degree is tabulated below for different latitudes, as computed with the constants of Helmert.

<i>Latitude (degrees)</i>	<i>Meridian degree (km)</i>
0°	110.57
10°	110.61
20°	110.70
30°	110.85
40°	111.03
50°	111.23
60°	111.41
70°	111.56
80°	111.66
90°	111.69

For the mean latitude of the French geodetic chain, equal to 66°20'N, the table gives a meridian degree of 111.505 km, against the value 111.94 km of Maupertuis. In the words of E. Tobé:

“It was to take another 100 years before new instruments and new methods offered opportunities for re-examining the length of the meridian degree near the Arctic Circle.”

The most remarkable enterprise with that aim was the Swedish-Russian arc measurement of 1898–1902 in Svalbard.

THE SWEDISH-RUSSIAN ARC-OF-MERIDIAN EXPEDITIONS IN SVALBARD, 1898–1902

In order to resolve the doubts about the accuracy of the French arc measurements from the 18th century, it was gradually decided that measurements should be carried out as far north as possible. This would more clearly reveal the flattening of the Earth toward the North Pole. In view of existing transport facilities, such measurements could be made in north-western Greenland or in Svalbard, but the latter region was preferred in practical terms.

In 1822–23 the great English geophysicist Edward Sabine (1788–1883) carried out pendulum observations on both the east and west sides of the Atlantic Ocean, from latitude 13°S to near 80°N. He used a total of thirteen stations, the northernmost one being situated on Indre Norsköya in the north-west corner of Spitsbergen.

These measurements aimed at finding the variation of the apparent force of gravity g' with latitude. At the same time, they would show how much the Earth was flattened, as expressed by the quantity $1 - (b/a)$ where a and b represent the equatorial and polar radii. Sabine had found this quantity to equal $1/288$, the present-day value being $1/297$.

The prehistory of the Swedish-Russian arc measurements dates back to Sabine's stay in north-western Spitsbergen in the summer of 1823.

THE STAGES IN THE DEVELOPMENT TOWARDS THE SWEDISH-RUSSIAN PROJECT MAY BE SUMMARIZED

THUS:

1823 Edward Sabine carried out pendulum observations on Indre Norsköya, Spitsbergen.

1826 In a letter to the vice president of the Royal Society, Sabine proposed a plan for making arc measurements in Spitsbergen. As the geographical conditions were inadequately known, a preparatory expedition would have to be dispatched first, with the aim of investigating how the triangulation network should be placed. If a suitable ship were provided by the British Government, Sabine volunteered to carry out such an investigation. The proposal was met with great interest, but had no practical result.

1861 In the programme for his Spitsbergen expedition of 1861, Otto Torell included a reconnaissance for an arc measurement expedition. The triangulation network was supposed to run from Sjuöyane in the north to the Sörkapp region in the south. The northern half of the network was investigated by K. Chydenius, while the reconnaissance of the southern half had to be given up due to unsuitable calm weather and ice conditions.

1864 The southern half of the proposed network was investigated by an expedition under A.E. Nordenskiöld on board the schooner *Axel Thorsen*. Originally the reconnaissance was to be carried out by K. Chydenius, but he died shortly before the departure of the expedition, and his place was taken by N. Dunér, who had been the astronomer of the expedition of 1861 and was then to have investigated the southern half of the network.

The triangulation chain, as determined from the two years of reconnaissance, ran in a north-south direction: from *Vesle Tavleöya* among Sjuöyane, at about lat. $80^{\circ}49'N$ in the north, to *Keilhaufjellet* at about $76^{\circ}30'N$ near Sörkapp in the south. Hence, the meridian arc covered approximately $4^{\circ}19'$. But there was uncertainty as to how the chain should be taken

overland from southern Hinlopen to the bottom of Storfjorden. This passage was based upon one triangulation point, Chydeniusfjella, which had been seen in the distance by Chydenius in 1861. This problem was not to be settled until the Swedish-Russian expedition arrived.

After the two reconnaissances of 1861 and 1864, further work was prevented by the problem of how to finance such a great enterprise as an arc-of-meridian expedition. Reporting on their reconnaissance, Nordenskiöld and Dunér also indicated alternative triangulation chains: along the west coast of Spitsbergen; along Wijdefjorden and overland to Isfjorden, possibly even further south to the Bellsund region; or an E-W chain from Kong Karls Land to Salfjellet in the south of Prins Karls Forland (here Nordenskiöld used the names Giles Land and Saddle Point respectively).

Planning and organization

In 1891 the astronomer and geodesist Per Gustaf Rosén (1838-1914) awakened interest in arc measurements in Spitsbergen. In a lecture on the subject at The Royal Swedish Academy of Sciences in Stockholm in February, 1901, he outlined the plans and actions taken thus far. He also discussed the arc measurements from a climatological and geographical point of view, and made preliminary proposals for triangulation chains, measurements, personnel and costs. At the suggestion of A.E. Nordenskiöld, the Academy set up a committee to plan the measurements.

It consisted of the following:

A.E. Nordenskiöld (1832-1901), geographer and mineralogist.

K.J.A. Skogman (1820-1907), a naval officer, who had taken part in arc measurements in 1844-51.

P.G. Rosén (1838-1914), geodesist and astronomer.

In 1893 the committee submitted its report, published by the Academy and written by P.G. Rosén: *Projet de mesure d'un arc de méridien de $4^{\circ}20'$ au Spitzberg*. This paper, with 31 pages and one map, gave a more detailed discussion of how to carry out an arc measurement than did the article by Rosén in *Ymer* for 1891, the journal of the Swedish Society of Anthropology and Geography.

An arc measurement in Spitsbergen was too great an enterprise to be tackled by Sweden alone. Co-operation with at least one other nation, such as Great Britain, France or Russia, would be necessary. A decisive fact was that the head of the Russian central observatory of Pulkova near St. Petersburg was a Swede—the astronomer Johan Oskar (Oskar Andrey-

evich) Backlund (1846–1916). Backlund took a very deep interest in the plans.

It was essential that preparations in the field should begin at an early date. Nathorst had started in 1896 to prepare for his Svalbard expedition of 1898. Moreover, it was considered opportune that the expedition include two people who would be involved in the arc measurements. These were the geodesist Edvard Jäderin and the physicist Vilhelm Carlheim-Gyllensköld. The former was later to act as leader in the field, and the latter would be secretary of the committee that was to be set up.

However, it was soon clear that such a demanding reconnaissance and preparation could not be made alongside the ambitious Nathorst expedition. In addition, the plans for Swedish-Russian co-operation still existed only by way of contacts between scientists in the two countries. Actual co-operation had to be worked out in both countries, and related diplomatic contacts were necessary.

On November 10, 1897, Edvard Jäderin presented a proposal to The Royal Swedish Academy of Sciences concerning a Swedish-Russian arc measurement expedition to Spitsbergen. It was remitted for comments to three members of the Academy: Otto Torell, P.G. Rosén and A.E. Nordenskiöld.

P.G. Rosén had judged in 1891 that the arc measurements could be made during two summers and an intervening winter, even if preparations were included in the first summer's work. Edvard Jäderin, though, maintained in 1897 that one summer of preparations would be needed, if the span of two summers and one winter were to suffice for the measurements. A preparatory expedition therefore had to be dispatched before the Arc-of-Meridian expedition started. In particular, winter quarters had to be chosen, and signals had to be set up at some of the trigonometric stations, for example on Chydeniusfjellet far inland.

Jäderin's proposal to the Academy led to a request to the Swedish Government for grants for such an expedition. Private discussions with one of the leading members of The Russian Academy of Sciences indicated that a committee had now been set up, which—on the assumption of Sweden's participation—was to prepare for the dispatch of an arc-of-meridian expedition to Spitsbergen already in 1899.

If Sweden was to take part in the work, it would be indispensable to set up a similar committee working along the lines of Jäderin's proposal.

The Royal Swedish Academy of Sciences proposed to His Majesty that suitable persons be asked to make definitive plans in co-operation with a similar committee in Russia.

THE SWEDISH COMMITTEE CONSISTED OF:

Crown Prince Gustaf (later King Gustaf V), president.

A.E. Nordenskiöld, mineralogist and geographer.

P.G. Rosén, geodesist and astronomer.

N.C. Dunér, astronomer.

G. Mittag-Leffler, mathematician.

G.J. De Geer, geologist and topographer.

E. Jäderin, geodesist and astronomer.

On March 24, 1898, the Swedish Government requested the Swedish Parliament to vote for means to the expedition, including the disposal of a suitable naval ship. Meanwhile similar actions had been taken in Russia.

THE RUSSIAN COMMITTEE CONSISTED OF:

His Royal Highness Konstantin Konstantinovich (b. 1858), president of the Russian Academy of Sciences, chairman of the commission.

Fyodor Bredikhin (1831–1904), astronomer.

O. Backlund (1846–1916), astronomer.

F. Chernyshev (1857–1914), geologist.

Prince Boris Golitsyn (1862–1916), geophysicist.

The Swedish member, Backlund, had studied astronomy at Uppsala University, receiving his doctorate there in 1875, and was an assistant astronomer at Stockholm Observatory until 1876. At both places he and Jäderin developed a friendship which was to serve them well in connection with the arc-measurement expedition. In 1876 Backlund was offered a post as astronomer at the observatory of Dorpat in Estonia. He moved in 1879 to the Russian central observatory of Pulkova near St. Petersburg, becoming its head in 1895, having joined the Russian Academy of Sciences in 1887.

THE SWEDISH RECONNAISSANCE EXPEDITION WITH THE *RAN* IN 1898

Objectives, members and ship

A preparatory expedition would be fairly cheap, as it had to be privately funded. But the Swedish Navy allowed it to use a naval vessel, the old torpedo training ship *Ran*. This was, in fact, the ship of Nordenskiöld's Spitsbergen expedition of 1872–73, then named *Polhem*.

The expedition was to work in Svalbard in the summer of 1898.

THE EXPEDITION HAD THE FOLLOWING AIMS:

1. to complete the previous reconnaissances, notably in the middle part of the triangulation chain;
2. to climb the mountains which had been proposed as triangulation points, though not visited;
3. to set up signals on some of the triangulation points;

4. to carry out preliminary measurements and to take photogrammetric panoramas;
5. to survey and carry out depth soundings in suitable harbours near the triangulation points;
6. to select a site for a winter station.

According to the plans, the Arc-of-Meridian expedition itself was to work in the summers of 1899 and 1900. One group from each country would spend the intervening winter of 1899/1900 at a suitable place in order to begin measurements already in the spring of 1900. By the end of the summer of 1900, the measurements were supposed to be completed. But here ice conditions and weather were to interfere, and not until the end of the summer of 1902 would the expedition's field work be finished. Thus the two summers turned into five, although still with only one winter.

The pick of Swedish and Russian astronomers and geodesists were to become involved.

THE SCIENTIFIC STAFF OF THE SWEDISH PREPARATORY EXPEDITION COMPRISED:

Edvard Jäderin (1852-1923), Dr. h.c. (in 1907), geodesist and astronomer, leader of the expedition.

Vilhelm Carlheim-Gyllensköld (1859-1934), Ph.D., physicist and geophysicist.

Edvard Hugo von Zeipel (1873-1959), Ph.D., in 1900, astronomer and geodesist.

A representative of the Russian Committee, Lieutenant Colonel F. von Schultz, also took part in the reconnaissance expedition of 1898.

The commander of the *Ran* was *Harald* August Palme (b. 1856), captain in the Swedish Navy.

Jäderin was originally an astronomer, but later became a geodesist. He had carried out geodetic measurements in northern and central Sweden, and from 1878 he was a lecturer in geodesy at the Technical Institute in Stockholm. He is best known for his method of measuring geodetic base-lines with flexible metal strings or bands, commonly made of Invar (a nickel-steel alloy).

Carlheim-Gyllensköld was the secretary to the Swedish Arc-of-Meridian Committee. He had been a member of the Swedish Polar Year expedition of 1882-83.

Hugo von Zeipel was later to become professor of geodesy at Uppsala University.

Reconnaissance among the northerly geodetic stations

The *Ran* with the preparatory expedition on board left Stockholm on May 28, 1898. She passed by København and Bergen to supplement her stores, and arrived in Tromsø on June 11, where more stores

were taken aboard. The ship's company was then increased by a number of Norwegian sealers, among them the ice-pilot Pedersen, known as "the old man".

Tromsø was left on June 16, and the passage to Spitsbergen was uneventful until they were off Bellsund. Due to increasing wind in combination with a dense snowfall on the 20th, they decided to enter this fjord system to avoid missing the entrance of Isfjorden, which was their first goal. They left Bellsund on the 22nd and visited Isfjorden around Midsummer, favoured by fine summer weather.

On June 27 they left Adventfjorden, situated on the south side of Isfjorden, to proceed north and start the summer's work. The weather had deteriorated, and at Danskøya a full gale was blowing, but from the crow's nest they could see no ice. On June 30 they proceeded eastward. In the afternoon they passed the small island of Moffen; still no ice was seen, and the weather was fine, with light winds and a calm sea. It was decided to change the course and steam northward towards Sjuøyane. At midnight towards July 1, they reached the two northernmost islands in this little archipelago, Rossøya and Vesle Tavleøya.

Three men were landed on Rossøya. It is a tiny and fairly low island, reaching only 50 m a.s.l.. Very soon they found that it could not be used as a triangulation point. Instead they had to choose the nearby Vesle Tavleøya, which is higher though also small. But ice had appeared, drifting with the currents and winds from the east, so the *Ran* steered south and anchored in Sorgfjorden (Treurenberg Bay) on the afternoon of July 1.

The men on board were full of enthusiasm. It had been a dreamlike passage in an ice-free sea. Weather and ice conditions were exceptionally favourable. Close by was the mountain Heclahuken (434 m a.s.l.), which previously had been chosen to be included in the triangulation chain. Here they set up the first geodetic signal on July 3. The time until July 21 would be devoted to setting up signals on the triangulation points in the northern part of the network: from Heclahuken to Vesle Tavleøya in the north, including the stations Vesle Tavleøya, Parryøya, Waldenøya, Ekstremhuken, Kapp Hansteen and Heclahuken. All stations were easily attainable except Ekstremhuken, where a sledge tour would be needed to reach the mountaintop.

The work to the north commenced on July 5, when the *Ran* left for Lågøya and Kapp Hansteen. At Lågøya a reconnaissance was made to find out whether the island could be used for setting up a base-line. This island is low, but the terrain was not ideal: it had sandbanks and gravel ridges, and was half-covered by water-soaked snow. On the 7th, Carlheim-Gyllensköld

left the ship with assistants to set up a signal on Kapp Hansteen, and already next day they were back at the ship with the task fulfilled.

In the evening the ship proceeded north to reach Ekstremhuken (394 m a.s.l.). However, Beverly Sound to the south of Nordkapp was filled with ice in its eastern part, so a sledge expedition had to be organized. A group was landed on the ice in the afternoon of July 10. It managed to climb the mountain and set up the signal, returning to its boat at the prearranged time in the evening of July 13. Meanwhile the *Ran* had proceeded to Vesle Tavleöya, where a signal was erected—as also on Parryöya, though the latter signal had to be moved subsequently to a higher part of the island. On the 13th, the *Ran* was back at Beverly Sound.

On July 15 a group under Jäderin left the ship to set up a signal on Waldenöya. The weather was excellent, with a clear sky and a virtual calm. They rowed and sailed under a light south-east wind, then climbed the north-western summit. But they could not see the signal on Parryöya, which had been set up by Jäderin a few days previously. Nor could they see this signal from the other summits of the island, so they decided to go back to Parryöya and move the signal, which had been set up in a fog. This time, though, the conditions were excellent for observation. From the new place they could see the signals on Vesle Tavleöya, Waldenöya and Ekstremhuken, whereas the signal on Kapp Hansteen was behind the Nordkapp Land.

The coal store of the *Ran* was beginning to run out, and it was necessary to take the ship to Isfjorden to fetch a store of coal which had been laid up there. After the signal was set up on Parryöya on July 18, the ship proceeded south under a southerly gale and anchored in the evening in Sorgfjorden. The gale continued to blow till the 20th, when at noon it reached hurricane force.

*The boat excursions of Carlheim-Gyllensköld,
July 22–August 4, 1898*

The plans were now to leave a group consisting of Carlheim-Gyllensköld and four Norwegian sealers, to continue setting up signals and doing other preparatory work. For transport they would now have to use a boat. A depot with provisions and material was laid up on Fosterneset at the entrance to Sorgfjorden. The Carlheim-Gyllensköld group was to stay in the coastal waters of Hinlopen until about August 4, when the *Ran* was due to return from Isfjorden.

The *Ran* left for Isfjorden on the morning of July 21 and arrived in Adventfjorden on the 23rd, where she remained until the 31st. Most of the time was spent bunkering. On August 2 the ship was back in

Sorgfjorden, and two days later the Carlheim-Gyllensköld group joined the ship's party.

Carlheim-Gyllensköld and his men had performed much valuable work in the two weeks at their disposal. He was satisfied to use simple transport by boat and sledge. With four Norwegian sealers to help him, these means proved to be more effective than using the combination of crew and scientific staff.

They were landed at Parry's flagstaff on Crozierpynten in Sorgfjorden. They arranged the equipment in the depot, and three signals were laid up here. On the 22nd the weather had improved; after ten hours of rowing, Carlheim-Gyllensköld and his four assistants crossed Hinlopenstretet. They passed into Murchisonfjorden on the south side of Söre Russöya—in the narrow sound between this island and the Nordaustlandet mainland. There was fog and, besides, the chart was erroneous.

Having passed the sound, they steered north-east and came to an island, which they named Indre Russöya. They visited its eastern point in order to study the ice situation—the fog had now dissolved. Ice existed in the inner part of Murchisonfjorden, but it was fairly rotten. Then they returned to Söre Russöya, and found a lagoon in its eastern part, which was to serve as a good harbour for their boat.

On July 24 the ice in the inner part of the fjord had drifted southward, so it was possible to sail to Kvalrosshalvöya. There Carlheim-Gyllensköld climbed a mountain (140 m) and observed the edge of Vestfonna, the ice-cap in the west of Nordaustlandet. It looked like an almost vertical wall of ice, and was described as an "ice wall more than 1500 feet high" on the maps in those days.

On July 25 they rowed to Celsiusberget (351 m), where they intended to establish a geodetic station. In the evening they pitched their camp near the shore on the northern side of the mountain. Two of the assistants were sent to Sorgfjorden, to fetch more provisions and the remaining three signals from their depot on Crozierpynten. They were to place this equipment near the Russian cross on Nordre Russöya and then come back to the camp. Meanwhile Carlheim-Gyllensköld and the other two Norwegians were to set up a signal on Celsiusberget.

On July 26, Carlheim-Gyllensköld climbed Celsiusberget along a not very steep route. They first wanted to investigate the suitability of the place and, not least, to find out how many triangulation points could be seen from the summit. The map was found to be erroneous and Forsiustoppen in the south-west, which was to be a triangulation point, appeared as a mere mountain plateau. Celsiusberget was found to be usable as a trigonometric station, but fog began

enveloping the mountain. So they had to go down to the camp, and in the night the two men returned from Sorgfjorden.

Next day the signal was erected on the mountain. The weather was excellent to begin with. During the climb, and later during the measurements and the work with the signal, they went about in shirt-sleeves. The fog returned, and everything became drab and dreary, but by evening the signal was in position and the preliminary measurements had been done.

On the 28th, the group sailed under a favourable wind to Nordre Russöya, with its remains of old Russian hunting activity in the 18th century—the cross and the ruined hut containing implements. Carlheim-Gyllensköld, a man of many interests, devoted the day to investigating these relics.

Already in the following night they left Murchisonfjorden, to start the work along Hinlopenstretet. The boat was now heavily loaded; to their original load were now added the provisions, signals, and finds from the Russian hunting hut. They had a following wind and sea when they steered south into Hinlopenstretet, leaving the sheltered waters in the fjord. Fog soon enveloped them, and navigation was rendered somewhat uncertain by all the iron material they now had on board.

But a weak sun could be seen through the fog, which was enough to establish that the deviation of their magnetic compass was about 60° . Wind and sea increased; Carlheim-Gyllensköld prepared himself to throw their Nansen sledge and the skin of a big seal into the sea, and tow them after the boat. However, near Lomfjorden on the west side of Hinlopenstretet the wind calmed down. They rowed into the fjord to find a camping site, where they landed on the morning of July 29.

Here they stayed until August 1. During this time, they managed to set up a signal on Kapp Fanshawe at 378 m a.s.l. On the 1st they sailed across Lomfjorden and left a good part of the load on the western shore, to be fetched by the *Ran* when she returned from Isfjorden. Next day they rounded Kapp Fanshawe and steered south down the Hinlopen. They passed Lovénberget and found a suitable camping site south of it. On the 3rd, they climbed this mountain. With hard work, the signal was carried up to the summit at 434 m, and a cairn was built. Next day the *Ran* arrived, and the field activity was completed.

Before they left the summit, Carlheim-Gyllensköld found time to photograph the mysterious Chydeniusfjella, and to take bearings to these mountains. During the first reconnaissance in 1861, they had been observed in the distance by Chydenius, and were expected to play a decisive role in the arc measurement

programme—for taking the geodetic chain overland from Hinlopenstretet to Storfjorden (compare p. 36).

*With the Ran in Hinlopenstretet,
Wijdefjorden and Storfjorden*

It remained to find a route to the Chydeniusfjella, and to investigate their suitability for the arc measurements. An attempt was now to be made to reach the enigmatic mountains by sledge from the inner part of Wijdefjorden. But it was already fairly late in the season, and there was still other work to do in Storfjorden and Hinlopenstretet. First, they decided to supplement the triangulation chain in Hinlopenstretet. The next station was Tumlingodden. The *Ran* steamed south-east on the 5th to Wahlbergöya, where she stayed until the 8th. On the same day they reached Torellneset and built a stone cairn.

Here they found that it was possible to set up a baseline on the smooth low beach. Their store of iron signals had almost run out; from now on, most of the signals had to be constructed on the spot, by building stone cairns.

From Torellneset they proceeded southwards to Tumlingodden, the easternmost headland of Wilhelmsöya, rising to 565 m a.s.l. The view from its summit was fine, and in the clear air, through a tube, they could distinguish Kong Karls Land and many details on the mountain slopes. A large stone cairn was built on the summit to serve as a geodetic signal.

On August 10 the *Ran* steamed north again. A signal was set up on Forsiustoppen, farther north in Hinlopenstretet opposite to Heclahuken. Then, on the 12th, it was time to proceed to Wijdefjorden to solve the riddle of the Chydenius mountains. The expedition spent a fairly long time in Wijdefjorden occupied with mapping, astronomical determinations of latitude and longitude, and investigations of the glaciers in the area.

An attempt was made on August 20-23 to penetrate to Chydeniusberget by sledging along the Mittag-Lefflerbreen at the bottom of the eastern branch of Wijdefjorden. However, it was thwarted by the extremely rough surface of the glacier. On August 25 the *Ran* was back in Hinlopenstretet, from where she had started on August 12. The problem of a connection between the northern and southern parts of the trigonometric chain from Sjuöyane to Sörkapp was therefore still unsettled.

On the 26th, the *Ran* continued south. In the night towards the 27th, von Zeipel—the youngest in the scientific staff—climbed Svartberget (160 m) on Nordaustlandet opposite to Lovénberget. A signal was set up here. The works on the northern chain of

triangles were now completed, and the *Ran* could proceed to Storfjorden. Passing along Wilhemöya and along the east coast of Barentsöya, she entered the sound between this island and Edgeöya, Freemansundet (Walther Tymens Strait). There was no ice, except occasional grounded pieces. They anchored at Kapp Lee, the north-west point of Edgeöya at the mouth of Freeman Sound in Storfjorden. Next day, the 28th, they built a stone cairn on the headland.

The weather had been good until then, but on the 29th a strong easterly gale blew. A day later, the ship steamed north towards the small Anderssonöyane, yet fog forced her back to Kapp Lee.

On the 31st, though, it proved possible to reach these islands, where they anchored. The men feared being surprised by the winter, and they longed to go home.

On September 2 the ship lay hove-to, in a calm with fog off Mistakodden. They tried to reach Edlundfjellet at the bottom of Storfjorden, but the harbour beneath the mountain was filled with icebergs, so they returned to Anderssonöyane. Barometer and clouds gave warnings of an impending gale, and on the evening of the 2nd there raged a full gale from the east. The next day was fine, and Jäderin decided that they should go home on the first day with suitable weather. But the captain wanted to hunt reindeer, and not until the 4th did they steer homeward.

The course was set for Agardhfjellet on the western side of the fjord. From here they followed the coast southward. Carlheim-Gyllensköld took plane-table bearings from the deck, and found that the coastline did not proceed as straight as the chart indicated. On the 5th they saw Spitsbergen disappear to the north. Two days later they were battling against a fierce southerly gale and a rough sea between Norway and Spitsbergen. Most people on board kept to their bunks and hammocks, except those having the watch. The ice pilot Pedersen looked pale and worried, when he met Carlheim-Gyllensköld down below.

"Excuse me, Doctor," said Pedersen, "could you ever have found a more miserable tub in Sweden than this one? Here the Norwegians are sailing in their tiny craft, but if we now were to meet with a hurricane like the one I rode out last year, all of us would be mourned."

The night was miserable, but next day, September 8, they reached Tromsö. The expedition had enjoyed exceedingly favourable ice conditions, and the weather had benefitted its work to a great extent. In brief, it had been a happy venture, accomplishing almost everything it was expected to do. Yet one important

problem was still unsolved—how to take the triangulation chain over land from Hinlopenstretet to Storfjorden.

THE SWEDISH SUMMER EXPEDITION OF 1899

Members, ships and plans

The arc measurements were to begin in earnest during the summer of 1899. The Swedish group would concentrate on the northern half of the triangulation network, and the Russian group on the southern half. The Swedish work was thus to occur in Hinlopenstretet and farther north, while the Russian measurements were mainly to be made in the Storfjorden region. The land area between the two was still an open question.

Both groups intended to establish a winter station, the Swedish group preferably on one of Sjuöyane, the Russian group somewhere in the Storfjorden region. Both stations were to be manned for a year, 1899–1900, so that the measurements could get an early start in the spring of 1900.

The Swedish State supplied a rich allowance of money, and the Swedish Navy placed the gunboat *Svensksund* at the disposal of the Swedish Committee. In addition, a Russian cargo-steamer, the *Rurik*, was hired to transport the equipment.

THE SCIENTIFIC MEMBERS OF THE SWEDISH EXPEDITION GROUP WERE:

Edvard Jäderin (1852–1923), geodesist and astronomer, leader of the Swedish group, member of the wintering party.

Folke August Engström (1856–1926), Ph.D., first astronomer.

Robert Larssén (b. 1858), Ph.D., second astronomer.

Sven Tryggve Salomon Rubin (1874–1946), Ph.D. (1903), astronomer, assistant, member of the wintering party.

Hans Christian Andersen Fränkel (b. 1875), Master of Engineering, member of the wintering party.

Nils Conrad Ringertz (b. 1859), lieutenant in the Swedish Army, topographer.

Jonas Westman (1867–1922), Ph.D., meteorologist, member of the wintering party.

Emil Otto Solander (b. 1858), captain in the Swedish Army, Ph.D., physicist, geomagnetic observer.

Thorild Wulff (1877–1917), B.Sc., botanist.

To this list should be added Jacob Torgersruud (b. 1864), a naval surgeon attached to the *Svensksund*; on her departure for home, he became attached to the wintering group.

The botanist Thorild Wulff (see p. 236) had become a member of the expedition outside its scientific

scope of activities. Hans Fränkel was the brother of Knut Fränkel, who went with S.A. Andrée in 1897; he had taken part in the search for Andrée in Siberia in 1898 under J. Stadling. His name reflects the fact that the famous Danish author Hans Christian Andersen had been his godfather.

The two ships of the Swedish group had the following officers:

THE GUNBOAT *SVENSKSUND* OF THE SWEDISH NAVY
Captain Hugo Wilhelm Hamilton (b. 1859), commander.

Jacob Torgersruud (b. 1864), M.D., doctor to the expedition.

Lieutenant Lars Eric Arnelius (b. 1867).

Lieutenant August Baltzar Carl Jacob Lagercrantz (b. 1869).

THE CARGO STEAMER *RURIK*, HIRED FROM RUSSIA
Captain Cederlund, commander of the *Rurik*.

The Russian expedition had three ships at its disposal: the freighters *Bakan* and *Betty* and the icebreaker *Ledokol*. Of these, the *Betty* was hired from Sweden (see further p. 347).

The Swedish search for a winter station

When the bells of the two churches in Tromsø chimed midnight on June 25/26, a line of five ships started north. They carried the entire Swedish-Russian expedition towards its prospective fields of activity in the Svalbard archipelago. In front came the *Bakan* of the Russians, followed by the Swedish *Svensksund*, the *Rurik*, the *Betty* and finally the ice breaker *Ledokol*, at intervals of 200 m. It was indeed an impressive departure.

The two Swedish ships were to proceed to the north of Spitsbergen, where a winter station would be established, and preparatory work and measurements be carried out. Analogously, the three Russian ships were heading for southern and eastern Spitsbergen to do similar work.

Near Spitsbergen a dense fog forced the two groups to separate at 75°30'N. The *Svensksund* and the *Rurik* went north along the west coast of Spitsbergen. A visit was paid to Isfjorden, where coal was collected at Festningen for test-burning. From hunters and from a ship of the Italian crown prince, they heard that the ice situation farther north was very bad.

On July 1 they entered Virgohamna at Dansköya. Here they spent the following week. Tours of reconnaissance were made with a steam launch to investigate the ice conditions. Two ice reconnaissances were also carried out with the *Svensksund*. There was ice among the islands to the north-east, rendering boat-tours most troublesome.

On July 8, however, they decided to proceed eastward and managed, with much work, to come as far as Velkomstpynten. But their position seemed precarious and they turned back on the 9th. They got no farther west than longitude 13°30'E, and after a somewhat critical period among ice pressures, the two ships entered Raudfjorden.

A short time later the *Ledokol* arrived, with O. Backlund and the Russian geodesists on board. They had attempted to establish their winter station at Sörkapp, having found Storfjorden closed. But again the ice blocked the way, and finally they found a suitable place at Gåshamna on the south side of Hornsund—the Goës Bay of Nordenskiöld. The unloading of equipment was presently going on there.

Storfjorden seemed to be almost free of ice now, and it might be possible to reach the Swedish research area that way. But the plans had to be modified. The Swedish expedition would first of all find a winter station, land the equipment and build the huts; then it would hurry to Sorgfjorden, set up and measure a base-line at the foot of Heclahuken, and carry out the angular measurements to connect the base-line with the network of triangles. The *Ledokol* was later to return and unload the signals for the Swedish base-line.

The two Swedish ships moved westward and spent some time at the north-western corner of Spitsbergen. On July 14 they proceeded east again, but were stopped by the ice at Velkomstpynten. They steamed south into Woodfjorden; as its inner portion was fairly unknown, they intended to do some mapping and carry out astronomical observations for position. The fjord proved to penetrate about 1/3 farther south than the maps indicated.

On July 16 the two ships resumed the passage eastward. This time they reached almost the longitude of Verlegenuken, but the ice forced them to enter Wijdefjorden. However, next day it was possible to get beyond Verlegenuken, with Nordaustlandet, Hinlopenstretet and Heclahuken in sight. This would be their future area of work, which was most encouraging. Spirits had been rather low lately—there was so much to do, and nothing had yet been accomplished. It must have been a very trying time for Edvard Jäderin.

According to plan, they should have found a site for their winter quarters before July 20, and the unloading should have started that day at the latest. It would now be impossible to reach the proposed site on Parryöya in time, but Treurenberg Bay—or Sorgfjorden—would be good enough, considering the unfavourable ice situation. They managed to enter the fjord and, on its eastern side and on the south side of

Crozierneset, they found a suitable place for building the dwelling-house and the observation pavilions.

Immediately upon arrival, the two ships were moored on both sides of a piece of grounded ice. Two rafts were assembled. The unloading of equipment could start by using the two rafts as ferries. The crews of both ships did this work, and finished it on August 2, whereupon the ship's crews could take part in the building tasks. On August 6 the roof frame was mounted, and was celebrated with a traditional feast for about 50 persons, followed by dancing and athletic competitions.

Jäderin, however, had worries these days. According to an agreement with the Russians, the icebreaker *Ledokol* was to bring mail and equipment to the Swedish expedition—notably signals and a valuable universal instrument for the angular measurements. They were badly in need of this instrument, whereas the signals were now constructed on board.

Scientific work and excursions

On August 3 the *Rurik* was dispatched to Tromsø to load coal. While returning, she was to visit the Russian station at Hornsund for information, and a group of three men was to be landed in the inner part of Wijdefjorden. The group, consisting of Fränkel and the Norwegian Helmer Hanssen, would try to find a way up along a glacier in order to reach the Chydenius mountains. These played, as mentioned, an important role in the plans for taking the chain of triangles overland from Hinlopenstretet to Storfjorden. The party was to be fetched by the *Svensksund* on the 10th. But they met with bad weather on the glacier, Tryggvebreen, and were unable to reach the mountain and make certain that it could be used. Apart from this, a lone man, Wulff, was landed near Mittag-Lefflerbreen, where he was to botanize.

Meanwhile a base-line had been marked on the plain north-east of Heclahuken. Its length was measured during August 14–22, using Jäderin's method with Invar strings. Two measurements were made in both directions, giving a mean value of 10 024.185 m and differing by only 2 cm. With all corrections applied, the length was later established as 10 024.518 m $\pm$ 12 mm. In this connection, it should be mentioned that the aim was to obtain the horizontal angles of the triangles with an error less than 0.6", and the final mean values of the measured latitudes with an error less than 0.3".

The *Ledokol* did not arrive, nor had the *Rurik* been able to contact her. On September 3 the *Rurik* left for home.

The topographical work under Ringertz could not start in earnest until August 14. All hands were needed

to land the equipment and build the house and huts. The survey work was first concentrated on Murchisonfjorden and Celsiusberget, during August 14–September 1, except for a few days' pause. The work was then transferred to Lady Franklinsfjorden, where it was possible to work from September 3 to 8. The rest of the time until the departure of the *Svensksund* on the 14th was devoted to surveying in the neighbourhood of the winter station.

The last day, September 1, that could be spent on the survey of Celsiusberget was used for excursions in the surrounding country, notably on the top of the ice-cap, later called Vestfonna. The party consisted of Ringertz, Torgersruud, Wulff and three assistants. They wanted to investigate the slope of the ice and the position of its edge towards the ice-free land. As noted above, on existing maps the slope was called an ice wall 1500 feet [450 m] high. Even as seen from Celsiusberget some 9 km away, there was nothing to say against such a description. However, on closer view, it was found to be a highly exaggerated statement, despite the slope's fair steepness.

Before they started the ice march, Ringertz wanted to carry out some reconnaissance for his survey work, so Torgersruud and Wulff separated from his group. They took a shortcut across a small, ice-covered lake in front of the edge of the inland ice. However, near the southern shore this ice was newly frozen, and could only carry a man of moderate weight if great care was exercised. Wulff used crampons, and apparently he was not careful enough. About 100 m from the southern shore, he suddenly found himself up to the neck in the cold water.

Torgersruud was 200 m from the place, but he heard nothing, as Wulff could not make a sound because of the cold water. Eventually he observed the situation and managed to crawl over the thin ice nearby. Wulff had a rope around his body for the march on the ice-cap, and was able to throw the end to Torgersruud, who had to drag him through the ice before getting him up on it. They had no dry clothes for Wulff, so he warmed up by running about. This was a narrow escape, and came very close to ending Wulff's adventurous life. The lake in question has been named Wulffvatnet (see p. 556).

They were now at the edge of the ice-cap, which here had a slope of 1:4–1:6, decreasing inland. The edge of the ice did not, therefore, resemble a "wall". The snow was only 12–16 cm thick and rested upon glacier ice. They continued their march southward to a point on the plateau of the ice-cap, about 6 km from the edge of the ice and at an altitude of almost 600 m. From there they could see down into Wahlenbergfjorden. This was near the place where a group from

Edvard Jäderin (1852-1923), geodesist and astronomer. Leader in the field of the Swedish expeditions to Spitsbergen, 1898-1900. (Jäderin-Hagfors, M.: Min far upplever polarnatten.)

Svenskund of the Swedish Navy and the Russian cargo-steamer *Rurik* operated for the Swedish geodesists in Spitsbergen in the summer of 1899. (Jäderin-Hagfors, M.: Min far upplever polarnatten.)

The winter station of the Swedish Arc-of-Meridian Expedition at Sorgfjorden, 1899-1900 (left above). (SSAG: Swedish explorations in Spitzbergen 1909.)

Mounting a geodetic signal on Celsiusberget, Spitsbergen, in 1898. The signal—a double cone—is seen to the left (right above). (Carlheim-Gyllensköld, V.: På åttionde breddgraden.)

The tours of the *Svenskund* in the summer of 1899. Outward course=solid line. Homeward course=broken line. A winter station was built at Sorgfjorden and the winter of 1899-1900 and the summer of 1900 were spent here. In the spring of 1900, Jäderin carried out a sledging tour of reconnaissance (left).

the Murchison Bay station, during the International Geophysical Year of 1957–58, would spend a fortnight in a snow cave doing meteorological observations. At midnight towards September 2, they were back on board the *Svensksund*.

The men at the winter station of Sorgfjorden had waited in vain for the *Ledokol* to bring their new universal instrument. They had therefore been obliged to measure with a smaller and less accurate instrument. The *Rurik* had returned from her trip to Tromsø on August 21. Along the way back to Spitsbergen, she had visited the Russian base at Hornsund, and had stopped at Storfjorden to look for the *Ledokol*. At two places, letters had been laid down with requests that the ship should call at Sorgfjorden.

The time at the winter station had been fully occupied with practical tasks, and there had not been much time for scientific work. Azimuth and latitude determinations had been made only on Celsiusberget. No pendulum observations had been carried out, as these were rather time-consuming. Fortunately the base-line had been carefully measured, but it had not been connected to the geodetic chain of triangles. During the autumn that followed, the weather was unfavourable for angular measurements: a thick fog lingered almost continuously over Hinlopenstretet. On the occasions when the mountain peaks were seen, their images were "restless" to a degree which made measurements impossible, so little effective work could be done.

WINTERING AT SORGFJORDEN 1899–1900

Personnel, research and routines

The *Rurik* had left on September 3, and on the 14th it was time for the *Svensksund* to go home. The wintering party was now alone, consisting of twelve persons.

Seven of these were assistants for the practical work, and the rest were the scientific staff as follows: Edvard Jäderin, geodesist and astronomer, leader of the wintering party.

Tryggve Rubin, geodesist and astronomer.

Jonas Westman, meteorological and geomagnetic observer.

Jacob Torgersruud, doctor to the party.

Hans Fränkel, engineer.

Among the seven assistants was a non-commissioned officer from the Swedish Navy. Another was the Norwegian Helmer Hanssen (1870–1956), later well-known as a companion of Roald Amundsen during his voyage with the *Gjøa* along the North-West Passage in 1903–06, on board the *Fram* to the Antarctic in

1910–12, and with the *Maud* along the North-East Passage in 1918–20. In the Antarctic he sledged with Amundsen to the South Pole.

The house was large and functional. Every man in the scientific staff had a room of his own on the ground-floor, and the assistants lived on the upper floor. There was a drawback in the equipment of the house—the 14 stoves, which were supposed to give ample amounts of heat during the winter. These stoves had no damper, and as a result—when the wind blew, as it often did—the consumption of anthracite was enormous and the rooms remained cold.

The first thing to do after the ships' departure was to get the provisions and other equipment into the house, and to lay them up in good order. Moreover, essential furniture had to be built to make a habitable home. Some observation-pavilions were constructed, and others were improved by building vestibules at the entrances.

The meteorological observations were started only a few days after the landing on July 20. The meteorological journal contains observations in the period July 26, 1899–August 18, 1900, with the exception of some meteorological elements which were added a little later in the autumn. Observations were carried out at 08.00h, 10.00h, 12.00h, 14.00h, 17.00h, 19.00h, 21.00h, and subsequently at 22.00h and 23.00h. In the beginning of September, a secondary meteorological station was arranged on Heclahuken at 400 m a.s.l. Here temperature and humidity were recorded. Check-readings were made once a week, except during part of the polar night.

Westman also arranged an observatory for measuring the intensity of the direct solar radiation. The magnetic observations were carried out from September 3, 1899, until August 10, 1900—although drifting snow, which the winter gales pressed into the hut, caused displacements of the mountings of the recording instruments. In addition, Westman devoted much time and energy to microphotographing the ice crystals of the snow precipitation. Aurora was observed between September 26, 1899, and March 17, 1900, but photographic registering of the forms during displays was not possible.

During the autumn and winter, several observations of the longitude were carried out at the station, and Heclahuken was connected with the observatory at the station via a triangulation chain. In this way the observations at the winter station would become useful for the regular triangle network. In an analogous way, the base of the Nordenskiöld expedition of 1872–73 at Mosselbukta had been connected with the observatory at Sorgfjorden; the astronomical observations at Mosselbukta were thus of use to the arc

measurement programme. A practical lesson of the winter observations was that the instruments failed at temperatures below -25°C : they got stuck and could not be turned.

Life during the winter proceeded by routine. There were observations to do and data to be studied, and the men always had something in need of repair or improvement. Except for the heating, everything functioned well, and their house was comfortable. Among the conveniences was electric light, with a generator driven by a paraffin motor—although this consumed much more oil than they had been told at home, so a certain economy had to be practised. Their food was rich, and the cook was excellent. But, of course, they could not avoid the mental influence of the darkness. Sleepy by day and sleepless at night, some of them became irritable and others simply wanted to be left alone.

The polar night lasted about four months, and for about half of that time it was dark even at noon.

A fatal slip

One of the first planned operations was a sledge-tour southward across the ice-cap to reach the Chydenius mountains. The two youngest and strongest in the scientific staff, Rubin and Fränkel, were to make this tour with some of the assistants. But fate decreed otherwise.

The route crossed the sea-ice on Sorgfjorden. At the southern end of the fjord was an outlet-glacier, Dunérbreen, coming from the large ice-cap Åsgårdfonna. This ice-sheet, covering a good part of Ny Friesland, was supposed to provide a convenient way south to the mountains seen from the distance by Chydenius, and later also by Carlheim-Gyllensköld.

In the upper reaches of Dunérbreen, a nunatak protruded through the glacier ice—Sörfjellet. Fränkel wanted to reconnoitre the route past this mountain and, possibly, some distance farther south on Åsgårdfonna. But he intended to go alone, with little equipment and food. He was reckless, and Jäderin could not dissuade him. The nights were still dark, and it was cold, when he started his march on the morning of March 8. A few hours later he was seen through the tube from the station. He arranged a mark on Sörfjellet for azimuth determinations. The weather was excellent with strong sunlight.

They watched him on the mountain until 14.00h, and figured that he would be back home at about 17.00h. When he did not return, they thought he had continued some distance south and would appear later in the evening. However, Fränkel was gone all night, and a relief expedition prepared to start at dawn. They worried over his fate, especially since it

was quite cold at -34°C . The relief party of Westman, Rubin, and two assistants set out with a sledge and a pair of dogs.

At 17.00h the party was back at the station and Fränkel was alive, though dragged on the sledge. He had fallen down a very steep snow-slope, 200 m high, on the northern side of Sörfjellet. He had broken a thighbone, and his toes had frozen, while not too severely. He had lost one mitten, but prevented his hand from freezing by holding it in his pocket. His rucksack had vanished, but fortunately his cap stayed on his head. All night he had observed the lights from the station; it looked as if a late party was going on there.

Fränkel had a very robust physique and a humorous mind. Yet he was now fettered to his bed for several weeks. Besides, Rubin and Carlson in the relief party had frozen their own toes, and it was wondered at first whether Rubin's toes would have to be amputated. So Fränkel's lone walk had consequences. He and Rubin would be unable to go on the sledge tour to the Chydenius mountains. They were, as mentioned, the strongest in the scientific staff. There remained Jäderin and Torgersruud, as Westman had to stay at the station to take care of the running observations. Jäderin seems to have worried over the situation.

The sun was rising higher in the sky, and spring was approaching, but it was still rather cold. Even at the end of May they were forced to keep a night-watch for tending the stoves, which could not raise the temperature indoors higher than $+1^{\circ}\text{C}$.

A sledging tour towards the Chydenius mountains

The long sledge tour began on May 16, with six men: Jäderin, Torgersruud and four assistants. They had only 7 dogs at their disposal, as the original number of 13 had been reduced during the winter by mutual fighting. Their sledge was heavily loaded, and they often had to help the dogs dragging it.

They reached the edge of Dunérbreen in the south of Sorgfjorden. Here they pitched camp. A dense fog had developed, and it was impossible to find a suitable route on the glacier. This was perhaps a stroke of luck, as the next day enabled them to shoot a polar bear, which meant extra meat for the dogs. It emerged later that their stock of dried fish was insufficient.

The march proceeded along a smooth slope without crevasses. At times there was a biting wind. On the 21st they reached the highest part of the ice-cap, at 1200 m a.s.l. For a while they were surrounded by just a white plain of snow. But mountains started to creep above the horizon as they continued southward. It was soon clear that a mighty, broken chain of mountains

lay ahead of them. A pyramidal mountain, which was called Cheops after the famous pyramid, was recognized from observations in the summer of 1898.

The ice-cap sloped downward in front of them, so the going was good, but the men worried over the struggle which awaited them on the home march. They entered a maze of mountain peaks, deep ravines and ridges. Finally they became enveloped in fog and had to camp. Next day a gale was raging, and the fog prevailed during almost the entire remainder of their stay on the ice, though lifting now and again. On the whole, they had to wait in their sleeping-bags. They worried over their store of fuel, which was running low. On May 27 they could march south some distance, before they had to pitch camp again.

The fog cleared temporarily next day, and they discovered that deep vertical ravines would prevent them from reaching the Chydenius mountains. They had intended to make a number of angular measurements on a suitable peak here, and to build a cairn as a signal at the place. But they could not reach the summits, and in this respect the sledging tour was considered an absolute failure. Still, it was then the second longest inland journey in Svalbard, after Nordenskiöld's ice march in Nordaustlandet in 1873, and Jäderin now had material for a map of unknown territory.

The return trip was slow to begin with, but on June 3 they were back at the station. Jäderin's health had declined, and he suffered a heart attack from the strain of the march. His sledging-companions—among them the doctor—thought that his life had been in jeopardy. But Jäderin never mentioned the incident afterwards, either in his letters or diary, to his family or to the Commission in Stockholm. He merely asked to be released from his position as leader of the Swedish group, explaining that it was impossible to combine the duties of a leader with those of a field-working geodesist. However, 23 years later, when about to undergo an operation in hospital, he confided the truth to his doctor—and the latter told his family, upon Jäderin's death from heart failure during the operation.

A miserable summer 1900

The summer of 1900 proved to be awful. Ice lay close upon the coast, dazzling white. At the beginning of June, the men began to count the days until the *Svensksund* could be expected. But there was no change in the ice situation. Polar bears appeared, which the men considered a bad sign. They wanted strong winds, from the north in order to break the ice floes along the coast, and from the south-east to disperse the ice.

They were more or less confined to the station. They had hoped for open water and a ship, enabling them to visit the geodetic stations and make the measurements rapidly. But they could only carry out some measurements in the neighbourhood. In August they began to consider the prospect of staying for a second winter, which would probably not turn out as well, since their fuel for the paraffin motor was getting low, like the anthracite for the stoves. The question of food did not worry them, though, and they had ample amounts of antiscorbutics.

On August 7, Jäderin assembled his comrades on a hillock, their lookout near the station. Punch was brought, the flag was fluttering, and Jäderin thanked them for their work during the past year. Then he informed them about the strong possibility of a second wintering. The meeting became a discussion of their stores, and of how best to organize life at the station.

While they were talking, the wind had started to blow. It began with gusts of gale force, and some pieces of glacier ice were seen moving among the sea-ice. A later visit on the hillock revealed that the sea-ice was now also moving—and in the right direction, northward. The wind rose to a howl during the night; and at about 02.00h on August 8, other noises were heard. It sounded like someone banging on the door. There were men outside, nervous and impatient. At last, the ship had come.

MONTHLY MEAN AND EXTREME TEMPERATURES (°C)

Sorgfjorden (Treurenberg Bay), Spitsbergen, 1899–1900.
Latitude 79°55'N, longitude 16°51'E, near sea level.

Month	Mean	Max.	Min.
<i>Aug. 1899</i>	+2.1	+8.3	-1.1
<i>September</i>	+0.3	+8.4	-6.2
<i>October</i>	-10.5	-0.8	-19.8
<i>November</i>	-13.9	+0.7	-24.0
<i>December</i>	-11.9	+5.5	-32.0
<i>Jan. 1900</i>	-8.5	+2.9	-23.1
<i>February</i>	-22.6	-5.5	-34.1
<i>March</i>	-27.0	-7.0	-40.1
<i>April</i>	-16.5	+1.6	-30.8
<i>May</i>	-9.6	+3.2	-19.1
<i>June</i>	-1.1	+4.6	-8.7
<i>July</i>	+1.2	+9.5	-5.9
<i>1–15 August</i>	(+ 5.3)	(+11.5)	(+0.1)

Data from the publications of the Arc-of-Meridian expedition, *Mission scientifique* etc. (see bibliography p. 591).

THE RUSSIAN EXPEDITION IN 1899

For the summer campaign in 1899, the Russian Commission had invited two Swedish guest scientists—a geologist and a topographer—to take part in the Russian reconnaissances in Spitsbergen. Gerard De Geer, and his topographer Otto von Knorring from the Spitsbergen expedition of 1896, were chosen for this mission. They brought the same or similar equipment as had been used on the expedition of 1896: some Nansen sledges and two Norwegian hunting-boats, which were to be shared among the Swedish and Russian reconnaissance groups.

The departure from Tromsø of the Russian and Swedish groups, at midnight towards June 26, has already been described (p. 341).

Ships, members, and the winter station

The Russian expedition had three ships at its disposal: the two freighter-steamers *Bakan* and *Betty*, and the icebreaker *Ledokol II*.

The *Betty*, hired from Sweden, was intended for transporting construction materials. In the following, the third ship will be referred to simply as *Ledokol* ("icebreaker"), as seems to have been done also among the men on Spitsbergen.

These ships were commanded by C. Yergomishev of the *Bakan*, Y. Yakimovich of the *Ledokol*, and Captain Arvidsson of the *Betty*. With them went two Finnish foremen and eight Norwegian workers, who were to take part in the house-building at the Russian winter station.

THE SCIENTIFIC MEMBERS OF THE RUSSIAN ARC-OF-MERIDIAN EXPEDITION IN 1899 WERE:

F. Chernyshev, Academician, geologist, leader of the Russian group.

D. Sergievski, geodesist, leader of the wintering party*.

A. Ashmatov, astronomer*.

A. Hanski, astronomer.

A. Piedashenko, astronomer.

A. Vassiliev, astronomer*.

A. Beyer, physicist*.

E. Stelling, meteorologist.

A. Bielanichski-Biroula, zoologist.

I. Sykora, astrophysicist*.

Helge Backlund, tender of collections, interpreter.

A. Bunge, physician*.

The representative of the Russian Committee, O. Backlund, stayed with the expedition during the summer of 1899. His son, Helge Backlund, also took part in the summer's work. Besides, as mentioned above, two Swedish guest scientists were included in the

scientific staff during the summer of 1899—Gerard De Geer and Otto von Knorring.

The Russian expedition was supposed to have another two ships at its disposal: the strong new ice-breaker *Yermak* under Admiral Stephan Makároff, and a freighter with 200 tons of coal. However, Makároff had left Tromsø with the *Yermak* before the arrival of the ships of the Russian and Swedish expeditions. He left a letter stating that he had heard that the ice situation in Storfjorden was such that he considered that he could not go there with the Russian expedition ships.

The intention had been that the Russian station would be placed at Storfjorden, and the *Yermak* was expected to help the Russian ships in the ice, which was assumed to linger in Storfjorden. According to Laktionov (1960), the *Yermak* had undertaken a trial run in arctic ice in the Svalbard region in the summer of 1899, but had suffered damage to her hull and propellers, and had been taken to the shipbuilders in Britain for repair.

As a result, the Russian base station was chosen in a more accessible region than Storfjorden, namely the Sörkapp region. As ice hindered the expedition there too, Gåshamna on the south side of Hornsund was chosen. This harbour was sheltered, and it seemed possible to obtain a connection from here with the planned triangular network; it even seemed possible to reach the two southernmost geodetic points overland from the station.

The unloading of huts, dwelling-house and observation pavilions started immediately upon arrival. On July 7 the *Ledokol*, with the geodesists on board, left for the north coast of Spitsbergen in order to start the measurements in the northern part of the triangulation network, together with the Swedes. However, the ice was dense in the north and the ship had to return south again (compare p. 341).

The work of reconnaissance parties

On July 15, the *Bakan* was able to take the two reconnaissance parties of the Russian expedition into Storfjorden, and leave them there to look for suitable triangulation points and to establish signals. The *Bakan* and her crew of 90 men went back to the Russian station to help finish the work there.

The two reconnaissance parties consisted of the following men:

THE CHERNYSHEV PARTY

Chernyshev, geologist, leader.

Piedashenko, astronomer.

Helge Backlund, collector, interpreter.

Two assistants from Mesen, Russia.

Two assistants from Tromsø, Norway.

*) Members of the wintering party in 1899/1900.

THE DE GEER PARTY

De Geer, geologist.

von Knorring, topographer.

Four assistants from Tromsø, Norway.

The parties formed two boat groups, and their equipment included some Nansen sledges (compare above).

The *Bakan* returned on August 2 in order to transport the parties to their next triangulation points. By then, they had erected signals on Keilhaufjellet and Hedgehogfjellet, the most southerly stations. They were told that the geodesists on board the *Ledokol* were coming to Storfjorden, as the north coast of Svalbard had been found blocked by ice. An unsuccessful attempt was, however, made to reach Hinlopenstretet and the Swedes by passing through Freeman Sound (Thymensundet) between Edgeöya and Barentsöya.

It was therefore vital to erect signals at those points which could be measured from Kapp Lee and Kvalpynten. All necessary signals had been set up on August 20, and next day the reconnaissance parties were fetched by the *Ledokol* in Ginevrabotnen—in the north of Storfjorden—to be taken to the Swedish station at Sorgfjorden, with mail and the much-desired universal instrument.

However, a little south of Mistakodden, the north-west point of Barentsöya, the *Ledokol* ran aground. Thanks to her speed she slipped off, but the protection frame round the propeller was broken in two places and had to be fastened provisionally with wire ropes. It was possible to reach the harbour at Anderssonöyane to investigate the matter and carry out repairs with the assistance of people from the *Bakan*.

Meantime, on August 24–25, De Geer and Chernyshev were trying to reach the Swedish station with the coal freighter *Betty*. But they failed, apparently mainly because of the pessimistic outlook of the ice pilot on board. According to De Geer, he mistook a fairly narrow band of ice, between Kapp Fanshawe and Nordaustlandet, for the broad northern ice which had been pressed southward into Hinlopenstretet. The *Betty* was not a strong ship, so they returned. The Swedes at Sorgfjorden did not get the universal instrument, and the air was full of rumours, even saying that the *Ledokol* had accompanied the icebreaker *Yermak* to England for repair.

The ice situation in the Svalbard seas seemed on the whole to have been almost as good as in 1898, except along the north coast. In Storfjorden, the ice was reported to have broken in mid-July, and the Russian expedition was able to do its work in that region under favourable conditions. Ice in the north is very largely

determined by the prevailing winds, and less by the temperature conditions. The working conditions of the Swedes on the north coast were in sharp contrast to those of the Russians in the south.

But these favourable conditions applied to ice and not to weather. Storfjorden was closer to the open waters and the prevailing cyclone tracks. The weather was therefore more unsettled in the south, with a greater frequency of low clouds and fogs. The mountains gave rise to orogenic (or orographic) clouds—which formed in the ascending air on the windward side of the mountains and eventually dissolved on the leeward side. The mountains on one side of Storfjorden might be shrouded in clouds, while on the other side of the fjord they might be free or partly free. Such weather situations were sometimes prolonged, forcing the geodesists to stay long on the mountain peaks. The Swedish group in the north occasionally experienced similar situations. Another difference between the conditions in the northern and southern parts of the triangulation chain was the longer distances between signal points in the south.

A visit to the Chydenius mountains led by De Geer

We have repeatedly discussed the still unsolved problem of taking the triangulation chain overland in its middle part. However, in the summer of 1899 this problem came near a solution during an ice march by the De Geer reconnaissance party.

The Chydenius mountains were actually thought at first to be a single peak, but the observations of Jäderin and Carlheim-Gyllensköld had revealed it to be a range with several high summits. Some distance further south was a mountain called Svanbergfjellet, which De Geer had seen in 1882 during his geological expedition with Nathorst. This he had photographed from another mountain or nunatak, near the bottom of Billefjorden (see p. 193), which would later be named after De Geer by the British traveller Sir Martin Conway. A visit to the Svanberg mountain was essential, and a sledge tour to it was arranged, while Chernyshev's reconnaissance party was setting up signals on Edlundfjellet in the north of Storfjorden.

The sledging party consisted of De Geer, von Knorring and five Norwegian assistants. The two reconnaissance parties were landed by the *Ledokol* in the harbour to the south-east of Edlundfjellet, on the north side of the mighty ice-stream of Negribreen—about 25 km wide—coming from the ice-cap in the interior. Having rowed about 15 km, they reached a place where the glacier was so low that their boats could be dragged up onto the ice.

The ice march started at 22.00h on August 17. Chernyshev's party accompanied De Geer's during

the first hours, and helped them to pass over the rather rough glacier surface. After 10 hours of travel, and a working-day of 22 hours, they pitched camp on a lateral moraine near some nunataks, at a height of about 330 m.

Next evening they continued, leaving one of their two sledges at this place, with sleeping-bags and other items of equipment which were not needed now. A march of 7 hours brought them to the foot of Svanbergfjellet, and after some rest they started the climb. It lasted 2 hours and took them from 575 m a.s.l. to about 1000 m on the summit. This consisted of a fairly smooth plateau, partly covered with large blocks from dolomite strata.

As the temperature was a few degrees Celsius below freezing, the building of the signal was laborious, as most of the blocks were frozen to the ground. They started to build the cairn immediately on reaching the top. The cairn was placed on the southern side of the plateau. To the north, the view was hidden by a small ice-cap and, unfortunately, Chydeniusfjellet lay behind it. A connection would, however, be possible with the help of a minor triangulation chain.

After 5 hours of hard labour the group had constructed an impressive signal, perhaps the most imposing of all in the Spitsbergen area. It was a truncated cone, 2 m high with a diameter of 3 m at the base and 1.2 m on top, where an ordinary cone with a height of 1.5 m was added. Its total height was thus 3.5 m. The bearing to the signal could be measured almost at once by the vigilant Russian geodesists at Kapp Lee on north-western Edgeöya.

The descent from the mountain was fast, thanks to "skin sledging" down the snowy slopes. After a short rest at the bottom, there remained a march of four hours to their previous camp, where the sledge and sleeping-bags were laid up. They had then worked for 24 hours, and got a good rest. Next day, August 20, they reached the sea. Their route had covered 74 km in 2 1/2 days, and they had contributed greatly to solving the problem of taking the geodetic chain across the ice-covered land between Hinlopenstretet and Storfjorden.

Yet they had not quite seen Chydeniusfjellet, as the intervening ice-sheet and the ice-dome of Svanbergigfjellet had been covered by fog. De Geer recommended that the geodetic party, which would visit the latter mountain, should also establish a signal on one of the Chydenius mountains, besides carrying out the geodetic measurements from the two mountains. If ice conditions proved too severe in Storfjorden, the mountains might be reached from Billefjorden via Nordenskiöldbreen, as De Geer had found out in 1882 and 1896 (compare p. 193).

De Geer's reconnaissance tours had given him good opportunities to study the geological conditions in the Storfjorden region. He also collected observations of glacial striae, which indicated a mighty ice-stream from Nordaustlandet and the Hinlopen region—a flow in a southerly direction along eastern Spitsbergen and off-lying islands (see map p. 353). This extension of the ice-sheet probably reflected the conditions during the latter part of the preceding Ice Age, according to De Geer.

However, the time that could be set aside for the ice march and the visit to Svanbergfjellet had been limited, as they were to be fetched at Edlundhamna on a specific day. The field season was approaching its end, and on August 29 the geodetic works in the Storfjorden area would have to be completed.

A visit to the Russian winter station

The winter station of the Russians at Hornsund was visited before leaving Spitsbergen. The buildings were now set up, and the wintering party was preparing the station for the coming season.

Finally, on September 10, the *Bakan* and the *Ledokol* left Spitsbergen waters and set course for home. They passed by Björnöya, where the geological-biological expedition of J.G. Andersson was to be fetched. But this party had already arranged to go home on the German expedition ship under Theodor Lerner (p. 289). On September 13 the Russian summer expedition, including De Geer and von Knorring, reached Tromsø.

THE RUSSIAN WINTERING PARTY INCLUDED THE FOLLOWING PERSONS:

- D. Sergievski, geodesist, leader of the wintering party.
- A. Vassiliev, astronomer.
- A. Ashmatov, astronomer.
- I. Sykora, astrophysicist.
- A. Beyer, physicist and meteorologist.
- A. Bunge, doctor to the party.

In addition there was an appropriate number of men for the practical work.

Their dwelling-house was low and spacious. It was specially constructed to stand the severe gales of the region. The large living-room, which faced towards the south, was partly surrounded by the cabins of the expedition members. These were separated from the outer walls of the house, by a number of small storage-rooms and by the photographic darkroom. The house was heated by a number of tiled stoves. In the words of De Geer, it

"testified in all respects to having been devised by a most experienced polar winterer."

*A FIGHT AGAINST THE ICE:
THE SVENSKSUND IN
SPITSBERGEN WATERS IN 1900
Ships and expedition members*

For the Swedish operations in Spitsbergen in the summer of 1900, the Swedish State placed the gunboat *Svensksund* at the disposal of the Swedish Commission, as in the previous year. For transport, the sealing yacht *Gjöa* and the collier *Lofoten* were hired.

THE LEADING OFFICERS OF THE *SVENSKSUND* WERE:

Captain *Henning* Vilhelm Mauritz von Krusenstjerna (b. 1862), commander.

Lieutenant Lars *Eric* Arnelius (b. 1867).

Lieutenant *Björn* Ryno Sydow (b. 1867).

Three persons went by the *Svensksund* to join the scientific staff which had wintered at Sorgfjorden (Treurenberg Bay):

Folke August Engström (1856–1926), Ph.D., first astronomer and geodesist, leader of the expedition until the wintering group was reached.

Robert Larssén (b. 1858), Ph.D., second astronomer and geodesist.

Nils Conrad Ringertz (b. 1859), captain in the Swedish army, topographer.

Roving in Svalbard waters

The *Svensksund* left Karlskrona, Sweden, on May 12, 1900. She passed via København, and Trondheim where the scientific members embarked on May 22. Tromsø was reached on the 26th, but the ship could not proceed north until June 1, as one man of the crew was taken ill and had to be exchanged from Stockholm.

Björnöya was passed on June 4, and soon afterwards the ship met with ice and had to make a long detour west. Off Hornsund the course was set east, and it was found possible to enter the fjord and visit the Russian station at Gåshamna, to be informed on the Russian activity during the preceding winter and on the Russian plans for the summer. The chronometers of the station were also compared with those of the ship.

On the 6th, the *Svensksund* proceeded south, following a lane of open water along the coast, the intention being to investigate the ice conditions in the Sörkapp region. However, the ice did not permit the ship to attain either Sörkapp or Keilhaufjellet, with the two most southerly of the triangulation points. So she turned back and continued north along the Spitsbergen west coast.

An attempt to bunker coal at Festningen, south of the mouth of Isfjorden, failed owing to the snow-covered ground. The ship therefore resumed her northerly course and reached Virgohamna in the

north-west of Spitsbergen on June 9. The stay here was short, and after only a few hours she proceeded east, but off Raudfjorden she had to return to Virgohamna because of heavy ice. The expedition would now have to watch for changes in the ice situation.

On June 16, a reconnaissance tour was taken to study the distribution of the ice. Norsköysundet was found to be blocked by the ice, so once again it was necessary to return to Virgohamna. Besides, the boiler of the steam launch had become damaged. On arrival at Virgohamna, they found the *Gjöa* riding at anchor in the harbour. She had left Tromsø with a cargo of coal, which was transferred to the *Svensksund* on the 18th.

The winds had been mainly south-westerly, causing the ice to pack against the islands in the north-west corner of Spitsbergen. On the 24th, the ice drifted south and passed Amsterdamöya; but on the 29th it appeared to have scattered, so a path was forced out to sea. In the evening they were visited by members of the Russian expedition, who had come by the *Batan* and were heading for Pike's house at Virgohamna.

These Russians reported that the southern part of Storfjorden had become navigable only a few days after the visit of the *Svensksund* to the Sörkapp region. Geodetic work was going on at Kvalhovden. The decision to go south therefore remained. But the *Gjöa* received orders to stay in the area, await changes in the ice situation and, if conditions were favourable, proceed eastward to the winter station.

The *Svensksund* started south with the intention of reaching Agardhbukta on the west side of Storfjorden, to begin measurements there as agreed with the Russians. South of Kvalhovden (Whale's Head) the ship met with ice, which forced her east toward Kvalpynten in the south-west of Edgeöya. Ice was there too, so she turned west again and approached Kvalvågen. This was closed by ice, in which they saw the two Russian ships, the *Ledokol* and the *Rurik*.

At first the *Svensksund* stayed near the ice-edge, but the ice began drifting south. She was forced to go with it, while keeping to the open water off the ice-edge. Here she was joined by the *Batan*, which had come up from Hornsund. The two ships tried to penetrate northward, but could not get very far. The store of coal on the *Svensksund* was running seriously low. Moreover, the steam launch needed repairs.

It was therefore decided to leave for Tromsø, where the ship arrived on July 8. The bunkering and repairs were completed on the 14th, whereupon she again steered north and, according to agreements with the Russians, returned to Storfjorden. However,

this time the ice in the Sörkapp region, especially off Hedgehogfjellet, was found to be so severe that they had to retreat on the 17th, and instead proceed north along the Spitsbergen west coast.

A man among the crew needed medical treatment, but the ship's doctor, Torgersruud, was at the Swedish winter station. The ship headed for the Russian base, but it was unattainable because of ice, so they headed for a Russian group which worked in Isfjorden. The group was found at Kapp Thorsen, and the suffering man was left on board the *Batan*. The *Svensksund* then continued north, and reached Virgohamna on July 22. The *Gjöa* was still there, as the ice had prevented any attempt to go east.

On July 25 the two ships tried to penetrate eastward, but they got no farther than Biskayerhuken. Now they returned to Fair Haven, where it would be possible to study the changes in the ice situation. Some useful work was also done, notably mapping the region. On August 1 the *Gjöa* came back from an ice reconnaissance tour, which revealed that the ice lay close upon the coast.

The *Svensksund* next went to Virgohamna, hoping to come across the Norwegian collier *Lofoten*, which was expected to come up with coal from Tromsø. Finding her there, the *Svensksund* bunkered, and the two ships headed east on August 7. They were not hindered by ice until the mouth of Wijdefjorden. The captain of the *Lofoten* dared not proceed any farther, but he promised to remain near the ice-edge for another 24 hours, while the *Svensksund* was trying to reach the winter quarters at Sorgfjorden. At 23h on August 7, the *Svensksund* started her battle against the ice near Verlegenuken; and at 03.20h on August 8, she anchored off Crozierpynten, on which the winter station was situated.

The voyage of the *Svensksund* had been filled with adversities and hard battles against the ice. Now the ship had reached its destination, and the station personnel was caught napping. For both parties the summer had been frustrating—time just slipped away (compare p. 346).

Evacuating the winter station

Two days later the *Gjöa* arrived in Sorgfjorden. Work was started under Westman for leaving the winter station. Meanwhile, the *Svensksund* attempted to reach some of the triangulation points which remained. But ice blocked the way everywhere, so the geodetic work failed. Still, surveying was accomplished on both land and sea, and pendulum measurements were made at Sabine's observatory.

The ice conditions presented a risk to the ship and personnel, especially as the summer was drawing to a

close. In accordance with regulations, the commander of the *Svensksund* conferred with the ship's officers about the steps to be taken for her safety. Jäderin held a similar conference with his own men. Consequently, it was decided that the *Svensksund* should leave Spitsbergen already on September 3.

The work in Spitsbergen had been highly frustrating in 1899 and 1900. Ice blocked the way in a most unexpected manner. According to the original plans, the arc measurement programme should have been finished by now, as far as the field work was concerned; but in the Swedish part of the triangulation chain, measurements had been made from only two triangulation points—Heclahuken and Celsiusberget—and even these were far from complete. However, a base-line had been established and measured.

Russian sledging tours and research in 1900

As mentioned, the Svalbard ice conditions during 1900 were particularly unfavourable along the north coast of Spitsbergen and Nordaustlandet. The southern limit of the polar pack-ice had been displaced southward, which especially affected the Swedish field work. But the Russians in the south of Spitsbergen encountered severe ice conditions, due to the great amounts of drift-ice which passed between Nordaustlandet and Franz Josef Land.

This drift-ice generally barred the entrance to Storfjorden, and at times to Hornsund and the Sörkapp region. Even at the beginning of September there was much ice between Sörkapp and Björnöya, where the water is usually ice-free at that time. The ice and weather conditions obstructed the Russian field activities, although not to the same extent as in the north with the Swedes.

During the spring and summer of 1900, a number of sledging tours were carried out by the Russians, notably across the ice-sheet from Hornsund to the triangulation points on Keilhaufjellet and Hedgehogfjellet. On both mountains they succeeded in carrying out the geodetic and astronomic measurements, thanks to a perseverance which inspires great respect. On Keilhaufjellet, the measuring programme was completed after waiting for three months upon the summit!

It will be remembered that the weather conditions in the south of Spitsbergen are worsened by the repeated passages of cyclones along tracks in the area between Spitsbergen and Norway. Besides, the high air humidity causes frequent fogs and orographic clouds to envelop the upper parts of the mountains. The observer, and/or the mountain to be observed, can often become engulfed in fog or clouds. The sides of the triangles here in the south were 100-140 km

long, and much could happen between the stations to disturb the conditions for measurement. These data were obtained by the wintering party of geodesists and astronomers—Sergievsky, Vassiliev, Ashmatov and Sykora.

The ice conditions prevented the ships of the Russian summer expedition from penetrating farther into Storfjorden than to Kvalhovden (Whale's Head). There a party, including the geodesists Kostinski and Piedashenko, managed to complete the series of measurements, except for the bearings to the signal of the triangulation point at Cape Agardh, which had apparently blown down.

While the geodetic party stayed on Kvalhovden, the drift-ice entered Kvalvågen. As a result, a relief expedition had to be organized to bring supplies by dog sledge from the west—from Van Mijenfjorden and along Kjellströmdalen. However, before the sledge expedition had arrived at Agardhbukta, the geodetic party had been reached by a ship.

The most important sledging tour was carried out from Billefjorden via Nordenskiöldbreen to Svanbergfjellet, where De Geer had established a signal in 1899 (see p. 349). Complete measurements were carried out from this geodetic point, except towards Cape Agardh where the signal was missing.

From Svanbergfjellet, Vassiliev and Helge Backlund sledged towards Chydeniusfjella, where the most suitable peak was chosen as a geodetic station. A large stone cairn was built on the top. When coming back to Svanbergfjellet, they set up auxiliary signals for connecting the principal signal on Svanbergfjellet with that on Chydeniusfjellet. It was not necessary to revisit the latter signal, as it would suffice to do the measurements from the surrounding geodetic points. A very important part of the measuring programme had now been carried out—the harassing task of taking the triangulation chain across the ice-sheet between Hinlopenstretet and Storfjorden.

SWEDISH ACTIVITY IN THE SUMMER OF 1901

Personnel and ship

The severe ice conditions—especially in the summer of 1900—had delayed the measurements so much that one might have thought they were just beginning when it was time to leave the field at the end of the summer. Thus a prolongation of the arc measurement programme was indispensable.

This was, of course, a matter of both economics and personnel. Fortunately, both the Swedish Parliament and the Russian Government granted means to continue the measuring activity during the summer of 1901.

Some of the scientific personnel now wanted to be released. Edvard Jäderin, the geodesist and leader of the Swedish measuring activity, had spent the summers of 1898–1900 and the winter of 1899/1900 in Spitsbergen. He wanted to be exchanged, officially because he had found it impossible to act both as a geodesist and as the leader of the Swedish expedition. In the former case he was expected to be working away from the ship or a base, while in the latter capacity he should be available to the expedition members. We know today that there was a second and more serious reason: he had strained his heart during the long sledging tour towards Chydeniusfjella in the late spring of 1900 (p. 345).

The Swedish Committee therefore did not choose a geodesist-astronomer as his successor. Instead the geologist Gerhard De Geer, a member of the Committee, was selected. He had been a guest scientist with the Russian expedition during the summer of 1899, and had then done extensive scientific work in the field during the reconnaissance tours.

There was, however, another highly qualified scientist, related to the Committee and, besides, possessing considerable arctic experience: the secretary to the Committee, V. Carlheim-Gyllensköld, the physicist and geophysicist.

It is the belief of the present author that the Committee's decision was a deep disappointment to Carlheim-Gyllensköld.

The gunboat *Svensksund* was not available in the summer of 1901. Instead the Committee had hired the renowned polar ship *Antarctic* from Otto Nordenskjöld, who was preparing his antarctic expedition and was in need of money (compare p. 363). THE OFFICERS OF THE *ANTARCTIC*, THOUGH, WERE FROM THE SWEDISH NAVY:

Captain Hans *Olof* Fredrik Gylden (b. 1867), commander.

Lieutenant *Axel* Theodor Blom (b. 1877), second-in-command.

Dr. Jacob Torgersruud (b. 1864), ship's doctor.

The members of the scientific staff were:

Gerard Jakob De Geer (1858–1943), Ph.D., geologist, leader of the Swedish Arc-of-Meridian expedition of 1901, member of the Swedish Committee for the arc measurements.

Per Gustaf Rosén (1838–1914), Ph.D., astronomer and geodesist, member of the Swedish Committee for the arc measurements.

Edvard *Hugo* von Zeipel (1873–1959), Ph.D., astronomer and geodesist.

Sven *Tryggve* Salomon Rubin (1874–1946), Ph.D. (1903), astronomer and geodesist.

Karl David Petrus (*K.D.P.*) Rosén (1874–1961), Ph.D.,

Summer of 1901, the ice caused trouble for the ship *Antarctic*, but towards the end of the summer the expedition met with more favourable conditions in the Hinlopen region (shaded area) and the planned measurements could be completed, except at the northernmost stations. Measurements were instead carried out here in the summer of 1902, as late as in August and September (above).

Some theoretical considerations on arc measurements and the size and form of the Earth. For explanations, see text on p. 328. Note: the ellipsoidal form of the Earth is, of course, highly exaggerated (right).

P.G. Rosén's map in his proposal for carrying out arc measurements in Svalbard. Published in Ymer 1891.

The ice-conditions in the summer of 1900 were severe. The *Svenskund* had difficulties in reaching Sorgfjorden. Not much geodetic work could be carried out in the summer of 1900 (left)

astronomer and geodesist, responsible for the pendulum observations.

Johannes Ehlers (1875–1902), B.Sc., scientific assistant.

Nils Conrad Ringertz (b. 1859), captain in the Swedish Army, topographer.

Professor Per Gustaf Rosén was to spend only a part of the summer in Spitsbergen. His son, K.D.P. Rosén, who would deal with the pendulum observations, had been given opportunities to study the methods of such measurements at Potsdam, Germany.

North-west of Spitsbergen—ice again

The expedition's ship, the *Antarctic*, was to leave Göteborg on May 15 and pass by Tromsø on her voyage north. The exact dates, though, are not given in the reports of De Geer. The scientific members left Stockholm by train and boarded the ship at Trondheim, Norway. The expedition reached Tromsø on June 2, and stayed for five days. Six assistants for practical work, boat and skiing tours came aboard here, besides some equipment. For excursions and tours, the expedition brought polar sledges, a steam launch and boats—but no dogs because of limited space.

During the stay at Tromsø, pendulum observations were carried out. Such measurements had been made previously there, and the same site was now used to connect these two series of observation with each other, as well as with similar observations in Europe.

The *Antarctic* left Tromsø on June 7. Björnöya was passed in fog, but in a sea free from ice—and so it remained. Sörkapp was sighted on June 10, and the passage along the Spitsbergen west coast was favoured by open water, except for some fjord ice which came drifting out of Isfjorden. The outlook for the future looked bright. But on the evening of the 12th, they met with drift-ice at lat. 79°25'N. It became gradually denser, but they managed to navigate through it and enter Virgohamna. Here they met a German expedition under Bauendahl, which had wintered in Pike's house in the vain hope of reaching the North Pole over the pack-ice!

After noting that all was well with the German expedition, the *Antarctic* proceeded eastward. Already in the night towards the 14th, she was stopped by very heavy ice, four metres thick in places.

To get some useful work done in spite of the ice, a boat was landed at Sabine's observatory on Indre Norsköya. The party brought instruments for the pendulum observations, and a rich store of provisions in case the stay on the island were to be prolonged by the ice. Meanwhile the *Antarctic* went to nearby Fair

Haven for the purpose of cleaning her boiler. She would then proceed to Kongsfjorden with the intention of investigating and mapping this interesting fjord. The boat party would have a rallying point at Pike's house and its depot.

Weather conditions were excellent, and the pendulum observations were done before the boiler was cleaned, so the boat group boarded the ship in time. The geodesists were satisfied with the knowledge that there now existed a measurement of gravity at this famous observation-site, and that the measurement had been carried out with due attention to all necessary corrections.

But the ice conditions did not improve. Before the ship could leave Fair Haven, the drift-ice approached from the west on the 16th, preventing the planned departure and visit to Kongsfjorden. The captivity in the ice could, however, be used for topographic and geological work. Not until June 30 was it possible to leave the "dock" in the ice, where the ship had found protection against the drifting ice.

The interval of freedom was short. It was possible to reach the area south-west of Fuglesangen; yet there, considerations of safety persuaded them to anchor on the *eastern* side of this island. In this way they avoided the ice pressures which were caused by persistent westerly winds. On July 1, the ship was enclosed by the ice and was carried with it along a haphazard course. Not until July 7 was it possible to begin working the ship out of the ice towards open water, which could be seen to the west some 10 km away, but was reached only in the night towards the 9th.

The eastern route northward

The expedition proceeded to Kongsfjorden, where the *Antarctic* stayed until the 13th—with good scientific results. It was then time to leave for Adventfjorden in Isfjorden, to meet the German tourist steamer *Augusta Victoria*. Mail was expected, and P.G. Rosén was to go home on this ship, having established that the pendulum equipment functioned well.

They would now try the eastern route to the north coast, since the winds which had forced the ice toward the west coast should logically have driven it away from the east coast.

But the *Antarctic* met with strong headwinds at the mouth of Isfjorden and could make no headway. Shelter was found in Trygghamna, where De Geer and Ringertz took the opportunity to do survey work and to take photographs from several of the mapped points.

Next day, July 17, they left the anchorage and proceeded south. At Sörkapp there was fog, which

lasted all the way until they reached Kvalpynten, the south-western headland of Edgeöya.

The *Antarctic* called at the so-called Russian Harbour, near the "Point", to learn whether the Russian expedition was working in the neighbourhood—which it did. The *Bakan* was discovered in a small bay to the north, and next morning, July 20, the *Antarctic* anchored close to her. After a discussion on future activities and a visit to the Russian base-line, which had just been measured (final length 6 219.192 m), the *Antarctic* weighed anchor on July 22 and proceeded northward.

It was considered that the ice conditions in the south of Hinlopenstretet could best be observed from the eastern mouth of Heleysundet (Helissundet), rather than from Freemansundet between Edgeöya and Barentsöya. It would then also be possible to visit the Russian geodesists who were working at Mistakodden (Förväxlingsudden). The visit offered possibilities of studying those signals, which they were later to sight in their tubes from Hinlopenstretet.

On the 23rd, the *Antarctic* passed through the northern arm of the narrow Heleysundet, which was feared by sealers because of its very strong currents. She had to fight a fierce westgoing current, but with a following wind and with the engine working at full speed, she crept through the sound and proceeded north toward the southern entrance to Hinlopenstretet. At first there was no ice; closer to Bastianöyane they met with ice, but the waters to the north seemed fairly open. It seemed possible to reach Svartberget on Nordaustlandet, one of the stations in the geodetic chain. However, they were not in a position to waste time: they would have to seize the opportunity of measuring at those stations which could be reached easily, without following a rational plan.

Luck smiles in Hinlopen

On the morning of July 24, they occupied the station Thumb Point, a summit 565 m high on the eastern part of Wilhelmöya. They had agreed to leave this station to the Russians, expecting that they themselves would be fully occupied further north. The station was now manned by von Zeipel and two assistants. These men were left with a tent, instruments and provisions for one week; below on the shore, the ice-boat and two boxes of reserve provisions were laid up. It was vital that the landings could be carried out rapidly, so De Geer had arranged for eight boxes to be packed with provisions for shore depots, and rucksacks with weekly rations had been packed for the stay on the summits during the first week. To get the equipment up to the summit, 10-12 carriers were used.

With von Zeipel and his two men settled on the summit of Wilhelmöya, the *Antarctic* proceeded northward along an open lane leading to Svartberget (154 m) situated on Nordaustlandet to the south of Wahlenbergfjorden. It was important to visit this trigonometric point early, as the signal, a double cone upon a pole, had been blown down during a gale. Rubin and his two assistants and also K.D.P. Rosén and Ehlers were left here, the latter two for making pendulum observations.

The position of the ship off Svartberget was highly exposed, and in order to find some shelter she proceeded north along the coast on July 26, to investigate the conditions in Wahlenbergfjorden. The fjord was found to be fairly free of ice, but they were attacked by a severe gale, which—as they were told later—had threatened to blow away the tents of the two mountain groups.

On the 27th, the ship stayed for one day near the largest of Gyldeöyane, while De Geer and Ringertz were surveying the outer part of Wahlenbergfjorden, where it was close to the triangulation chain. They found that the fjord was broader than given on the maps. On the 28th they made an attempt to pass across Hinlopenstretet to Lovénberget, but beyond Fosteröyane the ice became impassable, so they steered into open water south of the islands.

In the evening the ship became enclosed by the ice and was carried by it southward. The situation became serious. For four days the ship drifted about 80 km with the ice, passing close to Wahlbergöya and the many small islands near it, fortunately without suffering shipwreck. When they passed Thumb Point on the 31st, they could see von Zeipel signalling with a heliotrope to inform them that his measurements were completed. The drift was, however, so fast that they could not fetch him and his men.

On August 1 the ship came into scattered ice, where she found a way out and finally reached Thumb Point to fetch von Zeipel's group. At the same time it was possible to complete the surveying work in the region. Failing to reach Langeöya (Jäderins Ö) to leave a message about their operations for the Russian geodesists, they passed through open ice towards Svartberget, where the measurements were now finished and the scientists with their assistants could be picked up here as well.

Lovénberget was still unattainable, so they continued northward and passed inside Kapp Fanshawe, where von Zeipel and his men and carriers, and also Ringertz and a few men, were landed. When the carriers had returned, the ship was to be taken to Forsiustoppen situated on Nordaustlandet, about half-way between Murchisonfjorden and Wahlenberg-

fjorden. However, near Isrundingen north of the mouth of Lomfjorden the ice became too heavy. They moored the ship to an ice floe and drifted with it into Lomfjorden.

From Carlheim-Gyllensköld's reconnaissance in 1898, it was not certain that the signals on Lovénberget would be visible from Forsiusberget. It was therefore essential to visit Lovénberget and check that the signals still existed, or else erect new ones.

The chances of reaching Lovénberget from Hinlopenstretet seemed small, and there was the risk of drifting ice to consider. De Geer therefore decided to reach the mountain by passing across the ice-cap from Lomfjorden, and Rubin with his assistants and carriers managed in fact to reach Lovénberget that way.

It was found that the two signals, which still existed, could not be seen from Forsiusberget. A new signal had to be set up about 1 km further to the north. Moreover, a special triangulation had to be carried out to connect the new signal with the other two. Rubin and his group were back on board the ship on the 17th and the group of von Zeipel had completed their measurements on Kapp Fanshawe. K.D.P. Rosén and von Zeipel could therefore be landed on the small and low Footöya in Lomfjorden, to make pendulum observations for comparing the local gravity on the low islet and on Kapp Fanshawe at 378 m a.s.l. The two points were connected with a special triangulation chain using a special base-line. Besides, the whole of Lomfjorden was mapped, topographically and geologically.

The geodetic work was completed at Lomme fjorden on August 17. Next day the ship worked her way out of the fjord, battling against ice which threatened to fill it. She was slowly carried out of the fjord, and as the ice gradually became more scattered, she steered northward on the 19th towards the narrowest part of Hinlopenstretet. They did not visit Forsiusberget now, as they already possessed measurements from other geodetic stations, which fixed its position satisfactorily. Instead they continued north until, between Verlegenhukén and Langgrunnodden, they reached the edge of the polar pack-ice and had to turn back. They entered Sorgfjorden and, on the evening of the 20th, moored at a piece of grounded ice near the winter station.

While the crew was bunkering from the coal depot there, Rubin and his assistant and carriers climbed Heclahuken (486 m) to carry out latitude and azimuth determinations at the signal of this geodetic station. K.D.P. Rosén made pendulum observations at the winter station, assisted by von Zeipel, while Ringertz supplemented his previous topographic work on the

west side of Sorgfjorden, and De Geer carried out geological and glaciological studies.

When this work was finished on August 27, the *Antarctic* was again taken northward, to learn whether the ice conditions had improved so much that some of the more northerly triangulation points could be reached. Improvements had indeed occurred, but to the north-west—not along the coastal zone of Nordaustlandet. The coast from Murchisonfjorden via Langgrunnodden and Lågöya was blocked by drift-ice, which was replaced farther north by a strip of ice, probably several years old and resting upon the land.

There was a lane of open water between this ice and the polar ice in the sea farther from the coast. But the waters here were foul and shallow, and in case of a westerly wind the ship's situation might become critical.

They were hoping to reach Kapp Hansteen, to determine the latitude of the trigonometric point there and measure some angles in the geodetic chain. It appeared, however, that 7.5 km of very rough ice barred them from reaching the cape. The transport of their instruments and other equipment would need some days, and they dared not endanger the ship in doing so. There was nothing to do but steer south.

They followed the edge of the ice until the southern approach to Murchisonfjorden, where it proved possible to penetrate the strip of ice and enter the fjord. Along the northern side of the fjord there still remained winter ice, but otherwise the fjord was fairly open, and they were able to reach the northern foot of Celsiusberget on August 28.

The mountain was climbed by von Zeipel and K.D.P. Rosén with assistants. They managed to make a determination of the latitude, and measured angles in the triangle chain to supplement the measurements from the previous year.

On August 31, two more geodetic points were visited: von Zeipel and Rosén landed on Krossöya for making latitude and azimuth determinations; Rubin and Ehlers camped on Forsiusberget to the south of Murchisonfjorden for carrying out complete astronomical and geodetic measurements.

The tasks were done on September 2, and the *Antarctic* proceeded southward in Hinlopenstretet, the intention being to supplement the previous measurements of the horizontal angles from Svartberget by including the new signal on Lovénberget. They also wanted to improve the map of and from the islands in the sound. They were successful in spite of the ice which lay in the south-eastern part of the strait.

Time to go home

On September 5, her aims accomplished, the *Antarctic* steered north through the entire strait and 12 nautical miles farther north. A severe gale forced her to seek shelter in Sorgfjorden, but on the 7th she made another attempt to go north. Fairly soon she reached the ice, which was driven southward by the still fresh winds. The ship passed Verlegenuken in the nick of time, before the way was closed behind her. She passed along the Spitsbergen north coast without being troubled by ice, but an ice-blink in the northern sky indicated that the ice was not far off.

On the 8th she passed Magdalenefjorden, and in the evening she entered Krossfjorden to do some supplementary photography. Here the *Antarctic* slid up onto a smooth submerged rock, though without suffering any noticeable harm. After a while she slid down and was free. Naturally the rock was now entered on the map.

The home voyage was started on September 9 under a fresh north-west wind. When they passed Sörkapp next day, they could see the smoke from the homing Russian ships. On the 14th they reached Tromsø, where the ships of the Russian expedition had arrived on the previous day. On September 27 the *Antarctic* arrived in Göteborg.

DE GEER'S SUMMARY

De Geer concluded his report on the Swedish Arc-of-Meridian expedition of 1901 as follows:

"Thanks to the Swedish expedition [of 1901] a fully completed triangulation network has been measured from Celsiusberget at latitude 80° N and farther south along the whole of Hinlopenstretet to the triangulation points at Storfjorden, which have been measured by the Russian expedition. The leader of the Russian expedition, Academician Chernyshev, has supplied the information that the work at Storfjorden is also now fully completed. Thus there now exists a complete series of Arc-of-Meridian measurements from Sörkapp to latitude 80° N, comprising a distance of about three and a half latitude degrees, and these measurements are connected with both the Swedish and the Russian baselines. Near the present northern end of the triangulation chain there have been made no fewer than 6-7 determinations of latitude.

If it seems desirable to extend the chain to the originally planned length—or up to Sjuöyane—measurements at two or preferably four more geodetic points will be needed, which might easily be accomplished by one geodesist-astronomer

during one month, if the month of August is chosen, as this month is generally the most favourable in these regions. Since 1898 and 1899 [read: after 1898] the Sjuöyane have, however, been blocked by ice. It would therefore be wise to limit a possible expedition to such dimensions that, if need arises, it can be repeated without too heavy costs."

It proved economically feasible to launch such an expedition already in the following year.

*THE FINAL EXPEDITION IN 1902**The ship and the men*

For the remaining measurements in Spitsbergen, the Norwegian sealing vessel *Laura* was hired. She was a three-masted schooner with a steam-engine, captained by Jens Öjen.

THE SCIENTIFIC STAFF WAS SMALL, CONSISTING OF:

Sven Tryggve Salomon Rubin (1874-1946), astronomer and geodesist, leader of the expedition.

Edvard Hugo von Zeipel (1873-1959), astronomer and geodesist.

Nils Hilding Dunér (b. 1875), lieutenant in the Swedish Army, topographer and photographer.

As we know, Rubin had spent the summers of 1899-1901 and the winter of 1899/1900 in Spitsbergen, serving the Swedish Arc-of-Meridian expeditions; von Zeipel had done so during the summers of 1898 and 1901. Thus both men had rich experience, and Dunér possessed an arctic heritage: his father N.C. Dunér accompanied A.E. Nordenskiöld on the expeditions of 1861 and 1864 (see pp. 26 and 45).

Ice again

The expedition left Tromsø on one of the last days in July. Like the previous expeditions, it was initially prevented by ice from reaching its region of operation.

Severe ice conditions forced it to remain inactive at the north-west corner of Spitsbergen. During August 1-18, it stayed at the ice edge to the north of Norsköyane. On every second day, reconnaissances were carried out in the broken ice which lay between the open sea and the closed ice, in order to locate a lane through.

One such reconnaissance, on August 14, found them steering through rather dense drift-ice, when they were suddenly caught by a dense fog. They had to lie still, and as the fog lifted after a few hours they saw that they were surrounded by densely packed ice as far as the eye reached. The lane through which they had come was invisible. But the new surroundings

were made the most of, namely for hunting polar bears.

Their captivity drew to a close, and some days later an easterly wind started to blow, drifting the ice towards the north-west and opening it at the same time—though only slowly. After long and hard work, the ship came free on August 22 and finally reached the research area.

The two geodesist-astronomers, Rubin and von Zeipel, had acquired good practical experience in techniques of measurement during the previous summer. They were now able to carry out the work rapidly and effectively.

A mission is completed

The expedition was given two weeks of fine weather in combination with favourable ice conditions: one week at the end of August and another at the beginning of September. On August 29 they finished the measurements at the northernmost triangulation point, Vesle Tavleöya. But two points still remained—Parryöya and Ekstremhuken.

A feast was prepared on board while the ship proceeded towards Parryöya. However, the island was found to be blocked by the ice. As the crew had worked very hard for more than a week, it was decided to have a day off and stay near the island. They celebrated the occasion and had a bear hunt. But then, with a change in wind and current, the ice came drifting and gathered round the ship. Instead of a rest, they spent eight hours of labour against the ice.

On September 3 it was possible to carry out the measurements on Ekstremhuken, and from the 6th till the 8th on Parryöya. The whole triangulation chain from Keilhaujellet in the south, at about latitude 76°36'N, to Vesle Tavleöya in the north at 80°49'N—a latitude difference of 4°13'—had now been measured. In sum, the scientific field work of the Swedish-Russian Arc-of-Meridian expedition was now successfully concluded.

The work had required five summers, three more than originally planned, and one wintering. Except for the summer of 1898, the measurements had been hampered by awful ice conditions, especially in the northern half of the triangulation chain; only two weeks, now in 1902, were granted good conditions. In spite of the very short time at their disposal, it had been possible to complete the measurements at the remaining geodetic stations, bringing the Swedish-Russian Arc-of-Meridian expedition to a satisfying end.

A generation of Swedish astronomers and geodesists had been occupied in the field work during this period. Swedish naval officers and sailors, too, had

earned polar experience during their summers of battle against the ice. As a summary of this collective achievement, the following three tables have been prepared. The men and the ships had changed, but the work forged ahead on the lines that were originally laid out. Some of the scientists spent more than one summer in Spitsbergen, notably T. Rubin with four summers and one winter, and E. Jäderin and J. Torgersruud with three summers and one winter.

APPENDIX

The scientific results of the Arc-of-Meridian expedition were published in French, in two volumes from 1903 and onwards, in *Mission scientifique pour la mesure d'un arc de méridien au Spitzberg entreprises en 1899–1902 sous les auspices des gouvernements Suédois et Russe: Mission Suédoise/Mission Russe*. The first volume was planned to contain an introduction entitled *Histoire du voyage*, and Carlheim-Gyllensköld was to have written the history of the Swedish contributions; but he never did, and the history of the Swedish expedition is still unwritten. This is a great pity, as information now has to be collected from mostly scattered notes and short official reports, some containing only one or a few pages.

There exist, though, two books in Swedish dealing with certain stages of the expedition: Carlheim-Gyllenskiöld's *På åttionde breddgraden* (On the Eightieth Parallel), which describes the preparatory expedition in 1898 and the historical background to the Arc-of-Meridian expedition; and Maja Jäderin-Hagfors' *Min far upplever polarnatten* (My father's experiences of the polar night). The latter book describes the wintering at Sorgfjorden in 1899–1900. Its author, being a daughter of Edvard Jäderin, was able to build upon his letters, diaries and personal reminiscences. Both books, though different in style and composition, also depict the human aspects of polar research.

Map showing the Mosselhalvöya, Sorgfjorden and Hecla-huken regions where A.E. Nordenskiöld Expedition of 1872-1873 and the Arc-of-Meridian Expeditions of 1898-1902 worked. The little point of land on the eastern side of Sorgfjorden is Crozier-pynten, on the south side of which the Swedish Arc-of-Meridian Expedition of 1898-1900 had its winterstation. On the west coast of Mosselhalvöya is Mosselbukta, where A.E. Nordenskiöld wintered in 1872-1873 (left). Compare with aerial photo on page 361.

The Swedish part of the geodetic chain after completed mission in the field in 1902 (below).

Altazimuth used by the Swedish Arc-of-Meridian Expeditions. It is a theodolite used for measuring vertical and horizontal angles. The name stands for altitude and azimuth. The Swedish expeditions used two identical instruments from M.C. Bamberg of Friedenau, near Berlin, viz. Bamberg 7377 and 7378. It is possible that No 7378 was the "universal instrument" which caused so much worry to Edvard Jäderin in the summer of 1899. (Mission Scientifiques: Mesure d'un arc de Méridien au Spitzberg.)

SCIENTIFIC MEMBERS OF THE SWEDISH ARC-OF-MERIDIAN EXPEDITIONS, 1898–1902

	<i>Summer 1898</i>	<i>Summer 1899</i>	<i>Winter 1899–1900</i>	<i>Summer 1900</i>	<i>Summer 1901</i>	<i>Summer 1902</i>
Carlheim-Gyllensköld, V.	X					
De Geer, G		XgR			XI	
Dunér, H.						X
Ehlers, J.					X	
Engström, F.		X		Xs		
Fränkel, H.		X	X	Xsw		
Jäderin, E.	XI	XI	XI	Xlsw		
Knorring, O.		XgR				
Larssén, R.		X		Xs		
Ringertz, N.C.		X		Xs	X	
Rosén, K.D.P.					X	
Rosén, P.G.					(X)	
Rubin, T.		X	X	Xsw	X	XI
von Schultz, F.	XgS					
Solander, E.		X				
Torgersruud, J.		X	X	Xsw	X	
Westman, J.		X	X	Xsw		
Wulff, T.		X				
von Zeipel, H.	X				X	X

I = leader of the expedition;

s = member of summer expedition only (in 1900);

sw = member of summer expedition who spent the preceding winter at the winter station;

gR = Swedish scientist invited as a guest on the Russian expedition;

gS = Russian officer invited as a guest on the Swedish expedition.

SHIP'S COMMANDERS AND OFFICERS OF THE SWEDISH ARC-OF-MERIDIAN EXPEDITIONS

	<i>Officers</i>	<i>Expedition ship</i>	<i>Freighters</i>
1898	Capt. H.A. Palme*	<i>Ran</i>	
1899	Capt. H.W. Hamilton* Lieut. L.E. Arnelius Lieut. A.B.C. Lagercrantz	<i>Svensksund</i>	<i>Rurik</i>
1900	Capt. H.V.M. von Krusenstjerna* Lieut. L.E. Arnelius Lieut. B.R. Sydow	<i>Svensksund</i>	<i>Gjöa and Lofoten</i>
1901	Capt. H.O.F. Gyldeén* Lieut. A.T. Blom	<i>Antarctic</i>	
1902	Sealing Capt. Jens Öjen*	<i>Laura</i>	

*) ship's commander

GEODETIC POINTS AND OBSERVERS IN THE SWEDISH GEODETIC CHAIN

<i>Geodetic points</i>	<i>Latitude</i>	<i>Year</i>	<i>Observer</i>
Rossöya	80°49.6'N	1902	Rubin
Vesle Tavleöya (Little Table Isl.)	80°49.2'N	1902	v. Zeipel
Parryöya	80°39.1'N	1902	Rubin
Waldenöya	80°40.0'N	1902	Rubin
Ekstremhuken	80°22.9'N	1902	v. Zeipel
Kapp Hansteen	80°20.7'N	1902	v. Zeipel
Celsiusberget	80°00.2'N	1899,1901	Jäderin, Larssén Engström, Rubin, v. Zeipel
Heclahuken	79°52.6'N	1900,1901	Rubin
Forsiusberget	79°50.6'N	1901	Rubin, Ehlers
Kapp Fanshawe	79°37.2'N	1901	v. Zeipel
Svartberget	79°28.9'N	1901	Rubin
Lovénberget III	79°24.2'N	1901	Rubin
Tumlingodden	79°04.0'N	1901	v. Zeipel

Air photograph of Heclahuken and Basis-sletta. The little tongue of land is Crozierpynten with the winterstation of the Swedish Arc-of-Meridian expedition. Photo: Norsk Polarinstitutt.

34. THE SWEDISH ANTARCTIC EXPEDITION OF 1901–1903 UNDER OTTO NORDENSKJÖLD

HISTORICAL BACKGROUND

The history of discoveries and research in the Antarctic is young. The continent of Antarctica is surrounded by stormy and icy seas; it lies far from shipping routes and settlements. People long imagined a large and rich continent centred on the South Pole, but none had ever seen or visited this dreamland—*Terra Australis Incognita*.

In the 18th century, daring seafarers made thrusts southward, yet found only wide expanses of ocean and a few rather small islands. The great British sailor and explorer James Cook (1728–79) finally put an end to the visions with his two circumnavigations of the globe in 1768–71 and 1772–75.

In that century, too, the best-known and, no doubt, the greatest Swedish natural scientist was Carl von Linné (1707–78). Many of his pupils also became famous in the realm of natural science, and their names are often connected with faraway lands where they carried on their studies. Two of them are prominent in the present context: Daniel Solander (1733–82) and Anders Sparrman (1748–1820). Solander had come to England in 1760, where he made friends with the famous scientist Sir Joseph Banks and accompanied him on James Cook's first voyage round the world. Sparrman joined Cook's second voyage at Cape Town on the special request of the scientist on board, John Reinhold Forster.

Cook did not enter the Antarctic regions on his first voyage, though he pushed southward at Cape Horn and New Zealand. On his second voyage, however, Cook did his utmost to find out whether the hypothetical southern continent, *Terra Australis Incognita*, actually existed; but he found only rough icy seas. The southernmost position reached on this expedition was 71°10'S, well inside the Antarctic Circle. Thus, if a southern continent did exist, it seemingly had to be a desert polar land of no value.

The hypothetical southern continent was at long last discovered in the first half of the 19th century, but only parts of its ice-bound coasts were sighted. Especially notable among the expeditions of those days are the naval ventures of Bellingshausen in 1819–21, d'Urville in 1837–40, Wilkes in 1839–40, and the most successful of them all, the expedition of James Clark Ross in 1839–43. Nor should we forget the bold voyages carried out by sealers in small ships.

After Ross' expedition, the Antarctic remained practically unvisited for about 50 years. Occasional efforts were made to arouse interest in the southern continent, but mostly in vain to begin with. Attention was focused almost entirely upon the arctic regions, mainly due to the disaster of the British naval expedition under Sir John Franklin, which had been dispatched in 1845 to find the North-West Passage. The resultant search expeditions and their geographical discoveries captured the public and scientific eye for decades.

In 1892, however, the Antarctic became an attraction again. Five whalers were then sent south to the Weddell Sea region, four from Scotland and one from Norway. The captain of the Norwegian ship *Jason*, C.A. Larsen, brought back some fossils from Seymour Island, which awakened great enthusiasm among scientists. Larsen, who was later to become the captain of Otto Nordenskjöld's expedition ship *Antarctic*, returned the following summer to the Antarctic with the *Jason*. In the western part of the Weddell Sea he discovered King Oscar Land and Svend Foyn Land, both apparently constituting the eastern side of the Antarctic Peninsula; also a number of islands were seen for the first time.

At the geographical congress held in London in 1895, a resumption of Antarctic research was debated. It was resolved that the exploration of the Antarctic was the greatest geographical investigation that remained, and should be taken up before the end of the century.

The first expedition following upon this debate was that of the *Belgica* in 1897–99 under A. de Gerlache. It spent part of the summer of 1897/98 along the west coast of the Antarctic Peninsula. At the end of the summer, the ship ran into the ice south-west of the peninsula, became beset and was carried along an erratic course westward, until she was liberated at the end of the summer of 1898/99.

That was the first expedition to winter in the Antarctic. But only one year later, in 1900, a second wintering—the first on land—took place, at Cape Adare by the entrance to the Ross Sea. This expedition was British, although its leader, Carsten Borchgrevink, was a Norwegian. A general idea of the weather and climate in the antarctic pack-ice and in the coastal zone of Antarctica had now been obtained.

In 1898 there was a meeting in London of various scientists and others who were interested in a resumption of antarctic research. Among them were Sir Clements Markham and Sir John Murray of Great Britain, Fridtjof Nansen of Norway, and Georg von Neumayer of Germany. A result was the dispatch of two large expeditions to the Antarctic, one British

under Captain Robert F. Scott with the *Discovery*, and the other German under Erich von Drygalski with the *Gauss*. The British expedition spent two years, February 1902–February 1904, at Ross Island in the south-western corner of the Ross Sea. The German expedition spent one year, February 1902–February 1903, on board its ship off the Antarctic coast at approximately 90° E.

The German expedition also established a geomagnetic and meteorological observatory on the subantarctic island of Kerguelen. To fill the gap in the network of observations in the American sector, the Argentines assumed the responsibility for establishing a geomagnetic and meteorological station in Tierra del Fuego. Since 1904 the Argentines have operated a station on Laurie Island among the South Orkney Islands, which had been established by a Scottish expedition one year previously. The observations of the two expeditions and of the subantarctic stations were co-ordinated.

Otto Nordenskjöld prepares his antarctic expedition

Otto Nordenskjöld (1869–1928) was related to A.E. Nordenskiöld: his mother was the latter's sister, and his father belonged to a Swedish branch of the same family. Otto Nordenskjöld was a geologist and a geographer. Ever since his boyhood he had been inspired by his uncle. He prepared himself practically and scientifically for field work by leading an expedition to Tierra del Fuego in 1895–97, during which he studied, among other things, deposits from the latest Ice Age.

In 1898 he visited the Klondike region of Alaska; and in the summer of 1900 he was a member of the Danish expedition under G.C. Amstrup to East Greenland, where he became acquainted with polar travel techniques and equipment.

During the summer half-year of 1895–96, two scientists were engaged with the Tierra del Fuego expedition:

Axel Gabriel Ohlin (1867–1903), Ph.D., marine zoologist.

Per Karl Hjalmar Dusén (1855–1920), engineer, botanist.

Ohlin had carried out zoological studies during 1891 in the Norwegian Sea near Jan Mayen (p. 228), and during 1894 he had been engaged in the search for the missing Björling expedition (p. 227). Dusén had previously brought home fine collections of plants from Cameroon in Africa, and in 1899 he became a member of A.G. Nathorst's expedition to East Greenland.

Nordenskjöld's interest had fastened upon the antarctic territories which lie south of South America.

His expedition to Tierra del Fuego in 1895–97 may be viewed as a scientific reconnaissance for an expedition to the antarctic territories which are geologically connected to South America. Nordenskjöld prepared his expedition at the same time as preparations were going on in Great Britain and Germany.

Not until 1899 did Nordenskjöld work out his antarctic plans in greater detail. They were presented officially at a meeting of the Swedish Society of Anthropology and Geography in January 1900. Nordenskjöld planned to have Tierra del Fuego as a "depot" for his ship, the *Antarctic*, and to establish his base station on the east coast of the Antarctic Peninsula. For the sake of international geomagnetic and meteorological programmes, the land party was to spend a winter at the base. In order to coordinate the observation programmes, the Swedish expedition would have to leave home as soon as possible—early in the northern autumn or late summer of 1901.

Nordenskjöld's expedition was a private enterprise. It was financed partly by private patrons, and some of the equipment was donated. The *Antarctic* was offered to Nordenskjöld by the owner, the Danish Carlsberg Fund, at a very low price, but still Nordenskjöld's resources were insufficient. A petition to the Swedish Government for money was opposed by a small committee of experts delegated by the Royal Swedish Academy of Sciences: the zoologist Hj. Théel, the geologist A.G. Nathorst, and the astronomer and physicist B. Hasselberg.

The arguments of the committee were that the expedition would start with insufficient equipment, that its members were too young and inexperienced and—as was specially pointed out—that Nordenskjöld did not possess the polar experience that was needed. As a result, Nordenskjöld was to be troubled with debts for many years to come, and in the Antarctic the scientific staff had to spend valuable time on seal hunting. The *Antarctic* was leased for the arc measurements in Spitsbergen in the summer of 1901 in order to obtain money, with a resulting delay in the start (see p. 252). However, the enterprise was carried out in spite of all adversities.

THE EXPEDITION'S SCIENTIFIC STAFF CONSISTED OF:

Nils Otto Gustaf Nordenskjöld (1869–1928), Ph.D., geologist and physical geographer, leader of the expedition.

Johan Gunnar Andersson (1874–1960), Ph.D., geologist, second leader of the expedition.

Axel Gabriel Ohlin (1867–1903), Ph.D., marine zoologist.

Karl Andreas (K.A.) Andersson (1875–1968), B.Sc., marine zoologist.

Samuel August (S.A.) Duse (1873–1933), lieutenant

in the Swedish Army, surveyor to the expedition, meteorological and oceanographical observations. Anders Gustaf (*Gösta*) Bodman (1875–1960), Ph.D., physicist, responsible for the meteorological and geomagnetic observations.

Carl Johan Fredrik Skottsberg (1880–1963), B.Sc., botanist.

Erik Ekelöf (b. 1875), M.D., doctor to the expedition.

José Maria Sobral (b. 1880), lieutenant, Argentine Navy, scientific assistant.

The American artist F.W. Stokes took part in the expedition during the first summer; he had previously been a member of Peary's Greenland expedition of 1893–94.

Nordenskjöld had been fortunate enough to secure the Norwegian Carl Anton (C.A.) Larsen (1860–1924) as captain of the expedition ship *Antarctic*. Larsen had already paid two visits to the Weddell Sea and the Antarctic Peninsula. He was later to become one of the great names in the modern whaling industry.

Altogether—including the crew of the *Antarctic*—the expedition comprised 39 men.

Establishing a base in the Antarctic

The *Antarctic* was late in coming from Spitsbergen and, as she had run aground there, the repairs also delayed her departure.

But at last on October 15, 1901, the expedition left Göteborg, and on December 16 the *Antarctic* reached Buenos Aires. The Argentines showed great interest in the expedition. Since his Tierra del Fuego expedition, Nordenskjöld had possessed many valuable contacts in Argentina, both among the authorities and among private persons. As a consequence the expedition was twice presented with coal and valuable food supplies. Here an additional member joined the scientific staff—Lieutenant J.M. Sobral of the Argentine Navy.

The *Antarctic* left Buenos Aires on December 21, but before leaving civilization she paid a visit to the Falkland Islands, to procure some dogs for decimated dog teams. The passage south across Drake Strait was favoured by fine weather. On January 10, King George Island in the South Shetlands was sighted, and a short visit was made to Nelson Island. In his diary Nordenskjöld noted:

“I had not expected to find so much ice and snow.”

It was fairly late in the season, considering that they would have to find a suitable place for the winter

quarters of the land group. So there was no time to investigate the existence of a sound separating the outer tip of the Antarctic Peninsula from the rest of it, as was indicated by the latest charts. This quest was left for the next summer. Instead, the ship followed the coast of the north-eastern tip of the land and entered Antarctic Sound—named after their ship—and then sailed along Joinville and Dundee Islands. A landing was made on the small Paulet Island, which one year later was to play such a decisive role in the survival of the ship's party. The marine zoologists did some trawling and were full of enthusiasm over their big catches.

From Paulet Island the *Antarctic* passed across the Erebus and Terror Gulf, discovered by James Clark Ross in 1843. Many icebergs were seen, and pack-ice was sighted near Seymour Island. It was here that Captain Larsen had found fossils and fossil tree trunks in 1893, which had aroused the interest of the scientific world.

The ship proceeded southward, more or less following the route of the *Jason* in 1893. However, at 66° 10' S the ice had become so dense and heavy that any further penetration south was out of the question; in 1893 Larsen had reached another two degrees south.

Nordenskjöld had to give up his plan, of establishing his base at a fairly high latitude on the east coast of the Antarctic Peninsula, for another reason too: a wide shelf ice, the Larsen Shelf-Ice, lay between the land and the ship. At the moment Nordenskjöld was so taken aback by the formidable obstruction in their way that he gave no thought to an investigation of the shelf-ice itself. It should be mentioned that the mighty north-going current in the western part of the Weddell Sea was unknown in those days.

Instead of going south, the *Antarctic* was taken on a tour eastward into the Weddell Sea, before an attempt was made to find a site for the base station somewhere near Seymour Island. This trip was, however, of value: the marine zoologists got interesting catches from the deep layers, and hydrographic series gave information about the properties of the sea water.

On February 9, near Seymour Island, they were attacked by a strong gale with severe icing of the ship, and this gale was followed by another. But on the 12th they were able to proceed south along the western coast of the island. South of Seymour Island, across a narrow sound, lies Snow Hill Island, which is covered by an ice-cap, only its northernmost tip being free of ice. Here on a terrace above the shoreline, a suitable base site was found. This circumstance, and the fact that Nordenskjöld had found many fossils on the slope towards the sea, settled the choice.

Otto Nordenskjöld, 1869-1928, geologist and leader of the Swedish Antarctic Expedition, 1901-1903. Photo: F. Goldberg Collection.

Members of the Swedish Antarctic Expedition 1901-1903. Sitting from the left: Axel Ohlin, Otto Nordenskjöld, Captain Carl Anton Larsen, Erik Ekelöf. Standing from the left: Gösta Bodman, Carl Skottsberg, K.A. Andersson. Missing: S.A. Duse, José Sobral and Johan Gunnar Andersson. (Nordenskjöld, O.: Antarctic I.)

Johan Gunnar Andersson (1874-1960), geologist, second leader of the Antarctic Expedition. (Nordenskjöld, O.: Antarctic II.)

The Snow Hill base, view towards north (above). (Nordenskjöld, O.: Antarctic I.). The Snow Hill base, view towards south (below). Photo: F. Goldberg Collection.

The Swedish Antarctic Expedition of 1901-1903 worked at or near the tip of the Antarctic Peninsula (Graham Land on the map). The Norwegian-British-Swedish Antarctic Expedition of 1949-1952 worked in the west of Dronning Maud Land. Also in recent years the chosen research regions are on the western and the eastern sides of the Weddell Sea (above). (Swedish Polar Research Secretariat: Sweden and Antarctica).

The wintering party at Snow Hill. Below from left: Gösta Bodman, Otto Nordenskjöld, José Sobral. Above from left: Ole Jonassen, Erik Ekelöf, Gustaf Åkerlundh. (Nordenskjöld, O.: Antarctic I.)

The hut at Snow Hill (bord=table, koj=bunk, spis=kitchen range, kamin=stove. Measures are given in metres). (Nordenskjöld, O.: Antarctic I.)

The equipment of the wintering party was landed on the 12th and 13th, and in the morning of the 14th. Then ice came drifting under northerly winds and threatened the ship.

The *Antarctic* steered south to establish a depot for the southern sledge journey which had been planned. The depot-laying was, however, prevented by the ice, and on the 21st the ship was back at the base to inform those left there of the results. She sailed a few hours later.

The wintering party was left alone—and at first felt a little lonely and uneasy.

THE MEMBERS OF THE WINTERING PARTY WERE:

O. Nordenskjöld, geologist and physical geographer, leader.

G. Bodman, physicist, conducting meteorological and geomagnetic observations.

E. Eklöf, doctor to the party, making bacteriological investigations.

J. Sobral, assistant in the scientific work.

Ole Jonassen (b. 1874).

Gustaf Åkerlundh (b. 1883).

The two latter men were to take care of the practical work at the base.

The most important thing now was to get their living quarters completed. The hut was constructed, with minor modifications, from the drawings for the base hut of Amstrup's Greenland expedition. Its exterior dimensions were 4.00 by 6.30 m. It contained one central room, adjoined by four small rooms—a kitchen and three bedrooms, each for two men. The hut was entered through a small hall, and had ample storage-room in the attic. A robust structure, it still stands in its original place. However, the design caused some inconveniences, such as the smell of frying from the kitchen, accretion of ice on floors and walls, moisture and mould.

On February 24, 1902, the men moved into their new home, which gave them a feeling of security. They had already got to know the frequent and severe southerly to south-westerly gales—with low temperatures—which were typical of the place. To begin with, the worst gales still caused uneasiness, especially at night with the hut shaking and the wind howling—but they got used to it.

Near the hut they built a geomagnetic and an astronomical observatory, the latter for checking time. They also mounted the meteorological screen and the anemometer mast. They started making observations, and these were to continue without a break for 20 months. Bodman was responsible for the geomagnetic and meteorological work, but he was assisted by others at the base.

During their stay in the Antarctic they were to be troubled by long spells of hard southerly gales, with low temperatures, snowfall and drifting snow. Often such gales blew up suddenly, and could be both dangerous and troublesome. These gales were outbreaks of cold air from the continent. The flow of air was guided by the mountainous Antarctic Peninsula and was strengthened at the same time. To the wintering party, this type of weather and climate was something new. The cold-air invasions lasted for a few days, a week or even a fortnight. Such days meant a hard time for the observers.

The Snow Hill base had, however, a rather northerly position—well outside the Antarctic Circle, at 64°22'S, 57°00'W. In other words, there was no polar night in the winter. The place was situated near the principal tracks of the cyclones, so invasions of both warm and cold air were experienced, and the ice-free ocean lay nearby to the north. Thus, throughout the year, there occurred invasions of air with temperatures *above* freezing, alternating with the severe cold-air invasions described above.

The first year at Snow Hill 1902

As the number of persons at the station was small, and it was essential that the observations should not be discontinued or show gaps, no spectacular sledge tours could be attempted. Nonetheless, in the middle of March, 1902, Nordenskjöld and Jonassen tried to establish a depot some distance to the south, using the station boat. They were attacked by a gale, and no depot was established, but they did observe that Snow Hill was an island and Admiralty Bay a sound. A few sledge excursions were made in the winter to investigate Seymour Island and Admiralty Sound.

Nordenskjöld's principal sledge tour to the south started on September 30. He was accompanied by Sobral and Jonassen. They had two sledges, but only five dogs, so one of the sledges had to be man-hauled. They planned to be away for 50 or 60 days, but could only carry dog-food for 21 days; however, they hoped to find penguins and seals on the way. They also hoped to be picked up by the ship at Christensen Island.

Their route was parallel to a high mountainous land, a continuation northward of Larsen's King Oscar Land. On October 7, they reached the north point of Robertson Island, where Nordenskjöld climbed an old crater—previously referred to as Christensen Island. From the top he had a good view of the surrounding landscape. Between him and the land to the west, there extended a shelf-ice, a few decametres in height and about 70 km wide, as was found later. The Seal Islands, which had previously

The tip of the Antarctic Peninsula with neighbouring islands. This was the region which was investigated by the expedition of Otto Nordenskjöld in 1901-1903. (Andersson, J.G.: Antarctic.)

The latest map of the Antarctic Peninsula at the start of the Nordenskjöld Expedition in 1901. This map built in part upon observations carried out by C.A. Larsen and E. Dallmann before the turn of the century. In Sweden this map was published by Axel Ohlin in Ymer of 1898. It shows erroneously the tip of the Antarctic Peninsula as made up of small and large islands. This map was fundamentally changed after Otto Nordenskjöld's expedition (below). (Ymer 1898).

The start of Otto Nordenskjöld's sledge tour towards the south on 30 September 1902. (Andersson, J.G.: Antarctic.)

been seen and named by C.A. Larsen, were nunataks protruding through the shelf-ice.

This was the Larsen Shelf-ice. Their route had to pass across its flat surface, if they wanted to come closer to the land. But thus they would not get any penguins or seals to feed themselves and the dogs. Their course was, as before, south-westerly; and now a period of gales began, facing them with south-west winds at temperatures as low as -20° to -30°C . They were also stormbound for several days.

On October 18, they had come close to land and were troubled by crevasses in the shelf-ice. Before them lay an ice-filled valley, named Richthofen Valley, about 300 km from the base. They were attacked by winds of hurricane force, their tent was damaged, and Jonassen injured an arm while carrying a heavy stone to weigh down the canvas. The last of the dog pemmican was given to the dogs, and from now on the men would have to feed them with their own pemmican rations. It was time to return; they could not take the risk of any prolonged gale periods. On November 4 they were back at the base. November and December, 1902, were devoted to geological work in the surrounding country. They made exciting finds of plant fossils from the Tertiary, indicating that a mild climate had prevailed during this relatively late period, as had been the case also in the Arctic.

They were expecting the ship now, but the summer was cold and foggy, and the winds were light, so the pack-ice was not much affected. The warmest month, January, had a mean temperature of -0.85°C .

The height of summer passed with no sign of the *Antarctic*. So in February, 1903, they began to prepare for a second winter. They killed Adélie penguins and seals for food and fuel. In the middle of February, the periods with gales started again, but the second winter proved less severe and the south-westerly gales less frequent than in the first winter. They often experienced periods of light winds and low temperatures, as well as periods with northerly winds and mild weather.

The winter campaign of the Antarctic in 1902

Many things could have happened to prevent the expedition ship from reaching Snow Hill in the summer of 1902/03. She might even have foundered on her way back to South America, and in that case nobody would know of the whereabouts of the wintering party. In fact, the ship *had* met a severe storm in Bransfield Strait on her way north in the previous autumn, and it could have led to a disaster.

However, on March 4, 1903, the *Antarctic* had safely arrived in Tierra del Fuego. At Ushuaia her bunkers were filled with coal, after which she headed for Port Stanley in the Falkland Islands. Here the

American artist Stokes left the ship, and the expedition was joined by its second leader, J.G. Andersson. He was a geologist and had been a member of Nathorst's 1898 expedition, and in the summer of 1899 he had led a geological expedition of his own to Björnöya. He was late in joining the expedition, as he had defended his doctoral thesis after the expedition had left Sweden.

Before going south to take the land party home in the summer of 1902/03, the *Antarctic* was to be taken on a tour of subantarctic waters—in the midst of the winter. But first a damage she had suffered in the previous summer had to be repaired.

THE SCIENTIFIC STAFF ON BOARD CONSISTED OF:

J.G. Andersson, geologist, leader.

A. Ohlin, marine zoologist.

K.A. Andersson, marine zoologist.

C. Skottsberg, botanist.

S.A. Duse, surveyor and meteorological observer.

On April 11, the *Antarctic* left Port Stanley and headed for South Georgia. She passed a region of the Scotia Sea, where the bottom topography was unknown. It was possible to obtain some successful soundings, giving depths down to 5997m. At the same time observations of temperature and salinity were obtained from chosen depths. The two zoologists investigated the animal life in different layers, from the surface to the bottom, using trawls, dredges and bag nets. The botanist studied algae, which were found in great amounts along the shores.

South Georgia was reached on April 22, and in the evening the *Antarctic* anchored in Cumberland Bay, the largest of the fjords in the island. The ship remained here more or less stationary until June 15, while the geologist, the surveyor and the botanist spent part of the time ashore on excursions. The zoologists remained on board, occupied with zoological studies along the coast. The geologist found clear indications of two previous glaciations more extensive than the present one. All groups became familiar with the hurricane winds, which came rushing down from the glaciers in some weather situations.

In the southern part of Cumberland Bay, the shore party found a small bay surrounded by high mountains. It was an excellent harbour, officially unknown, though apparently a secret among whalers and sealers. Graves of British sailors were found, some of them marked with the years 1846, 1871 and 1891. A number of cauldrons and other remains were found. The place was given the name Grytviken (Cauldron Bay). It would later become the first antarctic whaling station, founded in 1904 by C.A. Larsen, the captain of the *Antarctic*.

On July 4 the *Antarctic* was back in Port Stanley, where she remained for two months. The scientists kept busy with their respective research projects. Ohlin, however, had to leave the expedition owing to illness; a previously contracted and apparently latent pulmonary tuberculosis had become active from his cold work on deck when classifying the marine collections. He died in Sweden in the belief that he was the sole survivor from the expedition.

The summer campaign of 1902/1903

In early spring—on September 6—the *Antarctic* left Port Stanley, and on the 15th Tierra del Fuego was reached. Before proceeding south it was found necessary to repair the ship, fill her coal bunkers and take extra provisions aboard, all this being donated by the Argentine state.

Moreover, two letters were dispatched, one to the Secretary of the Swedish Society of Anthropology and Geography, the other to the Swedish-Norwegian consul-general in Buenos Aires. The two letters, which were identical, contained instructions for a relief expedition—should one prove to be required.

The ship then left Ushuaia on November 5, 1902, to start the antarctic campaign of the second summer. Included in the programme was a survey of the western coast of Graham Land and the offshore islands to the north of approximately 64.5° S. In this region the latest maps showed a wide sound opening towards the south-east. The existence of this sound had not been checked during the previous summer. The most important task was, however, to evacuate the Snow Hill base.

In the night of December 11/12, the *Antarctic* met with dense pack-ice already at latitude 61° S. For ten days she had to force her way through the ice, until open water was regained off the South Shetland Islands; Bransfield Strait was also practically ice-free. Hydrographic series showed remarkably low temperatures in the bottom water here, -1.65°C, indicating that the strait must be a closed basin isolated from the ocean by submarine thresholds, which permitted only small amounts of warmer water to reach the area.

Surveying went on from November 26 to December 5. Every time the surveyor went ashore to take his bearings and astronomical determinations of position, he was accompanied by the geologist and the botanist, who made their observations and amassed collections—while on board the ship, the zoologist gathered samples of the marine fauna. This was a happy interval; and it was now established that there did not exist a sound through the peninsula.

The time had come to sail down to Snow Hill Island and the wintering party. Henceforth, the ship would

face dangers and adversities. Antarctic Sound between Joinville Island and the Antarctic Peninsula was filled with ice, and beyond it the Erebus and Terror Gulf appeared intensely white. Captain Larsen therefore attempted to pass round Joinville Island, but on this route he was faced with severe ice, whose edge he followed northward. On December 15 the ship was beset in the ice, and drifted with it in a north-easterly direction out of the Bransfield basin. The movement was also evident from a hydrographic series which showed a bottom temperature of -0.4°C, the normal bottom temperature of the Southern Ocean.

The ship returned to Antarctic Sound. Ice conditions had not improved there, and the probability of reaching Snow Hill that way seemed small. The land party was expecting them and had to be informed of a plan for evacuation, which had been worked out on board. A small sledging party was to be landed on the west side of Antarctic Sound, in Hope Bay, where a fairly large depot would also be established. The sledging party was to travel along the Erebus and Terror Gulf to join the Snow Hill group, and to await the ship. If the ship had not arrived by February 10, the whole party was to leave the base and travel to the depot at Hope Bay, and wait there until the *Antarctic* arrived to fetch them.

It had been decided that the sledging party should consist of three men: J.G. Andersson, S.A. Duse, and Toralf Grunden, the latter being one of the crew.

Shipwrecked and marooned

The sledging party with its equipment, and the stores for the depot, were landed at Hope Bay on December 2, 1902. The ship then stood out to sea on a north-easterly course, to pass north and east of Joinville Island in the hope of reaching Snow Hill that way. However, to the east of Joinville Island, the ship got stuck in severe pack-ice and drifted southward with it under a northerly wind—passing close to icebergs, small islets and reefs. For two days, January 3-4, the ice conditions improved and open water appeared in the direction of Seymour Island. The outlook now seemed bright, but the ice came back and surrounded the ship.

Worse still, a couple of days later a southerly gale drove the ice fields against Joinville Island, with a terrifying ice pressure as a result. On January 11 a large ice-floe was pushed under the ship, tore away part of the keel and some planks in the bottom, and broke the rudder and stem. Water flooded into the engine room, which also suffered damage: among other things, the propeller shaft was bent.

The ship rested on the foot of the floe for more than three weeks before sliding off it. Sails were then set

with the intention of heading for Paulet Island. Sometimes the engine was started when the ship was surrounded and threatened by icebergs, but this gave rise to an increased inflow of water. They had to keep the ship afloat until they reached a relatively large and safe ice-floe to which they could transfer men, boats, provisions and clothes. At first they hoped to be able to ground the ship near land, and in this way save practically all equipment.

On the morning of February 12, they found a suitable ice-floe and moved their equipment to it. Then they abandoned the *Antarctic*, which drifted slowly away from the floe and sank. Their hopes were now set on reaching Paulet Island. Meanwhile they adapted themselves to their new life. They pitched a tent made of sailcloth and woodwork; sleeping-bags were also fashioned of sailcloth.

Great difficulty was experienced in fighting against the unpredictable ice and currents. Only 45 km separated the men from Paulet Island, but it was a hard and unrelenting task to drag their boats and equipment over the pack-ice only to find, after a night's rest, that the current had carried them farther from their destination. However, after 16 days of toil the ice opened; soon they were surrounded by open water and, after 6.5 hours of rowing, reached Paulet Island on February 28, 1903. It was in the nick of time, because the following night a north-westerly wind increased to hurricane force.

The season was now late summer, and they had to prepare for the winter. They built a hut, consisting merely of a double stone wall around a room 5.4 by 6.0 m. They covered the construction with sails to serve as a roof; sealskins were added later. Their food during the winter consisted mostly of meat from penguins and seals. They were in good health, but one young sailor died subsequently of a heart disease. On the whole they came through the winter well, though their daily life must have been extremely dull.

Three men in a stone hut

But what of the sledging party which had been landed at Hope Bay on December 29, 1902? Their equipment was light and improvised. Their food was expected to last for 25 days. Yet they also had the depot to resort to, and it contained 556 kg of provisions. The three men were optimistic. They knew that the ice conditions could change rapidly, and the severe conditions the ship had run into might soon improve.

An agreement had been reached with Captain Larsen for the following two contingencies:

1. Only the *Antarctic* might reach the Snow Hill base. If the sledge party had not turned up at Snow Hill by January 25, 1903, at the latest, it would mean

- that their way had been blocked and that they should be looked for at the depot site in Hope Bay.
2. Only the sledging party reaches the Snow Hill base. If the *Antarctic* had not reached Snow Hill by February 10, everyone at the base should proceed to Hope Bay. The *Antarctic* would then visit the depot between February 25 and March 10.

The sledging party left Hope Bay on the very same day that they landed, December 29. The sledgers ascended the slopes of an ice-cap in a south-westerly direction, but the very next day they were surprised to find that they had reached an ice-divide, and were looking down over an ice-covered bay with several islands. They headed towards a snowy area to the south, which later proved to be a distinct island, and was named Vega Island. It was separated from James Ross Island by an ice-covered sound with a network of pools on the surface, which they considered unpassable with their present equipment. There was nothing to be done but return to Hope Bay, where they arrived on January 13.

The March 10 deadline passed—but no ship appeared. They now knew that they would have to spend the winter at Hope Bay. Something must have happened to the ship. Even before this date they had started preparing for the winter. It was essential to build a stone hut to get protection from the cold and from the severe gales. They decided on a hut of roughly 2.5 by 2.5 m inside, with just enough space for three sleeping-bags and a few boxes. They also built an entrance "hall". The stone walls were thick, roughly 1.5 m at the base. The roof consisted of a tarpaulin resting upon their sledge and whatever woodwork they could get hold of. Inside the hut they pitched the tent. There were no windows, so it was pitch-dark in the hut. They had a lamp, though: blubber burning in a tin box. Blubber was also used for cooking. As a result, everything in the hut gradually assumed a blackish hue—including the three occupants.

Still, the hut was safe. Whatever the weather raging outside, and whatever the temperature, they were well protected, especially once the hut had become embedded in the snow. They could not read to pass the time—they had no literature and it was too dark inside—but Grunden was a good story-teller, and Andersson gave lectures on various subjects. Duse, who was to become an author of detective stories, later published some of these stories of Grunden.

Each man took turns to do the cooking. It was a disagreeable occupation, but it gave some relief from the monotony of day-to-day life. Their clothes became impregnated with blubber, and provided poor

The expedition ship *Antarctic* is sinking, 12 February 1903. Paulet Island was reached by the ship's party on 28 February 1903 (left). Photo: F. Goldberg Collection.

The three sledgers on arrival at Snow Hill on 16 October 1903. The sledgers were rather dirty from using blubber for heating and cooking. From left: S.A. Duse, J.G. Andersson and Toralf Grunden (right). (Andersson, J.G.: *Antarctic*.)

The stone hut at Hope Bay. A sledging party of three was landed here on 19 December 1902 in order to inform the Snow Hill party, on an eventually delayed arrival of the ship. The sledgers however, had to return to Hope Bay, build a stone hut and spend the winter here and then make a new try the following spring (above). (Nordenskjöld, O.: *Antarctic II*.)

The stone hut at Hope Bay, interior. The size of the stone hut can be estimated from the size of the sleeping-bags (above). (Duse, S.A.: *Bland pingviner och sälar*.)

insulation against the cold. Consequently the three men went outdoors only for short intervals, and sometimes they stayed in their sleeping-bags for days on end. Soot adhered to everything and made their diaries almost illegible. In many ways, their life was similar to that of Nansen and Johansen in a hut on Franz Josef Land in 1895–96.

In order to get food and fuel, they organized an intense slaughter of Adélie penguins and seals. They lived in a penguin rookery, and were therefore surrounded by a great many of the undaunted birds before these left for the winter. Besides, they could always resort to the depot. Their state of health remained good, though they suffered from intellectual inactivity.

All the time they worried over the fate of their friends in the ship. The expedition was now divided into three groups, of which the Snow Hill group knew nothing of the other two—the Paulet Island group and the Hope Bay group. The situation can be better understood if the distances between the three groups are considered:

Snow Hill	– Paulet Island	100 km
Snow Hill	– Hope Bay	125 km
Paulet Island	– Hope Bay	60 km

The distances are in fact short, but the conditions—treacherous sea-ice, proximity to open water, the currents and the sudden changes in wind, weather and ice—made the distances insurmountable with the equipment at their disposal.

Their stay at Hope Bay was, however, not wasted from a scientific point of view. After the interrupted sledging tour in the previous summer, J.G. Andersson had found fossils in a boulder near the camp. During the following weeks, he looked systematically for fossils in the neighbourhood and on the slopes of a nearby mountain, Mount Flora. He managed to find the stratum of black schist in which the fossils were embedded. It was a most important discovery. Mount Flora proved to be a gigantic herbarium from bygone ages, giving proof of a previous mild climate. As far as the preparations for the winter allowed, Andersson spent all his time collecting fossils. As their food boxes became empty one after the other, they were filled with fossils. In spite of all his work, the finds were a mere drop in the ocean—so rich was the habitat.

After the return of the expedition, the collection of fossils was handed over for classification and analysis to the palaeontologist T.G. Halle, who was later—in 1918—to become professor and head of the Palaeobotanical Section of the Swedish Museum of Natural History. It emerged that the plant fossils belonged to

the Mid-Jurassic period, some 140 million years ago. Halle found 61 species, of which 20 were described as new to science.

During the winter it was not possible to devote any time to scientific work, even meteorological observations. Duse complained, for instance, that he had neither a thermometer nor an anemometer; he even lacked paper on which to enter his observations. Besides, the three men were more or less prisoners in their hut during periods of unsettled weather, and had no idea what was going on outdoors.

With the advance of spring, the preparations for the sledge tour started. On September 29, 1903, they left Hope Bay. They now looked like dirt-ingrained tramps. Their tour was of great interest from a geographical point of view. Duse's surveying supplied a connecting link between his previous survey of the west coast of the peninsula and Nordenskjöld's mapping of the eastern side and the offshore islands. Nordenskjöld's recent discovery of the large James Ross Island, and Crown Prince Gustaf Channel to its west, was important in this context.

Luck was in their favour this time: when they reached Vega Island they found open water to the east, which made them turn west to pass round the west point of the island. On October 12 they met Nordenskjöld and Jonassen who—coming from the south—had sledged round James Ross Island and were on their way home to the base. The meeting was dramatic; the dirty Hope Bay men were not recognized until they had introduced themselves. After another four days of sledging they arrived at Snow Hill.

Everyone at the base was in good health, although the fate of the ship's party worried them all. The second winter had been somewhat milder than the first. Observations were carried out as in the first winter. Nordenskjöld was enthusiastic about the fossil collection waiting to be fetched at Hope Bay.

The two geologists were given another month for geological studies in the neighbourhood of the base. J.G. Andersson was struck by the different character of the Hope Bay and the Snow Hill regions. The former was an unfolded plateau-land bordering a shallow sea, while the latter contained a deep sound with fjordlike bays; it was folded land with a rich variety of sedimentary and eruptive rocks. Nordenskjöld and J.G. Andersson had observed, in their respective regions, evidence of a previous glaciation more extensive than at present. On South Georgia too, as already mentioned, Andersson had made similar observations.

On November 8, four men were seen coming towards the station. This was puzzling, as only two

Captain Olof Gylden, commander of the Frithjof expedition 1903 for the relief of the Nordenskjöld expedition. Inset: Lieutenant Axel Blom, second in command (above). (Klinckowström, A.: *Klinckans minnen.*)

A view from Hope Bay (above). (Nordenskjöld, O.: *Antarctic II.*)

A map of Hope Bay, surveyor: S.A. Duse. The stone hut was built in March 1903 at the tip of the little tongue of land right under the word "vik" (left). (Duse, S.A.: *Bland pingviner och sälar.*)

Otto Nordenskjöld at his writing-desk at Snow Hill, 1902 (above). (Nordenskjöld, O.: *Antarctic I.*)

Gösta Bodman at his working-table at Snow Hill, 1902. Bodman was responsible for the meteorological and the geomagnetic observations (left). (Nordenskjöld, O.: *Antarctic I.*)

men were absent from the base. The visit marked an unexpected change in the course of events at Snow Hill—and on the same day, another group of visitors arrived. The fate of the *Antarctic* and the ship's party would thus be revealed to the men at the station. But first let us consider what had taken place in Sweden and Argentina during the preceding six months.

RELIEF EXPEDITIONS

Before the *Antarctic* left Ushuaia to embark on her second antarctic campaign, a memorandum had been composed by J.G. Andersson and Captain C.A. Larsen. As we noted earlier, it gave some advice about a relief expedition in case the ship had not returned to the Falkland Islands by April 30, 1903. In the middle of April, as nothing had been heard from the expedition, it fell upon A.G. Nathorst to present a petition to the Swedish Government requesting money for a relief expedition.

On May 8, the Swedish Parliament voted 200 000 Swedish crowns for the purpose (equivalent to somewhat more than a million U.S. dollars today), on the condition that a further 50 000 Swedish crowns were obtained by private means. The difficulty was to find a suitable ship at that time of the year. But the relief committee managed to hire the Norwegian sealer *Frithjof*, a three-masted barque with a steam engine, which had been used by G. Kolthoff's zoological expedition in 1900 (see p. 292).

The Government appointed Captain Olof Gyldeén and Dr. Jacob Torgersruud to act as commander and ship's doctor respectively. The Royal Swedish Academy of Sciences handled the funds, and was represented by its members A.G. Nathorst and Gerard De Geer. It will be recalled that Nathorst had been a member of the committee which had recommended a rejection of Nordenskjöld's petition for money before the start of his expedition. Yet from now on, Nathorst would be of great help to the Nordenskjöld expedition.

THE OFFICERS OF THE RELIEF EXPEDITION CAME FROM THE SWEDISH NAVY:

Hans Olof Fredrik Gyldeén (b. 1867), captain, commander of the *Frithjof*.

Axel Theodor Blom (b. 1877), lieutenant.

J.E. Menander, lieutenant in the reserve.

S.R. Bergendahl, lieutenant in the reserve.

Jacob Torgersruud (b. 1864), naval surgeon.

In the ship's party was also included a "paying guest": Axel Klinckowström (1867–1936), Ph.D., zoologist.

Gyldeén had been the commander of the *Antarctic* during her service to the Arc-of-Meridian expedition in 1901. Lieutenant Blom had taken part in the same

cruise. Dr. Torgersruud had served in the Arc-of-Meridian expeditions of 1899–1901. Klinckowström had been with Gustaf Nordenskiöld to Spitsbergen in 1890.

Argentina too organized a relief expedition, and its commander, Julian Irizar, was in close contact with his Swedish colleagues. To fit out his expedition, Irizar was assisted by three Englishmen—among them Ernest H. Shackleton, who had been a member of the recent British Antarctic Expedition.

In France, J. Charcot was organizing an expedition on board a recently built ship, the *Français*. This enterprise intended to investigate the Antarctic Peninsula. Its plans now also included relief measures for the Nordenskjöld expedition.

The *Frithjof* left Stockholm on August 18, 1903. A visit was paid to Funchal, Madeira, on September 13–15. The *Français*, with the French expedition on board, lay at anchor in the harbour, and the Swedes took the opportunity to discuss relief plans.

On October 30 the *Frithjof* reached Buenos Aires. There they were told that the Argentine relief expedition, on the gunboat *Uruguay*, was already on its way south, having left Buenos Aires three weeks earlier without waiting for them. Instead of cooperation between the two expeditions in relieving Nordenskjöld, competition seemed to have developed. The French expedition lagged ten days behind schedule, and dissension had arisen among the staff.

The *Uruguay* reached Bransfield Strait on November 4. She met with some ice, but had no difficulty in passing Joinville Island on the "exterior" route. Many large icebergs were seen, besides ice around Paulet Island, but it was possible to steer a course towards Seymour Island. The ship proceeded in spite of increasing amount of ice, and on the evening of November 6 she anchored off the western side of the island.

Next afternoon, a tent was observed near the shore. After landing, it was found that two men were in the tent, Bodman and Åkerlundh. They now took Irizar and one of his officers to the Snow Hill base. These were the four men who surprised the station's party on the morning of November 8.

But this unforgettable day was not over. Towards midnight, six men were seen coming. They turned out to be Captain C.A. Larsen, the zoologist K.A. Andersson and four men from the crew of the *Antarctic*. They had come by boat, rowing or sailing from Paulet Island—where all was well—after first visiting the depot and hut at Hope Bay.

The rest may be told briefly. Scientific notes and results, collections, instruments, and men were taken aboard the *Uruguay*. On November 11, the marooned party at Paulet Island went aboard the ship too.

Finally the collection of fossils was safely taken aboard at Hope Bay on the same day. Then followed the homeward voyage via Buenos Aires, which was reached on December 9, 1903.

The *Frithjof* had been too late to take any active part in the evacuation of the Snow Hill station. Not much was written about this expedition—just a few reports—until the zoologist on board, Dr. Klinckowström, gave a rather full description of the events in his memoirs, published in 1933.

This expedition also had an ample share of severe gales and heavy ice. On December 3, the *Frithjof* reached dense ice about 20 km from the Snow Hill base. Next morning a party of three—including the two lieutenants Blom and Bergendahl, and Dr. Klinckowström—left the ship in order to sledge to the base. After a strenuous march of 14 hours and a stay of 4 hours at the base, the party returned at midnight. In the dining-room of the hut, they had found an entry on a dirty oilcloth:

"The hut was evacuated on November 10, 1903 at 10.45 a.m."

Three corked bottles contained letters, one of these for Captain Gylden of the *Frithjof*:

"Captain J. Irizar, Captain of the Argentine Navy and Commander of the gunboat *Uruguay*, dispatched by the Government of Argentina for the relief of the expedition, etc., etc..."

Now they knew what had happened. They had come almost a month too late, but it was a comfort to know that the Nordenskjöld expedition and its scientific notes and collections had been saved. The *Frithjof* also paid a visit to Hope Bay, but the little stone hut was not found. A violent gale had been raging during the last few days, and the hut may have become buried in the snow.

On December 12, the mountains of Tierra del Fuego were seen in the distance and the antarctic adventure seemed to have come to an end. However, they were attacked by a terrifying gale with mountainous waves. The ship fought to survive during the following night and day. She leaked water badly, the steam engine stopped because of the flooding, and the pump stopped with it. The situation was desperate. To leeward—though invisible—lay Staten Island. Yet they managed to ride out the gale, with damage to the ship and with the loss of the zoological collections, which had been secured on deck.

On December 14 the ship steamed through the Beagle Channel, and in the beginning of April she

reached Göteborg. It had been an expedition plagued by adversities and disappointments.

SCIENTIFIC RESULTS

The Swedish Antarctic Expedition of 1901-03 had been adventurous, and its achievements in research were outstanding. Some of the notes and collections had, however, been lost when the *Antarctic* foundered.

In subsequent years, Nordenskjöld organized the publication of the results. He wrote several parts, as did the scientific members of the expedition. Contributions came also from other experts. The papers were collected in six volumes: *Wissenschaftliche Ergebnisse der Schwedischen Südpolar-Expedition 1901-1903* (*Scientific Results of the Swedish South Polar Expedition*). Published in the years 1904-20, these volumes contain 59 contributions, 322 plates and maps, and a total of 4000 pages, covering the following subjects:

Vol. 1	Geography, cartography, oceanography, geomagnetism and hygienics.
Vol. 2	Meteorology.
Vol. 3	Geology, palaeontology.
Vol. 4	Botany, bacteriology.
Vol. 5	Zoology.
Vol. 6	Zoology.

The expedition had surveyed the western coastline of the Antarctic Peninsula down to about latitude 64.5° S. It was established that the wide sound through the peninsula, which was shown on the latest maps, did not exist. Nordenskjöld's surveys of the eastern edge of the peninsula with off-lying islands extended almost to latitude 66° S, and the new configuration bore little similarity to the old maps. The geology of the same regions had been studied, as had that of South Georgia, the Falkland Islands and Tierra del Fuego; rich geological collections were brought home.

With respect to oceanography, depths and deep-sea temperatures were determined both in the Antarctic and in the Subantarctic. The geomagnetic and meteorological observations were made in collaboration with stations operating in both regions. The fauna and flora of sea and land were studied, and at the Snow Hill base the ground and air bacteria were observed and counted. The meteorological observations had disclosed an unexpectedly harsh climate, considering the relatively northerly position of Snow Hill. Both in Antarctica and in South Georgia, Nordenskjöld and J.G. Andersson had found indications of a more extensive glaciation than that of the present day.

The geological finds were probably the most interesting, and especially the abundant fossils from the

TEMPERATURE AND WIND AT SNOW HILL

Lat. 64°22'S, long. 57°00'W

	Mean temp. (°C)		Mean wind speed (m/s)	
	1902	1903	1902	1903
Jan.	—	-0.9	—	6
Feb.	—	-3.5	—	7
March	-9.5	-11.4	9.4	13
Apr.	-13.4	-14.2	7.3	8
May	-17.0	-19.4	11.2	6
June	-18.1	-21.3	11.2	6
July	-24.4	-17.3	11.0	8
Aug.	-22.5	-16.4	8.7	9
Sept.	-14.3	-17.0	8.0	7.5
Oct.	-12.7	-6.4	9.3	6
Nov.	-8.1	—	7.5	—
Dec.	-2.0	—	4	—

Tertiary and the Jurassic periods revealed the need for further research in the area. Thus, already on the way home, Nordenskjöld and J.G. Andersson discussed a future expedition. But the new collections had to be arranged and edited first, besides tending to personal requirements such as earning a living. Years passed.

AN ANGLO-SWEDISH ANTARCTIC EXPEDITION IS PLANNED 1911–1914

In April 1911, Otto Nordenskjöld delivered a lecture to the Swedish Society of Anthropology and Geography (SSAG). He summarized what was then known of the physical features of the Antarctic; much new information had been obtained from the expeditions which had worked around the turn of the century. Finally he gave a short presentation of his own ideas concerning a new Swedish expedition to the same region as the previous one had visited. It should preferably last several years, but could still be relatively inexpensive, since he hoped to obtain assistance from the whalers working in the South Shetlands area for the transport of supplies and personnel.

For years Nordenskjöld and J.G. Andersson had been toying with the idea of such an expedition, but they could not easily find money for it so soon after the 1901–03 expedition. On a visit to London in 1912, the two geologists had interested British scientists and institutions in an expedition, and in 1913 a Swedish Antarctic Committee was formed to take care of the expedition affairs. The chairman was Louis Palander, the captain of the *Vega* on her voyage round Eurasia, now a retired admiral of the Swedish Navy. The secretary was J.G. Andersson.

Among the members of the committee were the scientists of the expedition of 1901–03 and two arctic

explorers, A.G. Nathorst and Gerard De Geer.

At a meeting of the SSAG in March 1914, Palander and Nordenskjöld outlined the plans for the proposed Anglo-Swedish expedition, Palander speaking on the preparatory organization and Nordenskjöld on the scientific programme.

The Norwegians had by then embarked upon whaling activity in the South Shetlands area, using Deception Island as a base. The new expedition would have to rely on the whalers for transport of equipment and personnel between Europe and Deception Island. For transport between the island and the expedition base, a relatively small ship would be needed, “something like Roald Amundsen’s ship *Gjøa*.”

The ship would also be used for transporting scientific personnel within areas to be investigated. In order to obviate ice problems, a base in or near Antarctic Sound, either at Hope Bay or on Joinville Island, was preliminarily selected. Such a position was also considered advantageous from geological, zoological and meteorological points of view. The base would offer a good starting point for sledge tours along the eastern edge of the peninsula, too, and for biological and oceanographical studies on board the expedition ship.

The expedition was planned to last five years, naturally with annual replacement of personnel. Nordenskjöld had at first intended to act as leader during the first year, but other duties were to prevent this, so Skottsberg had consented to replace him. The personnel would number eleven men, five of whom would be scientists, including the leader and the doctor. The remaining six men would be responsible for the practical work at the base and for manning the small expedition ship. Two of the scientists would be British, and all collections would be shared alike between the two countries.

The long duration of the stay would guarantee unequalled geological and biological collections, a wider range of detailed geographical and cartographical work within wide areas, and good observation series in the fields of meteorology and glaciology.

The plans were far advanced, the interest among both British and Swedish institutions was great, and the economy of the expedition looked bright. In 1914 the Swedish Parliament had granted the funds that had been applied for, and it was intended to sail for the Antarctic in 1915. But in 1914 World War I broke out, and after the war the situation had changed in many ways: the expedition plans were given up, both in Sweden and in Great Britain.

The Swedish Government was informed in September 1919, the money was returned and the Swedish Antarctic Committee was dissolved.

GEOLOGICAL RESEARCH
AND COAL MINING
1909–1956

35. THE RISE AND FALL OF SWEDISH COAL MINING IN SPITSBERGEN

BERTIL HÖGBOM'S GEOLOGICAL EXPEDITION IN 1909

During De Geer's Spitsbergen expedition of 1908, the young geologist Bertil Högbom was a member of the field group which, under the palaeontologist Carl Wiman, worked in the Isfjorden region (see p. 325). Many valuable finds of fossils were collected, such as well-preserved relics of saurians in the Triassic formation north of Kapp Thordsen.

However, newly fallen snow had rendered the collecting difficult, and the ground was frozen. After the return home, plans for a new and less ambitious geological expedition gradually formed. Once its finances were secured, Bertil Högbom was invited to lead it.

THE FOLLOWING PERSONS WERE CHOSEN AS MEMBERS:
Arvid Bertil Högbom (1888–1962), undergraduate,
geologist, leader of the expedition.

Ossian Olofsson (b. 1886), B.Sc., zoologist.

A. Söderström, M.B.

F. Olofsson.

The latter two were substitutes for two sailors, who were prevented from going north at the last moment.

The equipment consisted of a 6.5-m hunting-boat built at Tromsø, provisions for eight weeks, two tents and sleeping-bags. The expedition was transported to Spitsbergen on the American steamer *W.D. Munroe* of the Arctic Coal Company, which had started mining at Adventfjorden (see p. 380) a few years previously.

The *W.D. Munroe* left Trondheim with the expedition on June 27, 1909. On July 3 she steamed into Isfjorden, only to find that fast-ice with pack-ice in front extended eastward from Colesbukta. The prevailing westerly wind abated on the 5th, after which the ship proceeded easily eastward to Adventfjorden, where the expedition pitched its camp near the shore below the American mine.

The ice stayed in Isfjorden for another 10 days, but westerly gales broke up the ice-cover. During a few calm days at the end of the period, the ice was "pumped" out of Isfjorden by tidal currents. On July 17 the expedition broke camp and, with provisions for three weeks, continued towards Kapp Wijk at the entrance to Dicksonfjorden. The boat was towed by the steam launch of the coal company, which henceforth was also to help them with the long transports.

They camped about 5 km to the south of Kapp Wijk, and with this point of departure they collected fossils in the mountains of the Triassic formation, which lie south of a line between Kapp Wijk and Skansbukta. Here they obtained bones of Ichthyosaurus: some were crumbled away from soft marl schist and were then extremely well preserved; others were fixed within more compact schist and consisted of spinal columns with ribs, pelvic girdles, scapulae and extremities.

On July 20, it was decided to study the conditions to the north-west of Isfjorden. With the least possible equipment, three men rowed to Sveaneset, south-west of Kapp Wijk, leaving O. Olofsson alone in the camp. An excursion was made to the Triassic mountains north of Sveaneset, where they collected bones from saurians—and Triassic plant fossils, which were of great interest, as very little was known of these in Spitsbergen. Next day they visited Bohemanneset.

On the way they passed along an almost unbroken glacier front, which was photographed. The latter ice-stream was a chaotic mass of piled-up blocks of ice; here the bay had become filled with pieces of calved ice, and tidal currents caused unexpected changes in their distribution. At Bohemanneset—or rather along the coast of Bohemanflya—they investigated the fossil-bearing Jurassic strata, but there was much snow on the ground so close to the mouth of Isfjorden.

They intended to visit Henschenodden, the east point of Erdmannflya, but high winds made them turn back to the Triassic mountains north of Sveaneset. In the night towards July 23, they landed about 5 km south of Sefströmbreen and increased their collections of Triassic plant and animal fossils. On July 24 they were back at their camp at Kapp Wijk, where Olofsson had also found rich collections.

In the night towards August 1, they moved to a new camp at Diabasodden by the entrance to Sassenfjorden. They wanted to get a profile through the Jurassic formation, and to learn about the discordance of this formation towards the Triassic. But they had to endure the high winds of this region of Spitsbergen; not until August 6 could they leave Diabasodden and move some 10 km farther into the fjord, where they pitched camp. They had originally planned to visit the mountain Pyramiden at Billefjorden, but the season was now late, and the weather had become unsettled. They dared not risk being too late for the departure of the tourist steamer *Neptun*, the last means of transport of the summer. They had, though, work to do at Sassenfjorden with tectonic studies and collecting fossils.

On August 13 they were back at Adventfjorden,

their first campsite. After a few excursions on Nordenskiöldsfjellet, they filled their last box for fossils. On August 16 they left Adventfjorden aboard the *Neptun*, and on August 25 they arrived at Trondheim. It had been a small but successful expedition.

HÖGBOM'S EXPEDITION IN 1910

Swedish mining-claims

Ever since the whaling period in Spitsbergen waters during the 17th and 18th centuries, the occurrence of coal was known and utilized. The early Swedish expeditions came across coal seams—both previously known and unknown ones—during their geological investigations.

There had been some talk of the desirability of a detailed investigation concerning the occurrence and practical value of the coal, but the question never came to the fore; nor was the question of coal then as “burning” as it became during the first decade of the 20th century. Besides, before that time, mining in such inhospitable regions probably seemed rather “fantastic”.

However, in 1904 two Americans, John Munroe Longyear (1850–1922) and Frederick Ayer, bought Norwegian coal fields on the west side of Adventfjorden, and in 1905 they extended their property considerably with large claims of their own. In 1906 the Adventfjorden area was transferred to the Arctic Coal Company of Boston, with Longyear and Ayer as main shareholders.

Mining began in the winter of 1906/07 under the leadership of Longyear. He was the first to start mining coal in Spitsbergen, and the mining village was named after him—Longyear City. In 1916 the properties were bought by a Norwegian company which was formed for the purpose of mining in Spitsbergen: Store Norske Spitsbergen Kulkompani Aktieselskap, which still owns the mine. Longyear City became Longyearbyen, and in 1925 it became the Norwegian administrative centre of Svalbard (see further p. 397).

Not until the Americans had begun mining operations was any attention paid in Sweden to what had happened in Spitsbergen. The relevant parties felt “left out in the cold”. In 1909, F.G. Stridsberg, an engineer of *Jernkontoret* (the Iron Office in Stockholm), proposed in a letter to this office that investigations should be launched in Spitsbergen concerning localities with coal. The proposal was supported by the office's engineer-in-chief, J.A. Brinell (1849–1925), and also by Professor Gerard De Geer, who gave advice on how such investigations might be carried out.

In the spring of 1910, the *Jernkontoret* asked Bertil Högbom to become the leader of a small expedition for investigating the coal resources in Spitsbergen and, if possible, claiming coal-fields on behalf of Sweden. The costs of the expedition were shared alike by *Jernkontoret* and by *Trafikaktiebolaget Grängesberg-Oxelösund*. Moreover, E.A. Bolinder, director of Bolinders Mekaniska Verkstad in Stockholm, placed a 60-foot motor-cutter, the *Venus*, at the disposal of the expedition.

In addition, some investigations were to be carried out by Karl Sidenvall (1878–1956), a Master of Mining Engineering, who was to visit Spitsbergen in connection with the excursion to the Isfjorden region during the international geological congress in Stockholm.

THE EXPEDITION CONSISTED OF THE FOLLOWING PERSONS:

Arvid Bertil Högbom (1888–1962), geologist, leader of the expedition.

Ossian Olofsson (b. 1886), M.Sc., zoologist.

G. Ohlsson, engineer.

For necessary work with explosives and for excavation work, a miner was included in the expedition, besides the crew of the cutter. Ossian Olofsson intended to devote himself to studies of the freshwater fauna, and to observations of biological and faunistic conditions. If time permitted, Högbom intended to collect further bones of reptiles in the Triassic strata, as the material from the previous expedition had shown unexpected strange forms, mostly from *Ichthyosaurus*.

The expedition reached Isfjorden on July 7, but ice prevented it from reaching the mountain Pyramiden, where it had planned to start the reconnaissance. The coal deposits near the mouth of the fjord were already occupied by the Americans, and any investigations there would scarcely lead to any Swedish occupation. Högbom writes:

“By the way, we were out at the eleventh hour, and the fact that we later succeeded as well as we did must be attributed solely to the advantage we had over our competitors, thanks to the earlier work of the Swedish expeditions: we had a good knowledge of the geological structure of the land. A number of expeditions were in the field with the same purpose as ours, and during the following summers they have been at least as great in number; we are informed that there were about 10 expeditions in 1912, and not less than 17 in 1913.

We did procure one coal-field in the north-west of Isfjorden, namely Erdmannflya (Erd-

manns Tundra), where we found a previously unknown occurrence of Jurassic coal." [Later identified as Cretaceous coal, according to Hoel.]

On July 12 they started to work at the mountain of Pyramiden, where they very soon managed to uncover coal seams. In the usual manner, annexation tablets were set up along the shores to announce the claim of possession. An example of the text in English upon such tablets may be given, from one of three tablets erected in the Pyramiden coal-field:

"Swedish occupation for coal mining. The district extends along the shore 8 kilometres north, 5 kilometres south and 3 kilometres into the interior of the land. Claimed and working started July 12, 1910.

B. Högbom O. Olofsson G. Ohlsson"

No trace of any previous occupation was found; but in order to emphasize the right of occupation, a small hut was set up near one of the three tablets. Building-material was obtained from a tumbledown hut near "Svenskehuset" at Kapp Thorsden (see Chapt. 12). A tablet gave the information that this hut was "Swedish private property".

The expedition had specially been ordered to investigate the Pyramiden district, whose Lower Carboniferous Kulm formation might bear coal of value for melting ore. Previously both Nathorst and De Geer had found pieces of coal here. And in 1910, during the visit of participants from the geological congress in Stockholm, Karl Sidenwall had spent a few days here for studying the conditions (see above).

As the Kulm strata proved to contain considerable seams of coal, and as they extended across the peninsula of Bünsow Land between Billefjorden and Sassenfjorden/Tempelfjorden, this district was also claimed. However, since these seams lie below sea level, the coal-field was more or less unknown. But there are also very great amounts of gypsum.

The expedition worked in the Pyramiden/Bünsow Land district for a month and got to know it satisfactorily.

The rest of the summer would now be devoted to studying the occurrence of Tertiary coals, especially as these seemed to be of higher quality. The expedition proceeded to Bellsund south of Isfjorden, to look for Tertiary coal seams which were suitable for mining. In the western part of Van Mijenfjorden—the northern branch of Bellsund—the seams were generally badly developed. In the upper Tertiary strata, the coal was good but the seams were rather thin. At the

inner part of Van Mijenfjorden, at Braganzavågen, the search succeeded: here the lower Tertiary strata reached above the sea level.

On both sides of the fjord they detected a coal seam worth mining. The seam was 3.3 m thick in one place, and the coal was as good as in the American mine at Adventfjorden. They uncovered this seam at several places.

On August 12 this district was claimed. The seam had certainly never been exposed or worked before. In this connection it should be remarked that an Englishman had long ago considered himself to have annexed the whole of Van Mijenfjorden, but no regard could be paid to his claim, particularly as no notice to that effect existed within the district. The Swedish occupation caused a conflict, but it was gradually settled very well, and no other contest arose later on.

The claim was notified in English by a tablet on Littrowneset, south of the mouth of Braganzavågen, with the following words:

"Swedish occupation for coal mining. The district extends N to latitude 78°, S to lat. 77°40', W to long. 16°20' Gr. and E to long. 17°. Claimed August 12th, 1910.

B. Högbom O. Olofsson G. Ohlsson"

This was the district where the Swedish mine *Sveagruvan* was later established.

During the summer of 1910, four coal-fields had thus been claimed:

Erdmannflya	July 1910	Cretaceous coals
Pyramiden	July 12, 1910	Kulm coals (Lower Carboniferous)
Bünsow Land	July 1910	Kulm coals
Braganzavågen	Aug. 12, 1910	Tertiary coals

Later, in 1913, another Swedish coal claim was made on the east side of Adventfjorden. This coal-field was called the *De Geer District*; the coal was of the Tertiary formation, but the occurrence was less valuable.

In the winter of 1910/11, Jernkontoret transferred the coal claims to the recently formed Company of Isfjorden-Bellsund, which had acquired the rights and properties that belonged to the phosphorite company Isfjorden of 1870 (see Chapt. 12).

HÖGBOM'S EXPEDITION IN 1911

Next summer, another expedition was sent to Spitsbergen. This time more comprehensive practical work was to be carried out, including test-mining.

Högbom was asked to become the leader.

THE MEMBERS WERE:

Arvid Bertil Högbom, geologist, leader.

Elis Mossberg, mining engineer, technical leader.

Birger Johnsson, mining engineer, technical assistant.

Karl Wedholm, B.M., doctor to the expedition.

For the work ashore, 14 men joined the expedition, and further assistance might be obtained from the ship's crew if necessary.

A steamer, the *Viking*, was bought for the purpose. She was old and fairly weather-beaten, but she was roomy, which was a "must" as she had to carry a large labour force and plenty of equipment, such as building-material and décauville tracks. Her commander was Captain Rudolf Österberg.

The expedition left Stockholm on June 15, stayed in Spitsbergen until September 9, and was back in Stockholm on September 29.

Among the tasks done during the summer were the following.

At *Pyramiden*: a drift was opened 35 m into the mountain, and a hut was set up.

Bünzow Land: a hut was set up at Gipsvika in the south, where two men were stationed. They were to do some work in the gypsum strata close by.

At *Gipsvika* and *Bjonahamna*, *Bünzow Land*: a considerable amount of gypsum was mined, and 90 tons were taken aboard the ship.

Braganzavågen: Blasting was carried out at several places to study the coal seams. A drift, 10 m wide, was opened 35 m into the mountain. A décauville track, 1.4 km long, was laid out temporarily from the mine to the shore, and with its help about 180 tons of coal were taken aboard the ship. Two houses were set up.

The summer's work was thus successful. Great amounts of coal and gypsum were taken home in order to subject them to practical examination.

THE EXPEDITIONS OF 1912–1915

The expeditions which were sent to Spitsbergen each summer in the period 1912–1915 will be only briefly summarized here:

Expedition of 1912

The members now counted only three, with the mining engineer Birger Johnsson as leader and two miners. They were taken to Spitsbergen by a small sealer.

The ice conditions proved to be severe, but they managed to carry out mining work for upholding the claims, and to do investigative work. However,

Braganzavågen could not be reached because of the ice.

Expedition of 1913

As in the previous summer, a small sealer was hired. The expedition was led by Birger Johnsson, but now it was joined by an English coal expert, Mr. B. Atkinson from Newcastle on Tyne. He was to give an opinion on the possibilities of exploitation, to make estimates of costs, and to set up plans for plants and mining. Atkinson got a very good impression of the occurrence of the coal, and he pointed out the merits of the Kulm coals, notably their value as "splint coal": they might be used in blast furnaces without coking.

Investigations were carried out at Pyramiden, on the east side of Adventfjorden, at Grönfjorden, Braganzavågen and Gipsvika.

Expedition of 1914

Yet another expedition was sent to Spitsbergen under the leadership of Birger Johnsson. Pyramiden and Braganzavågen were visited. In Bünzow Land, Gipsdalen was investigated in the vain hope of finding the coal seams of Pyramiden. In the Bellsund region, the occurrence of iron was studied, but it was found to be of no economic value.

Expedition of 1915

A small expedition under Birger Johnsson was sent up to Spitsbergen, but the extremely severe ice conditions prevented the expedition from landing in spite of persistent efforts.

THE SWEDISH COAL MINE SVEAGRUVAN¹

The mine is established

World War I and the rapidly rising coal prices gave the company Isfjorden–Bellsund opportunities to start utilizing the coal-fields which had been occupied. In November 1915, the Master of Mining Engineering, Birger Johnsson, supplied a summary of the occurrence of coal.

For the Braganza district a minimum figure of 340 million tons was given, most of it occurring in Liljevalch-fjellet. The average thickness of the coal seam was 2.15 m. The coals, which were Tertiary, were shining black. They crumbled easily to pieces or to coal dust, but when being fired they coked and did not fall through the grate. The content of ash was generally found to be less than 3%; the ash had the structure of a fine dust and did not sinter to the grate. The thermal value was high: 6840–7950 heat units for

¹The Swedish coal mining at Sveagruvan as described here is essentially taken from Adolf Hoel's standard work on Svalbard, Oslo 1966–1967; see References.

natural coal, and 7560–8290 for coal which had been dried at 100°C. The coal at the other Swedish coal districts was never mined by any Swedish company.

At a meeting in the spring of 1916 it was decided that money should be procured to begin the mining. For this purpose the board chose to form a new company, *Aktiebolaget Spetsbergens Svenska Kolfält*, and in May 1916 an invitation to sign shares was sent out. The company came to an agreement with the previous Swedish company *Isfjorden–Bellsund*, and with the British *Northern Exploration Company* which had interests in the district. The necessary capital was obtained within a few days. Establishment of the new company was looked upon as a national task, and it was incorporated on September 4, 1916.

In 1916, too, an expedition was dispatched to Spitsbergen, primarily for investigating and planning the loading port and other practical arrangements at the intended mine in the Braganza district. The expedition, led by Birger Johnsson, consisted of 10 persons and was paid by the new company. The old company *Isfjorden–Bellsund* continued to exist for several years, looking after its interests in the new company.

The mining was planned and organized by the administrative director of the company, Bror Granholm. About 150 men were to be sent to Spitsbergen in the summer of 1917 to set up the mine at Braganzavågen. The mine was now given the name of *Sveagruvan* (Svea Mine). Mining was to be carried out already in the first winter 1917/18, and a production of 25 000 tons was aimed at. However, the expedition met with severe ice conditions and did not reach Braganzavågen until the beginning of August 1917. Mining could be started, though, and during the winter 4000 tons were produced.

The war had created a tremendous rise in coal prices—which was an advantage here—but it also made materials, foods, and freight more expensive, which was obviously a disadvantage. Further, two ships proved necessary, specially built for arctic service. So the company needed more money, and new shares were issued in October 1917.

Next summer, *Sveagruvan* was developed for effective coal mining. Several dwellings and other houses were built, an aerial ropeway was erected, and a quay for loading the coal was constructed. During the summer 4000 tons of coal were shipped to Sweden and Norway—in the former country mainly to the State Railways, as was to be the case also in the following years. The ships hired were small, less than 400 tons. A new ship, the *Braganza*, built in Norway, was delivered in the autumn of 1918.

Expanding operations

The next year of mining ran from July 1, 1918 to June 30, 1919. A total of 130 persons spent the winter there, and the labour force rose to 200 in the following summer. The installations were extended, and during the winter 23 000 tons of coal were produced; in the summer 20 000 tons were shipped to Sweden and Norway.

A second ship, named *Bellsund*, was bought in the USA. In the summer she was engaged for the Sweden–Spitsbergen traffic, while the *Braganza* was used for transferring personnel and material between Narvik and Sveagruvan. As the latter ship was specially built for arctic service, she could keep the traffic going for six months of the year.

During the year 1919–20, 144 persons wintered at Sveagruvan. The installations grew further; for instance, a building was constructed to hold 40 swines and 4 cows. In the mine itself, the ventilation system was improved. Now 27 000 tons of coal were produced and 38,000 were shipped—partly coal which had been stored. Four ships with a total capacity of 10 000 tons shipped the coal in the summer of 1920. The ice conditions were good.

From the gunboat *Svensksund*, hydrographical surveying was carried out in Van Mijenfjorden under the leadership of Captain Gustaf Reinius of the Swedish Navy. Co-operation with the Norwegian Svalbard Expedition of 1920 under Adolf Hoel was established, the Swedish expedition obtaining trigonometric data and coastline maps of Bellsund and Van Mijenfjorden from the Norwegians.

It was now found desirable to produce 100 000 tons of coal annually. This demanded extra capital which would not be obtainable in Sweden. The company might either get capital from abroad or sell the mine abroad, but the second alternative was considered least suitable. Instead, the company requested a loan from the Swedish State. This was granted with a first payment in 1921, and a second one in 1922.

Operation in 1920–1921

This year 201 persons wintered. The labour force was reduced by 75 per month in May and June 1921, but it was again increased to 160 men after July 1—these changes being mainly a consequence of new contracts with the labour force. Additional installations were made, including a more powerful radio station. Mining began in a new coal seam that was thicker than the first one. Production amounted to 52 000 tons by June 30, and 38 000 tons were shipped by five colliers with 14 000 tons of total capacity.

The coal prices were now falling, and there was talk of discontinuing the mining. The ice conditions were

also bad, though the harbour had nonetheless been open for 85 days. On June 27, 1921, a new company was incorporated: *Svenska Stenkolsaktiebolaget Spetsbergen* (The Swedish Coal Company Spitsbergen).

Operation in 1921–1922

During this new company's first year of operation, improvements and extensions were made. A small lake with an area of 1 km² was created by damming up a brook near the mining village; this lake supplied the village with drinking-water. Both mines were in operation, the new one—Mine II—now yielding 57% of the output, against 43% from the old Mine I. The labour force was 220 men. The production of coal was 54 500 tons, amounting—along with a store—to 92 000 tons at the end of the year of operation. Of these, 73 000 tons were shipped in 1922 by eight time-chartered ships with a total loading capacity of 25 000 tons. The ice conditions were normal; the quay of the mine was accessible for 92 days.

However, the times were terrible. The coal had to be sold at prices far below the costs of production, and the drop of the coal prices upset the financial plan. As a relative indication, the price per ton of coal on New Year's Day in Sweden was 162.50 crowns for 1920, decreasing to 37.68 for 1921, then to 28.73 for 1922. As a result the company suffered from a chronic lack of money.

In the autumn of 1921, it asked for new working capital from the Swedish State in order to keep the mining going. The State signed further shares at the beginning of 1922; moreover the State Railways, which bought most of the coal, paid in advance. There was hope of attaining a more normal relation between sales price and cost of production.

Operation 1922–1923

Now 191 persons wintered; of these, 172 men and 13 women were employed in the service of the Company. In the summer, the labour force amounted to 250 persons. Of the annual production of coal, 26% were supplied from Mine I, 74% from Mine II. In the latter, the seam had a thickness of 2.32 m of pure coal, and the coal was of a considerably higher quality than in the previous year. Production was 81 000 tons—which, with the stock of 52 000 tons from 1922, gave a total of 133 000 tons. During the shipping season in 1922, the vessels took 72 000 tons, leaving a “year-end” stock (on June 30, 1923) of 59 000 tons. The freight was carried by eight time-chartered ships to Sweden, and by a Norwegian shipping company to Norway. The ice conditions were normal, and the quay was attainable for 97 days.

The losses per ton produced were now consider-

ably lower than in the previous year. Operating expenses in Spitsbergen had been reduced by 22% with better working methods, and the fixed expenses were, so to speak, spread over a greater amount of coal. This coal had acquired a good reputation, and was classed with the Best South Yorkshire Coals. It was now marketed under the name of *Braganza coal*.

But the difficulties were not eliminated by a mere issuing of preference shares. In a memorandum to the Swedish Department of Trade, the company gave notice that the only way to continue mining would be if the state-owned institutions, which used the coal in great amounts, entered into a contract with the company about future delivery. This delivery should occur at a fixed price and part of it should be prepaid.

An investigation into the future survival and operation of the company was made, and concluded in the autumn of 1922. There existed a possibility that the business *might* pay if the production was increased to 200 000 tons per year. In any case, the losses would then be less than if the mining was shut down for a long span of time. Moreover, the State should have a majority in the board. It was also pointed out that the Norwegian and Dutch companies in Spitsbergen had been granted government guarantees.

The Swedish Parliament was highly critical of the Government's request for a large loan to the Company. However, after much discussion the Company was granted a somewhat smaller loan in May 1923.

Operation in 1923–1924

This year 204 persons wintered, of whom 192 men and 8 women were engaged in the service of the Company. In the summer of 1924, the labour force was increased to 240 persons. Production reached 98,000 tons, 24% in Mine I and 76% in Mine II. With the stock of coal on June 30, 1923, this amounted to 157 000 tons at the beginning of the shipping season of 1923, when 85 000 tons were shipped in July–October 1923. In 1924, when the ice conditions were normal, 101 000 tons were shipped.

Yet there was still a deficit, in spite of lower operational expenditure and lower freight charges: the coal prices had fallen still more.

FIRE IN THE MINE AND FINANCIAL STRUGGLES AT HOME

Operation in 1924–1925

Now 216 persons wintered, of whom 186 men and 11 women served the Company. Of the production, 19% originated from Mine I and 81% from Mine II. The coal seam was about 1 m thick in Mine I, but up to 5 m in Mine II. Unfortunately on May 12, 1925, Mine II caught fire. This event proved fatal to the mining at

Sveagruvan and to the continuation of the Swedish coal mining in Spitsbergen.

The fire started in an engine shed in the main tunnel, about 40 m from the entrance to the mine. Petrol fumes caught fire in connection with the cleaning of a petrol-driven engine. Attempts were made to extinguish the fire with CO₂ syringes and water, but in vain. The strong gas and smoke emission prevented the firemen from tackling the scene of the blaze. The whole outer part of the tunnel became filled with a mass of stones falling from the ceiling, after the timber supporting it had been consumed by the fire.

The inner parts of the tunnel, however, were unaffected because the fire was concentrated in a small area near the entrance to the tunnel. But mining in Mine II had to be stopped, because the main tunnel was blocked with stones. In Mine I, which was situated 10 m lower, the work could go on until May 31. Poisonous gases had by then penetrated the intermediate layers of rock.

The snow was now melting, so the water from a mountain brook could be pumped into the mine and brought to rise above the scene of the fire. This pumping went on throughout the summer until the first days of September. All exterior signs of a fire had by then disappeared, but no attempts to get into the tunnel were made, because of fears that a supply of oxygen might start a new fire from embers.

The fire extinction was finished in September, and all openings were closed to prevent air from entering the mine. It was considered that the mining had to be stopped for two months, but later a decision was taken to stop for the entire winter. The Company received a loan from the State to cover wages and the extra expenses for fire extinction and supervision.

In the summer of 1925 the labour force was reduced to 120 men. Since the fire had started at the end of the year of operation, 1924–25, coal production for the year was not reduced much by the fire. An output of 115 000–120 000 tons had been aimed at, but it stopped at 116 000 tons. With no fire, about 135 000 tons would have been produced.

On June 30, 1924, the stock was 69 500 tons. With the amount produced during the year of operation 1924–25, a total of 185 500 tons was obtained. Ships took away 101 000 tons in the navigation season of 1924, and 80 000 tons in 1925. But the coal prices had fallen still more, to 19.02 Swedish crowns per ton. The mining had reached a net loss of 206 590 crowns, although including the expenses of 129 077 crowns due to the fire.

Operation in 1925–1926

During the winter, a watch consisting of one foreman

and four workers with families stayed at Sveagruvan. A tunnel of transport was opened into Mine II, and a connection was made with the inner parts of the transport system inside the fire-damaged area of the mine. The fire proved to have been extinguished, and materials at the scene were found undamaged. Mine I was quite intact and accessible.

According to the stipulations in an addition to the Spitsbergen treaty of February 9, 1920, all claims to territory should be delivered to the Spitsbergen commission by the governments of respective countries not later than November 14, 1925, three months after the treaty came into force on August 14, 1925. In the case of Sweden, the claims had reference to Braganza-vågen, Pyramiden and Ebbadalen. The Company had given up the claim to Bünzow Land, as the Scottish Spitsbergen Syndicate Ltd. had occupied the area already in 1909 and notified the British Foreign Office on the matter on August 12, 1909.

This syndicate had protested in July 1910 against the occupation by Aktiebolaget Isfjorden–Bellsund. The last mining of gypsum took place at Gipsvika during the year of operation 1918–19. The Swedish company now instead announced claims to a region at Ebbadalen east of Petuniabukta at the inner part of Billefjorden, which had been investigated by De Geer. The claims were entered on maps, where the boundaries had been drawn.

Their areas were as follows:

Braganza district	740 km ²
Pyramiden district	40 "
Ebbadalen district	101 "
Total	881 km ²

On February 25, 1926, the Swedish Government presented a bill to Parliament for liquidating its financial engagement in the Swedish mining in Spitsbergen. The Company needed a certain investment to keep the claimed districts in Swedish possession, besides a small annual sum for administration. As for the claim to the Ebbadalen district, it emerged that the Scottish Spitsbergen Syndicate Ltd. possessed older claims here than Sweden. An agreement was reached and Sweden "left the field".

According to the regulations for mining in Svalbard, some work had to be started in a claimed district after 10 years, and after another 5 years mining should have begun with at least 15 men throughout the year. But the amounts paid by the Norwegian and Dutch states to keep their respective mines were greater than what Sweden was willing to pay.

There was much discussion of what to do with the

Topographic map showing the area around Sveagruva. (Norsk Polarinstitutt, Oslo.)

Air photo of the area around Sveagruva. Photo: Norsk Polarinstitutt, Oslo.

Erik Stensiö, 1891-1984, palaeozoologist and leader of several Spitsbergen expeditions. Photo: Department of Palaeozoology, Swedish Museum of Natural History.

Gunnar Säve-Söderbergh, 1910-1948, palaeozoologist who worked in East Greenland. Photo: Private collection.

Erik Jarvik, b 1907, palaeozoologist who worked in East-Greenland and Spitsbergen. Photo: Department of Palaeozoology, Swedish Museum of Natural History.

On the formation of talus slopes. For description, see Chapt.36 p. 396. (Norsk Polarinstitutt; Skrifter Nr 119.)

Swedish coal districts—notably Sveagruvan. On May 26, 1926, the Parliament voted to liquidate the State's engagement in Svenska Stenkolsaktiebolaget Spetsbergen. The expenses for this should be limited to 105 000 crowns, which meant that the coal districts could be kept for at least ten years. A month later, at an extra general assembly, the Company decided upon liquidation.

The great coal strike in Great Britain in 1926 changed opinions about the value of Sveagruvan. Countries which obtained most of their coal from Britain were now in for hard times. Among them were Sweden and Norway, which had to face unexpected expenses.

A private proposal was presented to the Swedish Parliament on January 1, 1927, that it should ask the Government to review the question of the coal-fields. The value of possessing coal reserves even in peacetime was pointed out, and Norway was given as an example. The Spitsbergen coal would also be important for the Swedish iron production, and for preparing liquid fuel from pit coal.

The standing committee of supply was positive to this proposal, but insisted that the matter must not become too expensive. Parliament voted along the same lines on March 9, 1927.

Capitulation

A guard of two men spent the winter of 1926/27 at Sveagruvan, to complete the transport tunnel which had been commenced in the previous winter. On March 14, 1927, a telegram reached Sweden from Sveagruvan, stating that three explosions had occurred during this work.

The last explosion, on January 23, had caused a new fire, resulting in all work being stopped. As the men lacked experience in extinguishing large fires, they had restricted themselves to closing the openings into the mine as effectively as possible. A relief expedition was now sent to Sveagruvan from Sweden.

In the spring of 1927, too, the Swedish Board of Commerce analysed the question of a liquidation of the Company. The original plan had been that the State would take over the rights and the active persons, but this could not be done for formal reasons. According to the Spitsbergen treaty, no state as such was allowed to possess mines in Svalbard. Thus a company had to be arranged with the State as main partner. Without mining the costs were now estimated at 10 000 crowns per year, and the treaty allowed such a pause to continue for at most 10 years, after which mining would have to begin.

The relief expedition, consisting of six men, arrived on May 10, 1927, after a voyage full of hardships.

They found that the scene of fire covered about 200 m² around the new transport tunnel and another tunnel parallel with it. A drain was arranged from a melting snow-field into the tunnel, but not until May 25 did water start to flow into the mine. The relief party stayed at Sveagruvan until August 22, and reported that the buildings and installations were undamaged. However, the new fire had increased the apprehensions of the Swedish State about new economic adventures in Spitsbergen.

What happened afterwards is more or less outside the scope of the present book, but may be summarized as follows. First, a new company was formed on April 23, 1928, with the State as principal owner. Its name was Nya Svenska Stenkolsaktiebolaget Spetsbergen (The New Coal Company of Spitsbergen). In November 1933, it contracted to sell its properties in Spitsbergen to a Norwegian counterpart, Store Norske Spitsbergen Kulkompani Aktieselskap. The price agreed upon was 1 million Norwegian crowns.

On January 24, 1934, the Swedish Government asked Parliament to approve the sale contract. This was done only after sharp debate, and some of the institutions asked to give their opinion were also critical. For one thing, a far greater sum of 10 million Swedish crowns had been "pumped" into the mining company.

In 1952 it was finally decided that the Company should go into liquidation, and the related general assembly was held on June 17, 1952. That was the definitive end of the Swedish mining enterprise in Spitsbergen. The coal-field Pyramiden had been bought by Russia already in March 1927, and the Ebbadalen district had been submitted to Scotland.

36. GEOLOGICAL INVESTIGATIONS IN SPITSBERGEN, 1912–1969

UPPSALA UNIVERSITY'S PALAEONTOLOGICAL EXPEDITIONS

The palaeontologist Carl Wiman (1867–1944) had been the leader of a geological field-group during De Geer's Spitsbergen expedition of 1908. He was then lecturer in palaeontology at Uppsala University. In 1911 he received a personal professorship in the subject at the same university, and in 1922 this chair became a permanent one in palaeontology and historical geology. Wiman retired in 1933.

During his professorial tenure, Wiman dispatched a number of paleontological expeditions to Spitsbergen, primarily for collecting fossils from the

Triassic formation in middle Spitsbergen—notably in the Isfjorden region, at and near Sassendalen, and around Agardhbukta in Storfjorden. These expeditions took place in 1912, 1913, 1915, 1916, 1917, 1918, 1929 and 1930.

All but the last two ventures were led by the palaeontologist *Erik Helge Osvald Stensiö* (1891–1984), as he is called here (he changed his surname from Andersson in July 1917). The expeditions will be summarized from the notes supplied to *Ymer*, the journal of the Swedish Society of Anthropology and Geography. One expedition, that of 1917 to the Storfjorden region, is not well documented; but it is known to have claimed, on September 2, a coal-field at Ebbadalen in the innermost part of Billefjorden (see p. 384).

The expedition of 1912

This group, led by Erik Stensiö, B.Sc., also comprised three undergraduates: Hugo Hamilton (b. 1889), Folke Sjöstrand, and Tor Sjunnesson. They set out from Uppsala on June 17, and reached Adventfjorden in Spitsbergen on July 2, when ice still remained in the inner parts of Isfjorden. A camp was established on Hotellneset, from where excursions were undertaken in the surrounding country.

On July 5, an attempt was made to sail to Kapp Wijk at the entrance to Dicksonfjorden. However, drift-ice from the inner part of the fjord forced the party to return to Adventfjorden. Not until July 11 did they succeed in reaching Kapp Wijk, after a difficult sailing tour in high wind. There followed several days of inactivity in the tent, due to strong winds with rain.

After they had orientated themselves on the stratification, it was time to start the fossil-hunting. The fish stratum proved to be especially profitable, whereas the upper saurian stratum was already partly investigated, and was difficult of access. The fish stratum was searched for fossils both along the coast and in Idodalen to the east of Kapp Wijk.

An effort to reach Sveaneset at the entrance to Ekmanfjorden was defeated by heavy winds. Instead they sailed to Sauriedalen (previously called Rendalen) near Kapp Thordsen. Their provisions were now running out, so Sjöstrand and Sjunnesson were sent across the fjord to Adventfjorden for new supplies. A severe westerly gale forced them to remain at Adventfjorden for five days, after which they were towed to Kapp Thordsen by the sealer of the Swedish “coal expedition”.

During their search for fossils here, they discovered the plant-bearing stratum which was previously known from Sveaneset. In the western branch of Sauriedalen, they found strata of the Permian forma-

tion and the fish stratum. The fossils in the latter stratum were scarce, but well preserved. The upper saurian stratum was either missing or situated near the diabase—and had then been burnt and transformed.

Their last camp was in Sassendalen, where they visited the Triassic mountains, notably the Sticky Keep on the south side of the valley. In the fish stratum, they discovered remains of labyrinthodonts. The plant-bearing stratum was observed here too; mainly silicon wood was found.

The weather during the summer had been extremely bad, with rain and gales almost every day in July. In the latter half of August the weather improved, but now their boat tours were impeded by ice which had entered Isfjorden. On August 20 they left Spitsbergen.

The expedition of 1913

This enterprise had two members in addition to its leader Erik Stensiö: his brother Axel Andersson, a student, and the botanist Erik Asplund (1888–1974), M.Sc. They left Uppsala on June 26 and reached Grönfjorden on July 5.

The past winter had been very rich in snow, and the land was still practically covered. On July 11 the sealing vessel of the Swedish Coal Company arrived to take the expedition to Sassendalen. The inner parts of Sassenfjorden proved to be covered with ice, but they managed to reach the mouth of Sassenelva on July 14. Here they established their main camp, as Sassendalen was to be their principal area of research.

The plan was to take a boat with a very shallow draught up the river, but this turned out to be impossible. Nor was it possible to ford the river, as the bottom was too loose. There was nothing to do but carry the equipment along the waterlogged tundra of the valley.

To begin with, some excursions were made around the main camp. On the north side of the valley, they reached Rabotbreen in the innermost extremity of the valley, but on the south side they were prevented by deep watercourses and swamps from reaching Milne Edwardsfjellet. They got rich collections on the north side of Sassendalen near Rabotbreen. They discovered Triassic formations upon the Permian plateau and, as this mountain sloped gently and was essentially situated above the vegetation limit, their collections of fossils were rich, especially from the fish stratum. Most numerous were, though, the remains of labyrinthodonts.

In the inner part of Sassendalen Spitsbergen reindeer were seen in great numbers. On August 7, having finished their work in Sassendalen, the men were

transported to Sveaneset at the entrance to Ekmanfjorden. Here on the top of Lundbomfjellet they found a new labyrinthodont stratum, but the fossils were badly preserved.

On August 20 the expedition left Spitsbergen. It had been favoured by fine weather, but the great amounts of snow, especially at high levels, had impeded the investigations.

The expedition of 1915

The geological expeditions of 1912 and 1913 had yielded many valuable experiences and results, and in 1915 a new expedition was dispatched from Uppsala University with the aim of continuing the profitable collection of vertebrate fossils in the Triassic formation in Sassendalen. A reconnaissance across the ice-sheet towards Mohnbukta at Storfjorden was also contemplated. However, the expedition had to face several adversities, and its scientific outcome was not up to expectations.

Apart from Erik Stensiö, its leader, the expedition consisted of Erik Asplund—who had been a member of the venture in 1913—and a medical student named Birger Sjöström. Considering that Sassendalen generally is free of snow in the summer, so that all equipment has to be carried, every possible step was taken to reduce the weight of the equipment.

The expedition was to be transported to Spitsbergen on board the mail-ship *Pelikanen*, a small motor-vessel of 50 tons. In the summer she carried the mail between the Norwegian radio station at Grönfjorden and Tromsø. When the expedition reached Tromsø to board her, they were informed that the *Pelikanen* had already made two tours without having been able to reach Grönfjorden, owing to severe ice conditions.

The ship left Tromsø on July 1, as determined; but in the night towards the 3rd, she sprang a leak. The situation was judged to be so serious that the ship returned to Tromsø, where it emerged that the leakage was situated at the propeller shaft. After repair, the ship left Tromsø on July 7. The course was set east of Björnöya, but ice was met with in the evening of July 9. A plan to visit the island of Hopen had to be given up. Here the ice was densely packed and a few large icebergs of table type were seen.

The *Pelikanen*, which also carried mail for sealing vessels, now followed the ice-edge, which stretched towards the west or the south-west. A new leak was noticed, but its position in the ship could not be found, and the matter was left at that. For a day and night she proceeded on the same course in a dense fog, which caused much trouble. In the evening they were near Björnöya according to dead reckoning, but the fog did not make any orientation possible, until sud-

denly the fog dissolved—and there was Björnöya surrounded by ice. They rounded the south point and set the course along the ice-edge, which now stretched north-west.

On the morning of the 11th, all hands were called on deck. The leak had increased and there was a risk that the ship could not be kept afloat. The pump worked, and with buckets and pots everybody tried to do his share. The leak was found—under the motor, the packing tow between two planks had been pressed into the ship by the water pressure. Repair was out of the question, and there was nothing to do but prevent the damage from becoming worse.

They hoped to reach land as soon as possible, but along the Spitsbergen west coast extended a belt of ice some 12–15 nautical miles wide, ruling out an approach at Hornsund, Bellsund and Isfjorden. The weather, however, was fine and a calm prevailed.

Off the mouth of Isfjorden, the ice situation was like that farther south along the coast, but to the north of the mouth extended a tongue of ice in a westerly direction. The ice was scattered and the ship easily worked her way through the tongue, then followed its northerly edge until Prins Karls Forland was almost reached off Forlandssletta, where only a belt of ice about 1 km broad blocked the coast.

The crew was gripped by pessimism, which had gradually increased in intensity. They were intent upon returning to Norway immediately. The store of provisions was beginning to run out, and it appeared that every man had provisions of his own; the company did not bother about that.

The ice was moving rapidly northwards, and the tongue of ice threatened to cut off their retreat to open water. They could either try to proceed to Kongsfjorden and await an improvement in the ice situation, or else return to Norway. They chose to proceed along the western side of Prins Karls Forland to its north point, Fuglehuken, where fog was met with. But the ice was scattered here, and for a day and night they roved about in it.

When the fog dissolved, they found that the mountain they had taken for Alkhornet at the northern side of the mouth of Isfjorden was in reality Salpynten (Sörhuken), the south point of Prins Karls Forland. They were in the midst of the drift-ice, and for a couple of days they tried in vain to steer into Isfjorden. Finally, on July 17, they were able to approach Daudmannsöyra on July 17; but the ship was now caught in very heavy ice.

Next day the situation improved, and luck was at last in their favour: they discovered a steamer proceeding with good speed on the southern side of the mouth, which indicated good ice conditions. The

motor was started, and already after about one hour they had reached scattered ice; on July 18, Grönfjorden was reached. Next day the *Pelikanen* left for Norway. It had been impossible to obtain any provisions here, and the captain dared not enter Isfjorden under such conditions. The expedition was forced to stay at Grönfjorden and to live in hope.

On July 24 they sighted a ship belonging to Director Karl Meyer who, a few days before the arrival of the expedition, had managed to reach his coal fields at Adventfjorden. Thanks to his courtesy, the expedition reached Sassenfjorden on July 26. With a delay of a few hours, they would not have done so, as a strong westerly wind then pushed the ice into the fjord. During the rest of their stay, Sassenfjorden was covered by compact ice as far as the eye could see.

It was now late in the season and the original expedition programme could not be realized. There remained nothing but collecting as many valuable fossils as possible—stegocephalia and ganoid fish. The work was continued on Stensiöfjellet, which was rich in fossils of Triassic vertebrates and well known from the expedition of 1913. They also worked on Wallenbergfjellet, where the collecting was less profitable.

In the middle of August, the ice situation was still unchanged, and new ice had now started to form. The situation was somewhat critical. Thoughts of a wintering did not seem unrealistic. The expedition was not equipped for such a contingency. On their visits to the coast they had met two Norwegian hunters, including the legendary Hilmar Nöis. These, too, were beginning to consider a wintering, but were supplied with food for another year.

Before taking any action, they had to contact the Arctic Coal Company at Adventfjorden concerning the store of provisions. The information they received was not entirely agreeable. To this was added the fact that the cold weather continued, and the ice-floes in the fjord were becoming fixed to each other by the freezing of the water.

However, the weather situation changed: the wind became easterly and increased to a full gale. The masses of ice were driven out to sea, and several colliers could reach Adventfjorden. It was impossible to return to Sassenfjorden and fetch their store of fossils, but this was fetched by a vessel belonging to the hunter Daniel Nöis. The mining company offered the expedition a passage to Norway on one of the colliers. They arrived at Tromsø on September 2.

The expedition of 1916

The next enterprise consisted of Erik Stensiö, its leader, and two others: Erik Lundström, a research assistant, and Axel A:son Stensiö, an undergraduate.

The party travelled with the expedition which had been dispatched by Aktiebolaget Isfjorden-Bellsund to investigate the occurrence of coal. Owing to unfavourable weather and ice conditions, the expedition did not reach its field of research, Sassendalen, until August 8, and the stay here was reduced to only 10 days.

The main camp of the expedition was pitched below Marmierfjellet, and farther into the valley a depot was established. The eastern and southern sides of Trehögdene (Tridentfjellet) and Milne Edwardsfjellet with the valley in between, as well as lateral valleys, were investigated. The work was concentrated on the lowest fossil-bearing layer, the so-called fish stratum.

With this expedition, practically all of the Triassic formations in the entire Isfjorden region had now been studied, at least with regard to the fish stratum. Remaining strata had not been followed so carefully, due to lack of time and to difficulties of access. Besides the vertebrate-bearing strata found by Bertil Högbom in 1909, another two strata had been found by Stensiö's expeditions—one in the sandstones above the vegetation limit on Lundbohmfjellet at Sveaneset west of Ekmanfjorden, and the other in the form of a bone-bed in the north-western corner of Vikinghögdä (Hamilton's Berg) in Sassendalen, 18 metres above the fish stratum. Similar thin strata in the form of bone-beds occur at several places, indicated by loose boulders.

Until then, the Triassic formation of Spitsbergen had yielded a total of some 50 species of vertebrates, including about 30 of fish. The rest of the fauna consists of stegocephalia, ichthyosaurs, and plesiosaurs—the latter represented, though, only by fragments of vertebrae. As for the fish fauna, it generally has a considerably older character than, for instance, the Triassic fauna in Tessin, Lombardy and the Tyrol.

Stensiö spent the last week of August at the Swedish coal-field at Braganzavågen in Bellsund. Illness impeded the work considerably, so that only a few excursions could be made. These went to Kjellströmdalen, where a coal-seam belonging to the Jurassic formation was found in a brook's intersection near the bottom of the valley. To judge from its position, this seam is probably equivalent to the Jurassic seam at Adventfjorden. One stratum with plants, among others the ginkgo, was found by the technologist Norin in the Tertiary formation under the large coal-seam at Braganzavågen.

The last week of the stay in Spitsbergen was devoted to studies of the geology in the neighbourhood of Pyramiden at Billefjorden. Beautiful collections were obtained from Mimerdalen, and especially

Nathorst's fish-cleft supplied some interesting fossils. There was a well-preserved part of a cranium of a large fish belonging to the crossopterygians—and also remains of carapace fishes, several of which seem to have giant forms within their respective groups.

In the Kulm formation on Pyramiden, a new fossil-bearing stratum was discovered, with remains of plants and with scales of palaeoniscoid fishes. During an excursion to De Geerfjellet on the north side of Nordenskiöldbreen, they found under the gypsum—which Nathorst had referred to as “a more than 250 m thick stratum of white gypsum at the inner end of Billefjorden”—a stratum with fossils of brachiopodians and gastropodians, which could be of help in determining the age.

Spitsbergen was left behind on September 22, and after three days with a violent northerly gale the expedition reached Norway.

The expedition of Per Thorslund in 1929

This venture was more substantial than the preceding ones.

THE EXPEDITION CONSISTED OF THE FOLLOWING MEMBERS:

Per Axel Thorslund (1900–81), M.Sc., palaeontologist, leader of the expedition.

Backa Erik Eriksson (1905–58), undergraduate.

Gustaf Sigurd Hoffman (b. 1903), undergraduate.

Per Evert Peterson, undergraduate.

Gustav Westström, undergraduate.

Carl Zetterlund, undergraduate.

The expedition left Uppsala on July 4 and arrived by collier at Adventfjorden on July 12. A motorboat had been hired at Tromsø, and with its help the expedition was transported to Sassendalen, where a main camp was pitched on the shore to the east of the delta in Flowerdalen.

From the camp, four men marched along the southern side of Sassendalen to Milne Edwardsfjellet. A depot with a tent for two was laid up at Trehögdene (Tridentfjellet). From their camp at Milne Edwardsfjellet, they carried out excursions on this mountain and on Wallenbergfjellet, and the profitable fish stratum was searched for long distances. Fossils were also collected from the lower saurian stratum, although here it is poor in well-preserved fossils. The finds were carried down by groups of two men to the main camp at Sassenfjorden. In exchange for fossils, the rucksacks were filled with provisions for continued work along Sassendalen and Fulmardalen.

One of the principal aims of the expedition was to collect remains of an interesting marine reptile which Professor Wiman had described a year earlier: *Grippia*

longirostris. Only a piece—a cranium—had been found in 1927 at Agardhfjellet at Storfjorden, by a German expedition under Professor Gripp from Hamburg. As its position in the Triassic strata was not determined, and as this fossil had not been found during the excursions in Sassendalen, Thorslund and Backa Eriksson made a trip to Agardhfjellet along Fulmardalen and across Elfenbeinbreen. They found the *Grippia* stratum and were able to ascertain its position between the fish stratum and the lower saurian strata.

A number of invertebrate fossils were also collected in the same stratum, as well as remains of fish and a labyrinthodont. Interesting geological observations were made—foldings and overthrusts of the Triassic strata in the eastern part of Agardhfjellet—but fog and cold weather (-2°C) made any detailed studies impossible. They were at last forced to undertake the return march across Elfenbeinbreen, in dense fog and strong winds with snow. After a rapid march they reached the camp at Milne Edwardsfjellet on August 18.

With this tour finished, the work in Sassendalen was completed for the time being. Thanks to the inconsiderable amount of snow-precipitation in Sassendalen during the previous winter and the relatively low summer temperature, the amount of water in the rivers was slight, and the men were able to march dry-shod on all excursions.

Two members carried out zoological investigations in Sassenfjorden. Owing to severe ice conditions and troubles with the boat motor, this part of the expedition programme was less satisfactory.

The difficult ice conditions, which had delayed the departure from Uppsala, continued during the latter part of August, and the men experienced some difficulties when they were leaving Spitsbergen for home—first in coming to Adventfjorden with their motorboat, and then during the passage with a collier through the ice barrier at the fjord mouth. They left Spitsbergen on August 27.

The ice conditions in Svalbard had not been so severe since 1915. The temperature had been relatively low, it had rained, and snow had fallen.

The expedition of 1930 under Torsten Svensson

Like the previous ventures in 1912–29, this expedition was dispatched by the Department of Palaeontology of Uppsala University. The main target of past studies was the Triassic formation at or near Sassendalen, though in 1929 Thorslund and Backa Eriksson had penetrated eastward to the region of Agardhfjellet at Storfjorden.

The present enterprise aimed to investigate the Triassic formation on the east coast of central Spitsbergen.

THE EXPEDITION HAD THREE PARTICIPANTS:
 Torsten Svensson, palaeontologist, leader.
 Ragnar Fendin, undergraduate.
 Lars-Erik Floberg, undergraduate (medical student).

It would have been an advantage if the expedition had come to the research area, north of Agardhbukta, on board a hired sealer. However, this was prevented by the economy. Instead it was necessary to go by collier to Adventfjorden, from there with a boat to the bottom of Tempelfjorden, and finally by sledge eastward over the glaciers.

The expedition left Uppsala on June 12 in order to catch a collier at Oslo, which arrived at Longyearbyen on June 21. Here they had to wait for five days before a suitable boat could be placed at their disposal, but the time was useful for arranging their equipment in good field packs.

On June 26 the expedition left Adventfjorden with a vessel which had been hired from the "sysselman", Mr. Thordsen. The course was set for von Postbreen at the bottom of Tempelfjorden. There was no ice, and they entertained hopes of reaching the glacier already the same day. But coming into Tempelfjorden they found that the ice still lingered in the inner part of the fjord. Two attempts to enter the ice failed, so they had to land on the south side of the fjord and transport the equipment along the shore with the help of their sledge. This was feasible at first, but soon they had to begin carrying their possessions.

When they at last reached the glacier, they found to their disappointment that it was impossible to climb the front, which was vertical and 40-50 m high, and filled with crevasses. There was nothing to do but continue the hard march towards a point where they expected that the glacier and an old lateral moraine would meet. The passage over and along the moraine was very hard and disagreeable, to say the least.

But they proceeded upwards, and after 15 hours of hard toil they had got their equipment of 400 kg to a point from where it could be hoisted up onto the glacier. Their first camp was pitched on a little plateau about 1 km from where they had started the climb. Next day they were awakened by a strange roaring sound, and found that the depression where they had toiled was now filled with a large rushing river.

Von Postbreen was crossed in its lower and middle part by a great number of large crevasses. Most of these were 3-4 m wide and had depths of perhaps a few hundred metres. The crevasses were mostly covered with relatively thin snow bridges, and great care had to be exercised when passing them. One man had to march in advance and investigate the surface with a staff. However, on one occasion the sledge was on

the point of falling down into a crevass. The skis could not be used during the first days, and the loads often had to be relayed by traversing the same distance several times, owing to the steep slope. The day's march was therefore short.

On the sixth day, July 2, the expedition passed the highest point, 800 m a.s.l., on the route to Storfjorden. Here they got to know the fog, a nuisance of the polar regions. On the first day they did nothing, but on the second, they chanced it and steered downhill towards Hayesbreen. At a breakneck speed they descended for about a kilometre. Then the terrain became somewhat more level. The compass was their guide. It was an adventurous tour into vast unknown expanses.

During the next few days the weather improved. They could make marches of 10 km at most, with the sledge fully loaded. Hayesbreen was not so crevassed as Von Postbreen, but instead they had to cross a number of broad watercourses in its lower reaches. Some of these were impossible to wade across, and had to be either followed until the water disappeared into some ice tunnel, or else passed upon insecure snow bridges.

On July 5 the expedition reached Kroghfjellet at Mohnbukta. This mountain was steep, inaccessible and largely covered by snow and ice. It was thus impossible to carry out any continuous stratigraphic investigations. Where bare rock was seen, it proved to be a greyish-yellow sandstone, poor in fossils and with great probability belonging to the Triassic formation. Only a few inconsiderable invertebrate fossils were collected.

Their intention was to continue towards the south along the coast to Dunérbukta, but an enormous river blocked the way and forced them to turn back. The only possibility was apparently to "feel" their way along some glacier leading towards the interior of the country. Long reconnaissance tours showed Königsbergbreen to offer the only passable route, so again they had to set about glacier climbing. After three days they reached the crest between the Königsberg and Rabot glaciers. On a snow-free mountain between the two main arms of the latter glacier, they placed a depot with provisions and fuel. Then they set off in the direction where Dunérbukta was estimated to lie.

The terrain was becoming more flat but, as the maps of these interior areas were unreliable, they had to make long reconnaissance tours. The fog was now also a persistent companion. Having taken some large turns in order to avoid the largest rivers of Usherbreen, they arrived on July 9 at the northern lateral moraine of Ulvebreen, where they pitched their camp about 1 km from Dunérbukta. For three days they were

occupied with investigations of the mountain north of the bay.

First they tried to reach the bay via the southern side of the mountain. This proved to be impossible, as the mountain was steep here and covered with ice, and it was separated from the glacier by a river at least 100 m wide. They then decided to climb the mountain and find a way of getting down to the sea. They found none, but Svensson managed to climb down a cleft and descend so far that he was able to observe the stratification to the foot of the mountain.

The crest of the mountain was almost entirely covered with dolerite, and the strata fell steeply towards the north. About 100 m to the north of the place where the profile was taken, the contact surface between the Triassic and the Jurassic was roughly 50 m lower, and farthest to the north it had almost sunk to sea level. In the Jurassic strata they collected a number of beautiful invertebrate fossils, especially ammonites. Also at the moraine they obtained fossils. Here the stone material was mostly from the Carboniferous and the Triassic, but otherwise rather mixed. At one place even some pieces of granite were found.

During the stay of the expedition at Dunérbukta, the ice broke up on Storfjorden. They also witnessed another natural event there. On the glacier below their camp was a lake some 400 m long and 200 m broad; the outlet was the gigantic river mentioned above. One day, as if by a stroke of magic, the lake and river disappeared. Apparently the water had made its way downwards through some crack in the ice. This occurrence suited the expedition well. Instead of making a long detour towards the west, they could now traverse the previous lake bottom with dry feet and without reloading.

From Dunérbukta they sledged southward to the mountains at the inner part of Agardhbukta. Here they found Jurassic strata having the same appearance and containing the same fossils as the strata they had just left. No fossils were collected from this place. Their goal was still the strata of the Triassic formation in the Agardh Range, a series of mountains immediately to the east of Elfenbeinbreen. But to get there, they had to make a detour westward, pull the sledge up along a steep slope, pass a crest at 600 m and descend on the soaked ice of Elfenbeinbreen. This march was one of the most laborious and time-consuming of the whole expedition. Not until July 15 did they reach their destination.

Agardh Range is the edge of a plateau which is divided by transverse valleys into a number of independent mountains. The three most westerly mountains consist exclusively of the Triassic formation; in the fourth mountain the Triassic strata dive below the

Jurassic ones. The stratification in the middle Triassic mountain was studied.

According to previous investigations, a stratum here was supposedly characterized by the reptile *Grippia longirostris*, which we have mentioned in connection with the expedition of 1929. But whether the species is restricted to this stratum could not be established by the present party. Owing to lack of time, they could not stay for more than two days at the Agardh Range. In spite of that, a rather considerable number of fossils was collected. Unfortunately only a small part of it could be brought home—invertebrates, light plants and concretions with invertebrate fossils. The rest was laid up in a depot to be fetched by some future expedition.

On July 18 the expedition started for home with a heavily loaded sledge. The course was set northward up along Elfenbeinbreen towards the depot near Rabotbreen. The tour home can be described as wet and laborious. The glacier was wet, and for three days they were restricted to their tent because of a dense fog. Here the tent got wet and their clothes drenched—and provisions were now running low. When the fog at last lifted, they sped up their pace to the utmost, firmly resolved not to rest until they had reached the depot near Rabotbreen. They arrived after 24 hours of continuous marching.

On July 26 they were to be fetched at Tempelfjorden. Only four days remained now. They would have to take a short cut towards the north-west, passing through an incompletely mapped region via a lateral glacier to Von Postbreen, namely Maritbreen (Marien-Gletscher). But conditions proved better than they had expected, or encountered on the outward tour. Instead of the wet snow on the glaciers, there was ice—though full of holes—and the crevasses could be seen.

They reached Tempelfjorden on July 25, one day earlier than agreed upon. They went by collier to Narvik and arrived in Uppsala on August 1. It may be of some interest to note a few comments from the leader of the expedition, Torsten Svensson:

“That our expedition, in spite of unfavourable weather conditions, managed to carry through its programme certainly depends to a great extent upon the solid and, for the conditions in Spitsbergen, well-adapted equipment.”

The expedition had obtained valuable help in these matters from the director of Norges Svalbard- og Ishavs-undersøkelser, Dr. Adolf Hoel.

Finally, Torsten Svensson makes the following comment:

"I only wish to call attention to the fact that a sledge expedition across the glaciers is too difficult a way of reaching the east coast; it takes too long and offers too small possibilities for carrying collected material in addition to the necessary equipment. A future expedition would probably gain both time and security by using a ship which has been hired for the *whole* time."

Erik Stensiö and international co-operation

After his Spitsbergen expeditions in 1912-18, Erik Stensiö devoted himself to study of the rich material. In 1921 he disputed for his doctoral degree, and in the same year he was appointed lecturer (docent) at Uppsala University. In 1923 he became professor and head of the Palaeozoological Section of the Swedish Museum of Natural History, where he remained until 1959, when he retired.

Stensiö specialized in fossil fishes, notably from the Triassic and the Devonian formations. In 1926 he was asked by the Danish geologist and polar traveller Lauge Koch to co-operate in the Danish geological investigations in East Greenland, which had then started. This co-operation became close, and included both scientists and technical workers from the Palaeozoological Section (see Chapt. 37).

The early Swedish expeditions until 1898 had discovered and investigated the fossil-bearing Devonian strata in the fjords on the north coast of Spitsbergen and in the Isfjorden region. However, the many Norwegian expeditions of 1906-27 (see p. 399) brought great amounts of fossils, which exceeded the Swedish collections. Stensiö was offered the excellent *Cephalaspidea* material for study, and in 1927 he published his classic work on the *Cephalaspidea* of Spitsbergen.

THE BRITISH-NORWEGIAN-SWEDISH PALAEONTOLOGICAL EXPEDITION TO SPITSBERGEN IN 1939

Meanwhile the idea of a purely palaeontological expedition had matured in Stensiö, now with the principal aim of collecting Devonian vertebrates. These plans led in 1939 to a British-Norwegian-Swedish Spitsbergen expedition with three leaders: Dr. E. White, British Museum (Natural History), London; Professor A. Heintz, Palaeontological Museum, Oslo; and Professor E. Stensiö, Stockholm, the latter being the head of the expedition. The expedition had twelve members, among them the Swede Erik Jarvik (b. 1907), who took part in the Danish geological investigations in East Greenland from 1932 until 1956 (see p. 399).

With the hired ship *Heimen* of Tromsö, the Isfjorden

region and the Spitsbergen north coast with fjords were visited. The geologists worked in three groups, each consisting of four men. They were landed at suitable places by the motor-boats of the ship, and in the evening they were fetched again with the material they had collected during the day. It was valuable to discuss and scrutinize the day's harvest of fossils, which was laid out each evening upon the deck of the ship for labeling.

However, in the middle of August the British members had to leave the expedition because of the tense political situation. When the *Heimen* on September 1 reached Tromsö, World War II had broken out. The collections will be discussed in connection with the Danish investigations in Greenland (see Chapt. 37).

THE FRENCH PALAEONTOLOGICAL EXPEDITION TO SPITSBERGEN IN 1969

Another group visited Spitsbergen in 1969 under the leadership of J.-P. Lehman from Paris. Erik Jarvik was invited to take part in the enterprise, which worked along the lines of the expedition of 1939, although the equipment was now much more technical and allowed the group to work more effectively. From the shipping company of Jacobsen, Tromsö, a larger ship was hired. For communication with the ship and with the areas of research, two helicopters were used. Again there were twelve specialists for collecting the fossils of Devonian vertebrates.

A breakdown of the ship's engine near Björnöya delayed the expedition. The ship had to be exchanged for another vessel, the *Norsel*, known among other things from the Norwegian-British-Swedish Antarctic Expedition in 1949-52. She left for Spitsbergen on July 15, and reached Woodfjorden in northern Spitsbergen on July 20.

The new way of working was effective and comfortable. The four groups of palaeontologists were transported to their respective areas of research by the two helicopters, with necessary camping equipment, and after two hours they were all at their respective places. There was no slavery with rock-filled rucksacks as in the past. One had only to contact the ship over the radio and ask for a helicopter, and the day's fossil harvest was soon on board.

The expedition worked for three weeks on the north coast, and then moved to Isfjorden. There half the force of palaeontologists worked in the Triassic mountains in Sassendalen, where Stensiö had toiled in 1912-18. The collection of fossils which Stensiö had been forced to leave in the inner part of the valley at the time could now be fetched by a helicopter. The French expedition reached Tromsö on September 3-

with 20 tons of fossils, against 1 ton from the expedition of 1939.

The research work of Stensiö and his co-workers is further treated in Chapt. 37.

THE GEOLOGICAL EXPEDITIONS OF TOR HAGERMAN IN 1920 AND 1924

The young geologist Tor H. Hagerman (1899-1986) carried out geological research during 1920 and 1924 in the neighbourhood of the Swedish mine Sveagruvan and eastwards into Kjellströmdalen. Hagerman was a university undergraduate at the time of his first expedition, and a B.Sc. during the second. Later he devoted himself to geological research in Argentina, practical geology and consulting activities.

Hagerman's Spitsbergen expedition of 1920

With the help of Gerard De Geer, Hagerman and an assistant were furnished with the opportunity of visiting the Bellsund and Isfjorden regions. Their task was primarily to establish the position of a coal seam which was supposed to exist, besides the seam where mining was going on. Luck was in their favour, and already one month after their arrival the new mine, Mine II, was opened (see p. 382).

Hagerman's expedition to Kjellströmdalen in 1924

The research area of this expedition extended from Van Mijenfjorden and Kjellströmdalen to Agadhdalen at Storfjorden.

THE MEMBERS WERE:

Tor H. Hagerman (1899-1986), B.Sc., geologist, leader of the expedition.

Fredrik Cöstr, B.Sc., doing studies in Quaternary geology.

T. Kjellberg, certified forester, responsible for geodetic measurements.

B. Strömberg, Master of Engineering, cartographer.

S. Bünzow, assistant.

The thick strata of sedimentary rocks which build up the tableland of southern Spitsbergen were deposited, during the Mesozoic and Tertiary, at the coasts of continents that have nowadays disappeared. Partly by investigating the increase and decrease in thickness of these strata, and partly by microscopic studies of corresponding rocks, it should be possible to determine the position of the old continents.

The aim of the expedition was to help solve this problem with stratigraphic measurements, sedimentary and petrographic collecting of specimens. At the same time, investigations into the tectonics of the region were carried out. It emerged that Tertiary strata had a considerably smaller extension east of

Braganzavågen than had previously been assumed.

The valleys of Spitsbergen are extremely difficult to pass in the summer, because of the great amount of meltwater which then have to flow through them. It may thus be of some interest to know that the expedition managed to navigate Kjellström River up to Päljöbreen with the help of a shallow-draught boat. In the autumn, when the worst flooding declines, it is probably possible to follow the deep-furrow as far as Lundströmdalen.

As the region was only partly mapped, the expedition had to procure the fixed points which were needed for the survey work. Therefore Lundström established a small triangulation network in Kjellströmdalen and Lundströmdalen.

The Quaternary development of the region was studied by Cöster. He noticed that most of the investigated glaciers were in a state of regression or, at most, were stationary. In Kjellströmdalen, the men found Quaternary formations of different kinds, related to the postglacial subsidence of the earth's crust as well as to a period with ice-dammed lakes.

The expedition had left Sweden at the end of June and returned in the last days of October. Judged by normal Spitsbergen conditions, the weather had been favourable. Only for a short period—in the beginning of August—did a rainy period prevail.

ANDERS RAPP'S EXPEDITION TO TEMPELFJORDEN IN 1954

In 1954 Anders Rapp, a student of physical geography at Uppsala University, led an expedition of four members to Spitsbergen.

THE MEMBERS WERE:

Bror Anders Edvin Rapp (b. 1927), M.Sc., physical geographer, leader of the expedition.

Karl Åke Holm (1909-89), Ph.D., zoologist (expert on spiders).

Tage Roos, B.Sc., zoologist (entomologist).

Hans-Erik Dahl, Norwegian, assistant.

Rapp was a geomorphologist, and he intended to do geomorphological studies of the denudation of slopes in an arctic environment—specifically the mountain *Templet* in the Isfjorden region, where talus slopes and mountain cliffs would be investigated.

The two biologists wanted to acquire collections of the spider and insect fauna at Tempelfjorden. They were also interested in ecological studies, and wished to use modern thermometric equipment to elucidate the living conditions which the climate at and near the soil offered to the lower fauna in Spitsbergen.

The expedition travelled by passenger ship to Longyearbyen. Passage to the research area was made

on board the official ship *Nordsyssel* of the "sysselman" of Svalbard. They arrived in Bjonahamna near Templet on July 9. Here were a few huts belonging to the Norwegian hunter Hilmar Nöis, and these were to be the headquarters of the expedition.

Rapp gives a vivid and clear description of the mountain Templet:

"It looked like the ruin of a gigantic building, with long talus slopes between the pinnacles and the towers, which shimmered in grey, sandy yellow and rust-red below the white roof of snow on the plateau on top... On both sides of the fjord the plateau mountains rise with steep walls. They are built up of rocks of the Carboniferous formation. The strata are practically undisturbed and have a very slight slope towards the south. The plateau on top of Templet reaches a height of about 500 m a.s.l.. The lower parts of the cliff faces are entirely covered by talus mantles.

The visible upper part of the cliff face is hollowed out and is formed with marvellous regularity by the forces of denudation. The step morphology is found throughout. It is conditioned by the fact that hard strata alternate with looser ones. At the bottom of the visible cliff face lie a series of limestones, alternating with several strata of gypsum. Above follows a steep wall of spirifer limestone, which is very rich in fossils; and above this layer is a series of small steps, with thin strata of sandstone, which lie like protecting roofs over limestone which decomposes more easily. On top of Templet along the edge of the plateau, one can see regular rows of limestone pillars with blocks of sandstone as a protecting roof-tile on top.

The erosion furrows begin high up at the plateau edge as a series of vertical cracks at relatively regular distances from each other. The erosion furrows—small to begin with—converge downward and break through underlying hard strata at a common point. This is repeated, step after step. In this way a series of funnels are formed, which become larger and deeper the farther down one comes in the wall. The lowest, niche-formed funnel has a smooth, often semicircular rear wall of spirifer limestone. Part of the stone material from the walls will remain in the bottom of the funnels, part continues downward and gives rise to the proper, dome-shaped talus formation. As the talus accumulation in the funnel is connected with the rest of it, the whole formation assumes the appearance of an hourglass."

The study of these talus formations was an important part of the expedition's programme in physical geography.

Rapp found that the transition towards the shore terrace was sharp. The terrace was strewn with blocks, which had fallen down from the mountain. However, the rock-slides seem to be a fairly rare occurrence. The expedition had opportunities to compare photographs which had been taken by Swedish and Norwegian expeditions since the Nathorst-De Geer expedition of 1882—in 1882, 1896, 1908, 1924, 1936, and finally Rapp's photographs of 1954. The comparisons showed little or no evidence of transportation in the cones, nor any development of the vegetation patches. Impact holes from falling boulders have remained unchanged, boulders can be recognized, and so on.

The work consisted of measuring heights, slope angles and depth to the frozen layer of the talus cones. A great many photographs were taken, both with and without colour. Further, a sunken beach spit was observed in Bjonahamna, which seems to indicate a land sinking of some 4–5 m in postglacial times.

The expedition stayed at Tempelfjorden for 24 days, from July 9 until August 2, and during this time meteorological observations were carried out. The weather was unsettled during their stay in Tempelfjorden; it was mostly overcast and the winds were strong, directed along the fjord from the north-east or south-west. The five last days of their stay were characterized by fine weather, with sunny days and nights as well as light winds.

They did not sleep much during that time, which was spent on excursions in the surrounding country: to Gåsøyane, Gipsvika and Gipsdalen. Their two last days were devoted to the southern side of the fjord. Here Holm climbed Marmierfjellet (709 m a.s.l.) and collected material for a study of the variation with height of the spider fauna. Roos visited lagoons of the Sassenelva in order to hunt water insects. Rapp observed talus slopes and mountain walls at Tejstfjellet.

On August 2 the *Nordsyssel* came to fetch the expedition. They left Longyearbyen on board the *Lyngen*, the passenger steamer running between Tromsø and Spitsbergen. A short, successful, expedition was ended.

SOVEREIGNTY OVER SVALBARD

In 1872, a Swedish company had been founded to mine the phosphorite at Kapp Thorsden for fertilizers. Already that summer, personnel and equipment were transported to Kapp Thorsden in order to establish a colony there and start the mining (see p. 73). As we have seen, the plans were given up, and the expedition returned home after having built a house and a décauville track. A petition was submitted to the

Swedish Government, requesting legal proceedings for international protection of the establishment.

A consequence of this petition was that the minister for foreign affairs, Count Carl Wachtmeister, attempted to seize the opportunity to take possession of the whole of Spitsbergen on behalf of Sweden-Norway. For this purpose, necessary inquiries were made to those powers of Europe which might have claims in Spitsbergen. The answers were all favourable except the attitude of Russia. Here arose a lively press polemic, and the Russian Government decided to give a friendly answer in the negative. Spitsbergen therefore remained a *terra nullius*—no man's land.

In 1905 occurred the breach of the union between Sweden and Norway. Due to the lawlessness which was then prevailing in Spitsbergen—above all with private occupations for mining—it was considered that something had to be done. In February 1907 the Norwegian Government turned to the states which had been involved in the exchange of notes in 1872.

The result was a meeting in Kristiania (Oslo) on July 19, 1910, between representatives of Norway, Sweden and Russia. The conference worked for three weeks, resulting in a proposal on how to set things right in the archipelago. In short, an international commission with one representative and one deputy from each of the three states—Norway, Sweden, Russia—was to be the authority for administration and for law and order.

Objections were raised against the proposal—notably from USA—and led to a second conference between the three states of Norway, Sweden and Russia. This conference opened in Kristiania (Oslo) on January 15, 1912, and lasted ten days. When the revised proposal was sent, the committee asked if the date of the final conference could be fixed at June 15, but the conference did not meet on that date. The USA had handed in a separate proposal, and Germany wanted to have a close look at it. So the meeting was postponed indefinitely.

In brief, the American proposal was that the legislative authority should belong to an international commission of three members—with Norway, Sweden and Russia appointing one member each—but that these appointments should unanimously be approved by the signatory powers. The arguments for this proposal were that the persons appointed would act on behalf of the signatory powers and should thus be under their control.

Twelve days before the international conference on Spitsbergen was to meet, the delegates of Norway, Sweden and Russia assembled to consider the proposals which had been submitted, notably that from the USA. Nine states had sent delegates to the conference:

Norway, Sweden, Russia, Great Britain, France, Germany, the Netherlands and Denmark. The USA did not belong to the signatory powers. However, the powers could not come to an agreement, so the conference was postponed till February 1915. The meetings had then gone on for one month and a half, until the end of July 1914—and World War I was about to break out.

After the war, Norway found it most appropriate to hand over the problem to the peace conference at Versailles, which agreed to consider the question and to contribute a final solution. As a result, Norway was awarded the sovereignty of the archipelago in accordance with the Svalbard treaty of February 9, 1920. On August 14, 1925, Norway took over the sovereignty.

According to the treaty, Norway has full and unlimited sovereignty over Svalbard, with a few restrictions. All subjects of the treaty parties are entitled to practise economic activity in Svalbard and its territorial waters. Norway was not allowed to establish, or let other nations establish, naval bases or other types of fortifications in the region.

When Sweden in 1872 had tried to claim sovereignty over Spitsbergen, the comprehensive scientific research of Sweden in the area was emphasized. It is a remarkable fact that, although Norwegian sailors and hunters were experts in the polar regions and helped other nations visiting these regions, Norway for a long time possessed no scientists who went north or south—except the geologist B.M. Keilhau, who visited Spitsbergen in 1827. But in 1888, Fridtjof Nansen crossed the Greenland inland ice, and now came the many expeditions which made Norway a master of polar exploration.

With regard to Svalbard, the Norwegians began research work in earnest in 1906, and continued with one expedition each year, mainly under the leadership of the geologist Adolf Hoel (1879–1960). The expeditions, which are listed in Table p. 399, were mainly devoted to geology, mapping and oceanography. They may be viewed as a preparation for a Norwegian takeover of the Svalbard archipelago, analogous to the Swedish claims on the region by reference to the Swedish research in the area. The Norwegian research areas of 1906–26 are given in Fig. p. 392.

In 1926, Norges Svalbard- og Ishavs-Undersøkelser was founded with Adolf Hoel as director. In 1948 the name of this institute was changed to Norsk Polarinstitut, since the official interests of Norway in the polar regions were no longer restricted to Svalbard and adjacent seas. The director of the new institute was Harald Ulrik Sverdrup. With him, too, the geophysical sciences became part of the activities of the institute.

The mountain "Templet" at Bjonahamna, Tempelfjorden.
(Norsk Polarinstitutt: Skrifter Nr 119.)

The four-legged fish and the ancestors of man, see p. 401. (Swedish Museum of Natural History: Flora och Fauna 1969.)

The four-legged fish, studied by Erik Stensiö and his co-workers. (Swedish Museum of Natural History: Flora och Fauna 1969)

NORWEGIAN SPITSBERGEN EXPEDITIONS
1906–1926

Year	Leaders of expeditions
1906	Expedition equipped by Prince Albert of Monaco and conducted by G. Isachsen
1907	Expedition equipped by Prince Albert of Monaco and conducted by G. Isachsen
1908	A. Hoel
1909	G. Isachsen
1910	G. Isachsen
1911	A. Hoel and A. Staxrud
1912	A. Hoel and A. Staxrud
1913	A. Hoel and A. Staxrud
1914	A. Hoel and A. Staxrud
1915	A. Hoel
1916	A. Hoel
1917	A. Hoel and S. Rövig
1918	A. Hoel and S. Rövig
1919	A. Hoel
1920	A. Hoel
1921	A. Hoel
1922	A. Hoel
1923	A. Hoel
1924	A. Hoel
1925	A. Hoel
1926	A. Hoel

(Compare with Fig. p. 392.)

Source: Hoel, A., *The Norwegian Svalbard Expeditions, 1906–1926*, Oslo 1929.

37. FOSSIL HUNTING IN EAST GREENLAND 1929–1956

OSCAR KULLING, GUNNAR SÄVE-
SÖDERBERGH, ERIK JÄRVIK, GUSTAV
WÄNGSJÖ

*Lauge Koch and the Danish investigations in
East Greenland after 1929*

In 1925, Denmark founded an Eskimo colony at Scoresby Sound. Here in the central region of East Greenland, an uneventful period had passed since the visits of Nathorst, Kolthoff and Amdrup at the turn of the century. However, this state of affairs was to change.

The great Danish Greenland explorer Lauge Koch

(1892–1964) then used Scoresby Sound as a base for a geological and cartographic investigation of East Greenland. In the autumn of 1926, he made a sledge tour northward along the coast to Myggbukta near Hold-with-Hope and back. In the spring of 1927, he travelled as far as Danmarks Havn at the northern mouth of Dove Bugt. Remembering Nathorst's geological finds in 1899, Koch was looking for fossils among the snow-covered Devonian mountains—but in vain.

In 1929, Koch led a new expedition to the area, this time in the summer. Among its members was the Swedish geologist Oscar Kulling (1898–1988). His principal task was to search for Devonian fossils in the area where Nathorst had made his discoveries. Kulling was successful and in his search on the northern slopes of Celsius Bjerg situated on the eastern headland of Ymer Ö. In consequence, Koch telegraphed to the Swedish palaeozoologist Erik Stensiö (1891–1984) of the Swedish Museum of Natural History in Stockholm, inquiring whether he would take care of the material for study.

Such was the beginning of a very close co-operation between Lauge Koch and the Section of Palaeozoology at the Museum. The vertebrate palaeozoologists and technical personnel of the Museum became largely engaged in the hunt for Devonian fossils and their preservation. For 14 summers the Swedish specialists worked on the material, and every autumn new fossils arrived at the Section of Palaeozoology in Stockholm.

The scientific investigation of East Greenland was favoured by tension which had developed between Denmark and Norway, during the latter part of the 1920s, because of the increasing Norwegian hunting activity in the area. This reached a climax in 1931, when Norwegian hunters occupied East Greenland for Norway. However, in 1933 the International Court of Arbitration at the Hague declared East Greenland to be Danish—with some reservations. The Danish research in East Greenland went on.

In consequence of the occupation, Lauge Koch had been charged with the leadership of large scientific expeditions, which were supposed to work in the field for several years. Under such favourable economic auspices, the Danish Three-Year Expedition was started in 1931. At its disposal were the two ships *Gustav Holm* and *Godthaab*. The principal activity took place in the summers, but there was also wintering personnel at scientific stations, notably Eskimonæs and Ella Ö. The investigations were interdisciplinary, but the greatest weight was attached to mapping and geological research, including attempts at mining operations. Airplanes were used for mapping, recon-

naissance and transport.

The scientific staff included a young and highly skilled palaeozoologist from the Swedish Museum of Natural History in Stockholm, Gunnar Säve-Söderbergh (1910–1948), who was to work with the Danish palaeontologist Eigil Nielsen. They were to be assisted in their field work by assistants. In 1932 and 1933, one of these assistants was Torgny Säve-Söderbergh (b. 1914), a brother of Gunnar Säve-Söderbergh, and later to become professor of Egyptology at Uppsala University.

In the scientific staff was, further, the professor of geology with petrology and mineralogy at Uppsala University, Helge G. Backlund (1878–1958). He had been a member of the Russian Arc-of-Meridian expedition in 1899–1901, where his father, Oscar Backlund, held a leading position (see p. 336). Helge Backlund worked with the Three-Year Expedition in the summers of 1932, 1933 and 1934.

Gunnar Säve-Söderbergh worked in East Greenland during the five summers of 1931–36. At an age of only 27 years, he was appointed professor of geology, especially historic geology, at Uppsala University. But he contracted pulmonary tuberculosis in the same year (1937) and died in 1948.

The Swedish investigations in palaeozoology in East Greenland continued until 1956, now under Erik Jarvik (b. 1907), who was a curator of the Section of Palaeozoology in Stockholm. He was to become the successor of Erik Stensiö as professor and head of the section in the period 1960–73. Jarvik's work in Svalbard in 1939 and 1969 has been dealt with already (see p. 393).

Geological field work and laboratory work at home

The work in the field was more or less devoid of great happenings in the ordinary sense. It was a search for Devonian fossils in talus slopes or terraces, and these fossils do not occur in great numbers. Let us here cite Erik Jarvik:

“The precipitous mountains tower above this lowland. These mountains, reaching 1200–1600 m a.s.l., consist of strata of sandstone, mostly red, but sometimes grey or greenish... In the long run of time, large or small pieces of stone have come loose and form, together with the loose material, talus slopes and terraces. These formations are our most profitable hunting-grounds. Slowly and carefully, with eyes turned downward, we move in this infinite collection of stones in order to catch sight of some fossil, which is shining bluish-white against the red stone, not unlike the ‘visiting cards’ of birds.

But the richness in fossils is not overwhelming. Sometimes days may pass with only occasional finds, which with some hesitation are put into the rucksack, but now and again it happens that we come across richer habitats. The value of the finds, though, is random. It is like taking part in lotteries, where the blanks are many and the top prizes are as rare as in the State lottery. What we find are remains of armoured sharks and lobe-finned fish, or—more seldom—of lungfishes and the much-coveted four-legged fish. Not once did we find complete skeletons within the Upper Devonian of East Greenland. Nor did we find fossil invertebrates. And our fossil plants have not awakened any enthusiasm among palaeobotanists. It may seem monotonous to climb among the innumerable pieces and blocks of stone, day after day and for 8–10 hours in succession; but at the same time as one gets good exercise, there is ever the hope of finding something of value, perhaps the real ‘dream fossil’. We never found it, but each summer brought us rarities worth remembering...

We recall with pleasure the ‘saloon stegoccephalia’, a well-preserved head of *Ichthyostega*, which during our voyage home was honoured to rest upon a blue velvet cushion in the saloon of the *Gustav Holm*... We also remember the summer of 1948. It was then that we first found fairly connected remains of the body skeleton of *Ichthyostega*, among other things a tail with a well-preserved hind foot—the oldest known foot in the world. Unfortunately, Gunnar Säve-Söderbergh did not take part in this event. He had passed away in June the same year.

The summer of 1949, when Gustav Wängsjö was leader of the collecting, was also successful. It was now time to start the difficult preparation work in earnest. The fossils—it must be emphasized that these were real remains of skeletons with preserved histological structure, not simply mysterious petrifications—are embedded in a hard sandstone, which must be removed as much as possible. This was done with the help of the same equipment as the dentists use, but the drill was replaced by a gramophone needle which, in short and rapid knocks, removed grain after grain of the rock. This difficult and trying work was highly time-consuming: just to uncover the bones of the pelvis demanded several months, and a great number of gramophone needles, before a complete reconstruction of the skeleton of the *Ichthyostega* could be presented in 1955. It was really a kind of four-legged fish that Säve-

Söderbergh had found, or perhaps—to be more correct—a four-legged animal with a fish-tail.

In order to be able to place this remarkable animal in its zoological connection, we had to go to other hunting-grounds, in the first place to the well-known fossil locality at Scaumenac Bay in eastern Canada.

While Stensiö in 1922 was collecting fossils in this extremely rich habitat with strata, which are only slightly older than those we had now come to know in Greenland, he seized the opportunity to create such good relations, with some of the French-speaking families on the spot, that they promised to go on with the collecting. And so one day in 1925 there arrived a fossil at the Swedish Museum of Natural History which surpassed all expectations. It was an extremely well-preserved specimen of a lobe-finned fish of the family *Eusthenopteron*, belonging to the group osteolepiformes or frogfishes.

Stensiö, who obtained this unique find for a mere 50 Swedish crowns, did not hesitate to 'sacrifice' its head, which had been preserved in its natural form, for an investigation by the so-called grinding method, which he had just used to complete his work on the *Cephalaspidea*. The grinding of the head, which was some 10 cm long, took a total time of 6 years, but owing to many breaks it went on for 25 years. When it was finished, there existed more than 500 drawings of cross-sections, full of details. These could later be used for building instructive wax models. As the well-preserved interior skeleton of the body had also been uncovered at the same time with the help of mechanical preparation, we got from this single specimen so complete a knowledge of the build of a Devonian fish as it is on the whole possible to arrive at with the help of fossil material.

The four-legged fish and ancestors of man

With this material at hand, it was easy to verify Söve-Söderbergh's opinion on the close relation between the four-legged fish and the osteolepiformes; but it was also possible to show that the osteolepiformes include the ancestors of the main part of the four-legged animals, among them the frogs and the mammals and man. It was our own forefather or, in any case, a close relation that Stensiö had managed to come across.

The grinding series of *Eusthenopteron* have, however, also disclosed many primitive features, and some time ago the opinion was presented that the osteolepiformes are perhaps the most

primitive of all fishes, more primitive even than the cyclostomes. The fact that we originate from the fishes has probably become part of the public consciousness; but the idea that we might trace our origin from the most primitive mammals, and besides—despite evident differences in external appearance—be related to the frogs, is one of those thoughts which are more difficult to come to terms with.

The frogfish from Canada, slightly more than 350 million years old, and the slightly younger four-legged fish have no doubt contributed to throwing new light on the question of the genesis of the four-legged animals, but they have not given us the *whole* solution of this intricate problem. We shall have to go to older series of strata—to the Lower Devonian strata in Spitsbergen."

In 1939 Erik Stensiö was one of the three co-leaders of a British-Norwegian-Swedish expedition to Spitsbergen (see p. 393). Again we cite Erik Jarvik:

"Among the rich material from 1939 were some parts of the snout of a lobe-finned fish, *Porolepis*. When studying these parts, and similar material which had been brought home by previous Norwegian expeditions, it emerged surprisingly that *Porolepis* differs fundamentally from the frogfish of Scaumenac Bay (*Eusthenopteron*). Since at the same time it was evident that *Porolepis*, in its snout anatomy, shows an astonishing correspondence with the tail batrachians or urodelians (newts, salamanders), while *Eusthenopteron* just as unequivocally connects with the tailless batrachians or anurians (frogs and toads), there remained the sole reasonable conclusion that the four-legged animals must be diphyletic: they have developed from two different groups of fish, the urodelians from porolepiformes (salamander-fishes) and the anurians (and other four-legged animals) from osteolepiformes (frogfishes)", see Fig. p. 398.

GEOPHYSICISTS AND AIRMEN 1910–1931

38. THE ARCTIC TRAVELS OF FINN MALMGREN

A SHORT REVIEW OF FINN MALMGREN'S LIFE

Finn Malmgren (1895–1928) was a meteorologist and an oceanographer. His active years as a scientist occurred at a time when no major polar expeditions were dispatched from Sweden (see p. 481). He carried out his scientific research as a member of non-Swedish expeditions. In spite of that, his career as a polar scientist was straight and direct, one step leading to the next, until the end at an age of 33 years in connection with a polar tragedy which stirred the world.

Malmgren studied at Uppsala University, and his long travels did not dissuade him from continuing to work there. In 1916 he received his B.Sc. and, having grown tired of bookish learning, he seized the opportunity in 1917 when Professor Axel Hamberg requested meteorological observers for the observatory on Pärtetjåkkå in the Sarek region of Swedish Lapland. Hamberg wanted to have young physicists for the two posts of “observer” and “assistant”, the former standing for the head of the observatory. Malmgren’s decision to apply for one of the two posts was to decide the course of his life and his future scientific activity—but also his ultimate fate.

Here is a summary of main events in Malmgren’s career:

- 1912–16 Undergraduate at Uppsala University.
- 1916 B.Sc. (mathematics, physics, chemistry).
- 1917–18 Observer at the meteorological observatory on Pärtetjåkkå (1835 m a.s.l., 67°09'N, 17°38'E).
- 1919–20 Studies at Uppsala University; he passes his M.Sc. examination.
- 1920–21 Assistant at the Meteorological Department of Uppsala University.
- 1921–22 Assistant at Bornö oceanographical station in Gullmarsfjorden in south-western Sweden.
- 1922–25 Assistant scientist on the Norwegian North Polar Expedition with the *Maud* during her drift in the Polar Sea.
- 1926 Meteorologist to the Norwegian expedition with the dirigible *Norge* on her flight across the Polar Sea via the North Pole.
- 1927 Ph.D. in meteorology, with a thesis entitled *On the Properties of Sea-Ice*; lecturer in meteorology at Uppsala University.
- 1928 Meteorologist on the Italian expedition with the dirigible *Italia*, flying over the Polar Sea towards Severnaya Zemlya and to the North Pole. The

Italia crashed on the ice to the north of Nord-austlandet.

June 1928 Malmgren died in an effort to find help for his expedition companions on the ice.

A meteorological observer in Swedish Lapland

Finn Malmgren had been especially fascinated by his studies in chemistry, and planned to continue them. However, at the beginning of January 1917 his father died. This was a hard blow to Finn and caused him a slight ailment of the heart. At the same time, he now felt free and did not want to go back yet to Uppsala. Thus he was grateful to Professor Axel Hamberg for an offer to become assistant for a year at the meteorological observatory on Pärtetjåkkå in Swedish Lapland. He needed to take a pause in his studies, and one year’s stay on a mountaintop seemed to him most promising.

He had never before visited the mountains in the north of Sweden. The experience made a deep impression on him. It was an entirely new world that opened up, and the scientist within him enjoyed the privilege of living among nature’s phenomena, which he had come to study. From now on the path of his life was determined; great adventures and enterprises would befall him, almost without his own doing.

The observatory on Pärtetjåkkå and the work there have already been described in fair detail (see p. 314). The two observers lived a life in isolation and privation under the simplest possible conditions, due partly to the rationing during World War I, and partly to the means of communication with the outer world: a man carried provisions and fuel up to the observatory from the village of Kvikkjokk, 33 km away.

The work on the mountain was demanding and gave few opportunities for leisure. There was an almost continuous fight against nature’s forces: high winds, drifting snow, fog, rime formations, cold and darkness.

Early in his stay on Pärtetjåkkå, Malmgren’s companion Manne Hofling died in an attempt to bring provisions up to the mountain from the lower observatory at Pårek, when the carrier failed to do so. Meanwhile Malmgren had to do the observations with one day’s provisions left, and fainted from exhaustion; finally he had to go down to Pårek, and then to Kvikkjokk, to report the disappearance. Hofling’s fate nearly became Malmgren’s as well. He was then alone at the observatory to take care of the observations, day and night, until he got an assistant on October 24—Bertil Viberg, an old friend of his from Uppsala.

The stay at Pärtetjåkkå lasted from July 1, 1917, until June 30, 1918. It provided Malmgren with a rich

fund of experiences, which were of vast importance in his later career as polar meteorologist and polar oceanographer.

The temperature in the hut was generally between +5° and +10°C. Heating was provided by ordinary paraffin lamps, with "exhaust" pipes bent to transfer maximum heat to the air in the hut before emerging into the outside air. The store of paraffin oil also had to be used to melt snow for fresh water, cooking and washing. As it was wartime, fuel had to be greatly economized on. The walls of the hut were coldest near the floor, where thick layers of ice formed. Part of the housekeeping involved cutting away this ice. Paul Wetterfors, the biographer of Finn Malmgren, writes:

"A cheerful mind was certainly needed for being happy here on the mountaintop. Finn Malmgren did possess that. From each situation he could always 'extract' something funny for himself and for his companion."

The two observers corresponded with their families and friends; their carrier took the letters down to civilization in Kvikkjokk to be sent on. They also corresponded with their friend from Uppsala, Sigurd Åstrand, who was the meteorologist at Påræk by the foot of Pårtejtjåkkå, only 7 km away.

"He represented a certain refinement in comparison with us barbarians on the mountain top. He lived below the tree limit, while we resided above the clouds in the real wilderness."

Bornö Oceanographical Station

After returning from Pårtejtjåkkå, Malmgren continued his studies at Uppsala University; he also had his military service to do. In 1920 he passed his M.Sc. examination, after which he worked as an assistant at the Meteorological Department until 1921. His teacher of meteorology was Professor Filip Åkerblom (1869–1942), who had been with Nathorst to East Greenland in 1899 (see p. 274).

In 1921, Malmgren was appointed assistant to Svenska Hydrografisk-Biologiska Kommissionen (The Swedish Hydrographical-Biological Commission). His work was assigned to the oceanographical station on the island of Stora Bornö, in Gullmarsfjorden at the Swedish west coast. He also went on oceanographic cruises with the research ship *Skagerak*. His superior here was Professor Otto Pettersson (1848–1941), a pioneer in physical oceanography in Sweden.

Pettersson had studied the oceanographical obser-

vations from the Vega expedition of 1878–80, and had published the results in the scientific report of the expedition. He had also taken part in the expedition to Spitsbergen in 1882 of the gunboats *Urd* and *Verdande* of the Swedish Navy during the Polar Year, 1882–83. The purpose of his visit had been to study the sea-ice in the area.

Otto Pettersson was actually a chemist, having got a Ph.D. in chemistry in 1872. He obtained a professorship in the subject in 1904. In 1877, Fredrik Laurentz Ekman (1830–90), a professor of chemistry like Otto Pettersson, had led an oceanographical expedition along the coasts of Sweden—a pioneering project in Swedish oceanography. Ekman, however, died before he was able to study the observations from that expedition. His work was taken over by Pettersson, who published the results in 1891.

In 1890, Otto Pettersson and Fredrik *Gustaf* Ekman (1852–1930) had carried out an expedition in the waters off south-western Sweden. From then on, they co-operated closely, and they may be regarded as the creators of Swedish oceanographic research—Otto Pettersson being the scientist, Gustaf Ekman the administrator and economist. In fact, Gustaf Ekman was also a chemist, but primarily an industrialist. He was related to Fredrik Laurentz Ekman. The latter's son was Vagn *Walfrid* Ekman (1874–1954), a professor of mechanics, who is perhaps best known for his mathematical theory of wind-driven currents (expressed by the so-called Ekman spiral) and for his invention of the Ekman current-meter.

The collaboration between Otto Pettersson and Gustaf Ekman continued with further oceanographic expeditions and, to introduce biological studies into the research programme, they began to co-operate with Per Teodor Cleve (1840–1905). Cleve specialized in marine plankton, but he was also a chemist, geologist and botanist. In 1893, Pettersson and Ekman founded Svenska Hydrografiska Kommissionen (the Swedish Hydrographic Commission), which in 1901 was changed to Svenska Hydrografisk-Biologiska Kommissionen, of which representatives of the fishing industry were also members.

Bornö Oceanographic Station, the research station for physical oceanography, was built in 1902 by Ekman and Pettersson. It was a two-storeyed stone house situated on the west side of Stora Bornö, a rocky island with deep water close to the house, enabling the research ship to berth at a quay attached to the gable of the house. In 1932, with a donation from the Wallenberg Fund, the station was made state property. Research work was carried out both at the station and on board the research ship, the *Skagerak*. During the first years, Pettersson's interest was directed to-

wards the mighty internal waves which were discovered and studied at Bornö from hydrographic series-measurements of salinity and temperature at different depths. Measurements of the currents in the sea were also made.

Among the scientific workers who collaborated with Otto Pettersson may be mentioned the theorists Nils Zeilon and Walfrid Ekman, the physicist Hans Pettersson—the son of Otto Pettersson, later to become his successor—and finally the successor to Hans Pettersson, Börje Kullenberg.

Finn Malmgren arrived at Bornö Station in 1921, and worked under the supervision of Otto Pettersson. He learned physical oceanography in both its theoretical and practical aspects, on the research ship as well as at the station.

He was also given the opportunity to attend a conference at Bergen, where he met Norwegian meteorologists and oceanographers, which helped to determine the next step in his life.

THE VOYAGE OF THE MAUD: THE NORTH-EAST PASSAGE

In 1908, the Norwegian polar explorer Roald Amundsen (1872-1928) announced his plans for a drift in the polar ship *Fram* across the Polar Sea, starting from a point farther east than Nansen had used in 1893.

As is well known, Amundsen did not realize his intentions; instead he steered south and ultimately reached the South Pole in 1911. Robert Edwin Peary (1856-1920) had reached the North Pole in April 1909, and a push north was no longer attractive to Amundsen.

However, after his success in the south, the dream of a drift in the arctic pack-ice revived. But the *Fram* was growing old and had to be overhauled and modified. In 1914, World War I broke out, which meant a further delay in the expedition plans. A detailed investigation of the *Fram* proved that she had to be given up, and a new ship built with the experience from the *Fram* and with fresh ideas. Amundsen now possessed the money to do it.

The ship was constructed at Christian Jensen's shipbuilding yard at Volden in Asker near Oslo. It all went according to Amundsen's intentions and to consultations with Captain Otto Sverdrup, and with Colin Archer (1832-1921) who had built the *Fram*. The ship was launched in 1917, and received the name *Maud* with permission from the Norwegian queen.

Compared with her predecessor, the *Maud* had a more rounded hull, and the superstructure of the dwelling quarters and the laboratories aft was much more ample. But the mast, rigging, rudder, and ar-

rangements for lifting both rudder and propeller out of the water, originated from the *Fram*.

In the summer of 1918, the *Maud* was ready to start her voyage. To begin with, she would proceed along the North-East Passage to a point of departure—near Bering Strait—for the drift in the ice. World War I was still going on. The *Vega* had almost completed the passage in one season, and Nansen's *Fram* made part of it—to the New Siberian Islands—in one season.

The crew was small, and only nine men left Norway on the *Maud*, including one young scientist.

THE CREW CONSISTED OF FOLLOWING MEMBERS:

Roald Amundsen (1872-1928), leader of the expedition.

Helmer Hanssen (1870-1956), master of the ship.

Oscar Wisting (1871-1936), mate.

Harald Ulrik Sverdrup (1888-1957), geophysicist, responsible for the scientific investigations.

K. Sundbeck, chief engineer.

M. Rönne, sailmaker.

P. Knudsen, second engineer.

P. Tessem, carpenter.

E. Tønnesen, seaman.

Genadi Olonkin, who was of Russian-Norwegian descent, joined the expedition at Yugor Strait, where he was radio operator and engineer. He took the place of Knudsen as second engineer, and Knudsen became seaman.

It may be noted that Wisting was perhaps the person closest to Amundsen. He had been with Amundsen to the South Pole and later, in 1926, he flew with him in the dirigible *Norge* to the North Pole (see p. 413). Sverdrup, though a geophysicist, was chiefly a meteorologist and an oceanographer, of a very high calibre.

There was no professional cook on board the *Maud*. In the summer of 1918 Sverdrup, Knudsen and Tønnesen alternated in that capacity. Nor was a doctor on board, but Amundsen had studied medicine in his youth, and Wisting had attended a medical course before the departure.

The voyage of the *Maud* along the North-East Passage is summarized on p. 149. It will suffice here to give a few main points. The ship met with much ice, which hindered or even stopped her progress. Instead of completing the passage in one season, three summer seasons and two winterings were needed.

During her passage, the ship had to winter near Cape Chelyuskin in 1918/19. From there, two men of the crew, Tessem and Knudsen, were sent to Dickson Harbour with copies of the observation journals, but died on the way.

The winter of 1919/20 was spent in Chaun Bay

Harald Ulrik Sverdrup (1888–1957. Norwegian geophysicist, responsible for the scientific work on board the *Maud*. (Dahl, O.: Odd Dahl og Maudferden.)

Finn Malmgren (1895–1928). Swedish meteorologist and oceanographer, who took part in the Second Maud Expedition, 1922–1925. (Behounek F.: Männén på isflaket.)

Bornö Oceanographical Station and the research ship *Skagerak*. Finn Malmgren gained experience here in 1921–1922, which contributed to his engagement on board the Norwegian polar ship *Maud* as assistant scientist (below). (Nyare Oceanografiska undersökningar i Sverige.)

Roald Amundsen relaxing in the wardroom of the *Maud*. The photo was taken during the First Maud Expedition, 1919–1921 (right). (Dahl, O.: Odd Dahl og Maudferden.)

The Norwegian polar ship *Maud* launched in 1917 for a drift with the ice in the Polar Sea. Vertical and horizontal sections give some idea of the strength of the ship. Cabins and laboratories surround a rather roomy wardroom aft. (Dahl, O.: Odd Dahl og Maudferden.)

Christmas Eve on board the *Maud* during the Second Maud Expedition 1922–1925. From left: Olonkin, Dahl (standing), Sverdrup, Malmgren, Wisting, Kakot, a Chukchi boy (standing), Hansen, Syvertsen. (Wetterfors, P.: Finn Malmgren.)

beyond Ayon Island. Here Amundsen informed the crew that he intended to call at Nome in Alaska near Bering Strait; anybody on board would then be free to leave the ship and go home. Three members of the expedition declared that they were willing to stay on: Sverdrup, Wisting and Olonkin.

Nome was reached on July 27, 1920. Already on August 8 the *Maud* left again, with only four men on board. Her destination was Cape Serdze Kamen, about 80 km east of Pitelki, the winter quarters of the *Vega* in 1878-79. The aim was to take aboard some Chukchis to serve as seamen. But the ice conditions were severe. Cape Serdze Kamen was not reached until September 1, so the ship had to winter here in 1920/21. Six young Chukchis were hired as crew. In May 1921, Amundsen left the ship for Nome and Seattle and home. The *Maud* left her winter quarters on July 1 and sailed to Seattle, where she arrived on August 31 after a trying voyage—with her crew of three Norwegians and six Chukchis, the latter being unused to the sea.

THE MAUD IN THE POLAR SEA 1922-1925 *Preparation and departure*

Measures were then immediately taken to continue the expedition. Amundsen prepared for a flight across the Polar Sea, and Sverdrup went to the Carnegie Institution in Washington D.C., where he spent five months studying the geomagnetic observations which had been made thus far during the expedition. He also procured some instruments. Wisting and Olonkin stayed in Seattle.

Amundsen paid a visit to Norway and, on his return, informed Sverdrup and Wisting that he intended to undertake a flight from Point Barrow, Alaska, to Spitsbergen. One man would go with him, Lieutenant Oscar Omdal; the airplane, a Junkers, was to be taken to Point Barrow by the *Maud*, before she could proceed into the ice in the summer of 1922. The *Maud* herself was supplied with a small airplane, a Curtis Oriole, for geographical investigations on both sides of the track of the drift. Its pilot would be a young man named Odd Dahl, who was also a promising radio technician and—as he was to prove later on—a technical genius of extreme value to the scientific work on board.

Sverdrup had previously told Amundsen of the need to add one more man to the scientific staff, which now consisted of Sverdrup alone—especially since Amundsen intended to leave the ship. Amundsen had made inquiries in Norway. A Norwegian oceanographer, Björn Helland-Hansen (b. 1877), had mentioned Finn Malmgren as a suitable man:

“He has spent a whole year on Pärtetjåkkå as a meteorological observer. He also has experience as an oceanographer and is now engaged at the Swedish Hydrographic Commission. Besides, he is a clever caricaturist, and he is of a cheerful disposition.”

When Amundsen returned to the USA from Norway in March 1922, he first went to Washington D.C. to consult with Sverdrup on this and other matters. As a result, Finn Malmgren received an offer to take part in the *Maud* expedition as scientific assistant. A few months later, Malmgren joined the expedition in Seattle.

THE MEMBERS OF THE EXPEDITION DURING THE SECOND PART OF THE MAUD VOYAGE, IN 1922-1925, WERE:

Oscar Wisting (1871-1936), master of the ship and leader of the expedition.

Harald Ulrik Sverdrup (1888-1957), geophysicist, in charge of the scientific work.

Finn Adolf Erik Johan Malmgren (1895-1928), M.Sc., Swedish member, meteorologist and oceanographer, scientific assistant.

Odd Dahl (b. 1898), aviator and technician, notably radio technician.

G. Olonkin, chief engineer.

S. Syvertsen, second engineer.

K. Hansen, mate.

Kakot, a Chukchi cabin-boy.

Amundsen and his pilot Oscar Omdal were to be taken to Point Barrow on the *Maud*, together with the Junkers plane that was intended for the projected flight to Spitsbergen. However, this enterprise failed even before it began, which was perhaps the best that could have happened.

The *Maud* left Seattle on June 3, 1922. She was heavily overloaded, and on her deck were the two planes, the Junkers and a Curtis Oriole, in their respective packing-cases. Amundsen had taken a passenger steamer to Nome and embarked the *Maud*, before she proceeded to the Siberian side of Bering Strait, to land three of the Chukchis who had been hired for the voyage to Seattle the previous autumn. Two of the group had already reached their homes, and the sixth, Kakot, had preferred to remain with the expedition.

The *Maud* then continued to Kotzebue Sound, where she had to stay for three weeks. A few trial flights were made with the Curtis Oriole.

Amundsen changed his plans when being informed that he and Omdal could be transported to Point Barrow on the trading schooner *Holmes*. The two

ships met at Point Hope on July 28, 1922, and the *Maud* could now start on her own mission—to enter the ice and become frozen in.

The drift begins

The *Maud* soon met with ice, but it was possible to follow leads and openings until, on August 8, 1922, she was beset in the ice near Herald Island to the east of Wrangel Land at about 71°N, 184°E. This was early in the season, and the latitude was very low, considering that the expedition had hoped for a drift at a fairly high latitude.

However, there was ample time to prepare for the winter; it was still summer. The rudder and propeller were taken up from the water, and a roof was built over the forebody of the *Maud*. The engine was prepared for the winter, their hot-air oven was set up, and the roof of the cabin was covered with snow for better insulation. The fresh-water tank was emptied; from now on they would get their fresh water by melting ice or snow (compare p. 410). And not least, their twenty dogs demanded much care and time.

Their toilet in a deck-house could not be used now. Instead a construction was arranged on the roof of the deck-house, projecting clear of the ship's side. The visitors found the arrangement somewhat cold but fully usable. Once a week, on Saturday evening, the men enjoyed a steam bath.

The scientific work on board the Maud

The *Maud* had at long last become an arctic observation post—it had taken four years since leaving home. In the new order of things, their daily routines were entirely changed: the scientific work came first, and everyone on board had to assist the two scientists, Sverdrup and Malmgren, when necessary. Previously Sverdrup had been engaged in the navigation of the ship, carrying out many of his observations and measurements when there was barely time for them. At night, a watchman was always awake, due to the risk of fire and the possibility of ice pressures threatening the ship; there were also observations to do.

During the first year, Malmgren was Sverdrup's assistant in connection with the installation of their instrumental equipment, on board and on the ice. It took some time to find a practical routine in doing the observations and measurements, and for taking care of the instruments in severe weather conditions. Odd Dahl helped to ensure a successful outcome of the scientific observations. As mentioned, he was a technical genius, and he was able to construct suitable apparatuses or devices—not least, recording instruments—with whatever material he could find on board. He could also overhaul strained instru-

ments. Olonkin, too, was helpful in these matters.

Odd Dahl's aviation activity was short, though. After the first winter in the ice he assembled his plane. Three test-flights were made. During the third flight he had engine trouble at the start, and was forced to land among the pressure ridges of the ice. That was the end as far as the plane was concerned.

During the drift of the ship, *astronomical observations* (19)¹ for determining the position were made whenever there were favourable conditions: the track of the drift had to be determined as carefully as possible. In winter and spring, such observations were generally carried out two or three times a week, but in summer and autumn—with greater cloudiness—the observations were taken more irregularly, in summer sometimes at intervals of a week or more. The *Maud* had a good radio station, which could always get time signals for reliable determination of the longitude and latitude.

The *geomagnetic observations* (20, 21)¹ were carried out on the ice, far enough from the ship to avoid magnetic disturbances from her. In the pack-ice, measurements of the magnetic declination were made at the same time as the astronomical measurements. The ice was not stationary, so a bearing to a terrestrial mark changed with time and had to be determined astronomically (19)¹. Hence no continuous recordings of the geomagnetic variables were made in the pack-ice. In winter, the observations were carried out in an ice-house; during the summer, protection against the wind was enough. The ice-house observatory, though, never survived the summer heat or severe ice pressures.

Aurora observations (9)¹ were made in the winter by the night-watchman on duty, each watch lasting two hours. Some brilliant displays of the phenomenon were also photographed.

The observations of *atmospheric electricity* (20)¹ were confined to measuring the potential gradient, or electric field force. Daily readings were made, and in fine weather they were carried out each hour day and night in order to determine the diurnal variation. A few years previously, the Smithsonian Institution in Washington D.C. had established that the diurnal variation of the electric field force over the oceans took place according to universal time, i.e. Greenwich time, independent of the position on the globe. Sverdrup was now able to confirm this result for the Polar Sea. To improve the observations, Odd Dahl constructed a recording electrometer. The data thus obtained were relative and had to be linked with the direct

¹The number refers to instrumental installations given in Fig. p. 411.

measurements over the undisturbed ice. The discovery of the Smithsonian Institution was later to become a fundamental principle in explaining atmospheric-electric phenomena; in fact the character of the diurnal variation of the potential gradient was a consequence of the total thunder activity over the globe.

The *meteorological observations* were carried out 6 times a day, every 4 hours. Besides the direct readings, pressure, temperature (16) and wind (14) were also recorded. As had been found on previous polar expeditions, the psychrometer measurements of humidity were unreliable or of no value at low temperatures, because of the small difference between the readings of the "dry" and "wet" thermometers. Malmgren solved the problem by connecting thermocouples in series between the two "dry" and "wet" bulbs. In this way he obtained a fairly large galvanometer reading, whose fluctuations could be eliminated by averaging several readings. Odd Dahl later constructed a recording galvanometer to avoid multiple readings. Using these values, Malmgren investigated the relationship between humidity and the formation of hoarfrost.

The *temperature variation with height* in the low layer of the atmosphere was first obtained by placing a thermocouple in the crow's nest in the main mast (30 m) and reading the thermo-current in connection with the ordinary meteorological observations. Then, too, the temperature nearer the surface of the ice was determined—in the meteorological screen (16) on deck at 4.5 m above the ice. In the winter of 1923/24 these measurements were improved: one series of the joints of thermocouples were spread out fan-wise on the snow, and the other series of joints were placed at 80 cm (11). The temperature difference between these two levels was obtained, and in the mast other resistance thermometers (15) were mounted and read off—as before—whenever the thermometer in the meteorological screen was read off.

The *duration of the sunshine*, the *direct solar radiation* and the *radiation from sun and sky* (13) were also measured. Odd Dahl, as before, contributed a recording galvanometer, by which the total incoming solar radiation upon a horizontal surface was determined. During the dark season, only the terrestrial infrared radiation was measured.

The *temperature and its variation within the ice* (8) was measured by electric thermometers. Using other data for the ice as well, the heat conducted through the ice from the water to the air could be computed.

The *Maud* expedition took place several years before radiosondes came into use for determining the temperature in the free atmosphere. Airplanes were

useless for this purpose in the present case; nor could relatively small balloons with light recording devices for temperature and pressure be used, because the balloon with its record would need to be found after it had burst. Instead, large kites with a recording device (24) were used. They had a motor (10) for hauling down the kite, but it gave trouble, and therefore the kite was hauled down manually, which meant 1–2 hours of hard work for 4–5 men. The kite reached 1–1.5 km, and at most about 3 km, which was enough for obtaining the most characteristic features of the temperature variation with height in the low layer of the atmosphere over the pack-ice.

Generally the temperature decreased with height below about 100 m, but then came a transition towards a temperature increase with height, a *temperature inversion*, which with decreasing strength reached up to 500–1000 m, where the normal temperature-decrease with height followed. The usually observed temperature-decrease with height next to the surface was due to the mixing of the air layers by the wind; with no wind the inversion would have reached right down to the ice.

The *upper winds* were measured in the classic way with pilot balloons (23), which were observed with a theodolite (18), measuring vertical and horizontal angles to the balloon every minute. In general there is a wind maximum at the tropopause, where the troposphere and stratosphere border each other. This maximum was found to occur at 8 km, which was thus also the height of the tropopause over the Polar Sea.

Together with meteorology, oceanography was the scientific discipline which was given most attention. The *depth of the sea* (4) was measured every day, in itself a simple procedure, but somewhat difficult in the winter when the holes in the ice froze over. Once a week, a *hydrographic station* (5) was worked: the temperature of the sea water was measured at standard depths from the surface to the bottom with reversing thermometers, and water samples were taken for determining salinity, oxygen content and pH. When the air temperature was below -40°C , haste was essential to prevent the sample from freezing after it had come out of the water. Sverdrup measured the density of the sea water while Malmgren carried out the titrations for determining salinity—or rather chlorine content—and oxygen content.

For *current measurements* (3) the expedition was equipped with an Ekman current-meter. This was difficult to handle in the winter because of freezing: after each measurement at one depth, it had to be taken indoors for some time, before it could be lowered to the next depth. Therefore Sverdrup and Dahl designed an electric meter which registered both

velocity and direction, the latter in relation to the orientation of a frame which had a bifilar suspension.

These current measurements were mainly carried out for determining the *tidal currents*. The measurements gave values relative to the drifting ice; the momentary drift of the latter was obtained by letting a weight—fastened to a wire—come to rest on the bottom (17). By observing the speed with which the wire was hauled out, and the bearing of the wire, the velocity of the ice drift was obtained. Correcting for this drift, true values of the prevailing current in the sea were obtained. In the summer of 1924, these measurements were supplemented with the Ekman current-meter, hourly measurements being made.

Already on board the *Maud*, Sverdrup had concluded that the tidal wave reached the continental shelf—over which the drift proceeded—from the north. Apparently the tidal wave passed straight across the Polar Sea from the Atlantic Ocean without being hindered by any land of continental size. A decade previously, an American scientist, R.A. Harris, had come to the opposite—and erroneous—conclusion.

During the drift in the ice, Malmgren carried out an investigation of his own on the *properties of the sea-ice*. He started from the specific property that sea-ice is not only mere ice. It consists of ice with hollows, in which brine is enclosed and—if the temperature is low enough—partly crystallizes into a third component: crystalline salt. Here Malmgren found clear relationships, where previously only anomalies had been observed. In the summer, the hollows unite more or less due to the solar radiation, and the brine proceeds downwards. Consequently, the upper portion of the ice becomes free of salt, and can be melted to get drinking-water and pools on the ice contains fresh water.

The drift of the Maud 1922–1924

The ship's drift was to become a great disappointment to both Sverdrup and Amundsen. The shelf to the north of Siberia is extremely broad, and the *Maud* never came out of it, but stayed over fairly low depths. Besides, the route followed during the drift was more or less the same as that of the ill-fated *Jeannette* in 1879–81.

However, the scientific work done on board the *Maud* was first-class and of great value. In fact the *Maud* expedition—during its last three years—may be regarded as the first geophysical polar expedition in the true sense of the word, apart from the polar stations during the Polar Year of 1882–83.

After the *Maud* had become enclosed in the pack-ice near Herald Island on August 8, 1922, she drifted with the ice along a west-north-westerly track, though

with many irregular detours caused by the wind. By the beginning of September 1923, she reached latitude 76°17'N to the east of the De Long Islands. The drift had then gone on for thirteen months. The *Jeannette* had taken two years to cover roughly the same distance.

They were now near the route of the *Jeannette* and were hoping to drift north of the De Long Islands. Perhaps they might even follow a route towards Spitsbergen, somewhat farther north than the drift of the *Fram* in 1893–96. However, northerly winds carried the ice and the *Maud* southward to about latitude 75°N. Next winter, during October 1923–April 1924, the ship remained almost stationary at that latitude, drifting back and forth to the south of the De Long Islands.

At the end of February 1924, Wisting received a telegram from Amundsen with the order that he should take the *Maud* out of the ice whenever possible in the course of the summer of 1924. On board the *Maud*, on the other hand, they did not think it possible to come out of the ice; instead they considered that their drift would continue like that of the *Fram*.

In the spring and summer of 1924, the drift was again proceeding west-north-west. The *Maud* passed between Wilkitsky Island and Shokova Island, two small islands which had been discovered from the Russian icebreaker *Taimyr* in 1913, and between Bennett Island and the New Siberian Islands. On August 9, 1924, the ice opened so much that the *Maud* became free and could proceed under her own power.

The drift had then gone on for almost exactly two years. The *Maud* had successfully coped with the dangers of the pack-ice. The special construction of her hull had matched the expectations of her constructors and crew. Severe ice pressures had occurred, especially in October 1923 and in May and June 1924, but the ship had escaped from being crushed. For the sake of security, three sledges were always placed on deck, packed with provisions for 8 men and 16 dogs during 40 days, besides other equipment such as a robust canvas boat and sleeping bags. Only once had it been considered necessary to take the sledges down to the ice.

After the ship had become liberated on August 9, 1924, the intention had been to take the ship southward along the east side of the New Siberian Islands. But that was prevented by the ice conditions, and the ship proceeded in almost ice-free water along the western side of the archipelago.

Homewards and afterwards

On August 20 the *Maud* passed through the Laptev Strait heading east, but soon she met with heavy ice

Finn Malmgren (1895-1928), occupied with meteorological research in May 1925 during the Second Maud Expedition. Malmgren was invited by Roald Amundsen to take part in the expedition as scientific assistant to H.U. Sverdrup. (Wetterfors, P.: Finn Malmgren.)

As a precautionary measure against severe ice-pressure, three loaded sledges with supplies for 40 days were placed on the deck of the *Maud*, always ready to be transferred to the ice if the situation became threatening. (Wetterfors, P.: Finn Malmgren.)

Arrangements for the scientific work on board the *Maud* during the drift in the polar ice 1922-1924. The scientific work was first class and of great value. The *Maud* expedition is regarded as the first geophysical expedition apart from those of the Polar Year 1882-1883. For descriptions and explanations see text, p. 408. (Dahl, O.: Odd Dahl og Maudferden.)

along the Siberian coast. It forced her into shallow water near the coast, and at Cape Baranov—between the Kolyma River and Ayon Island—the eastward course had to be given up.

Wisting decided to turn back towards the Bear Islands (Ostrova Medvezhi), where there had been open water when they passed.

However, there was now ice and they had to seek winter quarters in the ice—five miles from the easternmost island in the archipelago, the Four Pillar Island. The place was considered somewhat unsafe, but the ship remained at the same position until the beginning of July 1925.

The forced wintering was a disappointment, as they had reckoned with favourable ice conditions ever since they had reached open water west of the New Siberian Islands.

They left their winter quarters at Four Pillar Island on July 13, 1925. Nome was reached on August 22 and Seattle on October 5.

The return to civilization was also a disappointment to the *Maud* crew. The expedition had lasted seven years—as the ice had not been in its favour—and had cost more money than expected. Besides, prices had gone up during the post-war period. Amundsen had gone bankrupt, and at Seattle the assets of the expedition were called in.

The *Maud* was sold to the Hudson Bay Company, and was used for transports and trade along the north coast of North America for a few years. Later she was used as a radio station and a warehouse at Cambridge Bay in south-eastern Victoria Island. In 1931 she was driven ashore by the ice and gradually destroyed. The fate of the *Maud* was tragic, doubly so because she had been such a fine and “brave” polar ship.

Sverdrup took care of the main part of the scientific observations, which were published in the expedition report: *The Norwegian North Polar Expedition with the “Maud”, 1918–1925. Scientific Results*, edited by H.U. Sverdrup. This is a classic in polar geophysics.

In later life, Sverdrup rose to world fame in oceanography as head of the Scripps Oceanographic Insti-

tute in California. From 1948 until his death in 1957, he was the head of Norsk Polarinstitut, Oslo.

Malmgren published his studies, *On the Properties of Sea-Ice*, in 1927 and used this publication as a thesis for his doctoral degree in the same year. His measurements of the humidity at low temperatures were published already in 1926, as *Studies of humidity and hoarfrost over the Arctic Ocean*.

Malmgren's knowledge of the weather conditions over the Polar Sea was the reason for his taking part in the expeditions with the dirigibles *Norge* and *Italia* in 1926 and 1928 respectively. During the latter expedition, he met an untimely death on the pack-ice to the north of Nordaustlandet.

Wisting also went with Amundsen in the *Norge*, and later he worked on the restoration of Nansen's polar ship *Fram* to make her a museum ship at Bygdøy, Oslo. He died on board the *Fram* in 1936.

G. Olonkin was to become a participant in the flight of the *Norge*. But on the evening before the start from Ny-Ålesund, Spitsbergen, he fell ill and was replaced. For many years he worked at the Weather Service for Northern Norway at Tromsø.

Odd Dahl, the technical genius of the *Maud*, continued his career along these lines, though naturally with a much wider scope. He was to be the last survivor of the *Maud* crew of 1922–25.

Roald Amundsen managed in 1925 to procure money for a flight with two Dornier-Wal planes, N24 and N25, from Spitsbergen to the neighbourhood of the North Pole—approx. 88°N—and one year later he flew with the dirigible *Norge* across the Polar Sea via the North Pole.

In 1928 he disappeared with the French airplane *Latham*, enroute to Spitsbergen to join in the operations for rescuing the survivors of the *Italia* expedition.

Oscar Omdahl, who was Amundsen's pilot in 1922–23, his mechanic in 1925, and his motor mechanic in the *Norge* in 1926, disappeared in 1928 during a North Atlantic flight with the Danish-American Mrs. Frances Grayson.

MONTHLY MEAN TEMPERATURES (°C)

From the Maud expedition: in the pack-ice of the Polar Sea and at Four Pillar Island near the East Siberian coast.

Locality	Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Pack-ice	1922								-0.8	-5.3	-13.7	-23.8	-24.7
"	1923	-34.8	-26.0	-30.2	-20.8	-12.9	-1.6	+0.2	+0.1	-7.2	-14.5	-25.2	-34.3
"	1924	-30.2	-33.5	-31.6	-23.0	-11.6	-1.8	-0.3					
Four Pillar	1924										-11.7	-24.4	-23.8
Four Pillar	1925	-28.0	-32.2	-26.8	-21.8	-5.9	+0.4	+1.4					

*THE FLIGHT OF THE NORGE IN 1926**Previous flights in the Arctic*

S.A. Andrée in his balloon, *The Eagle*, had been the first to fly over the arctic ice in 1897. He was also the first and the last to use a free balloon for long flights in the polar regions. Vehicles heavier than air were coming to stay: in 1903 the two brothers Wilbur and Orville Wright had made the first short and tentative flight. A little more than a decade later, the airplane was used in the Arctic: in 1914 a Russian, Ivan Nagurski, carried out flights in the north-west of Novaya Zemlya using a Farman plane. He was very optimistic about the new means of transport and conveyance, and its use for investigating the polar regions.

The airplane developed technically during World War I. It was especially necessary to obtain reliable aircraft engines before any long flights could be attempted—flights into unknown regions of the Arctic and Antarctic. This state of development was reached about 1925, and the next years were in many respects remarkable. The period 1925–30 witnessed long transoceanic flights, as by Charles Lindbergh across the North Atlantic in 1927. At the same time occurred several long pioneering flights in the polar regions, but here arose a sort of rivalry between vehicles heavier and lighter than the air—the airplane and the dirigible.

The Norwegian polar explorer Roald Amundsen was one of the pioneers to use the airplane in the polar regions. Another was the Australian Hubert Wilkins.

In 1922–24, Amundsen and his pilot Oscar Omdal (1895–27) stayed in northern Alaska with the intention of flying across the Polar Sea to Spitsbergen in a Junkers plane (compare p. 407). However, everything failed, and they had to return to Norway, mainly due to an unsuitable motor. Amundsen was then in financial difficulties, as the *Maud* expedition had become unexpectedly expensive (see p. 412). However, during a lecture-tour in the USA in 1924, he was contacted by the American millionaire Lincoln Ellsworth, who nourished secret dreams of becoming a polar explorer. Ellsworth helped Amundsen by providing money for a new flight expedition, and became a member of the expedition.

In 1925, Amundsen was able to start with two Dornier-Wal seaplanes, N24 and N25, from the mining village Ny-Ålesund at Kongsfjorden in Spitsbergen. Each plane had a crew of three. It was to be a most adventurous expedition: N24 had become damaged already at the start.

After a long flight, both planes landed in an opening in the pack-ice at latitude 87°43'N, where it was found that the return flight had to be made in one plane, N25. The start was made on a runway, which

they prepared on the ice. The party got back, but only after 27 anxious days, during May 21–June 17. Amundsen had now lost confidence in heavier-than-air transport. Would the dirigible be the solution?

The plans, the men and the airship

Already in Spitsbergen in 1925, when Amundsen and his five companions were preparing for the start of N24 and N25, they discussed the question of using a dirigible for arctic research. Riiser-Larsen, the pilot of N25, mentioned that a suitable Italian dirigible could be procured.

After returning to Oslo, they contacted the Italian constructor of this dirigible, Umberto Nobile, a lieutenant colonel in the Italian Army. It was an airship of the *semirigid* type, with a light keel of steel and a metal framework in the front. The gas containers in the upper part of the airship kept its envelope stretched. Such an airship was generally considered more flexible than the rigid type with an overall framework to support the envelope. Nobile had designed two semi-rigid dirigibles.

Nobile came to Oslo for negotiations. He was even willing to lend Amundsen his airship, provided that it sailed under the Italian flag. Finally an economic agreement was reached: a price was fixed and—provided the planned flight across the Polar Sea were successful—the Italian Government would be willing to buy the dirigible back, though at less than the original price.

Lincoln Ellsworth again paid a substantial part of the expedition costs. The plan was to fly from Spitsbergen to Alaska via the North Pole. As in 1925, Ny-Ålesund at Kongsfjorden in north-western Spitsbergen would be the starting point of the polar flight. Since it would not be practicable to transport the airship to Spitsbergen on board a ship, arrangements had to be made for flying the dirigible all the way from Rome to Ny-Ålesund, where a hangar and a mooring mast had to be built.

It was agreed that Nobile would come with the expedition as pilot of the dirigible, and that a substantial part of the technical participants would be Italians. The expedition was to sail under the Norwegian flag, and the name of the airship would be *Norge*. Amundsen would be the leader of the expedition and Lincoln Ellsworth would be co-leader. Finn Malmgren, after his service on the *Maud* expedition in 1922–25, was an expert on the weather conditions over the Polar Sea, and became the meteorologist on board. In that capacity, he was to issue weather forecasts and advise on meteorological matters.

The crew of the *Norge* is given below, as it was determined for the last leg—from Spitsbergen—of the

long flight from Rome to the North Pole and then Alaska.

THE CREW OF THE "NORGE" DURING THE POLAR FLIGHT (MAY 11–14, 1926):

Roald Amundsen (1872–1928), leader of the expedition.

Lincoln Ellsworth (1880–1951), American, financier, co-leader.

Umberto Nobile (1885–1978), Italian, colonel, aviation technician, the constructor of the *Norge*, pilot of the expedition.

Hjalmar Riiser-Larsen (1890–1965), captain in the Norwegian Navy, navigator.

Emil Horgen (b. 1890), lieutenant in the Norwegian Navy.

Oscar Wisting (1871–1936), captain in the Norwegian Navy.

Finn Malmgren (1895–1928), Swedish, M.Sc., meteorologist and oceanographer.

Fredrik Ramm (b. 1892), journalist.

Birger Gottwaldt (b. 1880), captain in the Norwegian Navy, radio expert.

Frithjof Storm Johnsen, radio operator.

Vinzenzo Pomella (aged 28), Italian, mechanic in the aft motor-gondola.

Attilio Caratti (aged 31), Italian, mechanic in the port motor-gondola.

Ettore Arduino (aged 36), Italian, mechanic in the starboard motor-gondola.

Oscar Omdal (1895–27), lieutenant in the Norwegian Navy, mechanic in the starboard motor-gondola.

Natale Cecioni (aged 38), Italian, chief engineer.

Renato Alessandrini (aged 36), Italian, rigger (responsible for gas valves, ship's envelope, etc.).

Thus the crew comprised 16 persons: 8 Norwegians, 6 Italians, one American and one Swede. Storm Johnsen was a last-minute substitute for Genadi Olonkin, the *Maud* man, who had developed an ear infection.

Hjalmar Riiser-Larsen had been the pilot of the Dornier-Wal plane N25 during Amundsen's polar flight in 1925. He was an excellent aviator and navigator. Lincoln Ellsworth and Oscar Omdal had taken part in the same flight. Oscar Wisting and Finn Malmgren had taken part in the *Maud* expedition, in 1918–25 and 1922–25 respectively.

The dirigible *Norge* had been called N1—where N stood for "Nobile". Some modifications were made in her construction; notably the spacious gondola was exchanged for a smaller and less luxurious gondola. In this way the carrying capacity of the airship was increased, but instead the personnel, which worked in the gondola, had to be satisfied with extremely cramped

quarters offering practically no place for rest or even for sitting.

The length of the *Norge* was 105 m, and her largest diameter was 20 m. She weighed 10 tons, and could carry 11 tons, including 6 tons of petrol. Each of the three motor-gondolas had a motor of 250 hp. Usually only two motors ran at the same time, resulting in a speed of 80 km per hour with no wind. Giving maximal power to all three motors, 110 km per hour could be attained.

Navigation and meteorology on board

For the navigation of the airship, a knowledge of the wind conditions at cruising level was indispensable when flying in or above a cloud deck. Information on wind conditions was to be delivered by the meteorologist on board.

The wind drifts the airship away from the course being steered, and changes the speed relative to the ground. Both effects can be calculated easily when the wind's direction and speed are known. When wind conditions are not known, but the ground is seen, both the drift and the speed can be determined with a *drift-meter*, which is a horizontal thread in a tube facing vertically downward. The method is to rotate the thread horizontally until the objects on the ground are seen moving along the thread. The difference between the ship's heading and the direction of the thread then shows the drift. The ground speed is most easily obtained by timing the passage of an object on the ground, from a vertical angle of 45° until it comes immediately below the ship. This is simply the old sailor's method of taking a four-point bearing, though in the vertical plane.

However, the height above the ground must then be known, which is generally not the case in the polar regions, where no meteorological stations can supply information on the air pressure. Instead, glass bulbs containing a solution of some dye were used for the purpose. The time of fall of such a bulb can easily be obtained with a stop-watch, as the spreading of the dye upon the snow indicates when the bulb hits the snow surface. From the time of fall, the height of the airship is obtained. The relation between height and time of fall had previously been determined by experiments.

When flying in fog or clouds, though, all methods fail. It is important to understand the very primitive methods of those days, compared with modern ones.

Soon after his return home from the *Maud* expedition, Malmgren had been offered the post of meteorologist on the *Norge* expedition. In this capacity he was to supply the expedition with weather forecasts for the planning of the different flights which were to

be undertaken. He would also advise the airship's navigator on meteorological matters, not least concerning the direction and speed of the winds at different heights. The speed of the *Norge* was so low—about 80 km/h with no wind—that due attention had to be paid to the upper winds for correcting the course steered and for computing the airship's ground speed. A knowledge of the wind conditions at different heights would also enable the navigator to choose a suitable flying altitude. The weather forecasts were indispensable for deciding the conditions under which to make flights—as well as when not to make them.

In those days, the work in the weather forecasting service was much less refined than at present, largely because of inferior knowledge about the weather processes. But this knowledge was improving, thanks to a team of young meteorologists working under the great theoretical meteorologist and physicist Vilhelm Bjerknes at Bergen, Norway.

Swedish universities offered no courses in synoptic meteorology—the construction of synoptic weather charts and, with their help, the formulation of weather forecasts. A young meteorologist was trained in these topics during his work in the forecasting service. Besides, the new methods used at Bergen were not yet commonly known. After Malmgren's return home in 1925, he was a trained observer of weather processes and phenomena, an expert on the meteorology of the ice-covered Polar Sea and on the influence of mountains upon the weather. But he was not a trained weather forecaster and would have to learn the practical aspects of the branch.

One thing was certain: there existed no weather stations in the Polar Sea. Here Malmgren's experience would help him to “extrapolate” the weather chart into the unknown areas. During 3–4 months in the winter of 1925–26, Malmgren visited Bergen to acquaint himself with the new methods in synoptic meteorology. Weather reports and upper wind data from Europe and North America would be sent by radio to the *Norge* three times daily; with the help of such data, Malmgren would be able to draw synoptic weather charts and forecast the weather. From meteorological institutes near the route of the airship, he would also be supplied with weather forecasts.

The flight from Rome to Spitsbergen

Many kinds of preparations went on during the half-year preceding the start of the *Norge* from Rome. A hangar of timber and a mooring-mast were built at Ny-Ålesund in Spitsbergen, as was a mooring-mast at Vadsö in northernmost Norway to be used during the flight to Spitsbergen. Test flights were to be carried out at the end of February; and finally on March 29,

a ceremony was held at Ciampino Airport near Rome. The airship was officially delivered to Norway and the Norwegian flag was hoisted on the ship, which now obtained the name *Norge*.

At 09.32h on April 10, the airship lifted and started her long flight north, with 21 persons on board. The course was initially set westward, to avoid passing over the Alps. The first stop was at Pulham in Norfolk, England, which had large hangars for airships. The weather remained fine until northern France was reached, but here a cyclone was approaching.

The *Norge* stayed at Pulham until midnight of April 13/14, when she left for Oslo. The visit there was very short, because a cyclone was coming up from the west. The course was now set for Leningrad; it had been intended to pass over the cities of Stockholm and Helsinki, but fog prevented this. During the last part of her flight, the airship came considerably to the south of the planned itinerary.

At 22h on April 15, the *Norge* landed at the airship hangar of Gatchina near Leningrad. Here she had to remain until May 5, as the hangar in Spitsbergen had to be completed before she was allowed to start. This Spitsbergen hangar consisted of a framework of timber with an envelope of tarpaulins, except on top where the hangar was open. Nearby was the mooring-mast.

On April 30 the expedition was informed that the landing facilities in Spitsbergen were completed. But the weather had deteriorated, and not until 09.00h on May 5 was it deemed favourable to start. At Vadsö in northernmost Norway, the mooring-mast was constructed so that the airship could stop to take on fuel and gas before she crossed the sea to Spitsbergen. The flight to Vadsö was bumpy, and the port motor sputtered. Finally it went dead, so the starboard motor had to be started. At 6.50h on May 6, the *Norge* was moored to the mast at Vadsö, and already at 15h she started again for Spitsbergen.

The weather was excellent and it was vital to make the most of the favourable situation, as the flight had been much delayed. Generally, April offers the best flying weather in the Arctic; later the weather becomes more unsettled and the occurrence of low stratus clouds and fog increases. The passage along the south of Spitsbergen took place in the night, with the sun shining upon the snow-covered mountains. But soon they met with clouds and heavy snowfalls, and radio reports indicated that the weather was the same at Ny-Ålesund. However, Malmgren was convinced that this was a case of snow-showers alternating with improved conditions.

The airship landed at Ny-Ålesund in the morning of May 7. But the last part of the flight had been rather

exciting. The port motor, which had stopped even before Vadsö was reached (compare above), would have to be exchanged for a new one at Ny-Ålesund. Now, approaching Ny-Ålesund, the starboard motor also gave trouble, and had to be repaired in flight. Still, the *Norge* reached security in the Spitsbergen hangar after her long flight from Rome—a distance of 7600 km, covered in 103 flight hours.

Preparations in Spitsbergen

Amundsen and Ellsworth had travelled by train and ship to Spitsbergen and arrived in advance of the *Norge*. While the last preparations for receiving the airship were going on at Ny-Ålesund, a most surprising event occurred. The steamer *Chantier*, carrying an American flight expedition under Lieutenant Commander Richard E. Byrd (1888–1957), arrived on April 29 with the aim of reaching the North Pole by air. For that purpose, his expedition had a three-engined Fokker plane, named *Josephine Ford*. As had been the case 15 years previously, Amundsen would thus become involved in a race towards the Pole—in the present case, towards the North Pole.

The *Norge* arrived on May 7 and, well ahead of her, the *Josephine Ford* started her flight northward on the 9th. Byrd and Floyd Bennet—acting as navigator and pilot respectively—returned after a flight time of 15.5 hours (Byrd gives “nearly sixteen hours”). The plane had taken off at 00.37h GMT and returned to Ny-Ålesund at 16.07h (according to Berndt Balchen, then a member of the Amundsen expedition in Ny-Ålesund). Amundsen noted that the plane was sighted at 16.00h.

An anticyclone covered the central Arctic. In other words, the meteorological situation would be excellent for a flight to the Pole. From an analysis by the present author in 1960, it emerged that the cruising speed of the airplane and the meteorological situation were irreconcilable with the flight time; the plane could not have reached the North Pole, as Byrd had claimed. But these facts were, of course, not known or suspected in Spitsbergen at the time, and Byrd was supposed to have won the race for the North Pole by air.

Meanwhile preparations for the start of the *Norge* were going on and the weather situation remained unchanged. As for Finn Malmgren, he had an extra task to do. The Czech physicist František Běhounek (see p. 421) had been allowed to mount an instrument for measuring the electrical conductivity of the atmospheric air during the flight of the *Norge* across the Polar Sea. Malmgren was to carry out this work—he had experience of such measurements from the Pärtetjåkkå observatory and from the *Maud* as well.

All preparations for the flight were completed by the evening of May 10. The definitive list of the crew was settled (see p. 414). The meteorological situation was still fine, and the meteorologists of the Weather Service at Tromsø were unanimously of the same opinion. An anticyclone extended from Novaya Zemlya via the North Pole to Alaska and western Canada—indicating clear sky, fairly low temperature and light winds along the planned itinerary of the airship. Fog was, though, reported along the north coast of Alaska, and at Ny-Ålesund occurred gusts of fresh winds, which were a consequence of the gradual cooling of the air over the inland plateaus during the night.

Malmgren stayed at the hangar overnight in order to be in contact with the development of the weather situation. The gusty winds would involve a risk to the airship when it was taken out of the hangar. Weather reports, however, now indicated that a cyclone was approaching from the Iceland region of the Atlantic. So in spite of the gusty winds, the *Norge* was hauled out of the hangar, and soon before 09.00h GMT on May 11 the long polar flight began.

It was not a comfortable way to travel. The gondola of the airship was small. Ten persons resided here, which meant that it became quite overcrowded during flight. There were two chairs here, one used mainly by the journalist and the other by Amundsen. All others in the cabin would have to stand on their feet or temporarily sit on the floor. Throughout the flight, the men did not get any sleep, which of course was a hazard to the safety of the airship. The mechanics had a nook in the three motor-gondolas, and for sleep the narrow gangway on the kelson could be used—if there was time for that.

Across the Polar Sea via the North Pole

The first part of the flight was uneventful. Soon after they passed the north-western corner of Spitsbergen, the polar pack-ice was met with. From now on they were flying over floes or large fields of ice, often with openings or lanes of open water in between. The *Norge* moved north with two engines running, at a speed of around 80 km/h, and the weather was fine at first. The men took up their duties: Horgen was at the wheel of the rudder and held the airship on a steady course, and the wheel of the elevator was taken care of by Wisting. Two men were co-operating closely, the navigator Riiser-Larsen and the meteorologist Finn Malmgren. They were in need of meteorological data, as well as information for setting the course and, later on, for ensuring the safety of the ship.

The radio station of the *Norge* was strong, and connection was upheld with Stavanger Radio to get

The North Pole was reached by the *Norge* at 01.25 GMT on 12 May 1926. The photo shows the interior of the gondola of the airship when she was cruising in the Pole area. (Amundsen, R.: Över Polhavet.)

The flight of the airship *Norge* across the Polar Sea from Ny-Ålesund, Spitsbergen to Teller Alaska via the North Pole, 11-14 May 1926. Amundsen's flight in 1925, using two Dornier Wal airplanes, N24 and N25, is also entered in the chart. On this occasion he started from Ny-Ålesund and reached 88°N.

The airship *Norge* when landing at Teller, Alaska at 08.00 GMT on 14 May 1926. (Amundsen, R.: Över Polhavet.)

weather information, seven times daily. Storm Johnsen was the radio operator, and Gottwald the radio expert. The journalist Ramm sent his reports on the flight to the press by radio. But at first there was little to report. In the motor-gondolas the mechanics kept a steady watch on the behaviour of the motors. Inside the airship, the rigger Alessandrini moved about, checking the gas bags and their valves, the envelope of the ship, and so on. The three leaders of the expedition, Amundsen, Ellsworth and Nobile, supervised the flight and made themselves useful in several ways.

After about 12 hours' flight with a clear sky and excellent visibility, the *Norge* flew into fog, but by rising to an altitude of 700 m she came above it. At about 01.00h on May 12, the fog dissolved and the airship descended to 200 m.

At 01.25h GMT on May 12, Riiser-Larsen's observations showed that they had reached the mathematical pole of the Earth, which so many arctic travellers had tried to attain for so many years and with so many hardships and sufferings. R.E. Peary had reached the North Pole in 1909 by travelling with dog sledges over the pack-ice, or at least he came pretty close to it. And a few days ago Byrd had reached the Pole by air, according to himself (compare p. 416). To be correct, the men of the *Norge* were the first to reach the Pole by air—and, in fact, the first to do so independent of means of transport.

The airship circled round the Pole for several minutes. The Norwegian, American and Italian flags were thrown out from the cabin. Each flag was fastened to an aluminium stake, which pierced the ice and let the three flags stream in the wind. Finn Malmgren dropped a Swedish two-crown coin into a lane in the ice.

The remaining part of the flight would pass over quite unknown territory. The Norwegian geophysicist H.U. Sverdrup, from an analysis of tidal observations made on board the *Maud*, had inferred that there probably did not exist any land still undiscovered and of reasonable size in the Polar Sea, except possibly small islands.

The weather soon after the passage over the Pole remained fine. As before, the scenery consisted of wide expanses of snow-covered sea-ice with open lanes now and again. No life was seen. But at latitude 86°–85°N on the American side of the Pole, the *Norge* ran into fog. It was not very dense, as the pack-ice could be seen now and again below the ship. Now the men were threatened by a peril worse than anything yet experienced: icing of the airship.

The supercooled droplets in the fog were transformed into ice when they hit the airship. Her envelope, propellers, aerial, and other parts became coated

with ice. This added weight to the envelope. Pieces of ice came loose from the rotating propellers and were hurled towards the envelope of the ship with great power, keeping the mechanics under Cecioni busily engaged with repair work. The aerial became coated with thick ice and broke, as did a spare aerial; as a result the radio went dead, and the outside world heard nothing from the ship, so a catastrophe was assumed to have taken place. Nor was it possible to get any radio bearings for navigation. The icing upon the envelope was strongest on the fore part of the airship, which thus became heavier than other parts of the ship and was pressed downwards. To compensate for this effect, more petrol was taken from the fore containers.

Malmgren had studied the problem of icing during the drift of the *Maud* (compare p. 414). Thanks to his experience, he could advise the navigator Riiser-Larsen on suitable flight levels. The two men maintained very close co-operation during these critical stages of the flight.

A hazardous flight along the coast of Alaska

They were now approaching the arctic coast of Alaska. After they had left the North Pole, the course was set for Point Barrow, the north point of Alaska. Land was sighted at about 07.30h on May 13, after a flight of almost two days. It turned out that they had reached land about 2 km to the east of Point Barrow, a wonderful piece of navigation—if not of luck. But the wind was northerly, and the ship was now steered west along the coast to attempt a landing at Nome, where they hoped to get some shelter during the landing operations.

This place lies on the southern side of the Seward Peninsula, which constitutes the eastern coastline of Bering Strait. To get there, the *Norge* had to be steered south-west, and visual contact with the Alaskan coast had to be maintained. There were, though, low stratus clouds making it necessary to take the ship down below them. The airship ran a great risk of colliding with the sea-ice or the land. The utmost care had to be exercised by the man at the elevator wheel.

Finally nothing remained but taking the airship above the clouds/fog. In doing so they lost contact with the coastline. There was a clear sky with sunshine above the cloud/fog, but the extension of the cloud deck seemed infinite, and the ship was tossed by the strong winds.

They did not know the exact position of the airship, yet the sun helped them to get an idea of their whereabouts. The present part of the position-line passed over the sea, and after a few hours Riiser-Larsen took a second observation which, along with

the first, indicated that they were over the sea somewhere north of Bering Strait. The risk of colliding with mountains was thus eliminated, and a descent was risked. The *Norge* once again met with the dangers of icing, as well as the perils of high winds and a tremendous turbulence which made the ship undulate.

At 02.00h on May 14, the airship had been taken down through a dense cloud deck which was 1000 m thick. She had then settled at an altitude of 100 m in order to steer along the coast. The wind was now so strong that the airship was stationary relative to the ground, even though two motors were running—the third was in reserve. The engines were running at the cruising speed of 80 km/h, corresponding to 22 m/s. One of the two motors started causing trouble and an order was given to start the reserve motor. But there came no response to the signal of the engine telegraph in the motor-gondola, so the power of the functioning motor was increased to full speed. The other motor improved, but the reserve motor remained silent.

Both the airship and crew were approaching the end of their endurance. Later, after landing, Riiser-Larsen was informed on the matter by the chief mechanic Cecioni, who had been in the motor-gondola in question when the engine telegraph signaled. The man in this motor-gondola had seen the pointer of the engine telegraph moving, but neither he nor Cecioni was able to grasp the meaning of it; their brains had almost ceased to function.

Further such incidents occurred. When they were preparing to land, Riiser-Larsen thought he saw a squadron of cavalry riding along the shore—an excellent aid to the landing operation. However, the horsemen were just some strips of sand protruding from the snow. At the same time, Ramm envisioned a train with yellow Pullman wagons running along the shore.

The men were in so bad a state that they constituted a serious danger in the handling of the ship. Those in the cabin had been standing practically all the time—as mentioned, there were only two chairs to share—and nobody had slept at all. It was definitely time to land. At 03.30h on May 14, the *Norge* passed over Cape Prince of Wales, and here they came into the grip of the heavy winds. The airship was pulled downward by the wind and started to drift sideways.

As soon as possible they would have to land, give up the planned landing at Nome, and take whatever landing-place they could use. Amundsen noticed a few houses and some people, but not enough manpower to be of much help in the landing operation, which therefore had to be made without any help from the ground. They employed a trail-anchor and an oblong bag of sailcloth, filled with tools and other

heavy things they could gather. It was fastened to the airship with a long line passing into her forepart.

The airship was then taken close to the ground, and the motors were stopped. Soon she ceased to move in the wind, thanks to the two drift-anchors. By good fortune, the north-westerly wind abated during the landing operation—though only to increase afterwards. It remained to empty the gas bags and let the *Norge* descend on an ice-covered lagoon. In the words of Malmgren:

“The landing was a masterpiece of good luck.”

They had landed at 08.00h on May 14, at a little place called Teller situated about 90 km north-west of Nome. The flight had lasted 3 days minus one hour—71 hours. Malmgren himself had gone without sleep for 85 hours, as he had been watching the weather situation in the night before the start from Ny-Ålesund.

The *Norge* had crossed the Polar Sea, and the North Pole had been reached for the first time. Malmgren had successfully carried out measurements of the electrical conductivity of the air during the flight; no new land had been observed. Such were the results of the flight. Besides, they had learned that a dirigible could be used for polar research—although at great risk. The icing of the airship had been a tremendous hazard. Two years later, the danger of icing was to be experienced during a flight with a dirigible of the same type as the *Norge*, namely the *Italia*. And four years after the flight of the *Norge*, the discovery of the Andrée camp on Kvitöya (see p. 253) was to reveal that Andrée's balloon, too, had been a victim of icing and adhering water over the Polar Sea.

Moreover, several near-accidents had occurred during the long flight from Rome to Teller, Alaska. Not only that, but conflicts had developed between the Norwegian and Italian members of the expedition, notably between Amundsen and Nobile; their causes will not be discussed here.

Teller was not connected with the outer world by telephone or telegraph, so the radio of the *Norge* had to be assembled. Not until May 15 did the world at large come to know about the successful flight—there had been three anxious days. The expedition members travelled home via Seattle and New York, and on June 12 the Scandinavian group reached Bergen, Norway.

THE *ITALIA* EXPEDITION IN 1928

A scientific career opens to Finn Malmgren

Finn Malmgren returned home to Sweden in June, 1926. His plans were now to complete his academic

The airship *Norge* at the moment of landing at Ny-Ålesund, Svalbard, 7 May, 1926. (Amundsen, R.: Över Polhavet.)

Interior of the gondola of the airship *Italia*. (Nobile, U.: Med Italia från Rom till Nordpolen.)

The *Italia* passed over the centre of Stockholm on her way to Svalbard 3 May 1928. (Behounek, F.: Männen på isflaket.)

The *Italia* arrives at Ny-Ålesund, Svalbard, 6 May 1928, and moors at the mast. (Behounek, F.: Männen på isflaket.)

Umberto Nobile, 1885-1978.

The flight route, of the airship *Italia*, towards Nikolaus II Land (Severnaya Zemlya) in 1928. Only one hour before reaching their destination they had to return because of bad weather and lack of petrol.

studies with a Ph.D. Ever since 1917 he had been on expeditions, or worked in practical meteorology and oceanography. Now he wanted to have time and peace for devoting himself to studies and scientific work—mainly on his comprehensive observational material from the *Maud* expedition. At Uppsala, his teacher was Professor Filip Åkerblom, also a student of polar meteorology (compare p. 274).

In 1916 Malmgren had passed his B.Sc. examination, but it was to take until 1927 before he got his M.Sc., as one scientific task had followed upon the other. In May 1927 he passed his last examination, which involved courses in one subject—meteorology—and a fairly small thesis. There remained the “real” Ph.D., for which he had to write a comprehensive thesis and defend it officially. In his case the thesis was practically completed; the disputation took place on September 1, 1927, and fifteen days later a doctorate was conferred upon him.

He now also became a lecturer (docent) in meteorology at Uppsala University. He would now be able to devote himself exclusively to meteorological research. His thesis, *On the Properties of Sea-Ice*, built upon his observations during the *Maud* expedition. He had also published another paper from the same expedition, *Studies of humidity and hoarfrost over the Arctic Ocean*, and a paper from the Norge flight: *Mesures de la conductibilité électrique de l’atmosphère dans la région du Pôle Nord*.

There still remained material from the *Maud* expedition. Malmgren had become close friends with Sverdrup, who had guided him in his academic career. He also dreamt of organizing and leading arctic expeditions of his own. The future looked bright. But fate had decided otherwise.

In the autumn of 1927, Malmgren was asked by Nobile whether he was willing to take part in a new polar expedition with a dirigible, now flying under the Italian flag and with Nobile as the leader. He was not so willing, as he had plans of his own for the future; but when he heard that one flight was to go to Nikolaus II Land (Severnaya Zemlya) he replied in the affirmative. The east coast of this land had been discovered in 1913 from the Russian icebreakers *Taymyr* and *Vaygach*, but its western part was still unknown (see p. 148). The existence of land within this region had been assumed on board the *Vega* already in 1878: migrating birds had been seen coming from the north when the ship was near Cape Chelyuskin (see p. 125). Thus Malmgren decided to go with Nobile.

Plans, expedition members

During the *Norge* expedition in 1926, no specific scientific projects were attempted—except the meas-

urements of the electrical conductivity of the air, which the Czech physicist František Běhounek was allowed to carry out with the help of Finn Malmgren. Nobile intended to have a few scientists attached to his own venture. Professor Aldo Pontremoli would carry out geomagnetic measurements, and Professor Běhounek was now allowed to go with the expedition, this time to measure atmospheric electricity and radioactivity in co-operation with Pontremoli. Finn Malmgren was to take care of the meteorological observations during the flights; he was also the expedition’s weather forecaster and oceanographer.

There existed plans and equipment for making echo-soundings of the depth in the Polar Sea, and for measuring the water temperature and taking water samples. In order to carry out these studies it would be necessary to land a few men on the polar pack-ice. However, this was never done because of unsuitable weather. It should be added that General Nobile’s brother, Amadeo Nobile, acted as meteorologist at Ny-Ålesund.

The dirigible to be used was identical with the *Norge* apart from a few modifications and changes. Its gondola and radio cabin were made somewhat larger, the envelope was thinner, and special attention had been devoted to the problem of ice formation upon the propellers.

The crew of the airship—including scientists and journalists—is given below. The list contains those persons who went on one or both of the two long flights which were carried out from Ny-Ålesund. Which of the two long flights each person took part in is also indicated, according to the explanations at the top of the list. Those who had taken part in the flight of the *Norge* across the Polar Sea are also marked, with an asterisk (*).

N = participant in the flight to Nikolaus II Land (Severnaya Zemlya).

P = participant in the flight to the North Pole.

I = member of the “ice group” which landed upon the ice after the crash of the *Italia*.

D = member of the “balloon group” which disappeared with the crippled airship after the crash.

THE CREW OF THE *ITALIA*

NPI* Umberto Nobile (1885–1978, aged 43), general, aviation technician, constructor of the *Italia*, leader of the expedition.

NPI Adalberto Mariano (aged 30), lieutenant commander in the Italian Navy (Capitani di Corvetta), first officer.

NPI Filippo Zappi (aged 31), lieutenant commander in the Italian Navy (Capitano di Corvetta).

NPI Alfredo Viglieri (aged 28), senior lieutenant in the Italian Navy (Tenente di Vascello).

NPI* Finn Malmgren (1895–1928), Swedish, Ph.D., meteorologist and oceanographer.
 NPD Aldo Pontremoli (aged 31), Ph.D., professor, physicist.
 PI František Běhounek (aged 31), Czech, Ph.D., professor, physicist.
 NPI Felice Trojani (aged 31), engineer.
 NPI* Natale Cecioni (aged 40), master mechanic, also helmsman.
 NPD* Ettore Arduino (aged 38), chief motor mechanic.
 NPD* Attilio Caratti (aged 33), non-commissioned officer, motor mechanic.
 N(PI)* Vincenzo Pomella (aged 30), foreman, motor mechanic (killed in the crash of the *Italia*).
 NPD* Renato Alessandrini (aged 38), foreman.
 NPD Calisto Ciocca (aged 31), foreman, motor mechanic.
 N Ettore Pedretti (aged 34), non-commissioned officer, radio operator.
 NPI Giuseppe Biagi (aged 31), non-commissioned officer, radio operator.
 PD Ugo Lago (aged 28), Ph.D., journalist.
 N Francesco Tomaselli (aged 34), Ph.D., journalist.

Flight to Nikolaus II Land (Severnaya Zemlya): 16 persons—15 Italians, 1 Swede.

Flight to the North Pole: 16 persons—14 Italians, 1 Swede, 1 Czech.

After the crash of the *Italia*:

Ice group (PI): One person (Italian) killed in the crash, and nine survivors who comprised 7 Italians, 1 Swede, 1 Czech. Malmgren later succumbed during the ice-march from the Ice Camp to Nord-austlandet.

Balloon group (PD): Six persons (Italian), all of whom disappeared (were killed).

A hard flight to Spitsbergen

Experience from the *Norge* had shown that the flight from Italy to Spitsbergen was by no means free of danger from the weather. This time another route would be followed, mainly since the hangar at Gatchina near Leningrad had been pulled down because of old age. It would be possible to land at Stolp in Pommern near the Baltic (later Slupsk in Poland); the jump from Stolp to Spitsbergen would be long, but manageable. The mooring mast at Vadsö in northernmost Norge could still be used, but only in fairly good weather.

The *Italia*, as the airship had been named, left Milano at 02.00h on April 15, 1928. Before then, the expedition had been received by the Pope, who pre-

sented it with a wooden cross to be planted at the Pole. King Victor Emmanuel was visited next, and lastly the prime minister—Benito Mussolini.

The weather situation was not ideal over the route, or as Malmgren expressed the situation:

“We will meet difficulties. We will have some excitement, but we cannot expect much better weather during the next few days.”

Or to quote Nobile:

“This flight from the Po Valley to the Baltic was, from an aeronautical point of view, one of the most interesting which had ever been made by a small airship. During the 2,000 km which we covered, all possible atmospheric adversities had arranged to convene in order to try out the airship as well as its crew: strong winds, rain, fog, hailstorms, lightning, ice and snow—nothing was spared us.”

At 07.50h on April 16, the *Italia* landed at Stolp in northern Germany, with some damage to the ship and with a crew already filled by excitement. The airship now needed repair to endure long flights. This work lasted until April 28; on the same day, Nobile was informed that the mooring-mast and the hangar in Spitsbergen were fit to receive the *Italia*. But the *Città di Milano* with equipment and ground staff had been at Tromsø for several days, awaiting improvements in the ice situation in Kongsfjorden. This predicament threatened the entire expedition with the *Italia*.

However, a telegram informed the captain that it was not necessary to land at a quay in Spitsbergen. The fast-ice could substitute for a quay, and communications with the land could pass over the ice. On April 30, a weather forecast was obtained from Tromsø, saying that good weather would prevail over Scandinavia—although less good over the Barents Sea, where the wind was expected to attain force 5 Beaufort. There was also an addition to the forecast:

“...the weather conditions are as good as you can hope for at this time of the year. You will incur risks, but they are unavoidable.”

Yet the *Italia* still could not proceed upon her flight. The winds at Stolp were too strong to allow the airship to be taken out of the hangar.

On May 2, Nobile decided to start, after a conference with Malmgren. The flight would not be impossible, while definitely not agreeable. There was a headwind of 50 km/h at 300 m over the Baltic, but the

wind would calm down when they reached Sweden. Over the Barents Sea they would meet with rain and snow, and winds of 40 km/h.

The *Italia* lifted from Stolp at 03.30h on May 3. They had fuel enough for about 70 hours' flight with a speed of 80 km/h in a no-wind atmosphere. Stockholm was reached after 7.5 hours. In glorious weather the airship passed over the city; and in its western suburb of Äppelviken, a letter was thrown down over the home of Finn Malmgren and his mother.

The passage north was made under somewhat less favourable weather conditions. Winds drove them over Finland at Vasa, and during the night towards the 4th they passed northward over northern Finland.

They were informed from Tromsø that a cyclone had developed over the Barents Sea, leading to strong northerly winds between Norway and Spitsbergen. In a later telegram they were advised to increase their speed in order to reach the mooring-mast at Vadsö, while the winds there were still favourable for landing. At about 09.00h on the morning of May 4, they arrived in Vadsö and were safely fastened to the top of the mast.

They got replenishments for the stores of petrol, oil, hydrogen gas and water, and after four hours the airship was ready to start. But the weather objected, and the wind increased; during the night towards the 5th, the situation sometimes became critical. There was a risk that the airship would break adrift from the mast. Two motors were started and kept running at slow speed, to be ready for a quick start. Moreover, the airship was kept higher at the nose than aft, to avoid being pressed downwards by the wind gusts.

At about noon on May 5, the wind was beginning to fall. The meteorological reports indicated that the weather also seemed to have improved over the Barents Sea. Finn Malmgren recommended a start, despite the possibility of fresh winds at Spitsbergen. At 20.34h on May 5, the *Italia* left Vadsö. They had enough petrol on board to reach Ny-Ålesund, even with a headwind of 60 km/h.

The weather on the route to Björnöya was generally good, though they had to pass areas with fog or snow showers. At 04.30h on the 6th, they reached Björnöya. On the proposal of Malmgren, they passed over and round the little house of the two weather observers, whose observations and advice had been of great value during the flight.

Between Björnöya and Spitsbergen the weather deteriorated, and the wind direction of the forecast did not agree with reality. Instead of strong northerly winds, they encountered south-easters with a speed of 60–70 km/h. Near Spitsbergen the winds rose still more. Nobile notes:

“...we had to fight against a violent snowstorm. The whole atmosphere was in a commotion. The clouds were flying in all directions, though mostly towards the north-west.”

Malmgren remarked:

“The situation is full of risks. The atmosphere is full of energy.”

Nobile continues:

“Now and again the storm seemed to get the upper hand of us. We proceeded almost abeam. Without noticing it, we were also driven off our course. But in spite of all our difficulties I was not worried. I preferred fighting against the weather to lying anchored to the mooring-mast at Vadsö. I felt calm because I knew that we had enough petrol on board to remain afloat for three days in an emergency. We could also make use of the south-east wind to be carried out over the Polar Sea... This was a plan I had since 1926 and which now tempted me again to the extent that I decided to realize it.”

However, one of the motors now suffered damage and went out of use. So the airship proceeded northward along the Foreland Sound. At 11.22h on May 6, she steered into Kongsfjorden. At Ny-Ålesund, the wind was fresh to strong and the *Italia* could not be taken into the hangar, but had to be moored to the mast temporarily.

The airship had reached the point of departure for the planned flights over the Polar Sea. She had already met with many severe adversities, but at least they had now safely reached their headquarters. The *Città di Milano* was on the spot, and with her was the ground staff for the flight operations.

Severnaya Zemlya almost reached

Four days were needed to prepare the airship for the first flight. She had to be overhauled and repaired, and stores had to be taken aboard. Three major flights were contemplated, one going to Severnaya Zemlya (“North Land”) or, as it was then called, Nikolaus II Land. Two flights would go to the North Pole along routes leading across still unknown regions: north of Greenland, and between the longitudes 30° and 40° E. Nobile also intended a flight via the Pole to the mouth of Mackenzie River on the north coast of Canada.

The order of these flights would depend upon the weather in the regions concerned. Nobile had therefore made an agreement with the Weather Office at

Tromsø to be informed whenever any of these air routes were expected to have good flying weather. On May 10 he was informed that the weather looked promising for a flight to Severnaya Zemlya, the polar land—still only partly investigated—to the north of Cape Chelyuskin (see pp. 125, 136, 186 and 425).

The start took place the following day, May 11, at 07.55h. Unfortunately the weather situation did not prove suitable. They proceeded northward along the west coast of Spitsbergen. The temperature during the previous days had been fairly low, about -10°C , and the preparations for the flight had been made accordingly. However, on the 11th it was getting warmer, so the lifting capacity of the airship decreased, and some petrol as well as personnel had to be left at home. Thus only 13 men could take part in the flight; among them were Malmgren and Pontremoli.

At the island of Fuglesangen in northwest Spitsbergen, the course was changed eastward. Before they got that far, Alessandrini had made a serious discovery: one of the lines leading to the rudder was alarmingly corroded, and might break at any moment. After a preliminary repair, it was considered that the flight should continue.

But now the weather deteriorated, and for two hours the airship had to fight against fog, snow and strong winds. Near Nordkapp of Nordaustlandet, things became still more hopeless; and from the bulletins they obtained over the radio, it appeared that the weather had suddenly worsened along the route to Severnaya Zemlya. The only choice was to return, and at 16.10h they were back at Ny-Ålesund. Still, they had gained some scientific information during the flight: Pontremoli had measured the ultra-violet radiation, the electric potential gradient, the electrical conductivity, and radioactivity of the air.

On May 14 they received a telegram from Tromsø's weather service, informing them that the weather conditions were favourable over the route to Severnaya Zemlya. This meant a flight of at least 3500 km, taking about two days, besides the journey back to Spitsbergen. Much petrol would be needed, and Nobile decided to take 7000 kg with the airship, allowing 85 flight hours with a speed of 80 km/h in a no-wind atmosphere. Petrol would have to be given priority to ballast and water; yet their equipment—food and scientific instruments—weighed far more than on the previous flights. With the crew included, the *Italia* would have to carry a cargo of 11 800 kg, which was very much indeed for such a small craft.

The start was determined to take place between 02h and 03h on May 15. They were ready on time, but a fault in the oil circulation forced them to wait until 13h. This delay was spent by the men in the hangar,

which meant a loss of sleep in advance of the long flight. Sixteen men took part in the flight (see list, p. 421). It should be noted that the two scientists Pontremoli and Malmgren were included in the crew, but Běhounek was not.

The weather was excellent. They passed along the west coast and reached Fuglesangen at 14.15h. The sea was quite free of ice, in contrast to what had been the case when the *Norge* passed here in 1926. From the north point of Fuglesangen, they steered towards Nordkapp in the north of Nordaustlandet, just as they had done a few days ago. Near Kapp Hansteen there was some ice, but to the north lay open water—although a white line hung along the northern horizon, possibly the edge of the polar pack.

They passed the Nordkapp of Nordaustlandet at 17.25h. The sea was partly ice-covered, as it was to remain during most of the flight. Then the weather began to frown, and at 17.50h they met with snowfall. This, however, was fairly light—the weather was dominated by an anticyclone and the visibility never went below 10 km.

They were heading towards the enigmatic Giles Land, which was placed at about 81.5°N , 36°E , on the maps at the time. It corresponds to present-day Kvitöya, at roughly 80°N , 31.5°E . They never observed this island, as they became enclosed here in fog or, rather, low stratus clouds. It was regrettable to meet with low visibility just when entering an unexplored region. Besides, they now had to suffer icing upon the envelope and the cabin of the airship. But they got rid of the icing by descending to 150 m, below the stratus clouds.

They passed over an unknown region between Nordaustlandet and Franz Josef Land, and were again thwarted by fog or stratus with icing. At 22.30h the course was changed to north, in order to investigate the central parts of this region. Yet the easterly course was soon resumed when they saw no trace of land. They traversed the region along a stretch of about 300 km, with a visibility of some 30 km.

Steering towards Franz Josef Land, they came under low clouds. At 02.20h on May 16, they sighted an island, but the visibility was now low. Soon Armitage Island was reached, and Nobile decided to follow the northern border of the archipelago, in order not to go astray. They pursued an average north-easterly course past the islands of Arthur, Harmsworth, Salisbury, Jackson and Karl Alexander. At 09.05h they rounded Cape Fligeli, the north point of Prince Rudolf Island—and of the whole archipelago.

After that, the course was set for Severnaya Zemlya (Nikolaus II Land). The weather improved and for four hours they enjoyed a visibility of at least 50 km in

all directions. Near Cape Fligeli the pack-ice contained openings and lanes, but as they proceeded eastward these disappeared gradually. At about 13.00h, visibility decreased to about 15 km; between 14.00h and 16.30h, it had become only 9-10 km, and snow began to fall. As they approached Severnaya Zemlya, the ice contained more openings than previously, and they even believed that, from 80°N, 84.5°E, they could see land close to the horizon to the south.

Since leaving Nordaustlandet, they had been troubled by headwinds. Closer to Severnaya Zemlya the wind speed increased, and its direction became northerly, causing a drift of 30°-40°. Besides, the wind was gusty, making the airship roll by as much as 20°. The man at the rudder-wheel had a most troublesome time.

Nobile was worried over the home flight. They had now spent 10 hours more than estimated, and were already using the spare store of petrol. It was necessary to turn back, in spite of the fact that only 1-2 hours remained before reaching Severnaya Zemlya.

At 23.15h on May 16, they started the flight back to Spitsbergen. They had then reached 79°16'N, 91°40'E, according to their navigation, and the flight had lasted 34 hours. They were quite close to the unknown western coast of Severnaya Zemlya (see the maps, p. 420). But they had not yet seen the land.

Nobile now also had to consider which route to follow back to Spitsbergen. It was not advisable to fight against the strong north wind by retracing their former course. After a discussion with Malmgren, Nobile decided to set the course for Cape Zelantya, the north point of Novaya Zemlya, a route which was somewhat longer than that used on the outward flight.

They were still crossing unknown regions of the northern Kara Sea, but saw nothing of interest. At 04.20h on May 17, they reached Cape Vissinger Hoft on the eastern coast. Then they followed the rocky coast northward, passed Cape Zelantya, and continued in fog towards Cape Nassau, which they reached at 08.35h. From Cape Nassau they proceeded across the northern part of the Barents Sea, a peaceful flight at 600 m, now and again with a light snow-shower and low banks of fog.

They arrived at Cape Leigh Smith in the north-east of Nordaustlandet at 03.55h on May 18. From Cape Bruun they steered directly for Ny-Ålesund, across Nordaustlandet and over the northern part of Spitsbergen. After Cape Bruun the sky cleared up, and the sun shone over the ice-caps of Nordaustlandet. They noted that the interior of Nordaustlandet was not fully occupied by land-ice.

The latter part of the flight was made at a height of

2 500-2 800 m, under a cloudless sky and with scenery of mountains and ice:

"...which gave the men new courage and drove away all traces of fatigue, so that after the vigils and pains of three days and nights we felt hale and hearty, as if we had just started a flight."

The *Italia* landed at Ny-Ålesund at 10.20h on May 18. They had been on the way for 69 hours and had covered about 4,000 km. They had flown over unexplored seas, but had not seen any new land. It was a very great disappointment that they had been prevented from exploring Severnaya Zemlya.

On the other hand, Malmgren had collected meteorological data and had observed the ice conditions along the route. Pontremoli had measured the horizontal component of the geomagnetic field force, and had measured the electric conductivity and radioactivity of the air. He had also carried out a great number of measurements of the ultraviolet radiation. Nonetheless, there lingered a deep chagrin that their target of Severnaya Zemlya, the last still undiscovered land in the Arctic, had not been reached. There seemed to be no time for a new attempt, if they were to reach the North Pole first.

The flight to the North Pole -success and catastrophe

Preparations for the next flight were started immediately after the *Italia* returned from the Severnaya Zemlya tour. It was getting warmer now, and in daytime the temperature began to creep above the freezing point. As a consequence, the carrying power of the airship was decreasing. As summer approached, the frequency of fog and low stratus clouds would increase. There must not be any unnecessary delays, once they received a message promising good flying weather.

Nobile played with the thought that they might have to postpone the polar flight till the autumn. He was even contemplating a long flight, lasting a week, by riding on the wind to cover long distances while saving petrol. However, the flight to the North Pole was to be carried out as soon as possible. After the very long flight to Severnaya Zemlya, the polar flight seemed to offer no problems.

During this flight, moreover, attempts were to be made to land scientists on the ice for making oceanographic and geomagnetic measurements, as well as astronomical observations to determine the position accurately. Malmgren was to take care of oceanography, and Pontremoli of geomagnetism, while Běhounek on board the airship would carry out meas-

urements of atmospheric electricity and radioactivity. The oceanographic programme would consist of sounding the depth by an acoustic method (a simplified echo-sounding), taking water samples and determining the water temperature down to 2000 m.

The airship would be anchored at a height of about 100 m, while the measurements were going on. The landing of the scientists was to be carried out with the airship at about 50 m, using a rubber basket. The oceanographical programme was of particular interest, despite the fact that its measurements had to be limited to only one "geographical" point. They would yield information on the spreading of warm Atlantic water into the central Arctic, and on whether the central Polar Sea was a deep ocean basin. Amundsen in 1925 had measured a depth of 3000 m at 88°N, and G.H. Wilkins in 1927 had found 5400 m to the north of Alaska.

The expedition was supplied with excellent photographic equipment, but there was no professional photographer to use it. Viglieri had attended a short photographic course soon before they left Italy. Nevertheless, if the *Italia* were to pass over unexplored land regions, these would be photographed.

Great attention had been paid to the store of provisions on board the airship. Most important were the reserve provisions and equipment to be used in case of an accident. The equipment included four guns and some Colt pistols. However, after the crash of the airship it was found that the guns had gone with the balloon, while the ammunition stayed with the cabin on the ice. Fortunately, a Colt pistol with ammunition also stayed on the ice.

The preparations for the polar flight lasted two days, and from May 20 they were ready to start, whenever the weather conditions permitted. Already that day, they were informed from Tromsø about developments in the weather. On May 22, a message arrived:

"It is expected that the favourable conditions which have prevailed until now will not last for long, because warm air currents will give rise to fog. However, the situation is still so favourable that we can advise you to start upon routes 2 and 5, if the local weather conditions are satisfactory."

Route 2 was the region from Spitsbergen to Greenland and then the Pole, whereas route 5 extended from the Pole to Mackenzie River, Canada. Half an hour later, at 22.30h, Tromsø reported that the weather situation was unchanged, which was confirmed twice during the night. Malmgren advised Nobile to start.

At 03.00h on May 23, the gas bags of the balloon were filled with hydrogen gas. The airship was taken out of the hangar at 04.00h, the motors were started, the carrying capacity was checked, and it was found that Viglieri could be included among the crew. Padre Gianfranceschi read a prayer; the airship was liberated from the ground and started her flight northwards at 04.28h.

They sailed along the coast of Dei Sju Isfjella, passed the north point of Amsterdamöya at 05.41h, and continued on the northerly course along the meridian of 11°E. At 06.50h, having reached 80.5°N, 10°E, they set the course for Cape Bridgman on the north coast of Greenland.

Since they left Amsterdamöya, the northerly wind had increased, reducing the speed of the airship. A few minutes after setting the course for Greenland, they encountered the pack-ice and with it the fog, which was to follow them until 13.15h. At 10.40h they passed through fog but came above it already at a height of 500 m. At 14.45h the Greenland mountains were seen coming over the horizon. The fog was dissolving, and there was pack-ice on the sea, which enabled them to measure both speed and drift: 62 km/h and 30° to starboard respectively.

They steered towards the coast and followed it. They passed Cape Bridgman and continued some distance westward, but returned to the cape. From there, they steered due north for the Pole along the meridian of 27°W.

The sky was clear blue, and the weather looked perfect. Everybody felt happy. The wind was now in their favour, coming from behind and providing a speed of 100 km/h. They reached lat. 84°N at 18.00h, 85°45'N at 20h, and 88°10'N at 22.00h. Part of the way they flew over unexplored regions, between the routes of Peary and the *Norge*.

Nobile, though, was not fully satisfied, because the fairly strong wind which prevailed would prevent them from landing the scientists on the pack-ice at the Pole. Other problems were also coming up. Malmgren had drawn a weather map from the data he had received. The map indicated two cyclones, one over the Polar Sea near the Siberian coast and another over the Barents Sea. For the return flight from the Pole, they might have to battle against headwinds and clouds/fog.

Would it not be better to continue towards the American coast beyond the Pole? Malmgren advised Nobile to return to Spitsbergen, in which case there would be time and opportunity to pursue the research programme they had discussed previously—letting the wind more or less decide where to go, and steering with it instead of against it (compare p. 425).

They were now fairly close to the Pole. The wind conditions were still favourable, but at 22.00h the sky was clouding over in front of them, with a bank of clouds at a height of 1000 m, which

“...gave the impression of a rampart in a giant fortress... This bank of thick, dark clouds looked so threatening that I [Malmgren] was involuntarily seized with uneasiness. Beyond the pole, I thought, you cannot come. It is essential to turn back to the starting-point.”

Half an hour later they met with fog, and had to rise above it in order to view the sun: the officers were making repeated observations of the solar altitude as the ship was approaching the Pole. There was some excitement on board as they came closer. At 01.12h on May 24, the observations indicated that they had reached the North Pole. Since Cape Bridgman they had flown a distance of 706 km in 6 hours 50 minutes, corresponding to an average speed of 105 km/h.

The power of the motors was now reduced, and the *Italia* circled slowly over the Pole area. Soon the speed was increased again, the intention being to descend below the cloud deck. The pack-ice was seen anew, and the slow circling resumed while they prepared the celebrations which were to take place.

At 01.20h Nobile let go the Italian flag, and 10 minutes later it was followed by the Pope's cross. The motors were almost silent, a small gramophone played an Italian folksong, men shook hands, a bottle of liquor was opened and shared; telegrammes were sent to the Pope, King Victor Emmanuel and Prime Minister Mussolini. At the same time, Pontremoli reported to Nobile on the measurements of the horizontal component of the geomagnetic force, which he had carried out over the North Pole.

The return flight started at 02.20h on May 24. The *Italia* had stayed in the Pole area for 2 hours 12 minutes. The meridian of 25°E was followed southward at an altitude of 1000 m.

The sky became overcast soon after they left the Pole area, but they got a solar observation just before it clouded over. Now they would have to rely entirely upon the magnetic compass, and they could not determine drift and speed; nor did they know the wind conditions. At 10.20h, it was decided to go down through the clouds until the pack-ice became visible. At 200-300 m they were below the cloud deck and could use their drift-meter. A south-west wind was now observed, and it must have driven the airship eastward.

For about 24 hours they proceeded under the clouds at heights varying between 150 and 300 m.

Visibility was rather bad to begin with, but improved gradually. The pack-ice was

“...desolate and gloomy, everywhere snow-fields, blocks of ice, innumerable cracks... Now and then snow-showers, in which we temporarily became shrouded and were prevented from seeing the ice below.”

The men no longer enjoyed the flight, as they had done during the first part of the tour. Life had taken on a serious character. The icing of the airship, which had been such a grave menace during the flight with the *Norge* two years previously, appeared and lumps of ice were hurled by the propellers towards the ship's hull, piercing the envelope. Even the little propeller operating the generator for the radio sent lumps of ice towards the cabin of the airship.

Their ground speed was only around 46 km/h, as they had to fight against a headwind—generally of about 35 km/h, but occasionally 50 km/h. Malmgren worried over the situation. On the previous day he had thought that the southerly winds, which were favourable during the northward passage, would be exchanged for northerly winds on the homeward flight. But this had not happened. He wanted to get out of the sinister area as soon as possible, and advised Nobile to increase the speed of the ship.

Normally only two motors were running. Now they were given higher power and the third motor was started. In a no-wind atmosphere the airship would have had a speed of 100 km/h, but measurements indicated that her speed was only increased to about 62 km/h on average. Moreover, the fuel consumption had nearly doubled. In this way they continued from 19.00h on May 24 until 03.00h on May 25. The strain upon the airship due to the wind was great, especially with the greater motor power.

Nobile was concerned. On the whole, the flights had been hard ever since leaving Rome and, though the ship had proved to be robust, she had suffered much harm. So at 03.00h the speed was reduced. However, Malmgren's worries had deepened and again he told Nobile that they had to leave the area as soon as possible. From 04.30h on May 25, they resumed the struggle against the headwind with three motors running. The wind gusts threw the ship out of her course by 20°-30°, and the helmsman had a most strenuous task. The men had lost courage, and they had lost sleep for two nights and a day while battling the forces of the weather.

The navigation was becoming a serious problem. They did not know where they were, except that they were approaching the Svalbard archipelago. Naviga-

tion was the responsibility of the two naval officers Mariano and Zappi, but they were helped at the rudders by Trojani, Cecioni and Malmgren.

In this predicament, the radio became their primary means of determining their position. There existed an agreement with the *Città di Milano* that the vessel should take radio bearings upon the *Italia* when the airship approached the Svalbard archipelago. In those days the accuracy of such measurements was not great, but they would be of great help now. At 07.00h on May 25, there was still no land to be seen—just ice. According to their dead reckoning, land should have been visible. At 07.40h, a radio bearing from *Città di Milano* indicated that they should be somewhere along a line from Ny-Ålesund north-eastward, through a point about 10 nautical miles to the east of the isle of Moffen.

They continued steering south, and the southerly wind seemed to increase. At 09.25h, the elevator got locked and the airship descended towards the ice from about 250 m. But since she was “light”—lighter than the air—her downward motion could be arrested simply by stopping the motors. From about 80 m above the ice, she rose slowly like a free balloon. Meanwhile, Viglieri practiced the classic method of getting stubborn contraptions to function: in the present case, by giving the helm a hard blow. The *Italia* ascended through the cloud deck and, with the elevator in good order again, it was decided to pass up through the cloud in order to measure the solar altitude for obtaining the position. Cecioni had found no fault with the elevator; probably it had stuck because of ice. The airship was allowed to rise freely through the air until 1100 m was reached. The motors were then started, at 09.55h. As no mountains were seen, the ship was taken down again through the cloud, until at 300 m they again sighted the pack-ice. The wind seemed to have decreased somewhat, and there was no longer any need to start the third motor, so the problem of the fuel consumption seemed to be eliminated.

With the help of a radio bearing from the *Città di Milano*, and of the position line Viglieri had just obtained, they found the approximate position to be 45 nautical miles north-east of Moffen, or 180 nautical miles north-east of Ny-Ålesund. Hence they expected to reach home at 15.00h–16.00h.

They sailed at 200–300 m, and as the airship was “light”, they had to keep the fore somewhat low. Normal conditions had been regained on board the ship: Malmgren was at the steering wheel, and Cecioni at the elevator wheel accompanied by Trojani. At the chart desk in the rear of the cabin were Nobile, Mariano and Viglieri. Behind them Běhounek was busy with his instruments. Pontremoli and Lago had

gone up into the ship to take a nap. The mechanics were all awake: Pomella was in the aft motor, Caratti and Ciocca in the port and the starboard motors respectively. Arduini and Alessandrini were on watch on the ladder within the ship.

At 10.30h the speed of the airship was being measured, when Cecioni was heard exclaiming:

“We are heavy!”

The stern was seen sinking, and the ship descended at a rate of 0.5 m/s. Nobile gave orders to increase the power and start the third motor, which would be a way of stopping the downward motion. However, the ship continued to sink. There was then nothing to do but stop the motors in order to prevent a fire—and await the crash against the ice.

The crash took place at 10.33h on May 25, and its prelude had lasted 2–3 minutes. A few seconds before the impact, Viglieri noted that the *Italia* had sheared almost 180° and now took the wind against her stern, which was lower than the bow. He estimated the airship’s slope to be about 40°.

The aft motor must have hit the ice first, and Pomella was killed instantly. Next the cabin hit the ice and was torn away from the body of the airship. Some of the men in the cabin beheld the ship moving just above them; Viglieri, lying on his back, saw her bottom passing over him at barely one metre above the surface. He also noticed Arduini standing on the foot-bridge leading to the port motor, bare-headed and with his eyes wide open. Biagi gives a similar description of the crash: he too perceived the wide-open eyes and horror-struck look of Arduini. Běhounek watched the airship—minus her cabin and aft motor—slowly rise into the air and disappear towards the east.

Left on the ice, with the remains of the cabin and one motor, were Nobile, Mariano, Zappi, Viglieri, Malmgren, Běhounek, Trojani, Cecioni, and Biagi. Next day, Pomella was found dead in the wreckage of his motor.

In the body of the *Italia* as she drifted away were Pontremoli, Lago, Arduini, Caratti, Alessandrini and Ciocca. The first two actually had their place of work in the cabin, but—unfortunately for them—they had been asleep on the gangway inside the airship for several hours before the crash.

This “balloon group” of six men has never been heard of since. Shortly after the crash, those on the ice seem to have noticed a faint pillar of smoke to the east, which might have come from a burning *Italia*. The fate of this part of the expedition was to remain a mystery.

The men on the ice

Gradually the others came to their senses and began to assess the new situation into which they had literally fallen. At first they thought all had survived—Pomella was not found until the following day. However, three of them were incapacitated, and two severely.

Cecioni and Nobile had broken bones, while Malmgren had great pain in an arm. The rest had received bruises, and Cecioni was also gripped by terror of the surroundings. None in the group, except Malmgren, had been prepared for such a predicament. They had no knowledge of how to live in the polar environment.

But soon they started to cope with it. Looking around, they discovered some useful equipment: a tent and a sleeping-bag, belonging to the gear for the planned landing on the ice; pemmican, also for the landing party; chocolate, milk tablets and butter; a radio receiver and transmitter, as well as batteries for these. In and near the wrecked cabin of the *Italia* were other items of value. Běhounek found the notebook containing all his measurements during the flight. From thin boards supplied by the floor of the cabin, Zappi—who had taken some medical training—made ribs for splinting the broken bones of Nobile and Cecioni.

In the evening of May 26, the second day of their stay on the ice, Biagi picked up the first radio transmissions dealing with the fate of the *Italia*. It was assumed that she had run into a mountain in Spitsbergen. But the reception was bad and the transmission soon faded out. Biagi sent SOS signals every hour, telling about the crash and giving the position of the camp. But he got no answer.

There was always the danger of meeting polar bears. The men had few weapons: two hunting-knives, two hatchets, and a 12-mm Colt pistol. This had been intended for the landing party, and was now found in the snow with ammunition. In addition, they collected some navigation equipment: sextant, mercury horizon, chronometers and nautical tables. The radio receiver would provide time signals.

On May 27, Mariano measured their position for the first time: 81°14'N, 25°25'E Gr. The last position they had transmitted to the *Città di Milano* had thus been quite wrong, namely about 300 km to the west of where the airship crashed. Biagi and Cecioni investigated the radio transmitter in great detail, and finally found a faulty capacitor, which could be exchanged. But there were still no answers.

The tent was fairly small. It was meant for four persons, and they were nine; besides, the lead accumulators for the radio were now taking up space.

Mariano was conscious of the necessity of introducing some sort of routine in the men's life, and of giving everyone a specific task for which he would be responsible.

When the radio transmitter was found, the atmosphere in the camp had been rather optimistic. But the lack of response to radio calls produced a state of the deepest depression. While Nobile was remarkably composed, Cecioni's nerves were greatly strained and so, to some extent, were those of the other men. Malmgren had been apathetic after the crash, probably due to the pain in his arm. However, his mood improved, and his knowledge of the pack-ice could be utilized, not least in solving the problem of how to procure good drinking-water from the pack-ice.

On May 27 they cooked a soup with pemmican, and even liked it. They had found 71 kg of this concentrated polar food. With other such provisions, including the chocolate and butter, there were 125 kg, which should last for 45 days: famine was not immediately at hand.

They could now hear the *Città di Milano* calling them:

"We think that you are near the north coast of Svalbard between the meridians of 15° and 20°E Gr. Do not lose your courage. We are organizing help."

Many in the camp got the impression that the *Città di Milano* was not bothering to listen for their own calls. They heard interminable telegrams from journalists being transmitted. Otherwise, they received news bulletins from the radio station of San Paolo near Rome, but these were of very little interest to them.

For the homeward flight of the *Italia*, Malmgren had forecast northerly winds. Instead, the airship had received southerly winds; yet after the evening of May 25, north-westerly winds blew without a break. Malmgren's forecast had been one day too early.

Three men on a march over the pack-ice

On May 28, the weather became suitable for a second determination of their position: 80°49'N, 26°20'E. It meant that the camp had drifted 28 nautical miles during two days, under the influence of the north-westerly wind. Karl XII Öya was beginning to creep above the horizon to the south. The rapid drift of the ice was worrying, and surprised even Malmgren. Mariano and Zappi began to consider a march over the ice towards the north coast of Nordaustlandet.

Soon afterwards, Nobile was told that a group consisting of the three naval officers, together with Malmgren, planned to leave the camp and go for help.

They could not hear the *Città di Milano* over the radio, and from San Paolo they heard that she was now at the north coast of Svalbard. They were very doubtful of ever making contact with the ship.

The plan was discussed, and it emerged that the group should consist of three men—Mariano, Zappi and Malmgren. Nobile and Cecioni were invalids and could not walk; nor could Trojani and Běhounek, because of their weak physical state. Viglieri was needed at the camp for carrying out the astronomical observations of position, and Biagi had to take care of the radio communications.

Cecioni was very much alarmed at being left at the camp. He wanted to construct sledges for transporting him and Nobile over the pack-ice. Characteristically, none of the men yet had any idea of the horrors of travelling over the arctic pack-ice in the summer. To begin with, Nobile only ordered Cecioni to make two sledges for transporting the camp to a safer place, which Mariano and Malmgren were told to find.

On May 29, Karl XII Öya had vanished, but two other islands appeared to the south-west: Broch- and Foyn-öyane. Astronomical observations now gave the position of the camp as 80°41'N, 27°12'E. Thus, since May 26, they had drifted 29 nautical miles in the same direction as before, south-south-east. The three men who were to leave the camp became optimistic when they saw these islands so close, only about 10 nautical miles away, and they wanted to go at once.

By this time, Cecioni had constructed something which might be used to drag equipment upon, but definitely not invalids on the pack-ice. Moreover, fear arose that the accumulator batteries would soon be exhausted, removing the men's power to inform the world of their whereabouts. They were embittered to hear the *Città di Milano* wasting so much time on news bulletins and private telegrams.

Mariano, Zappi and Malmgren were anxious to start as quickly as possible. They aimed to follow the route Foynöya—Kapp Bruun—Kapp Platen—Scoresbyöya—Nordkapp, a distance of some 160 km, which they hoped to cover in 15–16 days.

Next day, the 30th, they intended to move the camp, which would give them some experience. Besides, Cecioni would then understand the impracticality of transporting two invalids with the available equipment.

Early in the morning, the sun appeared and Zappi went out to measure its altitude above the horizon. He returned after a few minutes, saying that there was a polar bear close to the camp. With their only firearm, the Colt pistol, Malmgren went out to meet the bear, which was at a distance of 20–30 m. Malmgren got it with the first shot. They had now secured a good

amount of meat—as well as the skin, which could be used on the floor in the tent.

The solar observation on that day gave their position as 80°36'N, 27°23'E. They had therefore drifted 5 nautical miles south-west, and were now only 7 nautical miles from Foynöya.

Zappi was extremely nervous and declared that the departure of the three men could not be postponed any longer. He felt that he was being hindered from utilizing valuable time. He had, however, now given up his previous argument—lack of provisions. Nobile questioned Malmgren about his arm, but was told that it was much better. It had suffered a strong blow, but no bone was broken, and Malmgren expected that he would be able to carry 15–20 kg.

Nobile was surprised at Mariano's desire to leave the camp; after all he was second-in-command. The days preceding the departure of the three men were filled with debate. Viglieri wanted to go, and Biagi also asked for permission to go. The men seemed to think that the ice-march was a path to life, whereas staying in the camp meant certain death. But if Viglieri and Biagi were to leave as well, Malmgren said he wanted to stay, as he could not bear to desert the incapacitated men. As a result, the group ultimately kept its definition: Mariano, Zappi and Malmgren.

The three men took no tent or weapons; the Colt pistol was left in the camp. Their clothes were good, but the weak point was their footgear: Lapp shoes of reindeer skin, which were not suitable on the wet surface of the pack-ice. Their provisions weighed 55 kg: pemmican 33 kg, chocolate 18 kg, malt-milk 3 kg, butter 1 kg. They did not bring a sextant; their navigational equipment was just maps and Malmgren's compass. Malmgren wore a rucksack containing 15–20 kg of equipment; the other two carried boxes on their backs, weighing 30 kg.

Before they left, Malmgren had a discussion with Nobile and gave him advice on several matters. On the evening of May 30, the three men left the camp. Mariano had estimated that they would be able to cover 10 km per day. But their progress was very slow; after two days they were only 4–5 km from the camp, and could still be seen.

After they had gone, peace settled over the camp. Nobile writes:

“The departure of the three was tantamount to the relief from a nightmare.

The question whether their plan would be granted or not had tormented us quite appallingly during the last three days. The long discussions, the obstinate stubbornness of those who wanted to leave and the many objections from the others,

the impatience of the former and the discontent which was openly shown by the latter: all this, in our little camp, had given rise to a nervousness which only heightened the unease caused by the drift of the ice and the silence of the radio. Our anxiety and depression were accentuated by the entreaties of Cecioni that we should all leave together, and by his absurdly violent resistance to any suggestion of splitting up into two groups."

Radio contact with the outside world

On the same day, May 30, Nobile asked Biagi if he was absolutely certain that the signals from his radio were getting out. A test was made: the receiver was placed 100 m from the transmitter, and the signals were heard. Further, Nobile wanted to know if the wavelength really was 32 m—and so it was. But from now on, the calls would have to be sent for one hour instead of 10 minutes.

On June 3, their position was 80°37'N, 26°50'E. But more important, that evening a young radio amateur, Nikolay Schmidt, living near Arkhangelsk, heard weak signals from the polar camp: "SOS Italia General Nobile". The latitude and longitude of the camp could not be heard; and as he had only a receiver, he was unable to call back. But the authorities were informed and, on June 6, Biagi heard in the transmission from San Paolo that his signals had been picked up at last.

The position on June 8 was 80°30'N, 28°10'E. In the evening, San Paolo informed them that the *Città di Milano* had heard their calls, including the position, and that she was going to listen for them on wavelength 900 m. Nobile was clear-thinking enough to reply that this wavelength would not do, as they had only a short-wave transmitter. The men were suspicious: had the *Città di Milano* listened for their calls during the preceding days?

On this day and the 9th, the *Città di Milano* was told about the crash of the *Italia*, and about the expedition's division into three parts—the Nobile group, the Malmgren group, and the balloon group, as these were generally referred to in the press. The *Città di Milano* informed them on the relief expeditions which were hurrying to their rescue. On the 9th, Nobile sent the message:

"Three of our companions are wandering along the coast on their way to Nordkapp."

But his judgement was failing, and the men's nerves were strained. Nobile developed a sort of "telegram fever", mixing important messages with unessential

ones in a haphazard way. It was a pity that the search for the Malmgren group was led astray.

The fact that Biagi's radio calls were not heard by the *Città di Milano* is curious indeed. From what has been revealed, mainly through the investigations of Nobile, it appears that the ship's commander, Captain Romagna, laboured under the impression that Biagi was dead, and that there was no point in listening for any calls from the *Italia*. As we have seen, the men at the ice camp learned only on June 6, the twelfth day after the crash, that the ship heard their calls. Evidently the ship's radio station was being used for other purposes—private telegrams, reports or guesses by journalists—and there was no time to listen, even if Biagi were alive. For the sake of formal correctness, the ship did listen during the short time that had previously been agreed upon, but then switched immediately over to talking with Rome.

Remarkable, too, is what happened in the evening of May 30. Pedretti, a radio operator on the *Città di Milano*, was on duty in the radio cabin, and the chief radio operator Baccarani was present. Pedretti heard weak signals and was able to catch the word "Italia", soon followed by "answer via Ido 32 K". Ido was the name of the radio station of San Paolo; 32 was the wavelength 32 m, on which Biagi operated; K was radio slang, meaning to answer fast. But Pedretti's chief waved the incident aside—Biagi was dead, and the signals came from Mogadishu in Benadir (Somalia), whose radio station used to call San Paolo.

This occurred on the same evening when Mariano, Zappi and Malmgren were leaving the camp. A call from the *Città di Milano* would have prevented the three men from leaving, or enabled them to be summoned back. In that case, Malmgren would have survived the expedition—and much hard work spent by relief expeditions, in the search for the three men, would have been avoided.

On June 14, the men in the camp on the ice heard the first airplane looking for them. From then on, an extensive search proceeded until the final rescue of the ice group and of Mariano and Zappi on July 12. A complete account of this activity is beyond the scope of the present book, but the following summary gives a general idea of what went on. A more full account is given of the Swedish relief expedition.

Events after the crash of the Italia

May 25 The airship crashed on the polar pack-ice to the north of Nordaustlandet at lat. 81°14'N, long. 25°25'E (as measured on May 27). This was about 300 km east of the last, and erroneous, position sent to the *Città di Milano*. The nine men in the airship's cabin landed on the ice; so did another man in the aft motor-

gondola, but he was killed. Six men drifted away with the hull of the airship and disappeared.

May 26 Transmission of SOS signals was begun from the camp on the ice by Biagi, the radio operator, but there were no answers to the calls.

May 30 The two naval officers Mariano and Zappi, and the Swedish meteorologist Malmgren, left the camp in an attempt to reach the north coast of Nordaustlandet.

June 3 Nikolay Schmidt, a Russian radio amateur near Arkhangelsk, received faint signals from the camp. He could not hear its position, but the authorities were informed. As early as May 30, signals from the camp had been heard by the *Città di Milano*, but no attention was paid to these.

June 6 By listening to the radio station of San Paolo near Rome, the men in the camp learned that the outside world now knew that at least part of the *Italia* crew were alive.

June 8 From now on, radio communication existed between the camp and the *Città di Milano*.

June 17 The first airplanes were seen from the camp; they passed 2–3 km from the camp without observing it. These were two Hansa-Brandenburg seaplanes, piloted by the Norwegian naval officers Hjalmar Riiser-Larsen and F. Lützow-Holm.

Relief expeditions are organized

In the spring of 1928, the Australian Hugh G. Wilkins and his pilot Ben Eielson were preparing a flight across the Polar Sea from Point Barrow to Spitsbergen, along a route closer to the north Greenland coast than the route followed by the airship *Norge* in 1926. Wilkins' airplane was a Lockheed Vega with a Whirlwind engine.

The two men took off from Point Barrow on April 15. After flying for 13 hours, they saw the north coast of Ellesmere Island. The flight had been favoured by fine weather; but five hours after sighting Ellesmere Island, they ran into a severe blizzard with strong winds and zero visibility. Eielson managed to land on the low ground north of the mouth of Isfjorden in Spitsbergen, Daudmannsöyra. Their flight had then lasted 20.5 hours. Here they had to stay until April 21, while the gale raged. After an awkward take-off and a short flight, they landed at the mining village at Grönfjorden. Wilkins had shown that the feat of the *Norge* in 1926 could be repeated with an airplane.

May 26 The Norwegian Government was informed about the disappearance of the *Italia*. On the same day, a dinner party was given in Oslo for Wilkins and Eielson, in celebration of their flight across the Polar Sea. Well-known arctic travellers were present, among them Roald Amundsen. During the dinner, repre-

sentatives of the Norwegian Government arrived, and proposed that a relief expedition be organized to find the missing airship.

May 27 Captain Egmont Tornberg, an aviator of the Swedish Navy, arrived in Oslo for discussions with the Norwegian aviator Captain Hjalmar Riiser-Larsen, but the latter had already gone north. In Russia, preparations had started for relief expeditions with the help of icebreakers.

May 27–28 The Norwegian aviator F. Lützow-Holm flew from Horten near Oslo to Tromsø, where his Hansa-Brandenburg seaplane was taken aboard a ship, the *Hobby*, for transfer to Spitsbergen. The sealer *Braganza* had been chartered for Riiser-Larsen.

The Swedish relief expedition

After Captain Tornberg's visit to Oslo, preparations began for a Swedish relief expedition, to be led by him. Two ships were chartered, the Norwegian sealer *Quest* and the Swedish cargo-steamer *Tanja*. The *Quest* had been Sir Ernest Shackleton's ship on his last expedition to the Antarctic in 1921–22. She was now to serve as the "flagship" of the Swedish expedition.

Three military single-engined aircraft—two Hansa seaplanes and a Fokker with skis—were included in the equipment. After the *Quest* and the *Tanja* had left Scandinavia, a civilian three-engined Junkers G-24 with floats, the *Uppland* with a crew of five, was dispatched to Spitsbergen. This plane belonged to the Swedish aviation company Aktiebolaget Aerotransport (ABA) and was used for the air service between Sweden and Finland.

June 13 The *Quest* left Tromsø for Spitsbergen.

June 19 The *Quest* and the *Tanja* arrived in Virgohamna in north-west Spitsbergen, the previous base of the Andrée expedition. That night, the three-engined Junkers plane *Uppland* landed at Virgohamna, having left Tromsø in the evening.

June 19–22 The three military Swedish planes were assembled at Virgohamna.

Members and planes of the Swedish relief expedition to Svalbard in 1928¹.

PERSONNEL:

PILOTS

Egmont Tornberg (1891–1951), Captain, Swedish Navy, leader of the expedition, pilot of Hansa seaplanes.

Lieutenant Einar Lundborg (1896–1931), Fokker.

Lieutenant Birger Schyberg (1897–1953), Fokker, Moth.

Lieutenant Bengt Jacobsson, Hansa seaplane.

¹ Source of data: *Flyghistoriskt Månadsblad*, No. 5–6, 1978

Mate Gunnar Svensson, Hansa seaplane.
Lieutenant Erik Ekman, Moth, Klemm-Daimler.
Sergeant Viktor Nilsson, Junkers plane *Uppland*.

OBSERVERS

Lieutenant Ivar Rosensvärd, Hansa seaplane.
Lieutenant Einar Christell (1896-1984), Hansa seaplane.
Lieutenant Ivar Carlsson, Junkers plane *Uppland*.

RADIO OPERATORS

Robert Ljunglund, Junkers plane *Uppland*.
Corporal Sven Enbergh, S/S *Quest*.
Thorvall Lindvall, S/S *Tanja*.
Birger Nordström, S/S *Tanja*.

WELDING OPERATOR

Hilding Nilsson.

MECHANICS

Axel Nordström, Junkers plane *Uppland*.
Bertil Sterner, Junkers plane *Uppland*.
Sergeant Carl Andersson.
Oscar Gull.
Corporal Axel Johansson.
Corporal Ragnar Örneklint.

RIGGERS

David Weibar
Einar Carlsson
Olof Andersson
Filip Johansson

OTHERS

Ragnar Huss, doctor to the expedition.
Johan Wilhelm Sandström (1874-1946), meteorologist to the expedition.

AIRPLANES:

Two *Heinkel HE-5* (Hansa), built by Svenska Aero AB.

Motor: 450-hp Bristol Jupiter.

Two *Fokker CVD*, built in Holland.

Equipped with wheels and skis.

Motor: 450-hp Bristol Jupiter.

Only one of the planes was used in Svalbard.

One *De Havilland Moth*, S-AABN.

Owner: AB Aeromateriel.

Equipped with wheels, skis and floats.

Motor: 80-hp Cirrus.

One *Junkers G-24*, S-AABG, *Uppland*.

Owner: AB Aerotransport (ABA).

Equipped with floats.

Motors: three 300-hp LV.

One *Klemm-Daimler L-20*, D-1357.

Owner: German aviation club.

Equipped with wheels and skis.

Motor: 40-hp Salmson.

TOTAL FLYING TIME OF THE AIRPLANES:

Heinkel (two planes) 92.25h

Fokker 7.00h

Moth 12.15h

Junkers 26.15h

Klemm-Daimler 4.05h

Total distance covered: 22 500 km (2/3 of it by the two Heinkel/Hansa planes).

The big planes and the Latham disaster

During the days before June 19, four large and strong seaplanes were at Tromsø, awaiting suitable weather conditions for proceeding to Spitsbergen. They included an Italian two-engined Savoia-Marchetti (with Major Umberto Maddalena), an Italian Dornier-Wal (commanded by Major Penzo) and a French Latham 47 (commanded by Guilbaud). The last had a crew of five others, among them two Norwegians: Roald Amundsen, and Leif Dietrichson (1890-1928) who had been a pilot during Amundsen's north polar flight with two Dornier-Wal planes in 1925. The fourth seaplane was the Swedish three-engined Junkers G-24, *Uppland*.

There was little co-ordination of the activities of the different nations involved in the relief of the *Italia* expedition. At the time it was still considered a feat to fly between Norway and Spitsbergen, and it would therefore have been desirable for the four planes at Tromsø to make the flight together—but they preferred to go alone. Maddalena's Savoia-Marchetti reached Kongsfjorden late in the evening of June 18, Penzo in his Dornier-Wal arrived later, and Nilsson with the *Uppland* landed at the temporary Swedish base in Virgohamna in the night towards June 20.

The Latham 47, with Roald Amundsen on board, left Tromsø on June 18. Radio contact with the plane was maintained for three quarters of an hour—and then ceased. The plane never reached its destination. Searches were undertaken in the Spitsbergen area, notably to the east of the archipelago, but in vain. Later, on August 31, a torn wing-float was found in the sea north of Tromsø, and subsequently a petrol tank, which had undoubtedly belonged to the missing aircraft.

Before relating the activities of the different relief expeditions, it is helpful to note the positions of the points of departure, or bases, which were used in the search operations from the air. The two Norwegian ships, the *Hobby* with Riiser-Larsen and one Hansa-

The *Italia* started her North Pole flight on 23 May 1928. The weather was favourable until near the Pole. On the return flight weather conditions became bad with low clouds, icing, and fairly strong head winds with turbulence, which impeded navigation. The *Italia* crashed on the pack-ice near Nordaustlandet on May 25. The gondola remained on the ice, but the balloon drifted eastwards and disappeared. Relief expeditions were organized, but the SOS signals from the radio of the *Italia* were not heard.

Later, when radio contact had been established, the gondola with its crew could not be seen because of the bewildering shadows that formed on the otherwise glaring ice fields. (Behounek, F.: Männen på isflaket.)

A landing at the camp failed. While trying to rescue the *Italia* crew, Lundborg's plane crashed 24 June 1928, and he found himself a member of the group on the ice. (Behounek, F.: Männen på isflaket.)

The last photo of Roald Amundsen (1872–1928) before he disappeared in a plane over the Polar Sea on 18 June, 1928 (Behounek, F.: Männen på isflaket.)

Sweden sent two ships and four airplanes; the leader was Captain Egmont Tornberg. (Behounek, F.: Männen på isflaket.)

Sergeant Viktor Nilsson flew the three-engine airplane *Uppland*. (Behounek, F.: Männen på isflaket.)

Lieutenant Einar Lundborg landed at the camp with a Fokker plane equipped with skis and managed to transfer Nobile to Murchisonfjorden together with his dog Titina. (Lundborg, E.: När Nobile räddades.)

Brandenburg seaplane on board, and the *Braganza* with Lützow-Holm and another plane of the same type, operated mainly from areas to the west and north-west of Nordaustlandet. The Italian relief expeditions—the *Città di Milano* and the two Italian seaplanes—operated from Kongsfjorden. The Swedish relief expedition, on the Norwegian sealer *Quest*, operated at first from Virgohamna in northwest Spitsbergen, but soon moved to Murchisonfjorden in the west of Nordaustlandet.

The Swedish expedition, as mentioned, initially had four planes: two Hansa seaplanes and a Fokker with skis, and the three-engined Junkers G24 *Uppland*. Later—at the base in Murchisonfjorden—the expedition was supplied with a small De Havilland Moth in exchange for the Fokker, which had crashed on the pack-ice near the Nobile camp¹. Besides, a Finnish single-engined Junkers plane, with a crew of three, joined the Swedish group. A small German Klemm-Daimler also arrived in Murchisonfjorden. One more Fokker had been transported to Spitsbergen, but it was never used.

The searches were not only carried out with the help of airplanes. From the *Hobby* and *Braganza*, sledge parties were landed on Nordaustlandet—notably two Norwegians, Rolf Tandberg and Hilmar Nöis, who travelled along the north coast of Nordaustlandet, establishing depots and looking for the Malmgren group, which was supposed to have reached this area. An Italian named Sora and a Dutchman, van Dongen, also landed on Nordaustlandet, intending to reach the Nobile camp by sledging over the pack-ice. The search operations concluded with the successful contributions of the Russian icebreaker *Krassin*.

What follows is a summary of the activities—chiefly the Swedish ones—in the north of Svalbard. It should be noted that, during the period of June 15–25, the weather was fine and suitable for flying.

A review of flight operations

June 17: Biagi made radio contact at long last with the *Città di Milano*, and was informed that the Norwegians were ready to fly to the camp. On that very day, two planes were seen approaching the camp, but they circled over the ice and never came closer than 2–3 km. These were the planes piloted by Riiser-Larsen and Lützow-Holm.

June 18: Riiser-Larsen's plane was observed from the camp, but again he turned back—west of the camp—

without having seen it. Apparently Foyn-öya was chosen as a point of reference; probably its position on the map was too far to the west. Confusing shadows formed on the snow-covered ice, and prevented the airman from locating the camp.

June 19: Late in the evening of June 18, the Italian aviator Umberto Maddalena had arrived in Kongsfjorden with his Savoia-Marchetti seaplane. After a short rest in Kongsfjorden he started towards the camp. At 08h his plane was heard from the camp, but he did not observe it due to the shadows upon the ice. The *Città di Milano* informed the camp that Maddalena would bring a radio the next day and wanted to be guided to the camp with its help.

June 20: Maddalena started from Kongsfjorden at 06h. Viglieri followed the plane in his field glasses when it approached the camp, and advised Biagi at the radio on the course to steer. Even though the plane came straight over the camp at a height of 100 m, the airmen were unable to discern it among the shadows on the ice. When called back, Maddalena went down to 30 m and finally noticed the camp. He returned to drop equipment, but much of this was lost in open lanes of water, or was smashed to pieces against the ice.

A short time later, the noise of a motor was heard in the camp. It was Riiser-Larsen in his Hansa-Brandenburg, but once more he could not find the camp.

Just before bedtime, engines were heard again. Three aircraft, one very large and two smaller, passed nearby and continued eastward. In the camp, they believed that these were the French Latham plane and the two Hansa-Brandenburgs of the Norwegians, seeking the balloon group. However, the planes were Swedish, looking in vain for the Nobile camp.

The Swedish relief expedition had its initial base at Virgohamna, in the north-western corner of Spitsbergen. After arriving on June 19, time had been spent in mounting the two Hansa planes and the Fokker. The three-engined Junkers, *Uppland*, arrived in the night towards June 20, having flown from Stockholm via Tromsø. The two Hansa planes were ready for flight on June 20, and the Fokker—equipped with skis—was ready in the evening of the 22nd.

On June 20, the *Uppland* and the two Hansa planes carried out a first flight eastward, trying to find the Nobile camp and supply its inmates with provisions and useful equipment. However, the three planes missed the camp by about 3 km (compare above).

June 21: The Norwegian relief expedition received a telegram from the Norwegian Ministry of Defence, with the order to look for Amundsen to the east of Spitsbergen as soon as possible.

¹ The camp was first referred to as the *Nobile Camp* then as the *Red Tent Camp*. After Nobile's rescue, the name *Viglieri Camp* was generally used.

June 22: In the evening, the two Hansa planes left Virgohamna to find the Nobile camp. The *Uppland* did not join them, as she had been troubled by their low speed on the 20th. The camp was now discovered, thanks to a smoke signal, and equipment was dropped over it.

June 23: The *Uppland* carried out a flight lasting six hours, to search for the missing Latham plane with Amundsen. The commander of the *Quest*, Captain Schjelderup, acted as observer. The route passed along the Spitsbergen west coast, Sörkapp was rounded, and the western side of Storfjorden was followed to latitude 78.5°N, where a westerly course was taken overland and then along the north side of Isfjorden. Finally the course was set northward along the Spitsbergen west coast to Virgohamna. Nothing had been seen of the Latham expedition.

In the evening, the two Hansa planes and the Fokker started eastward. One Hansa was to remain at Hinlopenstretet and seek a suitable site for a base, while the other Hansa and the Fokker proceeded to the Nobile camp. The crew of the Fokker consisted of two men—the pilot Lundborg and the observer Schyberg. The intention was to land the Fokker on an ice-floe near the Nobile camp and fetch one man, then return to Murchisonfjorden and land as recommended by the Hansa, which had been stationed there. The Fokker would return with Lundborg alone to fetch two more men from the camp, and so on. Each time the Fokker was to be escorted by a Hansa.

The landing was successful. The field had been investigated and found acceptable, flags had been laid out to mark the runway, and the wind direction was marked by a smoke signal.

Nobile had decided the order in which the men were to be taken away:

Cecioni, who was crippled with a broken leg.

Běhounek, who was snowblind.

Trojani, who was feverish.

Nobile, who was crippled with a broken leg.

Biagi and *Viglieri*, whose presence was indispensable—the former for communicating by radio, the latter for determining the geographical position of the camp.

However, Lundborg decided that Nobile should be the first to go, as he was to lead the rescue operations. As an officer, Lundborg should have known better than to insist upon this order; Nobile would have been spared much discomfort. So into the plane came Nobile, his little dog Titina, the log-book of the *Italia*, and copies of the telegrams from the camp to the *Città di Milano*.

The take-off succeeded as well, and soon the Fokker

reached Murchisonfjorden, where the two Hansa planes were seen on the water near Söre Russöya. This was the new base Tornberg had chosen. A suitable place for landing had been marked on a snow-field on Söre Russöya, and here Lundborg landed.

June 24: Already in the night towards the 24th, Lundborg flew back to the camp on the ice. He was accompanied by one Hansa, but he was now alone in the Fokker, as he intended to take two men back from the camp. The Fokker's engine was evidently not in the best of trim. During the passage over the pack-ice to the camp, it coughed a couple of times, and Lundborg tried hard to improve its state. The engine functioned well during the last stage of the flight—but when Lundborg was preparing to land, it started to cough again.

Lundborg had to land on the ice-floe at all costs, and did everything he could to get the engine to work properly. He came down in a weak wing-glide, not daring to risk full power, which might have adverse effects. He had to land where the plane chose to land, and that was by no means ideal. The plane bounced on the slushy snow, and the skis dug into it. Consequently the tail was lifted and the nose sank, and Lundborg found himself hanging upside down in his safety belt. As he wrote later:

“...there I was on the pack-ice with one of the world's best airplanes, it is true, but broken and lying on its back.”

The accompanying Hansa plane circled above the Fokker. Lundborg indicated that he was unhurt, and with this information the Hansa had to return to Murchisonfjorden. The disappointment was great, not least among the marooned *Italia* crew on the ice, as no other plane suitable for landing on the ice was to be found in Spitsbergen.

Lundborg now had to endure the nerve-wracking time at the camp, which the survivors had more or less come through. He was also to experience the wild desire to march towards Nordaustlandet over the pack-ice, which deteriorated day by day in the summer heat.

The camp was soon moved to the capsized Fokker, which became a safe and dry haven in the wide expanse of melting treacherous ice.

June 25: Nobile was taken by Tornberg to the *Città di Milano* on board a Hansa plane. The *Quest* arrived in Murchisonfjorden to serve as the base for the Swedish relief flights. The flight distances to the Nobile camp were too long from a base located at Virgohamna.

June 25–28: Fog prevailed in the Murchisonfjorden

area, and on the 28th also over the surrounding mountains.

June 29: The two Hansa planes started for the Nobile camp, but had to return after two hours because of the fog. A De Havilland-Moth plane arrived in Ny-Ålesund on board a collier. The plane had been ordered in Stockholm after the crash of the Fokker on June 25.

June 30: Both Hansa planes flew to the Nobile camp, and afterwards to the Storöya region farther east, for reconnaissance in connection with the coming rescue work.

July 1: The Savoia-Marchetti plane of Maddalena, the Dornier-Wal of Penzo, and the Swedish plane *Uppland* took off to visit the Nobile camp and to search for the balloon group. But fog forced them to turn back at Cape Leigh Smith.

July 2: Both Hansa planes started for the Nobile camp, but had to turn back near Cape Leigh Smith owing to fog.

July 3: One Hansa flew to Ny-Ålesund for the purpose of escorting Schyberg, who was to take the Moth plane to Murchisonfjorden. However, on the return flight, the Hansa had to make a forced landing on the ice in Wijdefjorden, while the Moth continued alone and reached Murchisonfjorden on July 4. With the other Hansa a mechanic, tools and petrol were transported to the troublesome plane; then both planes started for Murchisonfjorden. But the first Hansa had to make a new forced landing in open water near Verlegenuken.

Fog was prevailing and the two planes could not see each other. So one Hansa returned to Murchisonfjorden, while the other drifted with the tidal currents—first in a north-easterly direction, then south-east. But in the afternoon it drifted into Murchisonfjorden in a good state, though the floats had become somewhat damaged from the landing and start on the ice in Wijdefjorden.

July 4: The *Uppland* arrived in Murchisonfjorden from Virgohamna, to fetch Captain Schjelderup for a flight round Nordaustlandet, the intention being to search for both the Malmgren group and the Latham plane with Amundsen. The plane returned to Murchisonfjorden at 01.00h on July 5, after a flight of four hours. The Nobile camp had been visited and equipment had been dropped, with a message saying: "We will come with the Moth tonight [i.e. in the night towards July 6]." The Finnish Junkers *Turku* arrived in Murchisonfjorden in the night towards July 5, to become attached to the Swedish base in the fjord.

July 6: One of the two Hansa planes and the Moth reached the Nobile camp at 00.15h, intending to fetch Lundborg. Schyberg made a successful landing in the

Moth and, with Lundberg as passenger, flew to Esmarksöya in the north-east of Nordaustlandet, where he landed on the ice-cap. One of the Hansa planes had previously landed nearby, while the other, Tornberg's, circled in the air. The idea was that Schyberg should return to the Nobile camp at once to fetch the next man.

However, Tornberg's Hansa now landed for a discussion of a situation which had arisen. Christell, the observer in Tornberg's plane, was exchanged for Lundborg; in other words, Lundborg went with Tornberg in his Hansa, while Christell boarded the Moth of Schyberg. The latter was tired, and Tornberg decided that the rescue operation should be discontinued temporarily. All three planes returned to Murchisonfjorden, and in the Nobile camp people were waiting. It seems to have been a case of strained nerves.

In a stencilled article, *The "Italia" and the Swedish relief expedition*, Einar Christell gives the following account of the rescue of Lundborg:

"On a beautiful night with sunshine and moderate breeze, we flew eastward in the two seaplanes and a small Moth plane with double seats and with skis attached, to fetch the men in the camp on the ice. The seaplanes landed in open water between Esmarksöya and the ice-cap, while the Moth plane landed on the ice-cap nearby. Petrol, etc. was carried up to the ice-cap. A primitive base had thus become established.

In company with one seaplane, the Moth then flew to the Italian camp, where it landed and, according to given orders, the Swedish Fokker pilot was taken aboard and was carried to the temporary base on the ice-cap. The chief and I [Tornberg and Christell] remained in the air with the intention of escorting the Moth plane, when the remaining men in the camp were being rescued. However, down below on the ice-cap the Moth did not move, so we landed to find out why the plane did not proceed with the rescue work.

With astonishment and regret, we had to concede that the human factor prevented a continuation of the work that night. All three planes were therefore flown back to Murchisonfjorden, and our chief determined that, as soon as possible, we should return and try to rescue the remaining men. However, for several days unsuitable weather prevented flying, and in the middle of July the icebreaker *Krassin*—after a hard fight with the pack-ice—had reached the camp and taken the men aboard."

The meteorological situation during the polar flight of the *Italia* as given in 1986 by Petter Dannevig, Oslo. The chart shows the weather situation at 14.00 on 24 May 1928. The chart is based on the official weather reports in the area and reports from hunters. A cyclone with centre **L** is situated in the Pole area, and from it a front extends in a SSW direction, probably a cold-front. The winds have been estimated from the weather chart, both before and after the front—arrows indicate wind direction and wind speed is given in km per hour. The position of the front has also been estimated 24 hours before and after the front at 14.00, May 24. In a first approximation it may be supposed that the wind system keeps pace with the front. The flight track has also been estimated and is given by a broken line. This surmise should be fairly correct over the route from Spitsbergen to the North Pole, somewhat uncertain for the return flight. The divergence of the meridians and the course of the airship (having an easterly component) will lead to a delay in the arrival of the north wind as experienced by the *Italia* people. (From Dannevig, P.: Finn Malmgren—Nordens förste flygmeteorolog i været.)

Umberto Nobile and his dog Titina in the Swedish camp on Sörsöya together with Einar Lundborg, his rescuer, lieutenant in the Swedish Airforce, June 1928.

Flight tracks of the Swedish Junkers plane *Uppland* during her search for the French Latham plane with Roald Amundsen on board, June 1928. (Behounek, F.: Männen på isflaket.)

On the way to Murchisonfjorden, however, the Moth plane ran out of petrol and had to make a forced landing on the ice in Brennevinsfjorden. New petrol, filled into the tires of a rubber boat, was parachuted to the plane from a Hansa.

July 7: A day of rest.

July 8: The people to be housed on board the *Quest* were increasing in number. Now the Swedish journalist Knut Stubbendorff (1893–1965) arrived with the *Svalbard*, the ship of the Norwegian “sysselman” (governor). Compare p. 251.

Finally, on July 10 the Norwegian sealer *Braganza* arrived, with the mechanic of the Finnish plane and a Swedish sledging group. This consisted of H.N. Pallin, and Borg and Halvar Mesch, all well-known from their travels in the mountains in northern Sweden. Borg Mesch was also a renowned photographer. The small *Quest* now had to house 42 persons.

Meanwhile the large Russian icebreaker *Krassin* was steering eastward in the pack-ice to the north of Svalbard. Within a few days the men in the “Red Tent Camp” were saved and taken aboard the ship. The Malmgren group had been found and two of its men rescued—but Malmgren was not among them. He had perished one month earlier.

The Russian icebreaker takes the lead

The rescue operations were to end soon after Lundborg had been fetched from the “Red Tent Camp” on July 6. This was an achievement of the Russian icebreaker *Krassin*, at the time the strongest icebreaker in the world. Her displacement was 10 500 tons, and she could develop 10 500 hp—one horsepower per ton. Her crew numbered 116, and 79 of these were engine-room personnel.

According to plans, the *Krassin* was expected to seek the Nobile camp on the ice. Thus she would have to force the polar pack-ice to the north of Nordaustlandet, which many expeditions had reported to be heavily screwed locally. She carried a three-engined Junkers plane for reconnaissance and search.

Russia had also dispatched the ice-strengthened steamer *Malygin* to the area east of Spitsbergen. This ship searched between about 76° and 79° N, generally from the island of Hopen in the south to Kong Karls Land in the north. But she was outside the actual region to be searched, which was not yet known. Attached to the *Malygin* was a single-engined Junkers, piloted by M.S. Babushkin.

The *Krassin* had left Leningrad in the middle of June, visited Bergen, and proceeded north on June 24. On July 1, she reached waters to the north of Svalbard in the region near Nordkapp. There she met with severe ice, which reduced her speed to 4–5 knots. The

fight against the ice during the following days partly crippled her: the port propeller was broken and the rudder damaged. However, the ship managed to proceed on her mission.

On July 10, the fog which had enveloped the *Krassin* began to lift. In the forenoon, her Junkers search plane was able to take off. It flew along the north coast of Nordaustlandet, but the weather deteriorated with fog forming, and the plane had to return from the east. Near Karl XII Öya, the crew observed men on the ice. This had to be the Malmgren group, though the number of men differed in the observations. Their position was 80°43'N, 25°45'E.

The situation was dramatic. The plane, being in danger, looked for a landing place in Rijpfjorden, where it became damaged. But the *Krassin* had received a radio message. The Malmgren group had been found, and the position was understood: between Karl XII Öya and Broch- and Foyen-öyane. In sum, it was as far away from Nordaustlandet as the position had been when the three men started their march!

The *Krassin* steamed towards the position which had been given by the plane. At 06.40h on July 12, she reached the group. Zappi was running about on a little ice-floe like a madman; Mariano lay trying to lift his head, which fell impotently back onto the ice. There were only two of them; Malmgren had died a month earlier.

The different states of the two men, and the death of Malmgren, were to arouse much speculation. We shall not enter into these tragic events here, or touch upon the horrors of that march.

From the last camp of the Malmgren group, the *Krassin* steamed east, towards the Red Tent Camp and the five men who were anxiously waiting there. At 16.15h on the 12th, the men heard a steam whistle, and at an estimated distance of 15 km they saw the smoke from the *Krassin*. However, the ship steered too far south. As it was overcast and the visibility was reduced, the ship could not determine her position properly, and her route would take her well away from the camp. So they signaled from the camp with a smoke cartridge and rifle fire—which were observed. The *Krassin* now steered directly towards the camp, and in the evening of July 12, the five men with their equipment and the Swedish Fokker plane were taken aboard.

One part of the *Italia* crew had thus been rescued. The balloon group, which had drifted away with the crippled airship, was still missing. The officers of the *Krassin* suggested that an air reconnaissance should be made, but this proposal was seemingly neglected. The search for the *Italia* was given up, and the various

expeditions soon left Svalbard. No traces of the balloon group were ever found. An immediate search for it was essential, with the *Krassin* available in the area and with Italian, Swedish and Russian long-distance planes lingering in Svalbard. However, there appeared to be no interest in such a search.

The *Krassin* started her homeward voyage after retrieving her plane, which had crashed on the ice in Rijpfjorden near Cape Platen. On July 20 she arrived in Kongsfjorden, concluding a successful and effective mission. It should be noted that the *Krassin* reached a latitude of 81°47'N, which might be compared with the northern extreme of 81°42'N attained in 1868 during A.E. Nordenskiöld's expedition with the *Sofia* (see p. 59). The famous Russian icebreaker *Yermak* had reached 81°28'N in 1899.

A mission is completed

July 12: The Swedish relief expedition on board the *Quest* had obtained a telegram from the *Krassin*, stating that the two surviving members of the Malmgren group had been taken aboard the ship, and that the *Krassin* was heading towards the Red Tent Camp.

The two Hansa planes and the Finnish Junkers *Turku* took off at 09.30. Approaching the *Krassin*, they were informed that two men had been seen on the north point of Foynöya. The planes at once headed towards Foynöya, where they landed in a clearing of open water at the island. However, the clearing was closing rapidly. One of the men was taken aboard one of the Hansa planes, while the other man went aboard the Finnish plane. This rescue was made in the nick of time. Most of the men's sledge equipment and two dogs had to be left on the island—two other dogs in the team had by then served as food for the men. These were the Italian, Alpini Sora, and his Dutch companion, van Dongen. During their search for the *Italia* camp, they had come to Foynöya and been trapped there (compare p. 488).

July 13: Lieutenant Ekman arrived with the small German Klemm-Daimler plane, which had been placed at the disposal of the Swedish group for the search. However, the *Italia* relief operations were now finished, since the *Krassin* had taken aboard all men from the ice. There were now 45 men on the small *Quest*, but evacuation of the ship and of Murchisonfjorden had already begun. At 15.00h the *Uppland* and the Finnish plane *Turku* left for Kongsfjorden, with passengers.

July 14: The *Quest* prepared her homeward voyage.

July 15: The Klemm-Daimler plane was taken aboard, while the two Hansa planes and the Moth flew to Kongsfjorden. The two former planes chose a route along the coast, while the Moth used a direct

route over land. At 11.00h the *Quest* left for Kongsfjorden, where she arrived on July 17. It remained to load equipment aboard the *Quest* and the *Tanja*. On July 20, the two ships put to sea, reaching Tromsö on July 24.

CONCLUDING REMARKS

The rescue of the men from the crashed dirigible *Italia* had been a difficult operation. Six nations sent expeditions for the purpose: Italy, Norway, Sweden, Russia, Finland and Germany. In the literature it is stated that these relief expeditions had at their disposal 18 ships, 21 airplanes and 1500 men. However, this great contribution of material and manpower was not used in the most effective way, mainly because a central command and coordination was missing. This apparently has to be ascribed to a lack of interest on the part of the commander of the Italian base ship *Città di Milano*, Captain Romagna.

It was lucky that the *Italia* crashed relatively near the north coast of Nordaustlandet. Had the accident taken place a little farther north, it is doubtful whether any of her crew would have been rescued. The decisive contribution was made by the Russian icebreaker *Krassin*: she rescued seven—and Sweden one—of the eight men whose lives could be saved at all. No other country could provide such a strong icebreaker as the *Krassin*; but even she found the pack-ice to reach dimensions that matched her utmost capacity. It is of interest to compare the experiences of the *Italia* groups with those of Andrée and his two companions (see pp. 253 and 441).

The contributions of the Swedish relief expedition under Captain E. Tornberg are worthy of high praise. The meteorologist to the expedition, J.W. Sandström, has discussed the exceptionally good outcome of the expedition, and gives much of the credit to the winter training of the personnel in northern Sweden. The equipment, which had been tested and devised for field work, lay in order and ready in the military stores; only a few days were needed to assemble all that was needed for flying planes with floats and skis. And in Spitsbergen the planes could be mounted in the same way, with the same people and material, as had been done hundreds of times in Sweden.

Each sortie was prepared meticulously: the equipment to be dropped was fastened to small parachutes, and—not least important—it was possible to choose equipment according to the demands of wintry conditions. Besides, the Swedish planes carried provisions and equipment for the aviators themselves, estimated to last for two weeks, in case of accident; and for the sake of security, at least two planes flew together during the sorties. Each flight was followed

by 12 hours of careful work by the mechanics, in order to prepare the planes for the next sortie.

Equally important was the ability of the airmen to hit the most desirable places on the ice when dropping equipment. This had been learned by training to drop bombs in winter surroundings. Moreover, no aviator was killed and only one plane was damaged during the whole expedition. Sandström, though, concludes that the airplane is by no means a very suitable craft under the conditions of a relief expedition. It is too frail, demands too much time for attendance, and is difficult or impossible to start or land on the pack-ice with any degree of safety.

Things were expected to change; aircraft able to start and land almost vertically did exist. But most efficient would have been a combination of an ice-breaker with large and small airplanes. On the other hand, it is of interest to speculate over the outcome of an attempt by Norwegian sealers to fetch the *Italia* people by the "back way"—from the east during the break-up of the ice in the latter half of the summer.

THE HUMAN LOSSES IN CONNECTION WITH THE *ITALIA* CATASTROPHE IS SUMMARIZED HERE:

1. The ice-camp group: 2 men dead, Malmgren and Pomella.
2. The balloon group: 6 men dead, Pontremoli, Arduini, Caratti, Alessandrini, Ciocca, Lago.
3. The crew of Major Penzo's Dornier-Wal plane: 3 men dead.

On the return flight to Italy the plane hit a high-tension line and crashed into the Rhone; the whole crew was killed.

4. The crew of the French Latham 47 plane: 6 men dead.

The plane disappeared on June 18 during a flight from Tromsø to Spitsbergen; among the crew were the Norwegians Roald Amundsen and Leif Dietrichson, and the French pilot Guilbaut.

Total: 17 men dead

This may be compared with the eight of rescued men from the *Italia* crew:

Nobile, Mariano, Zappi, Viglieri, Běhounek, Trojani, Cecioni and Biagi.

In conclusion it should be mentioned that, in the case of Finn Malmgren, the *Italia* expedition was intended to be only an interlude, before he embarked on the scientific career which he had prepared until obtaining his Ph.D. And the expedition was not entirely a scientific loss.

Professor Běhounek had discovered his notebook, containing his observations, in the snow after the crash. He even found his electrometer for measuring cosmic radiation, which enabled him to carry out measurements in the Red Tent Camp (the Nobile Camp), far from the disturbing influences of land.

The very strong Russian icebreaker *Krassin* finally reached the Red Tent Camp on the ice. With that feat the relief operations in Svalbard were completed on 12 July 1928. However the balloon group was missing and will remain so. Finn Malmgren was never found. He had succumbed on a march towards Nordaustlandet with the two naval officers of the *Italia* to seek help and give information. Photo: F. Goldberg Collection.

The route of the Russian icebreaker *Krassin* in north Svalbard waters in the summer of 1928 (below). (Běhounek, F: Männen på isflaket)

39. THE ARCTIC FLIGHT OF THE GERMAN AIRSHIP *GRAF ZEPPELIN* IN 1931

In 1925 a number of scientists established an international society, *Aeroarctic*, with the object of investigating the Arctic by means of airships. At that time, the organization of scientific stations in the central Arctic was considered. In 1928, Fridtjof Nansen, who was then president of the Society, judged this to be one of its principal aims. He thought that a large dirigible might be used; but his plans seemed fantastic and did not yet arouse any enthusiasm.

The question was reconsidered in 1931 by H.U. Sverdrup, L. Koch and E. Sorge. It was regarded as vital to establish such a station during the Second Polar Year, 1932–33 (see p. 467). However, this proposal was not acted upon either. The Zeppelin firm at Friedrichshafen, Germany, was unwilling to place a dirigible at the disposal of *Aeroarctic*. Nor was the constructor Hugo Eckener (1868–1954) interested in stations on the drifting pack-ice. He had become the president of the *Aeroarctic* after Nansen's death in 1930.

A dirigible was, though, dispatched to the Arctic in 1931: the renowned German LZ 127, named *Graf Zeppelin*. But the programme was now less ambitious: meteorological and geomagnetic observations, investigation of ice on land and sea, and aerophotogrammetric studies of the arctic lands which the dirigible would pass.

Germany and Russia had taken the greatest interest in the programme of *Aeroarctic*, and were willing to cover most of the costs. The leaders of the arctic flight were therefore German and Russian. Its scientific leader was Professor Rudolf Samoylovich (b. 1884) and the general leader was Hugo Eckener (1868–1954). Eight scientists took part in the flight, among them the Swedish physicist Dr. *Gustaf* Samuel Ljungdahl (1882–1940).

The crew of the airship counted 46 men, scientists included. Ljungdahl was, since 1922, head of the geomagnetic department of the Swedish Hydrographic Office. He had founded the geomagnetic observatory on Lovö near Stockholm, and in 1925–26 he established and was the leader of the Danish geomagnetic observatory at Godhavn, Greenland. In 1928–30 he had carried out the first Swedish geomagnetic mapping of precision standard.

The *Graf Zeppelin* belonged to the rigid type of dirigibles: it consisted of a framework of duraluminium, around which the balloon-cloth was stretched. Her

length was 230 m, and her five engines could give her a speed of 120 km/h. Built in 1928, she was intended to be a kind of experimental ship for global flights. And in the summer of 1931 she embarked upon an Arctic research flight. In preparation, a hangar and a mooring-mast had been erected near Leningrad.

The arctic flight started from Friedrichshafen on July 24. A landing was made the same day at Berlin, and on the 25th Leningrad was reached. Here the dirigible stayed overnight to replenish gas and water, and on the morning of July 26 she embarked upon her remarkable arctic cruise. The weather was fine to begin with, with favourable wind and fairly high temperatures. The airship sailed at about 300 m.

In the evening, however, the weather deteriorated. The temperature dropped from +26°C to +4°C, rain fell and the wind shifted to north, reducing the ground speed to about 30 km/h. But soon the weather improved. They were then near Franz Josef Land, and could see the Russian steamer *Malygin* passing through the ice below. Franz Josef Land came into view; the scenery was exquisite and the colours looked delicate.

The airship approached Hooker island in the southwest of the archipelago. A meeting with the *Malygin* had previously been agreed upon: the *Graf Zeppelin* was to come down to the sea surface, and mail was to be exchanged with the steamer, as a way of getting some of the expenses of the expedition paid by philatelists. Yet the landing was by no means free of danger. The airship was driven by the wind towards piled-up ice, and there was a risk of damage to the gondola.

This event showed that such a landing could only be attempted in the very best of weather conditions, and with a first-class crew. It should be noted that Umberto Nobile—the commander of the dirigible *Italia*—was on board the *Malygin* on this occasion, for the specific purpose of finding relics of the so-called balloon group (see p. 428).

The *Graf Zeppelin* then passed over the western and northern parts of the archipelago, which were photographed with special photogrammetric cameras (see below). In the evening of July 27, the airship passed over the Norwegian sealer *Quest*, which was lying at anchor in the Cambridge fjord, with part of the Swedish-Norwegian expedition on board (p. 488). Greetings were exchanged over the radio. At midnight towards July 28, the airship passed over Cape Fligeli, the northernmost point of Franz Josef Land. From here the course was set east, towards the north point of Severnaya Zemlya.

The latter group of islands, which Nobile in the *Italia* had attempted to reach in 1928, was the object of research in 1930–32 by a Russian expedition of four men under G.A. Ushakov. Their base lay on one of

the Sergius Kamenev Islands in the west of Severnaya Zemlya. During sledge tours, the land was found to consist of four large islands and some smaller ones. The main traits of the geography and geology of this archipelago were investigated. This work was going on when the *Graf Zeppelin* passed over Severnaya Zemlya. The base of the Russian expedition could not be seen because of fog, but radio contact was upheld. The history of discovery of Severnaya Zemlya—or Nikolaus II Land—is described elsewhere (pp. 125, 149, 185, 423).

The flight over Severnaya Zemlya constituted the most interesting and, from a scientific point of view, the most valuable part of the arctic cruise of the *Graf Zeppelin*. The land was photographed consecutively with the photogrammetric cameras, and a very good idea was obtained of the geographical conditions, supplementing the discoveries by the Russian land expedition. The westerly coastal zone of the land, though, was covered in fogs or low stratus clouds.

The weather remained fine—but for fog over the sea—when the airship proceeded southward into the Taymyr Peninsula. At about latitude 75°N, the *Graf Zeppelin* headed westward and passed Dickson Island. Then a course was set towards the north point of Novaya Zemlya, where the airship steered homeward over the land or along the east coast of Novaya Zemlya. She landed in Leningrad and continued to Berlin, finally reaching Friedrichshafen on July 31, having flown for 100 hours and covered 13 000 km.

The scientific work on board the *Graf Zeppelin* may be summarized briefly. Two aerial cameras worked continuously when the airship was passing over or near land. They gave an excellent grasp of the geographical conditions. The aerial pictures were also used to construct maps of the regions photographed. These two cameras were built differently: one was a double camera and photographed the landscape in two directions. The other was an Aschenbrenner panorama camera, photographing the landscape with the help of nine lenses, which captured all of it from the nadir to the horizon.

The geomagnetic observations, which were carried out by Gustaf Ljungdahl, were limited to determinations of the horizontal intensity H of the geomagnetic field force, and to some measurements of the geomagnetic declination (the deviation of H from true north). The determinations of H are shown on a map (p. 444).

Below the airship a meteorograph was suspended. Here temperature, humidity and air pressure were recorded. At periods when the airship changed her altitude, as for photographic purposes, the stratification of the atmosphere was also obtained—the tem-

perature variation with height. A few times during the cruise, radiosondes were released, and in this way the temperature variation with height was obtained up to a high level.

The radiosonde was an innovation at that time. For use on board the *Graf Zeppelin*, the radiosonde with its balloon was connected to a weight which caused the apparatus to fall towards the Earth's surface. After 30 seconds the weight was released, so the balloon and radiosonde started to rise; at the same time, radio transmission from the sonde began. The meteorologists also conducted a weather forecasting service on board.

It had been a remarkably successful cruise, without dangerous events except the landing in Franz Josef Land. The weather conditions had been generally good and, not least in value, the scientific equipment had functioned perfectly. Also the men on board had been in good trim: they got the necessary amount of good sleep, and they had been served hot meals which were full of variety. There had been no problems with scarcity of fuel; when the airship reached her home port, fuel remained for two days' flight.

Nonetheless, the arctic cruise of the *Graf Zeppelin* was to be the last one with a dirigible in the polar regions. Subsequently the Aeroarctic society became less active, probably due to the political situation in Europe. There had also occurred a number of great catastrophes with large dirigibles: in 1930 the British *R 101* crashed over northern France and exploded; in 1935 two American dirigibles, the *Acron* and her sister ship *Macon*, crashed due to high winds on two separate occasions; and finally there was the explosion of the German airship *Hindenburg* at Lakehurst, New Jersey, in 1937.

The Americans were able to supply their dirigibles with the non-inflammable gas helium. Other nations had to use hydrogen, which is highly inflammable and meant a grave potential danger to dirigible and crew. Besides, a dirigible is very frail and sensitive to high and turbulent winds; it is also sensitive to icing, which the dirigibles *Norge* and *Italia* had experienced. But first and foremost, the dirigible was superseded by the airplane, mainly due to developments during World War II.

Severnaya Zemlya (previous Nikolaus II Land) was the most important region of research during the mission of *Graf Zeppelin* in 1931. In 1928, the *Italia* had failed to reach the archipelago, but in 1931 a Russian land expedition had begun investigating the islands from a base on one of the Kamenev Islands situated off the western side of the archipelago. When *Graf Zeppelin* passed Severnaya Zemlya the western side of the land was covered with clouds, but its eastern side could be photographed (right).

The flight track of the German airship *Graf Zeppelin* during her visit to the Arctic in July 1931. The airship followed a clockwise route. The Swedish physicist Gustaf Ljungdahl was invited to take part in the cruise. He carried out consecutive observations of the horizontal component of the geomagnetic field-force, which he entered along the flight track on his map (given in unit γ). (Ymer 1932.)

40. THE PIONEERING FLIGHTS OF ALBIN AHRENBURG IN 1929 AND 1931

AN ATTEMPT TO FLY FROM STOCKHOLM TO NEW YORK

Planning and plane, motor and men

The 1920s were a decade characterized by great improvements in man's ability to fly, both with vehicles heavier than air and with those that were lighter. During this time, the most significant process was the construction of strong and reliable motors for aircraft, which created the possibility to make long flights with reasonable safety.

Ever better aircraft were tested in the latter half of the 1920s. Daring flights occurred across the oceans and continents—and over the still unknown parts of the polar regions, northern as well as southern. A milestone in the airplane's development was marked by the successful flight across the Atlantic—from New York to Paris—which was carried out in May 1927 by Charles Lindbergh (1902–74), an American of Swedish descent.

Johan Oskar *Albin* Ahrenberg (1889–1968) had entered the Swedish Navy as a ship's boy and, after several years, become a non-commissioned officer. Having attended the aviation school of the Navy in 1919, he devoted himself to both military and civil aviation. His "tours all over Sweden", short flights with passengers in the summer season, made him a well-known figure. From 1927–31 onward, these ascents were carried out in the service of ABA (Aktiebolaget Aerotransport), which nowadays is a partner in SAS (the Scandinavian Airlines System). From 1932 Ahrenberg continued this activity with his own firm, and he came to represent a popular symbol of aviation. In his single-engined Junkers plane, equipped with floats, he flew almost wherever there was a jetty, in inland lakes or at the seaside.

In May 1927, Charles Lindbergh's flight across the Atlantic awoke the enthusiasm of many adventure-loving men throughout the world. It did so with Ahrenberg too. Since he worked in civil aviation, he began to speculate on the practical consequences. However, the long-distance flights of those days were necessarily made with hardly any payload; the planes were filled with fuel and with the aviator(s). A way to improve the situation was to carry out the flights by easy stages.

There was a discussion about the placement of

floating platforms along air routes. But a more realistic plan was to let a flight across the Atlantic follow a more northerly route, offering natural landing-places at suitable distances. This was the route of the old Viking sailors across the Atlantic, from Scandinavia via Iceland and Greenland, then south along the American coast. The Viking Trail, as it was usually called in America, could be flown by seaplanes to begin with, avoiding the costs of establishing airfields and reserve fields.

In fact, such a route had already been followed in 1924, on a round-the-world flight carried out by the US Navy. It had started with four planes and ended with two. The needs of the planes were satisfied by a number of depots with equipment, including spare parts. Along the route over the Atlantic, naval ships were stationed to supply the aviators with weather information and navigational aid—and, of course, to provide assistance in case of emergency. The technical chief of this enterprise had been a Swedish-American, Eric H. Nelson (b. 1888).

At the end of the summer of 1928, Ahrenberg was given an opportunity by his airline company, ABA, to make a flight across the Atlantic. But not until 1929 were all the preliminaries completed, with practical as well as financial arrangements. Ahrenberg had to go through all the nerve-wracking stages that are typical of public relations.

The kind of airplane to be used was a foregone conclusion. Ahrenberg would not think of anything else than a single-engined Junkers. It was robust and simple in construction, and he was accustomed to flying it.

The choice of crew was also easily made.

THE CREW CONSISTED OF THE FOLLOWING MEMBERS
Albin Ahrenberg (1889–1968), first pilot, leader of the expedition.

Axel Flodén, lieutenant, second pilot.

Robert Ljunglund, radio operator.

Sigurd Malm, mechanic.

Flodén had trained as a pilot under Ahrenberg, and he helped the expedition economically. Ljunglund had worked as radio operator at the Swedish mine Sveagruvan in Spitsbergen, and had taken part in the Swedish relief expedition to Spitsbergen in 1928, serving as radio operator on board the three-engined Junkers plane *Uppland* (see p. 433). In 1931 he was to go with Ahrenberg to Greenland (see p. 453). Malm had worked with Ahrenberg during his flights around Sweden.

The plane was the freight version of Junkers W33. It was an all-metal craft, provided with floats. There arose one problem during the preparations. Ahrenberg

would have to start with too high a load for the standard engine without any modifications. By using an air-cooled Wright engine the problem would have been solved, were it not for finances; that engine was expensive and its installation in the plane would demand extra money. However, the Junkers firm proposed a solution: by increasing the compression, the standard motor could be trimmed from 300 to 360 HP for the take-off. In Ahrenberg's words:

"We accepted this, having confidence in what they assured us—they were, of course, interested in the whole machine being a pure product of Junkers—but this confidence was a blue-eyed stupidity, which I was to regret and which I had to pay for at a high price."

The modification led to a whole series of consequences, which were to ruin the successful completion of the Atlantic flight.

"All these problems with the compression, the fuel, spark plugs, radiator and pump would have been avoided, if we had only possessed the means to buy an American air-cooled motor, and we had to regret bitterly that we did not wait until we got these means. The motor which was installed became the Achilles' heel of the enterprise—this motor and nothing else."

The expedition was indeed to suffer from it, and the effects must be characterized as unbelievable. It is remarkable that the expedition members returned home with their lives intact.

They had two alternative routes to choose between:

1. From Stockholm via Bergen, the Faeroes, Reykjavik, Angmagsalik (East Greenland), over the Greenland inland ice to Holsteinborg (West Greenland), across Davis Strait to Cumberland Peninsula, along Baffin Island to Port Burwell (Labrador), Port Menier (Anticosti Island) and Portland to New York;
2. From Stockholm via Bergen, Reykjavik, Ivigtut (South Greenland) and Anticosti Island to New York.

Alternative 2 was about 600 km shorter than Alternative 1, but the distances between the landing-places were longer. On the other hand, it was expected at the time that Alternative 2 would be chosen in a future air service.

Ahrenberg chose Alternative 2, but it should be noted that he did not then know the deviltries of the

plane's motor. He managed to get a small ground-staff of interested people at Reykjavik, Ivigtut and Anticosti.

Westward with a sullen engine

The Atlantic flight started from Stockholm at 06.00h on June 9, 1929, and at 12.00h the plane landed at Bergen, Norway. Already here they experienced the first of the many near-crashes that were to mark their way west.

They continued the flight at 14.00h. The take-off was somewhat troublesome in the calm air, and the engine became overheated. But gradually the instruments returned to normal values and the engine then worked well, though the pilots had doubts of its functioning. The Faeroes were passed later than expected. Was this due to a headwind? Then an exhaust pipe was lost. After 21.00h, the spark plugs caused disturbances in the radio reception, and no reception was possible after 23.00h.

At about the same time it was reported that the number of revolutions was decreasing steadily and had to be compensated for by increasing the gas. It turned out that fuel for only about 2 hours was left; normally fuel for six hours should have remained. One hour later, land was sighted. It was the shoreland and the dome of Vatnajökull in the south-east of Iceland. Practically no fuel was now left, but a steamer was seen near the coast, away from the breakers. Ljunglund transmitted to Reykjavik:

"We force-land at Skaptaros stop fuel finished stop try send boat with our petrol."

No answer was heard, so the message was sent several times. A shallow lagoon behind the shore was impossible to use for landing, so they had to land near the ship, *S/S Magnhild* of Bergen. A buoy was arranged for the plane while they awaited the Icelandic ship *Fylla*, which was coming with their fuel. Meanwhile the Icelandic inspection ship *Odinn* had arrived, and her captain proposed that the plane should be towed to Vestmannaeyjar to meet the *Fylla* there. To prevent the plane from being thrown abeam in the high sea, lines were fastened to the wings and manœuvred from the ship. Besides, part of the load in the plane was taken aboard the ship to let the plane float higher.

There were 100 km to tow, and happily the plane proved to ride the high sea well. Soon after noon it arrived at Vestmannaeyjar. The *Fylla* had not yet arrived, so the time was used to remove all spark plugs. These looked horrible; it was a wonder that they had functioned at all. The aviators had spare plugs, so after receiving the fuel, they started for Reykjavik and

arrived at 21.00h. Here they were to stay for quite some time.

They were given a banquet by the city of Reykjavik in the evening. Returning to the plane, they found that the Icelandic mechanics had loaded the tanks to "full" with fuel and oil, but Ahrenberg did not check how much of each had been loaded. This neglect was to result in further troubles and dangers: 100 revolutions per minute were missing, although full power was needed only for the take-off. The first take-off attempt failed; there was a calm. By reducing the fuel from 22 to 15 hours' worth, they managed to get airborne. But after half an hour Ljunglund reported:

"Disturbances from the spark-plugs, no radio reception possible."

There was nothing to do but turn back. The engine was investigated and proved to be full of soot. They could not reduce the store of fuel any more, so they waited for stronger wind to help them take off. Yet this time the plane ran into a high wave. It escaped sinking, but the motor stopped and the propeller was lost. The whole store of fuel had to be emptied into the sea, thus calming down the waves. As the Junkers plane had shown its robust construction in practice, they reached the harbour in safety, and they had a spare propeller.

The aviators were now desperate, and did everything to avoid newspaper men. At Ivigtut, their next destination, their two Danish helpers had begun wondering why they did not come, and sent a telegram:

"Here is the finest weather since the Viking Age. Come now."

They changed to a new propeller and made a test flight. Afterwards, the sparking plugs were found to be only normally sooty, so they decided to start for Greenland. To a certain extent they seemed to have lost their judgement.

On this attempt, they were attacked by another trouble: 200 km to the west of Reykjavik, the temperature of the cooling water started to rise slowly.

"A new devilry from this thrice-damned motor."

They had to return to Reykjavik, but it seemed doubtful whether they would ever get there. They had 28 litres of drinking water in the cabin, which had to be transferred to the cooling system with a cup. And near Reykjavik other liquids were added to the system in turn: three bottles of soda water, a bottle of port wine and, soon before they landed, three litres of

coffee from a thermos bottle! The plane was saved, and the motor too. They later found that the spark plugs had been at fault as before. Ljunglund had not said anything about it during these trying conditions.

A telegram was sent to the Junkers airplane factory with a demand that a motor engineer be sent at once, which meant that he was to come by the first available ship. The crew of the Junkers plane therefore got a rest, which was certainly needed. The engineer arrived at last, and now the shortcomings of the motor were detected one after the other. The main defect was that oil had got into the fuel, bensole, and had mixed with it. The engineer sent a telegram to the Junkers factory:

"Fault of motor detected stop...in pump fuel mixed with oil in great quantities stop in cylinder tops thick layers of burnt oil stop making motor dependable impossible here stop continued flight not possible in that case catastrophe stop new motor necessary stop awaiting orders stop."

The motor did come. The old one was sent to the Junkers factory, officially sealed by the Icelandic Customs Office, a seal to be broken only in the presence of Swedish experts. When the experts arrived, the seal was broken and the pump had disappeared.

A flight against all odds

On July 10 at 12.45h they started out, one month after they had left Stockholm. Everything worked well. At 18h they sighted a high bank of fog on the horizon ahead. Soon they entered it and climbed to get above it. At 21.40h they sighted land, and below was the pack-ice, with open lanes between the floes. They studied their chart, but the position was difficult to find, especially as the chart generally contained only the mouths of the fjords.

Finally they recognized Lindenow Fjord, shown in full length on the chart. They steered into the fjord, which gradually narrowed. Most disturbingly, Ahrenberg found that it was hard to maintain height: there must be foehn winds blowing down into the fjord from the inland ice. The fjord became so narrow that they could no longer turn back. In front was a glacier which sloped steeply downwards from the interior. But they passed the top of the glacier, with a margin of a few metres, and were then over the vast expanse of the inland ice. The weather was fine, and the sun was low in the sky, so they could relax and satisfy their stomachs with their dinner packet.

Approaching Julianehaab, they enjoyed the scenery along the western coast to the north. The mountains were shaped like loaves of sugar, giving the

impression of knight's castles, and a dark pennant or weather-vane was attached to every spire. This phenomenon of "cloudlets" was unknown to them; had they been able to interpret the signs in the sky, they would have realized that there were heavy winds to the north, and that they might risk encountering strong winds soon. In fact they did: stronger and more fearful winds than they could ever have imagined.

Near Ivigtut and Julianehaab, the radio reception was good, and they were wished welcome to Greenland. Soon they had come down from the ice and followed the wild coastal mountains between Julianehaab and Ivigtut. But at about 01.00h on July 11, they observed a high black curtain, rushing over the inland ice towards the coast. They were flying at 1200 m, and only 20 km remained until Ivigtut. Before the dark cloud masses reached them, they lost all control of the plane, which was flung about like a piece of paper. Then they were reached by the cloud-wall, and were flung downwards; it became pitch dark around the plane.

After a sudden braking, the plane was flung upwards, and Ahrenberg apparently lost consciousness for a while. Next it was flung downwards again, from about 1000 m. Ahrenberg varied the throttle instinctively, and was able to prevent the motor from stalling. Suddenly he regained control at 900 m, on a westerly course which he immediately turned east-towards the land, which could not be seen, though the sea below was quite visible. Now the plane faced a collision with the vertical rock of Arsuks Umanak, which marks the approach to Ivigtut. The hurricane was still raging here, but the air had become smoother. For a time they moved back and forth in relation to the rock, and even to the ground.

Eventually Ahrenberg decided to dive and head for the shore in front, run the floats onto the beach, and keep the plane grounded by using the motor power to counteract the wind. After a quarter of an hour the wind started to abate. But it was exchanged for a cloudburst, of an intensity that the aviators had never experienced or heard of. They were deafened, and everything inside the plane became a mess. Outside, the radio aerial was wrapped twice around the fuselage, luckily without getting tangled in the rudders.

Next morning, July 12, the weather was fine. A motorboat came to see them. A steamer had observed their struggle, and their navigation lights, when they were descending through the clouds at a furious speed.

Holes had appeared in the floats, so the plane needed to take off fast, nearly empty. Then the floats would require time to be emptied of water in the air. After that, the plane could land at Ivigtut, and be lifted

out of the water by a crane which existed there. This crane had been left by the American round-the-world enterprise in 1924 (p. 445).

Repairing the plane took a whole week. There was a foehn period at the same time, so much of the effort was devoted to protecting the plane. On July 17 they were on their way again, but they had to turn back because of a radio failure. Not until July 22 did the weather reports indicate that they could expect good weather on the other side—along the American coast. The plane was now more or less crippled, yet they judged it possible to start for America. This time severe vibrations forced them to return to Ivigtut. The frame plating on the wings had loosened, and the motor itself seemed to have become rather tired.

Finally on August 3 they started out, sincerely hoping to keep it up. They had already covered 4100 km of the air route, and 900 km remained to the Labrador coast. In just a few hours they would have crossed the Atlantic. But now they encountered a cold front, with thunderstorms along a north-south direction. They would have to pass through it, or else turn back. Trying to get through, Ahrenberg lost control of the plane, mainly due to the weak efficacy of the ailerons. The instruments pointed hither and thither, and the motor's shaking made the compass spin. In the radio department, Ljunglund was busy extinguishing a fire which had started in his apparatus. Ahrenberg writes:

"Now hell is loose, was my silent reflection. Could it get any worse? Scarcely!"

Five minutes earlier they had been flying in sunshine, and Ahrenberg had checked the dead reckoning, which showed that they were only 200 km from Labrador. How they emerged from the clouds, no one knew—but they were still on the wrong side of the front, to its east.

"Everything looked hopeless, but we would not yet give in. This was our last chance; a new attempt was inconceivable, considering the state of the motor. We therefore steered north, trying to circumvent the thunderstorms, but there was no end to them. Instead we were driven more and more upon an easterly course. We were simply being pushed away by someone who did not want us to come over.

At last I began to realize that it was useless to go on fighting. Not only could we not come through; I knew that, after such thunderstorms, the whole of the Labrador coast would be covered by fog and impossible to approach.

In 1930-1931 a British expedition stayed in southeastern Greenland to investigate the flight conditions for a proposed air-route to America. A lone man, Augustine Courtauld, carried out meteorological observations on the inland ice. Several unsuccessful attempts were made to reach him. Albin Ahrenberg, the well known Swedish airman, was given the task of finding Courtauld. After a dramatic flight across the Atlantic he reached the British base in Greenland with his Junkers plane.

Photo: F. Goldberg Collection.

Albin Ahrenberg (1889-1968). After the search for Courtauld he was promoted to the rank of Captain in the Swedish Navy. (Ahrenberg, A.: Ett flygarliv.)

The crew of the "relief" expedition. From the left: Sigurd Malm (did not take part in the flight), Albin Ahrenberg, first pilot, Axel Floden, second pilot, Robert Ljunglund, radio operator. (Ahrenberg, A.: Ett flygarliv.)

The Ice-Cap Station consisted of three dome-shaped "huts" connected via tunnels. The large hut was used for living in. Originally the huts rested upon the snow surface, but gradually snow accumulated, and the huts became buried. (Hayes, G.: The conquest of the North Pole.)

This was the bitterest moment of my life; the most ardent dream in an airman's career was shattered to pieces."

He turned the plane towards Ivigtut, and the Atlantic flight was given up.

"The course was now north-easterly. I did not know our position at all. I had not been able to keep up with courses and distances during the wanderings of the past hour, and the fog was still dense around us. The compass was utterly unreliable and the motor vibrations were increasing.

We certainly had a three-hour flight in front of us, before we could expect to be back in Greenland; the tailwind on the way out was against us now.

Would the engine keep going so long? Would we manage to get back in time, before the fog had closed all fjords and, with them, the options for landing? Hardly.

Our chance of escape—and I was absolutely sure that an escape would be needed—was evidently to make a landing upon the flat surface of the inland ice. We had provisions in the plane for a week, and during that time we would probably be able to get down to the coast with the help of the relief organization which existed at Ivigtut."

Ljunglund, after much work, had got the radio to function, and had informed Ivigtut of the events during the flight. He had also received an answer begging the aviators to hurry up, because the fog was entering the fjord. Ahrenberg dared not strain the motor and, besides, they did not know where Ivigtut was; neither the plane nor Ivigtut had any equipment for radio positioning.

Then things started to happen. Ivigtut reported that the motor was heard, and

"...before we had time to ask for the bearing, it started to get light around us in the fog; it split up into shreds, which gradually became smaller, and suddenly we came out into dazzling sunshine. In front of us we saw the inland ice glittering white and extending towards the horizon; below us were mountains and open water. And right down there, wasn't that Ivigtut?"

It was a miracle. They had been flying for six hours and had covered almost 1000 km. During the last few hours, they had roved about without knowing their position. They were simply hoping that their course would take them to Greenland. And the catastrophe

had been imminent. This was revealed by their Danish mechanic after they had landed.

One of the main fuel tanks had come loose and was hanging below the wing in the piping. The propeller shaft was bluish from overheating, and the conus ring of metal—towards which the hub is pressed—had started to melt. The propeller was loose on its shaft and, before long, both the propeller and the motor would have disappeared, resulting in an immediate crash. Besides, ten minutes after the landing, the fjord was swallowed by the fog. It had been a narrow escape. Though the date was still August 3, much had indeed happened since they started upon the leg which was supposed to be—and was—their last.

On August 22 a small steamer, the *Julius Thomsen*, was expected. Thus they had almost three weeks to prepare their voyage home, notably the packing of the plane. They found much time for relaxation, a necessity after their two months of severe strain. They made excursions in the surrounding country, and took part in social gatherings.

The *Julius Thomson* arrived on August 21. Already next day she left Greenland for København, which was reached on September 4. A day later, the Danish mechanics had put together the plane, which took off for Malmö. The adventurous—and heartbreaking—Atlantic adventure had come to an end.

The plane itself was taken over by the Junkers factories, and was sold to Spain. One year afterwards, it was bought by a German aviator, who intended to fly it from Germany to Australia. Finally it met doom on the bottom of the Timor Sea, but the crew escaped alive. Their own experiences of the plane had been similar to those of Ahrenberg and his companions. It was truly an aircraft dogged by ill luck.

In 1954, a quarter-century after Ahrenberg's misfortunes, the SAS company began routine flights across the Polar Sea and the Canadian Arctic.

THE RESCUE OF A LONE MAN ON THE GREENLAND INLAND ICE

The British Arctic Air-Route Expedition, 1930–31

The airborne "Viking Trail" across the Atlantic had also awakened interest in Germany and Great Britain. In 1929, a German expedition with a twin-engined Dornier-Wal seaplane visited Reykjavik, apparently to reconnoitre the route.

The expedition's leader, Captain Wolfgang von Gronau, did not see Ahrenberg then, but he did so in Stockholm at the beginning of August 1930. Ahrenberg told him all about the experiences of the luckless Swedish enterprise.

The German Atlantic flight was then carried out successfully along the same route as Ahrenberg had

chosen in 1929. Von Gronau took off from Germany on August 18, and landed in New York on August 26.

The British favoured a somewhat different Viking Trail—from London via Aberdeen, the Faeroes, Reykjavik, Angmagssalik, Godhavn, south-western Baffin Island, Southampton Island and along north-western Hudson Bay, to Fort Churchill and finally Winnipeg in Canada. It was, however, necessary to make studies along this route: weather, ice conditions, geography and so on.

Ahrenberg's flight in 1929 had been followed with fascination in Britain. A young man, Henry George Watkins (1907–32), had resolved to lead an expedition for studying the conditions in the regions where information was most badly needed: in south-eastern Greenland and over the Greenland inland ice. Watkins possessed a most remarkable character. He was a born leader of men.

In spite of his youth, he had led four expeditions by the time he died at only 25:

1. To Edgeöya, Svalbard in 1927, with nine participants including Watkins himself.
2. To Eastern Labrador in the winter of 1928–29, with three participants including Watkins.
3. The British Arctic Air-Route Expedition, 1930–31, based in south-eastern Greenland, with 14 participants including Watkins.
4. An expedition, supplementary to the last one, to south-eastern Greenland in 1932–33, with four participants including Watkins.

Watkins had also planned an antarctic expedition, mainly along the same lines as Shackleton's expedition with the *Endurance* in 1914–16, with a sledging tour across the Antarctic continent from the Weddell Sea to the Ross Sea. This expedition could not be realized owing to economy. Watkins drowned towards the end of the summer of 1932, while hunting seals from a kayak.

The British Arctic Air-Route Expedition had its

base at Sermilik Fjord, about 70 km west of Angmagssalik in south-eastern Greenland. It was a most ambitious enterprise. Long travels were carried out by dog sledge, boat and ship (see map, p. 452). Here we shall focus upon the meteorological station, which was established on the inland ice at an altitude of 2440 m a.s.l., at the position 67°03'N, 41°49'W.

The Ice-Cap Station was established on August 11, 1930, by a sledging party. Two men were left there to carry out meteorological observations. It was the intention to keep the number of observers at two, exchanging them every month or so. However, the meteorological conditions on the inland ice in the winter were not realized by the expedition members at first.

A summary of the events in connection with the maintenance and relief of the Ice-Cap Station is given below. The dates are those on which sledging parties departed from, and arrived back at, the base.

During the winter, three unsuccessful attempts were made to reach the Ice-Cap Station. Great anxiety was felt at the base and in England over the fate of the lone meteorological observer, Augustine Courtauld. It should be noted that Courtauld himself had insisted upon being left alone at the station, when it happened that provisions for two men, with reserves, could not be left by the sledging party. Thanks to Courtauld's decision, the observations for the winter were secured.

The Ice-Cap Station consisted of three dome-shaped tents. A large tent, 3.05 metres in diameter, used as a residence, was connected by tunnels with the two other tents, 2.44 metres in diameter, which were used for purposes such as storage (see drawing p. 449).

Courtauld's family was informed by Watkins about the efforts to reach him. On the last attempt, during March 9–April 18, the sledgers should have reached the station according to dead reckoning, but saw nothing of it. Watkins then sent a telegram home, ending with the words:

<i>Departure date</i>	<i>At the station</i>	<i>Arrival at the base, date</i>
<i>Aug. 11, 1930</i>	Station established. Sledging party returns to the base on Aug. 28; 2 men left at the station.	<i>Sept. 3, 1930</i>
<i>Sept. 21, 1930</i>	Station relieved Oct. 2; exchange of personnel on Oct. 4.	<i>Oct. 14, 1930</i>
<i>Oct. 26, 1930</i>	Station relieved Dec. 3; only one man (Courtauld) left at the station.	<i>Dec. 19, 1930</i>
<i>April 21, 1931</i>	Courtauld relieved on May 5.	<i>May 11, 1931</i>

The activity and travels of the British Arctic Air-Route Expedition, 1930-1931 under Henry George Watkins. The position of the Ice-Cap Station can be seen to the NW of Angmagssalik. (Scott, J.M.: Gino Watkins.)

Augustine Courtauld, now located on 5 May 1931, by the British sledging group under H.G. Watkins. (Ahrenberg, A.: Ett flygarliv.)

The Ice-Cap Station, as it appeared when found by the sledging group. Courtauld had then been alone for five months. (Ahrenberg, A.: Ett flygarliv.)

“There is always the possibility that Courtauld is dead or injured, in which case the station is probably completely concealed.”

This message brought the anxiety in England to a head.

An Atlantic flight before the search

On April 21, 1931, Watkins started a new sledge tour towards the Ice-Cap Station, and on April 24 the British Air Ministry sent inquiries to some countries which had practical experience of flying in the Arctic. The Ministry asked whether planes and crew could be obtained for the search, and could reach Greenland at the earliest possible date. One such request went to ABA (Aktiebolaget Aerotransport), and Ahrenberg was asked to make a flight, choosing his travel companions—radio operator and mechanic. The question of airplane equipment, and estimates of costs, were also discussed.

Already in the night towards April 25 a telegram was sent to London, stating that the ABA was willing to carry out the task. Once a definitive agreement had been reached, it would be possible to start for Greenland within two days. The ABA offered to place all its resources at the disposal of the enterprise, and to be responsible for the finances. An answer from England was received on the 25th, saying that a representative of the Courtauld family would arrive in Malmö on the 27th to make an agreement. Then the preparations could start in earnest.

Again the plane would be a Junkers: the SE-ACK, which at the time was used in the night postal service between Malmö and Hannover. It was similar to the plane SE-ABX, which had ruined the Atlantic flights in 1929. Yet this was a passenger version, with larger floats than the SE-ABX, and with a steel propeller. The motor was of the same type, but with only slight overcompression, and the choice of fuel presented no problems. Ahrenberg preferred the motor that was currently in use, being well run in. The lower power of the motor, relative to that of 1929, did not allow any marked increase in the normal amount of fuel, which was calculated for 7.5 hours' flight. This would be enough for the longest distances between fuel stations—although only with a tailwind, or no wind at all. A landing was thus necessary on the Faeroes, between Bergen and Reykjavik.

A crew was easily found. The mechanic and the radio operator of the flight in 1929 were glad to take part in the new enterprise, completing the party.

THE CREW CONSISTED OF THE FOLLOWING MEMBERS:

Albin Ahrenberg (1889–1968), pilot and leader.

Robert Ljunglund, radio operator.

Sigurd Malm, mechanic.

Malm had become acquainted with the plane and its motor during the postal service. All three men had common experiences from their venture in 1929, and this time fortune was to be in their favour.

The long Atlantic flight, preceding their search on the inland ice, dominated their thoughts to begin with. The problem was now the load they would have to take. For one thing, the plane would wear skis while flying over the inland ice, and otherwise floats—and different rudders were required in the two cases. They also had to bring spare parts for two damaged planes of the British expedition, and more such items would be loaded at Reykjavik.

They started from Stockholm at 11.00h on April 29, refueled at Stavanger, and landed at Bergen at 20.00h. Ahrenberg writes:

“One thing I had already noticed: the absolute absence of suspense at the prospect of the flight. Our mood was festive; this time we were convinced that we would be 100 per cent successful.”

The weather forecast for next day, April 30, was not the very best. Supercooled fog hung at the Faeroes, which would result in immediate icing if the plane came into it. They needed to land at the Faeroes, since they could not carry enough fuel for a direct flight from Bergen to Reykjavik. So they waited until May 1, and then the weather was promised to be fine as far as the Faeroes. But the situation was uncertain thereafter; a supplementary forecast would be supplied when they reached these islands.

They left Bergen at 06.00h in glorious weather: it was warm, calm, sunny and not at all bumpy. Flying high, they saw many fishing-vessels all the time. At about 10.30 it was time to land at Thorshavn. The sea surface was glassy, but there was a tremendous swell. This might have caused trouble, but Ahrenberg made the landing along the swell.

Theirs was the first aircraft ever to visit the Faeroes, and drew a great crowd. However, the fuel proved to be a problem. It had apparently been stored for several years, and contained plenty of dirt, which had to be filtered out through chamois-leather. The refueling took enormous time, and not until 15.00h were they ready to start. Meanwhile, gloomy weather forecasts came from both Bergen and Reykjavik: strong crosswinds, rain and low clouds, although no fog. They met the dismal weather already when leaving the Faeroes, and recognized the temper of the Atlantic. But Ahrenberg was relieved by a rough estimate that they had enough fuel to reach Reykjavik, if the wind did not turn onto their nose.

The flight proceeded normally at about 800 m, in

visual contact with the sea surface. Yet vibrations arose, seemingly coming from the left side of the cowl. Soon its front part was lifted and started to flutter. A locking device in front had loosened, but the cowl was still held by one in back. Great danger would result if the cowl became an uncontrollable rudder and interfered with the actual rudder. Malm, however, rescued the plane. Lying upon the cowl, with Ljunglund holding his legs, he managed to return the hook to its place.

All else went according to plan. They received bearings over the radio, and kept the dead reckoning in good order. Near south-eastern Iceland, it cleared up and they saw the glaciers bathing in the sunlight. They passed over Skaftaros, blessed in memory from their flight of 1929, and over Vestmannaeyjar. Soon after 21.00h on May 1, they landed at Reykjavik and were welcomed by the entire town.

To Greenland again—and with luck

The Icelanders now had an airline company of their own, and were kind enough to service the Swedish Junkers plane. Ahrenberg and his companions also learned that the Danish inspection ship *Hvidebjörn* would help the expedition. The ship was dispatched to the ice-edge, some 200 km from Angmagssalik, which was the next target of the aviators. The ship was to stay there, supplying the plane with bearings and weather reports, besides acting as a safety measure. Another inspection ship, the Icelandic *Odinn*, was to leave with a Junkers plane on board, which would be mounted on a large ice-floe to join the relief operations in Greenland. However, for some reason this ship returned with the plane next day.

The weather was fine on May 2 in Iceland—but not at the *Hvidebjörn*, which was stationed at the ice. Dense fog lay over the ice. At 15.00h the report was more optimistic: there was no longer fog towards the Greenland coast. But about one hour later, the ship reported dense fog. The plane was on its way west, and had to return.

Next day, May 3, things seemed to improve and at 11.00h they started in fine weather. After three hours, they observed a ship proceeding eastward. It turned out to be the *Odinn*, carrying her Junkers back to Iceland. She gave Ahrenberg the latitude and longitude, and an hour later the *Hvidebjörn* sent a telegram:

“We are lying at the ice-edge and have fog.”

It was no use turning back now; they had gone too far. In a lively exchange of telegrams with the *Hvidebjörn*, they asked for repeated bearings, so as to find her in the fog. At last they located the ship, and circled round

her at masthead height. She was their sole fixed point; to the west, the pack-ice was covered by the fog. The ship looked quite agreeable: it was Sunday, the decks were scrubbed white, and the crew were dressed in their best clothes, as always on a naval vessel's Sundays. The *Hvidebjörn* telegraphed:

“We are now heading towards Angmagssalik.”

The plane could thus set a correct course. Some time later, the ship reported that the drift of the plane had been 4° when it disappeared into the fog.

The flight which had now started was risky. The Greenland coast lay about 200 km away. It was mountainous, with summits reaching 1700–1800 m a.s.l. And high icebergs floated in the pack-ice. Flying in visual contact with the ice was essential. Close to the land, conditions would hopefully be better with open water.

“The pack-ice looked fantastic in the fog. Everything seemed enlarged, and the proportions were abnormal; white ice and black shadows gave one the impression of a town with the houses thrown over in a mess upon each other. Sometimes I saw dark shadows in our way and at the same height, I thought, and it appeared necessary to toss the plane aside to avoid a collision. These icebergs towered higher than the pack-ice. It was an exciting hurdle-race, a play with phantoms, and all senses had to be kept tense. The eyes ached from staring into this white hell, which never reached an end.”

To this was added the worst that could happen to them in the present situation: ice was forming on the wings and propeller. At the time, de-icing devices did not exist. Inevitably the motor was given ever more power, in order to delay a crash which—if conditions did not improve—was certain to occur. Ahrenberg even gave Ljunglund a message with the position, to let their relatives know where they had crashed: 65°30'N, 38°20'W!

But a miracle happened. Suddenly it grew dark ahead. The cause was open water; the fog grew thinner, and a cliff-face loomed in front of them. The plane was steered along the coast, between the mountains and a wall of fog offshore. The temperature was higher than before, and the ice on the wings and propeller melted. Then they observed radio masts, and realized that they had reached Angmagssalik.

The next problem was to land and avoid the fog, which came drifting toward the coast. It was possible to land on the water, without damage from the pieces

of ice floating about. The plane was placed with the floats against the edge of the fjord ice and, with its motor roaring, jumped up onto the ice. With the assistance of 100 Eskimos, it was dragged over the ice to safety near the village. From this operation, Ahrenberg acquired the name *Big Fat Seal* among the Eskimos. Ten minutes after the landing, Angmagssalik was enclosed in fog.

Two members of the British expedition had come to meet them. Ahrenberg learned that a relief expedition with dog sledges had stayed near the Ice-Cap Station for three weeks without finding it, probably because the station had become snowed over.

The Swedish group was happy at having completed the Atlantic flight. But now they confronted a still greater chore: finding the station. To them, it was like seeking a needle in a haystack.

Ahrenberg was also faced with the question of how to exchange the plane's floats for skis, as no special equipment was available—not even a jack. The solution was to raise up the plane on the ice, using wooden supports. Timber could be obtained by pulling down a building, which the Eskimos, being eager builders, would reconstruct later. By chopping away pieces of ice under the plane, its floats would be left suspended, and could be replaced by the skis with their undercarriage.

After this operation, the skis were hanging about a metre above the ice. A sloping platform of ice was built for them to rest upon, so that the plane could be dragged down it to the surface of the fjord ice. However, to avoid straining the wings and undercarriage, the plane had to be lowered slowly, until resting safely on the platform. This might have been done by pouring warm water at the bases of the plane's supports; but a suitable cauldron for heating water was not available, and fuel was expensive. Thus another warm liquid was supplied with delight by about 300 Eskimos, who were watching the work. The stands sank into the ice, and the plane was soon eased down to the flat surface.

Further preparations went on. No maps were available, but Ahrenberg drew a network of latitude and longitude on a piece of paper. He placed two points on it, the British base at Sermilik and the Ice-Cap Station, and connected them with a line, adding a few lines to show the geomagnetic declination. The inland ice was just a wide expanse of snow.

In the afternoon of May 4, the plane was ready for its new mission—the flights over the inland ice. A test flight was made, and Ahrenberg gladly noted that the plane was now easy to handle. Radio contact with the British base provided weather information.

During the test flight on May 4, it was stated that all

fjords were enclosed in fog. On the 5th, the base at Sermilik reported unsuitable weather. But on May 6 the conditions improved and, with the two Englishmen on board, Ahrenberg started for Sermilik. Arriving half an hour later, they found excellent runways on the deep-frozen fjord. The ice was smooth and the marked runways were several kilometres long.

The base consisted of a barrack about 8 m long and 4 m broad. It contained one room for sleeping and living, another resembling a "kitchenette" of our days, a workshop and a room for electric generator and radio. The sleeping facilities were six double barrack-beds, separated by a passage where two men had to sleep when all fourteen members of the expedition were present at the base. Often, though, at least some of the men were away on field work.

The aviators were surprised to see how young the expedition members were; only one man was middle-aged. Ahrenberg comments:

"I understood that their expedition was intended to be a manifestation of youth, more attentive to ambitions for discovery, imagination and physical fitness than to older, more prudent and one-sided experience.

They were all very affable young men, perhaps somewhat more mature now than one year previously, when they started their expedition. Living through a long arctic winter is no sine-cure. They had endured a continuous fight against the most bitter cold, severe gales and other difficulties. They expressed their surprise at our ability to organize and carry out our flight within so short a time. We were also wished welcome in the most cordial way."

While Malm was occupied with refueling and loading the plane, Ahrenberg and Ljunglund discussed the coming flights and the situation on the inland ice with the chief pilot, D'Aeth, and the radio operator Lemon. It was decided from the beginning that the Sermilik base would supply the expedition on the inland ice with provisions, in order to prolong the search if neither sledgers nor aviators located the Ice-Cap station.

A difficulty in locating the station from the air would, of course, be that they did not know the wind conditions over the inland ice. However, the men at the base told them that the wind was generally north-westerly. To get some information, the aviators brought ten sticks with a relatively heavy ferrule at one end and a flag at the other. These sticks would be dropped from the plane, to stand upright in the snow and let the flags indicate the wind direction.

The search over the ice

Already on May 6 at 16.00h, they started the first flight towards the Ice-Cap Station. They were not so optimistic as to imagine that they would find the station on their first attempt. Before flying in over the inland ice, they ascended to 1400 m a.s.l. Ahrenberg did not want to strain the motor, so the ascent was given the time it needed. In spite of all recommendations, though, they came in over the slope too early. The plane bumped on a rise in the surface, and Ahrenberg hurriedly changed the course 180°. He continued the ascent for a few hundred metres before steering towards the ice again.

Proceeding for half an hour over the ice, they lost all impressions of the world around the plane:

"I had to fly blind, for we were in an absolute vacant space, where nothing was marked. Above we had a blue sky, and the sun shone, but there was no horizon; it was like being in a giant cauldron of dazzling snow, reaching high up into the sky. There were no shadows, no dark patch down below to rest the eye upon. We two in the cockpit, Malm and myself, felt it worst because the sun shone straight into our eyes."

They dropped their flags one after the other, and turned back to observe the results. But they could see nothing, and thought that the sticks had penetrated too deep into the snow. Dropping a bag of aniline dye, they did not see it either. Then they realized that the effect must be due to the glaring white surface.

The same course was held until they estimated that they had reached the position of the Ice-Cap Station. Ahrenberg had allowed for a fairly strong headwind when making his flight plan; but to be on the safe side, he continued for another twenty minutes on the course. Yet nothing was seen below. The only choice was to return to the base and make a new attempt as soon as possible.

At the base, Ahrenberg rechecked the dead reckoning with regard to his flight time on the way out and back. This showed that he must have turned back about 20 km from the Ice Cap Station. Had he continued for just five minutes, he would have reached the station. The correctness of his course became clear during the second flight, when they flew right along the row of dropped flags. He could then make a better correction for the wind.

This flight was carried out next day, the 7th, before noon. The plane carried a passenger—the chief pilot, D'Aeth, of the British expedition. They experienced the same troubles with their eyes as on the previous flight. Ahrenberg tried to keep his eyes on objects in

the cockpit; but as they approached the Ice-Cap Station, he could not refrain from looking out upon the expanses of glaring snow in order to discover any dark objects. This time he had hallucinations, envisioning great numbers of tents and sledge expeditions—in fact, anything he was thinking of. He was afraid of becoming blind, which would not be nice for the flight. Would he be able to take the plane back and land it? Malm, who sat beside him, suffered the same illusions.

They were flying at 3000 m a.s.l. and expected to reach the station soon. But nothing was seen, so Ahrenberg continued along the course for another ten minutes. Then he turned back along a zigzag course. After about 15 minutes, he was beginning to see ghosts again, when he heard Ljunglund saying that the sledging party was in sight.

"I said to Malm, 'Now he's having visions, too.' But Ljunglund and D'Aeth came up, pointing and shouting: 'Don't you see them? There, there...' I still saw nothing, but I began believing... I swung the plane a quarter of a turn, and then I found out for certain. I discovered a bluish shading down below in the snow; it turned into a streak, which stretched straight across the vast expanses of the inland ice, until it was absorbed by the white haze. It was a sledge track... I turned quickly and dared not let the track out of sight; I followed it like a Swedish foxhound, and there, at the end of the trail, we found them.

I saw two sledges with their dog teams, and beside them, distinct against the white snow, were *three* men waving their hands frantically towards us. It was the relief expedition that we had found, and I was just giving orders to drop our load, when it seemed to me that there were more than three men below. I concentrated and counted them again. Certainly there were *four* of them—but then one of the four must be Courtauld.

We had found the mote, the speck of dust, on the infinite inland ice. We had *succeeded*."

The plane was 200 m above the group, and Ahrenberg wanted to come closer, so he decreased the motor power. This he should not have done, because the plane started to fall almost like a stone, and he had to increase power again. He even felt the plane touching the snow surface before it rose again. It was too heavy for the thin air at that altitude. Instead he circled round the sledgers, while in the plane they prepared the dropping of the load. They recognized Courtauld's enormous beard, and apparently he was in good trim, as he helped to collect the articles on the snow.

The sledgers were asked whether they wanted the plane to land. In the letter which was dropped, the men below were also given a sort of code, by which they could signal an answer. The reply was negative, but they added a new signal, which looked like the numeral eight. This was interpreted as a request that the plane should come up again after eight days—or was it an estimate that the sledgers would reach the base within eight days?

The plane now returned to the base, and the aviators had a message of joyful news to send to England. The adventure on the Ice-Cap station had ended happily. But in the plane D'Aeth seemed to be at a loss over something. It emerged that, in the excitement and hurry when dropping the load to the sledgers, he had let go his camera equipment as well. So he had not obtained any pictures from the meeting with the sledgers. But the sledgers had.

At 15.00h the aviators sighted the coastal mountains on the horizon, and at 15.30 they landed at the British base. They got a fine reception, both from the members of the British expedition and from the Eskimos. When they got to the base hut, a party was arranged, and half the store of champagne was consumed, the rest being reserved for the sledgers' homecoming. All the glasses at the base had long since been broken, so they had to use tins, slightly cleaned. The curiosity of the Eskimos was allayed by Captain Lemon, who told them about the flight and the discovery of the sledge expedition. In turn, the Eskimos elaborated the information by performing a ballet.

The following days were a peaceful period of revival for the flying group. In the morning of May 12, all were awakened by the howling of dogs. The sledgers were coming. They had made a very rapid passage from the meeting-place on the inland ice. The dog provisions they had received were an elixir to the teams, and they had travelled 20-22 hours per day. Courtauld was taken care of by his companions, and a bath was prepared. For six months he had not been out of his clothes.

Ahrenberg had a talk with Watkins, about a flight to Canada with some of the members of the British group. Watkins thanked Ahrenberg and his men for their achievement, but their mission was now completed and he had nothing more to offer them. Especially regarding a flight to Canada, he was definite. The aviators could stay as long as they wished at the base, even until the ship came to take the expedition home. It was most tempting to fly west, but the plane was not Ahrenberg's—it was not even Swedish property now, so the course would have to be easterly. Besides, the ABA needed the plane for the postal service.

Homewards and afterwards

They left the Sermilik base on the same afternoon, after a dinner of both welcome and farewell. The flight was short. At Angmagssalik they intended to change skis for floats, and await suitable weather for the flight to Reykjavik. They enjoyed the hospitality of the Danish officials, as well as that of the Eskimos.

The plane was ready to start on May 15, but next day was foggy. Conditions improved on the 17th, and soon before 19.00h they landed at Reykjavik. From there they continued by ship, reaching København on May 25. Next day they sat again in their Junkers plane and flew to Stockholm, where the plane would be delivered to the ABA as agreed.

Many people were at Lindarängen airport, Stockholm, to receive the aviators, including the Prime Minister and the British minister. Among cheers, the former told Ahrenberg that the King had appointed him Captain in the Swedish Navy. And in the following years his life was reshaped considerably. The ABA handed over its sightseeing flight operations to him, and he was offered his faithful old "servant" the SE-AAB. Now he began making "Round About Sweden" flights in both the summer and winter. With an increasing number of planes, he carried out other missions in addition to the sightseeing ascents, such as ambulance flights, documentary flights for newspapers, flying training and air photography.

Later, luck ceased to favour Ahrenberg. He lost his planes and money, and finally only his life remained. But at last he became the owner of SE-ACK, once the bringer of fortune during the Greenland flight of 1931. Then luck smiled again: during World War II, he spent five years in the Swedish Air Force, notably four years in the torpedo flying division. Subsequently, as chief of the Commission of Inquiry, he dealt with about 350 foreign airplanes which, in connection with bombing missions, had landed in Sweden during the last year of the war. He re-entered civil aviation after the war.

POSTSCRIPT: ALONE ON THE INLAND ICE

A question has been left unanswered: how did Augustine Courtauld spend his solitary period in Greenland? A short summary of his activities will be given here.

As mentioned, Courtauld had taken up the duties of a meteorological observer at the Ice-Cap Station on December 3, 1930. The sledge tour to the station had been very hard and had lasted almost 40 days. Only five months' provisions for one man could be left at the station by the sledgers, who considered that the observation activity should be given up. However, Courtauld insisted upon being left alone at the sta-

tion. This was done only by reducing the rations of the returning sledgers to an absolute minimum. They started for Sermilik Fjord on December 6, when Courtauld's five months as a hermit began. Three attempts to reach him from the base were made, but failed owing to the extremely severe weather conditions on the inland ice.

Meanwhile Courtauld pursued a routine life, dominated by the meteorological work, which had to be performed every three hours. There was also practical work to do: chores, cooking, and clearing the camp of snow which collected during every gale or period of fresh winds. The snow accumulated more at the camp than on the surrounding snowfields, and difficulties soon arose. It was hard to open the entrances when working from the inside. The snow could not be disposed of, and finally Courtauld became a prisoner.

After March he was completely snowed over, and the meteorological observations were discontinued. He feared that the tent would collapse under the snow, that the air would become exhausted, and that the sledging parties would miss the buried camp. However, he hoped that the Union Jack, which fluttered upon its pole, would guide the sledgers. The

tent did not collapse and the air in the tent remained fresh, thanks to good ventilation through the porous snow. He spent his time reading and, we may suppose, sleeping. Courtauld had pluck and good nerves.

Finally the store of oil was beginning to run short, so he had to live mostly in darkness, and to suck on snow for water. He needed very little food, as he could not get any exercise. His Primus stove gave up on May 5, but a few hours later he heard scraping sounds from Watkins' sledging party. They had found the camp thanks to the Union Jack, which was still fluttering on its pole and still visible. The sledgers were now digging themselves down into the snow. Courtauld was well, in spite of his need of exercise.

The observations had been carried on at the Ice-Cap Station from the end of August till March 22. Together with the simultaneous observations from the German station Eismitte, farther to the north, they provided the first evidence of the extreme climate which prevails on top of the Greenland inland ice. It should be noted that the British station was situated closer to the prevalent tracks of the Atlantic cyclones, so that higher temperatures and higher accumulation of snow were a natural consequence.

The British relief party together with Courtauld and the airplane. Sledgers and airmen returning to the base at the coast. (Ahrenberg, A.: Ett flygarliv.)

41. J.W. SANDSTRÖM AND THE GULF STREAM

The meteorologist and oceanographer Johan Wilhelm Sandström (1874–1946) was an unusual figure. He grew up on a small crofter's holding at Degerfors in northern Sweden (approx. at 64°N). It was a poor place to get any book-learning, but a boy with an open eye for the wonders of nature had much to learn here from atmospheric ice crystals, the drifting snow and its accumulation near buildings and objects, and changes in weather conditions throughout the year.

At an early age, Sandström had to assume responsibility for his family. When his father died, he loaded the most necessary belongings on a cart and, with his mother and younger brother, walked to the town of Sundsvall on the coast of the Sea of Bothnia, a "promenade" of more than 200 km.

He obtained no formal education except that of ordinary elementary school, yet his gifts were recognized—not least his aptitude for mathematics and for observing weather phenomena.

Thus, at 19, he moved to Stockholm and was given means to study, first at the Technical Institute and later at the city's University. During his years there, he came to know the theory—daring at the time—of Nils Ekholm about the influence of the Gulf Stream on the climate of Scandinavia, published in 1899. He was also influenced by a paper of Professor Otto Pettersson, dealing with the possibilities of forecasting the weather in Europe from observations of the temperature of the Gulf Stream water.

These experiences set the course of Sandström's life, and made the events in it logical.

His appointments may be summed up as follows:

- 1898–1903 Meteorologist at the Meteorological Institute (Meteorologiska Centralanstalten), Stockholm.
- 1903–06 First assistant at the Swedish Hydrographical and Biological Commission (compare p. 404).
- 1906–08 Scientific assistant to the Norwegian physicist and meteorologist Vilhelm Bjerknes, the founder of the so-called Bergen School in synoptic meteorology.
- 1908–14 Deputy director at the Hydrological Bureau, which became a separate bureau in 1908.
- 1914–19 Meteorologist at the Meteorological Institute, Stockholm.
- 1919–39 Deputy director of the Meteorological Bureau of the Meteorological and Hydrological Institute, which was established in 1919 by a fusion of the meteorological and the hydrological bureaus.

Sandström's most decisive period was his assistantship to the famous Norwegian physicist and geophysicist Vilhelm Bjerknes (1862–1951), who had been appointed a lecturer of mechanics at the Stockholm University of in 1893, and a full professor of mechanics and mathematical physics in 1895. He remained at that University until 1907, when he was called to the University of Kristiania (Oslo) as a result of the dissolution of the union between Sweden and Norway in 1905. As Sandström's work with Bjerknes from 1906 onward had greater significance to him than any other time in his life, it is of interest to know how this came about.

No biography of Sandström has been written, but in that of Bjerknes—published in the memorial volume presented on the centenary of his birth—his collaborator in the Bergen School, Tor Bergeron, has supplied some information. Bjerknes was working with methods for making "numerical" weather forecasts, and for that purpose he contemplated a rational system of meteorology and hydrography. From 1905 until 1941, Bjerknes was granted funds by the Carnegie Institution, Washington D.C., enabling him to employ assistants in his work. It was in this connection that Sandström entered the scene. Bergeron writes:

"He (Sandström) came to Stockholm University (where at that time anyone was admitted as a student without any previous exams) to study natural science with a stipend from benefactors at the industry where he had been a workman. Bendixon (the professor of mathematics of the University), being the supervisor of this stipendiate, had to summon him to report from time to time on the progress of his studies, but Sandström never appeared. At last, months having elapsed, he turned up at Bendixon's office with a huge pile of...Russian books and dictionaries! 'This is what has kept me so busy, professor,' said the promising young student of natural science! Evidently, Bendixon was a little shocked and did not like that turn of events too much. After having suitably reproached Sandström, Bendixon turned to his friend [Nils] Ekholm, who said that Bjerknes might need such an assistant, probably assuming that Bjerknes would be the right person to keep Sandström's brains working along fruitful scientific lines. In fact, Bjerknes, having the Norwegian natural and straightforward ways, must have been much more apt to take care of that 'uncut diamond' Sandström than the formal and circumstantial Swedish professors. Ekholm could hardly have guessed how right his judgement of Sandström was. The years with Bjerknes were

probably Sandström's best, scientifically speaking, although it is not sure that he realized that himself."

On the basis of his grand programme, Bjerknes could now begin, already in Stockholm, to prepare the contents of his first great book in the new field: a "Dynamic Meteorology and Hydrography", aided by the very practical and ingenious Sandström.

Theoretical studies and field work

The scientific work of Sandström was theoretical at first, but gradually it became experimental and observational. This development began with the famous "circulation theorem" which Bjerknes had presented in 1897 during a lecture series at Stockholm University, and had published in 1898. To explain the subject in detail is beyond the scope of the present book, and an outline will suffice.

Bjerknes' discovery enabled the idealized formulas of classical hydrodynamics and thermodynamics to be applied to the actual conditions in the atmosphere and in the oceans. Here the density varies with the pressure, temperature and other properties. Motions can be generated and eliminated within such a medium—not only started by external forces to continue forever, as in an idealized model. A radiator in a room illustrates the resultant flow: air is heated at the radiator, rises and spreads, but is then cooled and descends back to the radiator, and so forth. On a global scale, the air over the Gulf Stream warms and ascends, spreads and sinks over Europe, where it delivers heat before returning westward to the Gulf Stream area.

Sandström had come to Bjerknes at the right time for learning the applications of the circulation theorem. He had long been interested in how Europe—especially Scandinavia—is heated by the Gulf Stream in winter. Nils Ekholm had shown how greatly the air is heated over the Gulf Stream in winter, by up to 27°C above the mean temperature at the given latitude (as computed around the parallel circle). These conditions are ideal for a study of the flow and the heat transfer. Investigation of the Gulf Stream and its influence upon the European climate, notably in Scandinavia, was to remain Sandström's scientific passion.

To begin with, he wanted to learn the structure of the air currents over the Scandinavian mountain range in the winter half-year. So he had to become a winter traveller in these regions—a hardy and dangerous undertaking at the time, as they were practically devoid of people and accommodations, in striking contrast to the situation nowadays. Besides, his travels

were made with extremely simple means and with few assistants. Sometimes he journeyed alone or, later, with his sister's daughter Miss Thea Ahlberg, who was to become his travel companion on his Gulf Stream expeditions.

On the western side of the Scandinavian peninsula, the horizontal variation of the air temperature reaches a maximum:

"This is one of the workshops where the wind is generated."

This fascinating region was visited by Sandström for the first time in 1910. He came by ship from Trondheim to Mo, and observed

"...how the air rushed down towards the sea surface with such a force that the water was lashed into smoke high up in the air and it was almost impossible to remain upright on the deck of the ship. The offshore wind was strongest near land and decreased towards the sea. Along the coast stretched an area of fine weather; here the air was sinking. Farther out to sea was a dense bank of cloud and fog—there the air was rising."

Later, when sledging uphill from Mo to Umbugten, he had to fight against a strong easterly wind.

"The sledge became quite thick with the drifting snow. The shape of the cloud hoods at the high mountaintops indicated that the wind at this altitude was westerly. The solenoids were thus situated below the level of the mountaintops, and I would thus get at them by climbing the mountains."

He did so farther inland, and noted that the transitional layer between the two air currents was very thin.

Sandström lived in snow huts during this trip, but found it a quite impractical way of living for his purpose. Therefore he constructed a sort of "caboose", a tent-like framework of ribs placed upon a sledge and covered with a cloth. The structure was pointed at both ends, for minimal resistance to the wind. It provided room for three persons; however, being rather heavy, it was generally used as a movable base and a starting-point for excursions.

On one such excursion, the severe easterly winds struck Sandström and his assistants, so that they were unable to return to the caboose. Forced to ski with the wind at their backs, and with partly frost-bitten faces, they managed to reach a farm in Norway. When the

weather improved, the party returned to the caboose. But the assistants refused to come with Sandström when they heard that they were now to proceed into the central parts of the mountain region. They simply raised a mutiny.

"They undid the tent, packed everything except the tent framework on the sledge and set off for home, down through the valley of the Vindel River. Left to myself, alone in the mountains, I had no choice but to follow along with my fleeing assistants."

At the village of Ammarnäs, he left his unreliable men and succeeded in getting two new assistants. With reduced equipment, they made a long journey via Kvikkjokk, whence he reached the Riksgränsen railway at Murjek by horse and carriage.

Sandström learned how to interpret the effects of the strong winds upon the snow surface—the "sastrugi". From these he could draw conclusions as to wind direction and speed, which were of value in situations with reduced visibility and where the conditions were affected locally. And in the spring he could study how the wind conditions had been during the preceding winter.

He experienced how the wind speed is reduced on the windward side of a mountain due to its content of snow particles, which have been stirred up from the snow surface. He also noticed how the snow-laden air on the leeward side often attains hurricane force under the influence of gravity. These winds can be terrible. Moreover, he studied the fluctuating winds which are commonly observed in the mountains.

He dreamed of an observing station in the mountains, situated in the solenoid region where the wind-generating power is at its maximum—to the west of the Sarek and the Kebnekaise mountains. Here recordings of temperature, humidity and wind should be carried out at different heights, in both the westerly and easterly currents. To some extent, he was able to carry out such studies on the Riksgränsen mountain near the Luleå-Narvik railway. Yet he stayed on the lookout for a more suitable mountain.

For this purpose he constructed a small and very light tent, with two ski sticks for tent-poles. With an assistant—"the best Swede that at present can be found as a companion on tours of this kind in the mountains"—he travelled all over the mountain region in northern Sweden and in Norway.

These tours were often hazardous, for example with snow too sticky for skiing, and with prolonged periods of strong winds in addition to scant provisions. Sandström frequently ran into very tight cor-

ners, but there was a guardian hand over him, and he came to no grief.

Thus he became well acquainted with the meteorological conditions in the local mountain region, and with its role in the transfer of heat from the Gulf Stream to Europe, notably Scandinavia.

In the summer of 1928, Sandström took part in the Swedish expedition for the relief of the members of the dirigible *Italia*, which had crashed on the polar pack-ice to the north of Nordaustlandet, Svalbard (see pp. 433 and 440). The message, telling him to join this expedition in the capacity of a meteorologist, was received on a tour among the mountains in northern Sweden. He had just enough time to catch the rest of the expedition on its way north.

His duties during the expedition were mainly to advise the airmen on the prevailing weather conditions, and to supply them with weather forecasts. To this end, it had been arranged with the forecasting centre at Tromsø that the expedition was to receive a simplified description in code of the weather situation.

Sandström's visit to Svalbard was of great value to him. He got to know the meteorological and climatological conditions in a high arctic region which is strongly influenced by the Gulf Stream. He also learned much about the difficulties in connection with transports over the pack-ice, not least by using airplanes and dirigibles. He speculated about an expedition for studying the thermal conditions and the extension of the Gulf Stream at and near the ice-edge. In an article in *Ymer* of 1928, he described the events during the Swedish relief expedition of 1928 and his own experiences, concluding with proposed plans for an oceanographical and meteorological expedition:

"Even if the polar ice is more or less unapproachable, the ice-edge is, by contrast, easy of access. It can be reached with small sealing vessels, which enable oceanographical observations to be carried out easily. The problems met here are of a different kind than on the polar pack far away from its limit, but they are no less important, as they are closely connected with the weather conditions in Scandinavia. These depend to a great extent upon the Gulf Stream, and upon the distribution of the ice to the west and north of Norway. A reconnaissance and mapping of the ice-edge, in combination with measurements of the temperature, the salinity, and the motion of the sea water near the ice-edge, down to a depth of 300 m, are required, and that is easy to carry out. Such a concentration of polar research upon practical and useful aims, I think, will be appro-

priate now, while waiting for technological advances to develop so far that it becomes possible to penetrate the polar ice and carry out deep-sea soundings and hydrographic measurements there."

THE EXPEDITION OF 1929 TO THE GREENLAND AND THE BARENTS SEAS

Preparations

After coming home from the expedition, Sandström started preparations for the new expedition and its financing. It would be a private enterprise with contributions from funds and private benefactors. The newspaper "Dagens Nyheter" launched a subscription for the research enterprise. Sjökarteverket (The Swedish Hydrographic Office) contributed an echo-sounding apparatus, while the office's cartographer and astronomer, Per Collinder, joined the expedition to take care of the echo-soundings. Other institutions of the State helped the expedition too. The Navy provided a radio operator; the Swedish Hydrographic-Biological Commission, and the Swedish Meteorological and Hydrological Institute, supplied oceanographical and meteorological instruments respectively.

A sealer, the *Björnöy* from Tromsö, was hired for the cruise. She was 13 years of age, her length was 20 m, and she weighed 50 tons. Her 50-hp Bolinder motor gave a speed of 6 knots. Her captain was Viktor Corneliusen, who had spent 25 summers in arctic waters, 18 of them as a captain. The owner of the *Björnöy*, Captain Hans Andersen, joined the expedition as mate. Including these, the all-Norwegian crew numbered seven men.

The members of the expedition were Swedish: Johan Wilhelm (J.W.) Sandström (1874–1946), meteorologist and oceanographer, leader of the expedition.

Per Arne Collinder (1890–1975), Ph.D. (1931), cartographer, responsible for the sonic depth-finding and for astronomical observations of position.

Miss Thea Ahlberg (later married to Hilding Olsson; see pp. 468 and 489), responsible for observations of weather and of the surface water temperature, analyzing synoptic weather charts.

T. Forsberg, Corporal, radio operator.

The installation of the radio station and of the echo-sounding apparatus required much time and consideration. But on May 26 the expedition was ready to leave Tromsö. Measurements were to be done both in the Greenland Sea and in the Barents Sea. On the advice of Captain Corneliusen, Sandström decided to carry out the measurements during two separate cruises. In late summer there is generally much fog in

the Greenland Sea; it would therefore be propitious to start the investigations in the west, and to cover the Barents Sea in the latter half of the summer.

Besides, Sandström wanted to travel with the current. He thus decided to go to Spitsbergen first, and proceed with the current towards Iceland. Then he would return to Tromsö and, after a few days, continue to Novaya Zemlya, finally returning from there to Spitsbergen and Norway. In this way he would be given the opportunity to cross the Gulf Stream along four sections (see the map p. 463).

A cruise in the Greenland Sea

Tromsö was left on May 26, 1929, and the initial course was set eastward along the coast. The reason was that a number of large icebergs had approached the Varanger peninsula and Nordkapp during May, which had not happened previously. Sandström wanted to get a look at these giants. The ship visited Hammerfest, and Honningsvåg near Nordkapp, but no icebergs were seen. She met with hard winds and winter conditions, and not until June 2 did she leave Norway. The wind was easterly, and increased in strength during the day. On June 3, the temperature of the water decreased: it was +4.2°C at 11.30h, +2.2°C at 17.00h, and +0.4°C at 22.30h.

The northern limit of the branch of the Gulf Stream which flows eastward along the coast of northernmost Norway was found at lat. 74°N. The first ice—just small pieces—was observed at 22.00h.

In order to see as much as possible of the ice-edge, the course had been laid east of Björnöya, and the meeting with the ice took place at long. 22°E in the night towards June 4. They followed the ice-edge west towards Björnöya, which was blocked by ice on its eastern side; but to leeward there was open water. They proceeded to the north-western corner of the island. Here they anchored, went hunting, and climbed the cliff 35 m high along a snow-drift.

During the night towards the 5th, there arose a severe gale with snow. The anchors dragged and the ship came adrift, and all hands had to spend the night on deck. The gale continued to blow on the 5th, and next night the ship was taken farther south to a place where five fishing vessels had found shelter. These had nearly been caught by the ice on the eastern side of the island. Like a mighty river, the current swept past the south point of Björnöya, carrying ice with it. Unexpectedly the current and the ice changed direction and proceeded northward; and to make things worse, in their wake followed dense fog. The *Björnöy* put to sea and followed the ice-edge towards the north-west.

In general, the expedition encountered fine weather

The crew of the sealer *Björnøy* of Tromsø and—in centre of the photo—Johan Wilhelm Sandström, Miss Thea Ahlberg and the radio operator T. Forsberg (nr one from the left). The photo was taken immediately before the start of the cruise to the Greenland Sea, 1929. (Ymer 1930.)

The temperature distribution in the layer 0–100 m in a section from the East Greenland Ice to Norway, from June 25–July 7, 1929; see the map above. The Gulf Stream water occupies half the breadth of the section and borders on the colder water in the west on a sloping boundary surface, an oceanic front surface. Shaded areas mark water temperatures below 0°C (right). (Ymer 1930.)

The routes followed by the *Björnøy*, 1929. The position of the ship is given for each day. Two cruises were carried out: one in the Greenland Sea and one in the Barents Sea. In this way four cross section measurements were obtained through the Gulf Stream. (Ymer 1930.)

The surface temperature and the ice-edge in the North Atlantic and in the Greenland and Barents Seas in the summer of 1929. The surface temperature is represented by "staples" on the route of the ship. Note further the "inland sea" in the north of Barents Sea, described in the text on p. 465. (Ymer 1930.)

to a very high degree. Two severe gales were experienced, though; this had been their first, and the second would occur in the Greenland Sea.

They tried to reach Sörkapp, but gave it up because of the heavy ice, and kept following the ice-edge northward. On June 10 they were off Prins Karls Forland, but again the ice prevented them from reaching the land. Instead they were forced westward. Next day the weather was foggy and, working along a southwesterly course to come out of the ice, they met with ice originating from the Polar Sea. It was several years old, piled up to almost 2 m above the sea surface. The edge of this flow of ice was impossible to penetrate, but beyond it there were openings and lanes in the ice running in a south-westerly direction, which the ship followed.

In the night towards the 12th, the ship could again proceed northward. But at 09.30h they encountered the Greenland ice, merging with the Spitsbergen ice at 78°28'N, 04°35'E. This region is called the *Bay of Death* by sealers, who never find any seals or polar bears here and, besides, are afraid of the place. Its ice-edge is of interest, being where the principal mass of the Gulf Stream water descends towards greater depths. The ice looked grand, piled up to heights of several metres; it was polar ice, several years old, in different stages of disintegration, about to meet the Gulf Stream and disappear therein. Kolthoff described the same type of ice (p. 298).

The next days until June 17 were overcast, and snow fell much of the time. They had to pass one more great bay in the ice, before the ice-edge took a south-westerly direction—parallel with the Greenland coast. The edge was densely packed by the easterly wind, so the ship proceeded in open water along it. On the 17th, she managed to penetrate the barrier and reach the open ice beyond. The easterly wind abated on the 18th, so the ice became still more open. The sea was glassy, and the ship passed through an archipelago of icebergs of different forms.

On June 20, they entered a deep embayment in the Greenland ice and set a westerly course for Greenland. The water was blue. A hydrographic series indicated that the water temperature reached a maximum of +1.64°C at 100 m. The Greenland coast was seen to the west. Two days later they reached Storbukta, the classic hunting ground for seals. Here lay sealing vessels from Ålesund and Tromsø, which had mail for them. The local current flows through a narrow groove and attains a high velocity—as do the icebergs with it.

In the evening of the 22nd, they were attacked by a severe gale with snow. Large blocks of ice were hurled against each other by the waves—a deadly place for a

ship. They found shelter behind an ice promontory, but pieces of ice were broken away from the ice-edge and drifted with the wind out to sea. The engine of the ship was kept running, but the ship was also drifting in the wind, away from the sheltering promontory. Several times the ship had to be taken closer to the shelter, passing among pieces of ice.

Finally the direction of the wind changed and the pieces, which had passed out to sea, now returned. To avoid being jammed in the ice, the ship had to put to sea. But in the evening of the 24th, Midsummer Day, the wind died down. The crew went to their bunks and slept for a night and a day, after their hard fight against this extremely hazardous ice/weather situation, while the scientific members celebrated Midsummer.

On the 26th, it was summer weather with a temperature of +6°. The crew got a reward of 107 seals and one polar bear.

The ship was now off Scoresby Sound and—only 70 km from the coast—the cold current was becoming narrower. There remained much work to do to the east of Svalbard; it was time to return to Tromsø, in order to replenish the stores of oil and provisions. They turned back at 70°N, 20°W, but at first they followed the ice edge northward. In this way they got to know the deformation of the ice-edge and the speed of the ice stream in the interval between their visits.

“The spits of ice had become displaced farther outward, and the whole stream of ice had become broader, probably due to the fact that the east wind had ceased. Like an elastic rubber band, the ice stream becomes broader or narrower with westerly and easterly winds respectively. When a calm follows, the current resumes its normal breadth determined by the speed, the amounts of ice, and the cold, less saline water which it has to bring out of the polar basin.”

They proceeded north until July 3. Visibility was reduced, mainly due to fog, and the ship generally moved at half-speed. They left the ice-edge at 73°40'N, 14°W, and the course was set for Tromsø. Now the weather was excellent. They saw no life—just a tourist steamer coming from Iceland and bound for Spitsbergen. They measured the water temperature and took water samples at different depths from the surface down to 100 m.

These data gave a fascinating vertical section from the Greenland ice to northern Norway. They found that the Gulf Stream reached halfway to Greenland, and that the boundary between the warm water in the east and the cold water in the west was very sharp and

sloping: it had the character of an oceanic front (see Fig. p. 463). The water surface temperature was at first $+1^{\circ}$ to $+2^{\circ}\text{C}$, but on July 6, when they were near the Greenwich meridian, it rose to $+6^{\circ}\text{C}$.

On July 10 the ship was anchored at Tromsø. The first cruise of the expedition had been completed successfully.

In the Barents Sea

The second cruise—eastward—was begun in the evening of July 17, 1929. The ship followed the Finnmark coast of Norway until Vardö, where on the 21st the course was set for the north of Novaya Zemlya. They were favoured by fine weather while crossing the Barents Sea. It was calm and only a slight swell. Large flocks of Arctic skuas flew round the ship in pursuit of gulls, and dolphins had a swimming race with the ship. The temperature at the water surface and in the air fell gradually as the ship proceeded east:

		Water ($^{\circ}\text{C}$)	Air ($^{\circ}\text{C}$)
July	21	+8	+8
"	22	+6	—
"	23	+5	+6
"	24	+3	+4
"	25	+3	—

On July 26 they reached Novaya Zemlya and anchored in Nordenskiöld Bay, to which a visit was paid. Next day the ship proceeded towards Franz Josef Land. They followed the coast of Novaya Zemlya, which was made up of high mountains, snow-covered all the way down to the sea surface, and of glaciers that reached to the sea. Clayey water from the glaciers extended a couple of nautical miles out to sea; beyond it the sea was blue. At 14.00h on July 28 the air temperature had decreased to $+1^{\circ}\text{C}$. The ice was now near, and already at 14.30h they met with the first ice at $77^{\circ}11'\text{N}$, $59^{\circ}10'\text{E}$, as well as rich animal life: auks, gulls, fulmars, Arctic skuas, and seals in thousands.

At 14.00h on the 30th, a period of dense fog began, which was to last till August 3. It was like playing blind-man's-buff; mostly they lay still, but sometimes they moved slowly forward. They encountered large icebergs, which were probably coming from Franz Josef Land. When the fog dispersed on August 3, they made an attempt to proceed to Franz Josef Land, but could not pass through the ice-edge. There was, however, a dark water-sky, which indicated open water farther into the ice.

Finally they found an entrance—about 1 km wide—which allowed the ship to enter an area of open water. There floated blocks of ice, supporting bearded seals

(*Erignathus barbatus*) and polar bears. The weather was fine with sunshine during the days August 4-9, when they were navigating in this "inland sea" of the pack-ice (see Fig. p. 463). It was as large as Lake Vänern in Sweden. The sun shone in daytime, but in the morning there was fog; in the evening, the sea surface became covered with newly formed ice, yet the air temperature remained above freezing, as the net outgoing infrared radiation was strong. No melting occurred within the pack-ice, but the ice within the embayment was melting rapidly. In Sandström's words:

"It was an extremely interesting phenomenon."

After cruising about in the "inland sea" in the pack-ice, and making several attempts to leave it, the ship finally came back to the narrow entrance through which she had entered. Here she reached freedom and could continue the westward voyage along the ice-edge. Fog appeared at first, and they had to follow the twists and turns of the edge. Finally on August 11 they rounded the headland of the ice, which protruded towards the south-east, and the course was set more or less westward. On August 15 they paid a visit to the island of Hopen, before continuing the passage along the ice-edge across the mouth of Storfjorden, where they sighted a table iceberg on the 18th.

The weather had been somewhat disagreeable lately, with rain, snow and fog. Autumn was approaching, and on August 20, when they were off Hornsund, they decided to return home. They passed along the western side of Björnöya on the 21st. There was still much snow along the cliffs; south of the island, they saw an iceberg and some piled-up ice. On August 24 they reached Tromsø, making a successful conclusion to the arctic cruise of 1929.

The scientific work

The expedition had aimed at a study of the Gulf Stream in regions north of Scandinavia—or rather within a sector from north-west to north-east. To these studies were added investigations of the colder water masses, which lie between the edge of the pack-ice in the north and the northern extension of the Gulf Stream in the south; of the properties and extension of the ice itself; and of relationships between the ice and the atmosphere, on both micro and macro scales. Furthermore, the depths of the Greenland and Barents Seas were measured.

IN SUMMARY, THE INVESTIGATIONS INCLUDED THE FOLLOWING:

1. The edge of the pack-ice was carefully mapped. The delineation of the ice-edge was drawn from

the crow's nest in the mast by the greatest expert in these matters on board, Captain Corneliussen. The position of the ship was carefully determined by Collinder with an ordinary ship's sextant, and with a bubble sextant when there was an indefinite horizon. Time signals were obtained over the radio. The distribution of ice and open water could also be obtained beyond the horizon by observing the dark water-sky.

2. Sandström studied the structure of the ice—its disintegration into separate blocks due to wind and waves, the packing and piling up of the ice, and the creation of local current systems by the cold ice in a relatively warm surface layer, giving rise to melting of the ice in this layer. Sandström also speculated over the creation of a cold layer of air immediately over the ice, causing a calm over the ice and within the pack-ice in suitable situations. Here Sandström applied the circulation theorem of Bjerknes, both in the air and in the sea water.

Professor Krogness of Tromsø had wished to send a zoologist with the expedition for studying the little-known animal life at the ice-edge. However, due to other assignments these plans led to nothing.

3. The most important task of the expedition was to investigate the effect of the sea upon the weather in thermal respects. This influence originates at the sea surface, so the water surface temperature was closely observed. In addition, the temperature and salinity were determined down to 100 m at a number of places, since the surface temperature depends largely on the conditions below. These measurements were carried out with a reversing thermometer by Thea Ahlberg. Some of the measurements are illustrated here, together with explanatory text (see Figs. p. 463).
4. Three times a day—at 08.00h, 14.00h and 21.00h—Thea Ahlberg carried out ordinary weather observations. She also plotted observations ("obses") from England, Denmark, Norway, Sweden, Finland and Russia, which Forsberg had collected over the radio. Through her analysis of these weather maps, the expedition got the situation in the northern ocean and northern Europe represented each day for comparisons.
5. Collinder measured the depth of the sea and carried out astronomical determinations of the position of the ship. He did all this work alone, due to the scarcity of personnel. For the soundings in the Greenland Sea, with great depths mostly between 2000 and 4000 m, an echo-sounding apparatus called a Behm limnolot, Type VII, was used. In the Barents Sea, with depths generally less than 300 m,

the classic method of measuring by hand with wire and lead was used.

"A discovery of some interest was the submarine valley, at least two degrees of latitude in length, running parallel with the Greenland continental shelf north of the island of Jan Mayen and with a depth of about 3000 m. According to the previous sparse ocean soundings, depths of 1700–2000 m were to be expected in this region."

In the shallower Barents Sea, by contrast, the measured depths agreed well with the observations of previous navigators.

CONCLUDING REMARKS

Sandström's interest centred during the rest of his active life upon the problems of the Gulf Stream. He was given means to continue his research, which he had started in 1929. He bought a suitable ship for this research: named the *Golfströmmen*, she weighed only 9 tons. Cruises were made during eight summers in the 1930s, though the research programme was less ambitious than in 1929, and he was again accompanied by Thea Ahlberg on several of the cruises. But in connection with the German attack upon Narvik in April 1940, the little ship was destroyed. This event—and the war as such—put an end to Sandström's field work on the Gulf Stream.

Throughout his travels in the mountains and at sea, J.W. Sandström had never spared himself and he had taken great risks. But he always returned hale and hearty. Luck was in his favour, and he passed the favour on to science.

42. THE SECOND POLAR YEAR 1932–1933

Initiation and planning

The Polar Year 1882–83 was not to remain a research enterprise isolated in time. Fifty years later it was to be followed by a second Polar Year on a somewhat larger scale. Hence the former event should be referred to as the *First Polar Year*.

Discussions concerning a *Second Polar Year* began in 1925, and in 1927 the first steps in planning it were taken. The head of the Deutsche Seewarte in Hamburg, H.M. Dominik, managed to awaken interest in the matter among influential international circles. Dominik had in turn been inspired by a scientist of his own institute, Dr. Johannes Georgi (1888–1972), later known as the meteorologist of the German observation station *Eismitte* (Mid-ice) of 1930–31, situated in the centre of the Greenland inland ice (see p. 164).

In 1932–33, fifty years would have elapsed since the first Polar Year, and it seemed appropriate to schedule a second Polar Year for this period. Dominik sent his proposal to the president of the International Meteorological Organization (IMO), and at a special meeting in London, the proposal was supported. A committee had been established, and now formulated a programme which was submitted to the Conference of Meteorological Directors in September 1929. The latter adopted the proposal, including the time which had been suggested: 1932–33. In addition, a desire was expressed that the Antarctic be included in the observation activity.

An International Polar Year Commission was now set up with *Dan* Barfod La Cour (b. 1876), from Denmark, as president. As a first step, the resolution which the meteorological conference had arrived at was sent through diplomatic channels to the governments of all the engaged states, in order to let them decide on the proposal.

At the meeting of the International Polar Year Commission in Leningrad in August 1930, there were representatives from 7 European and 3 non-European states, while 16 other states had announced their interest to take part in the Polar Year. National Polar Year Committees were now set up in these countries to plan the observation activity. In September 1931, the International Polar Year Commission assembled at Innsbruck, Austria; 44 countries had by then given safe promises that they would take part in the Year.

During the Second Polar Year, the observations were not to be restricted to the polar regions alone, but would be carried out all over the globe. There was

discussion of establishing stations on the drifting pack-ice in the Polar Sea; down in the Antarctic, four stations were to be set up, including one in the interior of the continent. The number of stations would, moreover, be markedly increased by comparison with those in the First Polar Year. Three scientific disciplines would be pursued to the greatest possible extent: *meteorology*, *geomagnetism* and the study of *aurora*—as had been the case during the First Polar Year.

Studies of the conditions in the free atmosphere, as well as in the upper atmosphere, were also to be undertaken, although the newly constructed radiosonde could be used at only a few stations. There were plans for studies of the electrically conductive layers in the ionosphere.

For studies of the upper atmosphere, it was hoped that a rocket constructed by the American professor R.H. Goddard would be used.

It very nearly happened that the whole Polar Year enterprise had to be given up, because of the global economic crisis at the beginning of the 1930s. This was avoided, thanks to the achievements of several enterprising men, among them the Dane D.B. La Cour. The observation activity during the Polar Year of 1932–33 did have to be markedly reduced, but the number of stations was still greater than during the First Polar Year (see Fig. p. 473). On the whole, the stations were placed in the same regions in both polar years, but no station was established on the pack-ice in the Polar Sea or on the antarctic continent. Only the Argentines made observations in the south—on Laurie Island in the South Orkneys, and on South Georgia.

THE SWEDISH CONTRIBUTIONS TO THE SECOND POLAR YEAR

To plan and organize the Swedish contributions, a Swedish Polar Year Commission was set up under the auspices of the Royal Swedish Academy of Sciences.

The members of this commission were:

Professor Vilhelm Carlheim-Gyllensköld (1859–1934), see pp. 176, 336 and 339.

Professor Gerard De Geer (1858–1943), p. 318.

Divice chancellor-General Axel Gavelin (1875–1947), Head of the Geological Survey of Sweden.

Professor Axel Hamberg (1863–1933), Department of Geography at Uppsala University.

Professor Filip Åkerblom (1869–1942), Department of Meteorology at Uppsala University.

Divice chancellor-General Axel Wallén (1877–1935), Head of the Swedish Meteorological and Hydrological Institute, acting as secretary to the commission.

Already from the beginning it was obvious that the Swedish contributions outside Sweden would be located in Spitsbergen. Two observation outposts were to be set up—one at the previous Swedish mine *Sveagruvan*, situated at the bottom of Van Mijenfjorden, and one on the summit of *Nordenskiöldfjellet* (1050 m a.s.l.) near the Norwegian mining village Longyearbyen at Adventfjorden.

For the coordination of the aurora observations, one man was to be stationed at Longyearbyen, which lay 45 km from *Sveagruvan* and 7 km from *Nordenskiöldfjellet*. Thus, in reality, three stations would be set up. The leader of all three stations, especially—in the field—of *Sveagruvan*, was the physicist and meteorologist Ferdinand Lindholm. The chief of the mountain observatory on *Nordenskiöldfjellet* was the meteorologist Hilding Olsson. Both men worked at the Swedish Meteorological and Hydrological Institute, Stockholm.

THE PERSONNEL AT THE THREE STATIONS CONSISTED OF THE FOLLOWING:

Sveagruvan

Vilhelm *Ferdinand* Valdemar Lindholm (1883–1963), Ph.D., physicist and meteorologist, leader.

Evald Hugo von Zeipel (b. 1906), M.Sc., in charge of the geodetic and photogrammetric work.

F. Axelsson, radio operator and assistant observer.

E. Eriksson, cook, responsible for stores.

Evald von Zeipel was the son of the geodesist Hugo von Zeipel, member of the Swedish Arc-of-Meridian expeditions of 1898, 1901 and 1902.

Longyearbyen

R. Widegren, radio operator, assistant in auroral observations.

Nordenskiöldfjellet

Hilding Olsson (1904–73), B.Sc., meteorologist, leader.

R. Cederstam, certified forester, cook and assistant observer.

O. Lagerquist, radio operator and assistant observer.

The Swedish programme also involved an increase of observation activity in Sweden, with more geomagnetic observations at Lovö geomagnetic observatory near Stockholm and at Abisko in Swedish Lapland—and more meteorological observations at Riksgränsen, situated in Swedish Lapland between Abisko and Narvik, Norway.

The programme at *Sveagruvan* contained mainly *geomagnetic* measurements, *meteorological* observations, and measurements of *upper winds*. The latter were determined in the classic meteorological way: relatively small balloons were observed with a theodolite during their ascent. Studies of *cosmic ray* were also

carried out. The temperature and the pressure in the free atmosphere were determined with the help of Molchanoff radiosondes, which were then a novelty—with a small radio transmitter attached to a balloon and sending signals from sensors for temperature and pressure. Very few of the Polar Year stations were equipped with radiosondes; more were used at *Nordenskiöldfjellet*.

Studies of the *aurora* were conducted at all of the three stations, including determinations of the height of the aurora above the Earth's surface. These required synchronous photographs or observations to be taken at *Sveagruvan* and Longyearbyen. To this end, the two places had to be in radio contact with each other for the coordination of the photographic exposures.

At *Sveagruvan*, the expedition members could be housed in existing buildings. But for the mountain observatory it was necessary, at an early stage, to decide upon the construction and transport of a suitable hut. Experience in that respect was already available in the country. Professor Axel Hamberg had carried out scientific investigations for several years in the Sarek region of Swedish Lapland (p. 310). A mountain observatory on *Pårtetjåkkå* (1835 m a.s.l.) had been in operation for four years, under conditions which were expected to be rather similar to those prevailing on *Nordenskiöldfjellet*.

Hamberg's hut on *Pårtetjåkkå* was therefore chosen as a basic model for the new mountain observatory in Spitsbergen: a strong framework, whose roof and walls were covered inside and outside with large plates of galvanized sheet iron. The space between outer and inner plates, amounting to 7 cm, was filled with four layers of tang mats and one layer of insulation padding. The components of the framework were constructed in the autumn of 1931 and immediately sent to Longyearbyen, together with other pieces of equipment, such as stoves, tents, tools, and Stevenson instrument screens.

The mining company at Longyearbyen, *Store Norske Spetsbergen Kulkompani*, stored the material and handled the transports up to the summit of *Nordenskiöldfjellet* during the spring of 1932. The Swedish group, on its arrival in Longyearbyen in the summer of 1932, would thus find the most cumbersome part of the equipment stored on the summit. The director of the mines, Einar Sverdrup, was extremely obliging to the Swedish group—and so was everybody in Longyearbyen.

TO THE SUMMIT OF NORDENSKIÖLDFJELLET
The two Swedish groups sailed to Spitsbergen on colliers. The group for *Sveagruvan* left Stockholm on

Plan of the hut on the summit of Nordenskiöldfjellet. The three men had one room each, for themselves and according to duties, viz C: H. Olsson, leader and meteorologist, lived with his instruments. B: R. Cederstam, cook, lived in the kitchen/dining-room. A: O. Lagerquist, radio operator, lived with his radio. Note: dörr=door; fönster=window; säng=bed; bord=table; matbord=dining table; stol=chair; ugn=stove; köksspis=kitchen range; vattentunna=water-butt; kolupplag=coal store; skafferil=larder. (Olsson, H.: 15 månader på Nordenskiöldfjellet.)

"The Drive" from Longyearbyen to the summit of Nordenskiöldfjellet (1050 m.a.s.l.), used by dog teams for transporting heavy equipment to a prospective meteorological station during the Second Polar Year 1931-1933. The "drive" passed along the entire length of Longyeardalen and via five stages, of different degrees of difficulty, the summit was reached, see description of the drive in the text, p. 470. See also the air photo below. (Olsson, H.: 15 månader på Nordenskiöldfjellet.)

Air photo towards SSW showing Longyearbyen and Adventfjorden in the foreground, and behind-in the centre-Nordenskiöldfjellet with Platåberget (480 m a.s.l.). Photo: Norsk Polarinstitutt.

June 11, going via Narvik and Harstad. It reached Longyearbyen on the 20th, and continued with another ship to Sveagruvan, arriving on the 22nd. This place was found to be an excellent observation post. The mountain group left Stockholm on June 15 and reached Longyearbyen on the 27th.

The mining village of Longyearbyen consisted at the time of houses built in two rows, roughly 100 m long, with a road in between. Mining had been started here about 1904 by the American J.M. Longyear, and in 1917 the mine was taken over by a Norwegian mining company, Store Norske Spitsbergen Kulkompani—or simply Store Norske. The mine of Sveagruvan had been run by a Swedish company until May 1925, when a fire broke out in the mine. The mining village had later been abandoned, apart from occasional watchmen (see pp. 380 and 382).

Those responsible for the transports to the summit of Nordenskiöldfjellet were faced with a delicate problem: how to carry out this operation. Most miners were untrained and lacked experience from the mountains. Nor could the equipment be just carried to the summit; dog sledges were necessary. A suitable route was reconnoitred in the autumn, and in the winter 1931/32. The route which was decided upon is shown on the map (Fig. p. 469). The distance to the top was 7 km as the crow flies, but 14 km along the reconnoitred route.

It was, though, possible to find an experienced dog driver who dared take upon him the very hard work—Ludvig Sørensen (1893–1973). He was soon to be assisted by a man who was equally enthusiastic, Johannes Hagen. The Swedish group was happy to have had the good luck of obtaining such helpers for a critical task.

The transports of the heavy loads were begun on March 1, 1932, and finished on June 1. During these three months, a couple of men and about 15 dogs were at work practically every day. In total, the number of working-hours was 3 000, and 15 tons of equipment were transported up to the summit. The weather often brought about trouble and hardships.

The dog team was made up of 7 to 16 dogs, depending upon the type of terrain. On level ground it was possible to drive with large loads and many dogs, but along steep slopes the opposite rule applied. The transports to the summit were therefore carried out by stages (see the map, p. 469). The route first passed up into Longyeardalen (Longyear Valley) and its terminal moraine. Between the points 1 and 2, the slope of the ground was so steep that the dogs were unable to drag a load upwards in the ordinary way. A tackle was thus fastened on top of the slope, and the dogs could drag the load up while they themselves

went downwards. Between points 2 and 3, the route passed across Longyearbreen, which was not so steep here. Between points 3 and 4, the route slanted along a slope, which was not *very* steep, but lay near a precipice, so this passage was dangerous and only a few dogs could be used. By point 4, the critical part of the route had been overcome.

After some driving, the hut and one ton of coal were laid up at point 4, situated on the terminal moraine of the apparently nameless glacier on Nordenskiöldfjellet. The further transport to the summit would have become too lengthy if the men and dogs had returned to the village each evening for the night. Hence a camp was established in the upper part of the glacier, at point 5. From here it was only 1 km to the summit along a smooth and rounded mountain ridge.

The work had been exceedingly hard, and the weather conditions had often been severe. The dogs were not at all pleased to spend the nights high up on the mountain. A constant watch was needed to prevent them from gnawing their harnesses into pieces and returning to the sheltered environment in the mining village.

On April 20 the first load reached the summit and, as mentioned, on June 1 the transport operation was completed. By then, 15 tons of equipment had ascended the mountain, including the hut, provisions, and 8 tons of coal. Men and dogs had covered more than 2000 km, making an average of 25 km per day.

A meteorological mountain observatory

The Swedish group visited the summit of Nordenskiöldfjellet for the first time on June 28, 1932, the day after their arrival in Longyearbyen. The weather was glorious and warm, and the snow was melting. To get up the mountain, the group used the steep little valley or ravine, Tverrdalen, which is marked III on the map (Fig. p. 469).

The bottom of the valley was covered with loose earth and stones, which prevented the climbers from sliding down along the steep slope. But still the slope created a constant feeling of insecurity. This route, and the one marked II, were later used for communication between summit and village.

The ascent on June 28 lasted four hours. The equipment on the summit was found to be shrouded in snow, but it had been well marked with sticks about 50 m to the south of the top cairn. On the ridge itself, the snow was only 0.5 m deep—yet there was about 1.5 m in a depression where part of the equipment had been placed. Consequently, a lot of digging was needed when they looked for their tent, and they had to find it. They also shoveled away snow from a flat area where they intended to build the house, as they did

not know whether the snow would melt during the summer.

There was, however, a good deal of equipment, which now had to be transported up to the summit: instruments, the radio, provisions and so on. They hoped that it would be possible to use the dogs for the last 500 m just before the summit, but otherwise everything had to be carried by the men, since there was no longer any snow at lower levels. They were in a hurry now, if they were to make use of the dog team. The weather was excellent, and the snow was melting apace.

With another man helping, they carried the equipment in rucksacks. At the steepest places, each man's pack weighed 20-25 kg, and they were in "harness" 15-20 hours each day. By July 8, all goods had been carried up to the "snow limit", and only the haul to the summit remained. But the snow was wet and bad for skiing or sledging, as well as for dogs and men. At night the snow surface froze, and cut into the paws of the dogs. When the very last load had come halfway to the summit, the dogs refused to drag any more. There was nothing to do but carry the load over the final few hundred metres to the top.

On July 11 the group made a permanent move to the summit—with heavy loads, including two tents. Sörensen and Hagen were again part of the group, aiming to help Olsson and his two companions to build the hut. The preparatory building work was troublesome and required much time. The summit was covered with stones, and solid rock did not crop out. But the stones were cemented together by ice and frozen earth. This was a hopeless material for laying foundations.

More problems arose when the woodwork began. The building timber had become deformed by moisture and variations in temperature, so the components no longer fit each other, and the timber had to be reshaped. On July 20, however, the framework of the hut was set up. It remained to fasten the plates of galvanized sheet iron, and to heat-insulate the walls and roof (see p. 469), not to mention all the interior fittings.

During this time the men had become familiar with the Spitsbergen mountain weather: strong winds, dense fog, low temperatures and frost-fog. Their clothes became wet, and drying was out of the question.

The observation activity of the Polar Year was to begin on August 1. It was now evident that the hut would not be completed in time. However, it would be possible to get along fairly well with temporary instrument installations. It was therefore necessary to search for the instruments and arrange places for the

different installations—some temporary and others definitive. The three Swedes had to do this, while Sörensen and Hagen continued with the building work.

On July 27, all energy was devoted to getting one of the rooms in the hut habitable. At this point the tents were full of instruments. The men had been greatly troubled by moisture; it came from outside in the form of frost-fog, which adhered to the clothes and then melted in their tent. It also came from the vapour when cooking, and finally it came from perspiration inside. Besides having no way to dry their clothes, they no longer had any dry extra clothing.

Preparing for the winter

On August 1 the observation activity began, and a new routine had to be obeyed. The times of observation were 02.00h, 06.00h, 08.00h, 10.00h, 12.00h, 14.00h, 17.00h, 19.00h and 21.00h—generally every two hours in daytime 06.00h-21.00h, and no observations at night from 21.00h to 06.00h except at 02.00h. Meteorological data were to be published for every hour. The recording instruments slaved away, and so they were hoped to continue until the voyage home next year. The weather was fine—during the very first days.

The autumnal gales started to blow early, yielding many surprises. Already in the first week of August, the men's tent was blown to pieces and they had to move into the hut, thus interfering with the building work. Twice the anemometer mast was bent towards the ground. The funnel of the hut was blown away, and so were some iron plates which had been intended for the walls. Much time was spent looking for the lost materials. Great amounts of snow fell, and they had to mark where the equipment was laid up. They also brought some equipment into the hut.

Worst of all, though, was that the pipes for the stoves in the kitchen were too small. When lighting a fire, the rooms became filled with dense smoke, and cases of near-poisoning by monoxide occurred. It was cold, unpleasant and unhealthy to be indoors. New pipes with a diameter three times the original were made at Longyearbyen. Cederstam was to carry them up to the hut. On the mountain they were informed over the radio of his start, but he was late in coming, so Olsson and Lagerquist had to go out and look for him. He was found some 10 minutes' walk from the hut, quite uncertain as to his whereabouts. The new tubes were installed on September 18, and from then on the draught was good.

On September 10, people from Longyearbyen came up to pay a visit. Sörensen, who had assisted during the last two months, was leaving. The work proceeded: getting everything to function, securing the

hut and the outdoor instruments, deciding what to do with instruments that made trouble because of the weather, establishing a satisfactory routine for the daily tasks, and so on.

An immediate chore was to carry provisions up to the station for the winter night, when the men would be isolated from the rest of the world—including Longyearbyen. They had already experienced the mountain weather of Spitsbergen, but worse trials were expected. They would face long periods of isolation, confined to the little hut by darkness, gales and low visibility. It is therefore relevant to have a look at their home.

The hut was situated about 50 m from the top cairn on Nordenskiöldfjellet. Externally it was 6.4 m long and 4.4 m wide, with a floor area of roughly 25 m². As mentioned, the walls consisted of galvanized iron plates fastened to both sides of a framework—with insulation of mats and padding between the plates. The roof had the same construction.

Inside were three rooms, one for each man and the equipment pertaining to his duties (see Fig. p. 469). Lagerquist, the radio operator, had the largest room (A), measuring 2 x 5 m²; he lived among his apparatuses. The cook, Cederstam, had his bed in the kitchen/dining room (B), with the area 2 x 3 m². The room (C) of the leader and meteorologist, Olsson, was the smallest with 2 x 2 m². Here were the meteorological recording-instruments for pressure and wind, besides a work-table for the calculations and writing which were an essential part of his daily duties, and for practical chores of all kinds.

The hut had two entrances with halls. One entrance, however, was nailed up and its hall was used as a larder and coal store. To get outdoors, the men therefore had to pass through the radio room. This entrance hall adjoined the toilet-room with an earth closet. But ventilation was bad here, so the latter room was soon exchanged for a snow-cave in a dune close to the hut. Finally, the hut had a spacious loft where part of the provisions, spare instruments and other things could be stored.

As we know, the construction of this type of hut had previously been tested on the Pärtetjåkkå mountain in the Sarek region of Swedish Lapland (see p. 314). Great care had been devoted to its building, not least the foundations. As a last precaution against hurricane winds, the hut was secured to the ground with two half-inch wires. These were stretched across the hut at two places, and fixed to iron rails about 2 m long, which had been buried in holes about 1 m deep. This anchoring job occupied one man entirely for two weeks. It was well done: the hut still stands on the summit of Nordenskiöldfjellet, in spite of hurricane

winds, and of artillery fire from German naval ships during World War II (see p. 476).

Next came the task of getting provisions up to the hut. The dark period was close at hand, with blizzards, low temperatures and fog. They had to reckon with an isolation of about 5 months. Besides food, they had to bring medicine, candles, and paraffin oil for their lamps. But time passed as they awaited snow for the transports with sledges; these could not start until a week into October. One man, Lagerquist, had to stay at the station and carry out the whole observational programme alone—so he did not get much sleep while the transports went on.

The two others, Olsson and Cederstam, carried the equipment from Longyearbyen up to the plateau at 500 m a.s.l., where it was stored in a depot. As a rule, it took one week to transport 800 kg to the depot. Generally they were able to carry 25 kg each and make three trips daily. The short time of daylight was such a hindrance that they also had to make use of the dark hours. It was rather risky to leave equipment on the mountain, barely covered with tarpaulins. The equipment was then transported by dog sledge to the summit during October 15–16. The weather remained in their favour, and the moon shone towards the end. But when the last load had reached the summit, a gale started to blow.

Winter: high winds and darkness

They could now wait in peace for the winter and the darkness. A snow-cave was dug for the provisions, and illumination had been provided for. There were 60 litres of paraffin oil for lighting in hours of work, and 200 candles for evenings and nights. Moreover, they got electricity from a small wind generator, when conditions were right. The sun was to be below the horizon for about four months, but a “real” polar night would last only two months. During one month after the sun’s disappearance in the autumn, and before its return in late winter, there would be twilight in the middle of the day.

On October 25 the last collier of the year left Longyearbyen. From Nordenskiöldfjellet the men could follow her passage out of the fjord. But they could not yet settle down to a quiet life for the winter. All measures for their security had been taken, and there was now time to see to their own comfort. Shelves, beds and tables must be constructed. The men worked carefully, and not until nearly Christmas were they ready with this furniture. They also had the routine observational work to do, as well as the cooking and the repair of troublesome instruments.

At the end of November, Lagerquist went down to the mining village with the wind aggregate, which had

Christmas 1932 provided an agreeable change for the men on the summit of Nordenskiöldfjellet and was celebrated in the traditional manner with decorations and the usual Christmas food. Lagerquist (left) and Hilding Olsson. (Olsson, H.: 15 månader på Nordenskiöldfjellet.)

Scientific stations in the Arctic and the Subarctic during the Second Polar Year, 1932-1933 (top right). (Nordisk tidskrift 1933.)

Stay-wires and intense rime formation. Hilding Olsson 1933. (above). Photo: F. Goldberg Collection.

The hut on Nordenskiöldfjellet, 5 May 1981. Photo: Per Holmlund.

been damaged during a severe gale. There he had to stay for 10 days, before he could walk up to the station. He made an early attempt to ascend, but ran into a gale and got only within 800 m of the hut. Here he left his rucksack and returned to the mining village, though he had to wander about for 10 hours before reaching security in the village.

It was routine to inform the station whenever men left Longyearbyen for the summit. This ensured the possibility of meeting them on the way if their arrival at the station was delayed.

The time before Christmas passed rapidly. A suitable routine had now been arranged for the work, which was dominated by the running observations. These duties were shared so that each man was the observer every third day, while the other two were occupied with different tasks.

The weather observer's day began with the observation at 06.00h. After that, he roused the others with coffee and cakes. The actual work then started at 08.00h—with cooking, in the radio station, and on the observation material which had been collected. Lunch was served at 12.00h, followed by a midday nap until 14.00h. More work filled the time to 18.00h. The evening and night were free, although the day's observer had to complete his observations at 02.00h. Life was thus divided into specific duties, and was poor in external events—save on the rather frequent occasions when the weather interrupted the routine.

They studied the reading matter which had come up with the summer's mail: daily newspapers, weekly journals and, of course, books. They discussed the daily events which were heard over the radio, but radio reception was often bad. A couple of times each week they played cards. That was all. Once a week, on Thursdays, they drank a snaps with their dinner, which on those days consisted of peas, pork and pancakes.

The winter blizzards were severe and trying. Now and again the outdoor observations had to be carried out by two men for the sake of security. With a strong wind blowing, the mountain gave rise to cloud formation or reinforced an already existing, so-called orographic (or oreigenic) cloud, which on the summit was observed as fog. The droplets of the cloud/fog were supercooled—at a temperature below 0°C. When driven by the wind against objects on or above the surface, they froze into ice droplets, which adhered to the objects and to each other, forming rime or even glazed frost.

During gales, monstrous rime-deposits were built up on the windward side of objects, such as the thermometer screen and the hut. The stay-wires might be surrounded by rime as thick as 30 cm (see

Fig. p. 477). The meteorological instruments became damaged or filled with snow, and had to be taken indoors for overhaul or repair. Often the nights were taken up by such work.

The men suffered from sleeplessness, a common complaint during the polar night. Here it was probably aggravated by the confined way of life which they were forced to lead. And due to lack of sleep, they often felt weak. Another problem was the entrance door, where drifting snow collected. It became damaged by repeated use, the hinges broke, and the handle was too weak. Sometimes the door froze to its frame, and had to be treated with spit and axe before the men could come out. Ultimately they had to hang a canvas in front of the entrance.

Christmas provided an agreeable change of atmosphere. Two days before Christmas Eve, three men came up from Longyearbyen with a dog team, bringing such delights as sweetmeats, brawn and pork chops. But the visit lasted only an hour: clouds drew in front of the moon, foreboding bad weather. Their Christmas was celebrated in the traditional manner with decorations, boiled smoked haddock as a substitute for ling, and naturally the usual Christmas food.

The time after Christmas was their hardest. Christmas Day began with a severe gale and drifting snow; such weather prevailed almost constantly during the next six weeks. A climax occurred on February 2–4, when a dreadful hurricane brought wind speeds reaching 59 m/s (normally “hurricane winds” are anything over 33 m/s). The meteorological equipment outdoors was virtually destroyed or blown away.

Only at the times of observation did the men need to go outside, and then only for the least possible time. They got no exercise, and their confined life was especially trying because the smoke from the stove spread into the rooms. There was no way of airing out the rooms, due to the intense drifting snow. The air indoors also became very humid, particularly when drying outdoor clothes covered with snow and rime.

Hilding Olsson's diary may be cited for February 2 and 3:

“I got up at 05.30h [February 2]. There was much snow outside in front of the entrance and in the entrance hall. I had to shovel for half an hour in order to come out. At 14.00h—between two heavy squalls—the wind speed was measured 41 m/s with a hand anemometer. When measuring, I ‘succeeded’ in getting my right hand frost-bitten. I had twinges of pain as if from needles. All the time I was worrying over the wind instruments. I feared that they would blow away; it was impossible to free them from glazed frost.

Lagerquist could not find the toilet, though Cederstam had been there one or two hours earlier. Large pieces of ice flew in the air. Dinner with peas and pork and a snaps.

At 19.00h I tried to reach the thermometer screen, but I came only 3 m [from the entrance]. Cederstam and I then made an attempt together by creeping on the snow. Cederstam lay under the thermometer screen holding my legs, while I rose to my feet and made the readings. At 02h on February 3 it was impossible to come outdoors. Throughout the night there raged the worst gale I have ever experienced. The hut vibrated violently, in spite of being quite embedded in the snow. The air pressure fluctuated incessantly, 4–5 mm Hg [= 5.3–6.7 mb or hectopascal], and even up to 6 mm [= 8 mb] within as many or even fewer seconds. I lay on my bed for an hour now and then. It was impossible to sleep, as the wind roared violently, and pieces of ice rattled against the funnel unceasingly; it sounded like gunfire. In the most severe gusts we were deafened. One of the anemometers stopped recording at 01.00h [February 3]. The other one kept going, but I expected any moment that it would be off. The store of coal in the hut was giving out, as we continually had to fill the stove to keep the hut warm. No observations were carried out during the whole night.”

It may be added that the highest wind-speed of the year (59 m/s) was noted at 01.00h on February 3 (compare Table p. 477).

This severe gale changed the whole routine of the life at the station. Thanks to the recording instruments, their observation programme had been simplified until then, reducing their duties especially at night. But with most of the instruments destroyed or blown away, they would have to carry out the observations every hour, day and night. They decided to work in shifts, at 01.00h–04.00h, 05.00h–08.00h, 09.00h–20.00h and 21.00h–24.00h, so that no man ever got the same watch in succession. With the new schedule, they could also have morning coffee together at 08.30h and work until dinner at 18.00h. However, the chats were few in the evenings, as the two men who were free from observational duties went to bed to get some rest.

Their reactions following the dark period (compare p. 474), and the scarcity of sleep, emerged after the sun reappeared. The rather cheerless routine of work went on until May 1. By then, the recording instruments had been repaired tolerably with the primitive facilities at hand. The night observations at

00.00h, 01.00h, 03.00h and 04.00h could be left out, thus restoring the old observation routine.

The light returns

On February 4, they could at last see the surrounding mountains. Daylight had resumed—though only twilight to begin with. This event was greeted with satisfaction and joy. Their confined life during the long storm period of six weeks’ duration was now over. They had looked forward to making ski trips in the surroundings—but these were almost impossible, for the strong winds had packed and polished the snow on the mountain slopes, and skis could hardly be controlled. On their first visit to Longyearbyen, they used crampons fastened to their skiing boots.

Among the first things that had to be done was digging out the hut, enough to free the windows and let daylight enter the rooms. On February 10 the lamps could be put out for a few hours in daytime. There was still only twilight, and not until the 18th did the sun appear—like a red ball on the horizon to the south. After another two months, the sun would stay above the horizon day and night.

In the middle of February, Hilding Olsson paid the first visit of the season to Longyearbyen. He was surprised to find that the wind-polished slopes of the mountain were changed into loose snow at levels near the valley bottom. In Longyeardalen he had to wade in knee-deep snow. It struck him that the people in Longyearbyen had also been affected by the darkness and the confined life: a certain tiredness and touchiness were noticed.

The return trip to the summit was carried out with a dog team and a sledge. The dogs, however, had to be dragged upward by the men at the steepest places. Spare instruments, left at Longyearbyen in the previous autumn, were now brought to the summit.

In March the store of provisions had to be replenished. They could use the dog team for these transports, but only halfway to the summit. The dogs did not get any foothold on the wind-polished slopes in the upper parts of the mountain. Over the rest of the way to the summit, the men had to carry the equipment, which was possible thanks to the crampons they had bought at Longyearbyen. After the return of the light, they had discovered crevasses in “their” glacier, and a few serious near-accidents had occurred. So they chose another route, where dog teams could not be used.

The weather had improved during the spring, and in March–April there were several days with a clear sky and a calm. But it was rather cold, in fact the coldest period during their stay in Spitsbergen, with monthly mean temperatures about -20°C and mini-

mum temperatures of -30° to -34°C (see Table p. 477). During the winter they had experienced fog and strong winds almost the whole time. Now they were able to put up a thermometer screen on the plateau halfway down to Longyearbyen, in order to get supplementary temperature data. Exchanges of recording paper in the thermograph, and check-readings of the temperature, were made here every five days. These visits could suitably be combined with a visit to Longyearbyen.

A miserable summer

From the station they had a good view out over Isfjorden and the fjord mouth. Consequently they made observations of the ice, and sent these by radio via Longyearbyen to the shipowners in Norway. On May 8 the first collier arrived—and with it their mail from home. No ice had been seen during the passage to Spitsbergen.

The second summer was fairly cheerless and monotonous. Snow fell, and the summit was never clear of snow. The temperature was sometimes a little above 0°C , sometimes a little below, and the mean temperature of the “warmest” month (July) was -0.6°C . Clear days were rare, although there were five of them in July. As then a calm occurred at that same time, the men made the most of the weather and sun-bathed. But below the summit, a billowy sea of clouds extended. The month of August then became colder.

Soon it was time to think of the homeward voyage. The dog team was useless now because of the crevasses in the glacier, and the new route could not be used for sledging. Thus the men had to carry the equipment down to the mining village. This work had already begun in July, along with their regular visits to the thermometer screen on the plateau. But not until August 20 were the transport operations progressing at full speed. One man in the group stayed at the station, while the other two carried down equipment. During the last few days, both transports and observations were taken care of by Olsson and Cederstam, as Lagerquist had to see the doctor in Longyearbyen after severely spraining an ankle.

After the midnight observation on August 31/September 1, and having eaten a farewell meal, Olsson and Cederstam took the remaining 70 kg on their backs, closed the station, and walked down to Longyearbyen. The melancholy of departure was softened by the prevailing weather—a blizzard with a temperature of -7°C . They were glad and satisfied. A difficult task was successfully accomplished, and they were both healthy in spite of hardships and privations.

It was truly an achievement, mentally as well as physically. Never before had human beings wintered

at 1000 m a.s.l. at such a high latitude. They had shown that this could be done without much risk—and while a continuous scientific observation programme was carried on. The optimism and humour of Hilding Olsson had been a valuable asset. Their gratitude to the Norwegians at Longyearbyen was great, especially to divice chancellor Einar Sverdrup and their helpers in the field, Ludvig Sørensen and Johannes Hagen.

At Longyearbyen the mountain group met Lindholm's party, which had spent the past year at Sveagruvan. There, too, the scientific work had been successful. The two groups were to go home together on board the same ship, the collier *Ingerfem*. On September 6 she left for Bergen, Norway, arriving on the 13th. The Swedish Polar Year expedition finally reached Stockholm by train on September 16.

POSTSCRIPT

As of the year 1990, the hut on Nordenskiöldfjellet still stood where it was built. During World War II it served at times as an observation post for the Norwegian garrison, stationed in Spitsbergen since May 1942. On the arrival of the troops, the divice chancellor Einar Sverdrup was killed in connection with a German air attack against Allied ships in the mouth of Isfjorden. Later, in September 1943, the hut was fired at by German naval ships, and a few shell splinters pierced its walls. Longyearbyen and the Russian mine village, Barentsburg, were burnt to the ground on the same occasion.

TEMPERATURE (°C) AND WIND DATA (M/S) FROM NORDENSKIÖLDFJELLET, SPITSBERGEN
AUGUST 1932–AUGUST 1933

Lat. 78°10.7'N, Long. 15°26'E. Height: 1050 m a.s.l.

1932	July	Aug.	Sept.	Oct.	Nov.	Dec.			
Mean temperature	–	-1.6	-8.0	-10.9	-16.3	-14.2			
Max. temperature	–	+5.6	-2.0	-1.5	-2.9	-4.9			
Min. temperature	–	-8.2	-13.8	-19.0	-26.6	-28.9			
Mean wind speed	–	–	–	9.5	10.3	13.0			
Max. wind (direction, speed)	–	–	–	E 43	E 35	ENE 40			
1933	Jan.	Feb.	March	April	May	June	July	Aug.	1932–33
Mean temperature	-10.3	-16.3	-18.9	-19.6	-8.9	-3.1	-0.6	-1.6	-10.7
Max. temperature	-2.1	-8.1	-3.7	-7.3	+1.0	+4.7	+7.1	+8.1	+8.1
Min. temperature	-24.5	-30.4	-33.7	-29.8	-19.4	-13.4	-4.4	-6.6	-33.7
Mean wind speed	13.7	12.5	8.3	9.0	7.4	6.5	5.1	–	–
Max. wind (direction, speed)	E 49	E 59	E 39	E 36	E 50	WbN 20	WNW 16	–	E59

E = East, ENE = Eastnortheast, WbN = West by North, WNW = Westnorthwest

The old meteorological screen buried in rime formed by supercooled cloud droplets in high wind, 5 May 1981. Photo: Per Holmlund.

THE AHLMANN EPOCH
1931–1952

43. HANS W:SON AHLMANN AND THE SCIENCE OF GLACIOLOGY

THE SCIENCE OF GLACIOLOGY

Glaciology is mainly the study of ice masses that are created on land, in gradual layers, by snow precipitation which accumulates instead of disappearing through melting and evaporation during the warm season.

In some regions, where the conditions are favourable, ice-fields of considerable extension have been created. They may cover islands, hills or mountains, completely or almost completely, and are then often called ice-caps. They may even reach continental or almost continental extent, as is the case in Antarctica and Greenland. They are then generally referred to as inland ice or ice-sheets.

Land ice conforms more or less closely to the underlying bedrock. On slopes, it flows down towards lower and warmer levels, where the ice and snow melt or evaporate. Alternatively, at places where the glacier or the ice-sheet reaches the sea or a lake, it may "calve", breaking up into large blocks and pieces of ice, which float away.

In the upper reaches of a glacier, called the accumulation area, there is a net gain of snow. But in its lower parts, there are average net losses of snow and ice due to melting and evaporation. Thus, land ice has an income known as "accumulation", and expenses which are termed "ablation". As mentioned, these expenses may take the form of calving. If conditions of equilibrium exist, the income and expenses compensate each other on an average, due to a flow of glacier ice down the slope.

By friction, the glacier ice erodes the bedrock, reshaping the ground. Dislodged particles, stones and blocks are transported by the ice, as well as by the melt-water, and are deposited in front of, along, below, within and outside the glacier. Different kinds of deposits arise. Studies of today's glaciers and inland ice masses have contributed to the interpretation of previous land ice. This is possible by studying the deposits from ancient land ice and comparing them with deposits from present-day land ice.

Glaciology developed into a scientific discipline from about the middle of the 19th century, when interest became focused upon the glacial deposits from the latest Ice Age. These deposits are now located far away from any considerable land ice. In order to solve the Ice Age problem, it was necessary to obtain analogies from currently existing glaciers and

ice-sheets. The science of glaciology thus developed as a branch of geology.

The formation and maintenance of land ice depend upon the regional climate. Rich precipitation of snow in combination with cool summers are among the conditions of glacier formation. Regions of glaciation outside the tropics, therefore, ought to be situated near the predominant cyclone tracks—and chiefly in regions which are influenced by the ocean, having high humidity and relatively cool summers with a low rate of melting. In the mountains, the temperature is fairly low in the summer and precipitation is high on account of orographic effects, which increase the precipitation on the windward side. Thus, mountain ranges often serve as "nuclei" when glaciers and ice-sheets are formed.

The rise and decline of inland ice, and other land ice, are consequently reflections of the climatic conditions and the atmospheric circulation in the regions concerned. Changes in the extent of land ice, then, reveal variations in the climate—land ice may serve as a *climate indicator*. More complicated, though, is the problem of exactly how the land ice is affected by the different meteorological and climatological variables, such as radiation, temperature, wind and precipitation.

These questions, including that of the physical properties of land ice, became prominent around 1930. Glaciology was turning into a *geophysical* discipline, after acquiring, as we have seen, a strongly *geological* character. The Swedish geographer Hans W:son Ahlmann (1889-1974) and his pupils were pioneers of this new trend in the science of glaciology.

Until about 1930, it had been possible to reach a rather clear understanding of the climatic conditions at and near the Pleistocene inland ice masses, by interpreting the evidence of so-called periglacial deposits. The climate could also be deduced from analogies with present-day land ice. But obviously we cannot find conditions today that would duplicate the melting of ice during the final stages of an Ice Age. Nor were the climate and weather known with any reasonable reliability on the Pleistocene inland ice.

Before 1930, no one even knew the climatic conditions on *present* inland ice—apart from observations by occasional sledge expeditions, starting with Fridtjof Nansen's sledge tour across the Greenland inland ice in 1888. And still less was known about how the large land ice masses react upon the climatological and meteorological variables. The decades following 1930 would see these problems solved, or at least studied, beginning with the meteorological and glaciological investigations in the interior of Greenland during the German expedition under Alfred Wegener (1880-

1930) in 1930–31, and during the British Arctic Air-Route expedition under H.G. Watkins in the same year (see pp. 164 and 445).

Swedish research in glaciology

The first Swedish descriptions of glaciers—in a scientific sense—originate from the versatile botanist *Göran Wahlenberg* (1780–1851), who in 1807 travelled through the regions of the Sulitelma Massif in the border district between Sweden and Norway, at about latitude 67°N.

Previously (Chapt. 4) we have touched upon *Otto Torell* (1828–1900), who during the years 1856–61 studied glaciers in Switzerland, Iceland, Greenland and Svalbard. He was one of the first scientists to embrace the hypothesis, advocated in 1840 by Louis Agassiz (1807–73) of Switzerland, about a previous extensive glaciation in north-western Europe. By studying existing glaciers and inland ice, Torell tried to find support for such a theory (see p. 22).

Fredrik Svenonius (1852–1928) travelled in 1878 in the Sulitelma Massif and adjacent regions. He noted that there had occurred a marked reduction in the extent of the glaciers during the 70 years since Wahlenberg's visit to the region. In many respects he could also confirm the observations of Wahlenberg. During 1887–1888 he carried out further studies of glaciers in Swedish Lapland. He became an internationally recognized researcher in glaciology.

We also recall *Gerard De Geer* (1858–1943) and his brilliant career as a Quaternary geologist and student of glaciers (Chapt. 32). At the International Geological Conference in Stockholm in 1910, he presented a summary and description of Swedish glaciers. Among other Swedish researchers in glaciology during the 20th century were Axel Hamberg (1863–1933), Fredrik Enquist (1885–1963), Hans W:son Ahlmann (1889–1974) and Valter Schytt (1919–1985).

Axel Hamberg was a versatile scientist. He had taken part in the Swedish polar expeditions of 1883 and 1898, and in 1892 he had made a voyage of his own in Spitsbergen waters (see Chapt. 31). His greatest achievement was, however, the great interdisciplinary investigation in the Sarek region in Swedish Lapland, which included a mapping and description of the local glaciers.

Fredrik Enquist discussed, among other things, the problem of the wind's role in the formation of glaciers. He also studied the history of glacial development in north-western Scandinavia. His photographs, taken in 1910 in the Kebnekaise Massif from marked places of exposure, have been of great value for our knowledge of the previous extent of the glaciers in this region.

Hans W:son Ahlmann was, as mentioned, a pioneer in glaciology. By his guidance and inspiration, glaciology developed rapidly in Sweden into a geophysical discipline. Ahlmann undertook and/or brought about a number of polar expeditions, where he consistently supported systematic study of the mass balance and energy exchange of the glaciers in climatically different regions around the northern part of the North Atlantic Ocean: the Norwegian Sea, the Greenland Sea, and their extensions northwards.

These studies were carried out during a period—the 1930s—when the climatic change that began in the middle of the 19th century was approaching or had reached an optimum. The glaciers had reacted markedly, receding and shrinking in the northern hemisphere; the arctic pack-ice had decreased in extent and thickness; many species of animals had moved northward. For the first time in the history of mankind, it had become possible to “experience scientifically” what happens in the atmosphere and sea during a change of climate, and to follow how the glaciers are affected by these shifts in climate and weather.

Valter Schytt (1919–85) was a pupil of Ahlmann's. He studied the glaciers in Scandinavia and the Arctic, as well as the inland ice and shelf ice in Antarctica (see p543). Other pupils of Ahlmann were *Carl M:son Mannerfelt* (b. 1913) and *Carl Christian Wallén* (b. 1917). The former investigated the shrinking of the Scandinavian inland ice and the creation of morphological forms during the Postglacial period in the mountains of Sweden and Norway; the latter studied the energy balance of a glacier in Swedish Lapland.

HANS W:SON AHLMANN *a summary of his activities*

Hans Jakob Konrad W:son Ahlmann (1889–1974) was primarily a geographer, but his interests were numerous. In word and deed he was chiefly characterized by his love of glaciers and mountains—and of Norway. His personality was also distinguished by an artistic turn of mind. This, and his literary talents, were evidenced by his article in the journal *Konstrevy* (1942, pp. 81–90) describing the group of artists—his friends—who worked at Smedsudden in Stockholm during 1917–23.

In his early years he pursued many paths: for example, in 1913–14 he lived in Paris to become a painter. In the summer of 1910 he took part as an assistant in the excursion to Spitsbergen arranged by the international Geological Congress in Stockholm (p. 326). At the beginning of his university career he exhibited a great interest in the economic and cultural branch of geography.

Subsequently he became a B.Sc. in 1910, Ph.D. in

1915, lecturer in morphological geography at Stockholm University in 1915, lecturer in geography at Uppsala University in 1921, professor of geography at Stockholm University in 1929–50, and Sweden's ambassador in Oslo during 1950–56.

Ahlmann's career as a glaciologist began in 1919. His life was then to follow a logical course in its events and general aim. He started his glaciological work in the mountainous region of Jotunheimen in southern Norway, where he did morphological research. In 1924–26 his glaciological studies on Styggedalsbreen in Jotunheimen initiated a series of systematic investigations. These always involved co-operation between Scandinavian countries. Their purpose was to understand the relations between the existence and life of glaciers, on the one hand, and meteorological and climatological conditions on the other—in other words, the interactions between glaciers and atmosphere.

After about 1910, interest in polar research had declined markedly in Sweden. No major scientific Swedish expeditions visited the polar regions during the period 1910–1931. But things changed in 1930, with the discoveries of the relics of the ill-fated Andrée expedition on Kvitöya, Svalbard (p. 251).

Ahlmann was a member of the committee which took charge of the relics, and as a joint editor he was responsible for the publication of the expedition report "*Med Örnen mot Polen*" ("With the *Eagle* towards the Pole"; English edition entitled "*The Andrée Diaries*").

In a very short time, these discoveries gave rise to enormous concern with polar matters in Sweden, making possible a renewal of scientific research in the polar regions. At about the same date, interest had turned towards studies of the physical properties of glaciers and the atmosphere's interaction with glaciers and inland ice.

In 1930–31 the German Greenland expedition, under Alfred Wegener (1880–1930), worked in central Greenland, partly from the station "Eismitte" situated in the island's centre. Now the climatic conditions, and the physical properties of the inland ice, were first becoming known. In 1922–25, during the Norwegian expedition with the *Maud*, H.U. Sverdrup (1888–1957) had studied climate, upper air conditions, and radiation over the pack-ice in the Polar Sea. The time was ripe for geophysical investigations of the land ice of the Earth.

In Sweden it was also time for a large interdisciplinary expedition to the Svalbard region. The focus would be upon Nordaustlandet, its large ice-caps, and the adjacent waters. Thanks to Ahlmann's many contacts in Norway, the *Swedish-Norwegian arctic expedi-*

tion of 1931 materialized. Led by Ahlmann, it would work in glaciology, meteorology, geology, botany, oceanography and cartography. Sir Ernest Shackleton's ship, the *Quest*, during his last expedition of 1921–22, carried the expedition to and from Svalbard, and on a tour round Nordaustlandet.

This expedition proved successful. The ice-caps of Nordaustlandet were studied during a sledge tour. At a station, Sveanor, on the southern side of Murchisonfjorden, the very first attempts were made to relate the course of the melting of an ice-field to the meteorological variables—even though the melting was studied on just a small snow-field near the station.

It would be necessary to study the relations under more realistic conditions and in closer detail. The ablation (melting and evaporation) would have to be measured, as would the radiation and heat transfer from the air to the snow surface. This called for a new venture, which was realized in 1934: the *Norwegian-Swedish Spitsbergen expedition of 1934*. Its leaders were Ahlmann and a good friend of his, the great Norwegian geophysicist Harald Ulrik Sverdrup (1888–1957).

The expedition worked under ideal conditions upon a flat ice-field, Isachsenfonna, situated north of Kongsfjorden in the north-west of Spitsbergen. The measurements which were carried out in the summer of 1934 were later to serve as a model for similar studies of glaciers in other parts of the world, above all when dealing with the rather sophisticated measurements of the transfer of heat from the air to the ice-field. Sverdrup was responsible for this part of the investigations.

Until then, Ahlmann had studied glaciers and ice-caps within maritime Scandinavia, and in the high arctic Svalbard which was also influenced by the ocean. It remained to study the glacial conditions in an *extreme maritime subarctic region with high precipitation*, and in a *continentally influenced arctic region with low precipitation*, as well as the conditions prevailing on *the inland ice and the shelf ices in the extreme cold of Antarctica*.

The extensive land ice of Vatnajökull in south-eastern Iceland fulfilled all conditions with regard to an extreme maritime climate. This large ice-sheet lies outside the Arctic, and near the predominant tracks of the North Atlantic cyclones, with strong accumulation and ablation as a consequence. To a certain extent, conditions here should resemble those which prevailed in north-western Europe during part of the Ice Age.

Thus arose the *Swedish-Icelandic expedition of 1936–38 to Vatnajökull*. While originally meant to occupy only the summer season of 1936, it was prolonged for another two summers, thanks to co-operation with

the Icelandic geographer Sigurdur Thorarinsson. The observations within the region had proved to be of great interest.

To represent a glacier in a region of continental polar climate with low precipitation, the small Fröya glacier was chosen. It lies on the north side of Clavering Island in north-eastern Greenland. The enterprise which visited this region, the *Swedish-Norwegian expedition of 1939–40 to north-eastern Greenland*, was more modest than the previous expeditions of Ahlmann.

During the war years 1939–45, Ahlmann had a great deal of work. Observations from the expeditions had to be studied and published. He had duties to fulfill as a university professor. His Swedish-Norwegian contacts and connections had to be kept open. And there were new expeditions and other scientific activities which called.

His expeditions had been “spot tests” of the glaciological conditions around the Norwegian Sea. Consecutive observations over several years from at least one glacier were now needed. This was most important, due to the continuing improvement of the climate and the ensuing regression and shrinkage of the glaciers. The Storglaciären in the Kebnekaise Massif, at lat. 68°N in Swedish Lapland, was chosen. The observations were started here in 1946, at first on a modest scale. This activity is still going on the research station *Tarfala*.

The Antarctic also beckoned. To begin with—during the first half of World War II—Ahlmann dreamt of an expedition to the Antarctic Peninsula in co-operation with Great Britain. However, in 1942 the scientific results from the German Antarctic expedition of 1938–39, with the catapult ship *Schwabenland*, reached Sweden. The many air photographs, showing mountains and mountain ranges which protruded from the inland ice, fascinated Ahlmann. The enthusiasm resulting from these studies led eventually to the large *Norwegian-British-Swedish Antarctic Expedition of 1949–52*.

Ahlmann's expeditions and research in the cold regions are summarized below:

- 1910 Visit to the Isfjorden region of Spitsbergen during the International Geological Congress in Stockholm.
- 1916–26 Morphological and glaciological studies in Jotunheimen in southern Norway, and on the Kårsa glacier in Swedish Lapland.
- 1931 Leader of the Swedish-Norwegian expedition to Nordaustlandet and surrounding seas.
- 1934 Co-leader, with H.U. Sverdrup, of the Norwegian-Swedish expedition to Isachsenfonna in north-western Spitsbergen.
- 1936–38 The Swedish-Icelandic expedition to

Vatnajökull in south-eastern Iceland. Co-leader with Jón Eythórsson.

1939–40 The Swedish-Norwegian expedition to the Fröya glacier on Clavering Island in north-eastern Greenland. The observation programme after the summer of 1939 was carried out by the Norwegian medical student Kaare Rodahl.

1946 Initiating and starting the activity at Tarfala glaciological station in the Kebnekaise Massif in Swedish Lapland, at lat. 68°N.

After 1945 initiating the Norwegian-British-Swedish Antarctic expedition, 1949–52. Ahlmann was leader of the Swedish group, but he did not visit the Antarctic, as other duties called; he was appointed ambassador of Sweden in Oslo for 1950–56.

THE SWEDISH-NORWEGIAN EXPEDITION OF 1931

Plans and personnel

Nordaustlandet was at the time an “unknown territory” in several respects. The extent and topography of its large ice-sheets were only imperfectly known, and there were problems in physical geography to be investigated.

Svalbard is situated near the border between the cold water and ice of the Polar Sea and the warmer water of the North Atlantic current. The exchange of water masses in the sea between Nordaustlandet and Franz Josef Land was unsatisfactorily known. An investigation of the meteorological conditions over and around large land ice masses had gained actuality since an American, W.H. Hobbs (b. 1864), introduced his theory during the 1910s about glacial anticyclones. Alfred Wegener's Greenland expedition of 1930–31 aimed at studying such anticyclones in Greenland, although their importance had been much overstated by Hobbs.

How did the atmosphere react in these respects at and near Nordaustlandet? This region is also more barren than the main island, Spitsbergen; its vegetation had to be studied. The Hecla Hook formation in Nordaustlandet, too, was imperfectly known and would give a geologist interesting work. To Ahlmann, a geographical and geophysical investigation of the large ice-caps was of highest priority.

During the Spitsbergen expedition of 1872–73, Nordenskiöld had sledged across the ice-caps of Nordaustlandet, but the weather had been unsuitable and had prevented many observations. Nor was the Oxford University expedition of F.G. Binney in the summer of 1924 favoured by weather and season. Three sledge tours had, however, been carried out across the ice-caps.

The programme of the Swedish-Norwegian expedition was ambitious, and aroused enthusiasm in both Sweden and Norway. Soon the expedition's list of members was complete and its financial status had been resolved. As expedition ship, Ahlmann managed to secure the Norwegian sealer *Quest*. Her owner, Captain L. Schjelderup, was now also her commander.

THE SCIENTIFIC STAFF CONSISTED OF:

Swedish members

Hans W:son Ahlmann (1889-1974), Ph.D., glaciologist and geographer, leader of the expedition.

Oskar Hjalmar Kulling (1898-1988), Ph.D., geologist.

Backa Erik Eriksson (1905-58), B.Sc., meteorologist. Einar Christell (1896-1984), lieutenant in the Swedish Air Force, radio operator, meteorological observer.

L. Rosenbaum (1889-1960), Ph.D., land-surveyor, serving as topographer and geodesist.

J. Sigvard Malmberg (1906-85), B.A., journalist.

Norwegian members

Håkon Mosby (b. 1903), Ph.D. (1934) oceanographer.

Per Fredrik Scholander (1905-80), Ph.D. (1934) doctor to the expedition, botanist.

O. Staxrud, technical expert for the planned sledge tours on the ice-caps of Nordaustlandet.

There were also two assistants, Severin Skjelten and Henry Schmidt. Skjelten, one year previously, had been a seaman on board the *Bratvaag*, when her expedition under Gunnar Horn (1894-1946) discovered Andrée's last camp on Kvitöya. Schmidt had served as dog-driver on the British Svalbard expedition in 1924 under F.G. Binney. Mosby and Scholander were later to become famous scientists—the former in oceanography, the latter in zoophysiology.

The expedition's programme involved building, and temporarily using, a scientific station at Murchisonfjorden on the west side of Nordaustlandet. Meteorological observations would be carried out here by Eriksson and Christell, and weather observations would be forwarded by radio to the weather office at Tromsø. Christell was also to coordinate the operations of land and ship parties by radio.

Two field parties were to start from the station. One glaciological group consisting of Ahlmann, Staxrud and Schmidt was to travel over the ice-caps of Nordaustlandet. A second group consisting of Kulling, Scholander and Skjelten was to travel by motor-boat along the west coast of Nordaustlandet, making geological and botanical studies.

Meanwhile, the *Quest* would try to proceed along the south and east coasts of Nordaustlandet, in an

attempt to reach Kvitöya and Franz Josef Land. The voyage back to Murchisonfjorden was planned to pass north of Nordaustlandet—if ice conditions permitted. Oceanographical observations would be made by Mosby, assisted by Rosenbaum and Malmberg. Rosenbaum was to carry out surveying and astronomical determinations of position.

The experiences of previous expeditions indicated that the tour over the ice-caps must be regarded as a fairly hazardous enterprise. During the long passage of the ship to and from Franz Josef Land, too, much could happen that might prevent the transport home of the land parties. The hut at Murchisonfjorden had, therefore, to be fit for winter habitation, and the personnel would need sufficient provisions, fuel and other equipment. No major polar venture had left Sweden for 20 years, and the expedition of 1931 was simply not allowed to fail.

With the Quest to the Sveanor station

The winter of 1930-31 in Svalbard had been the mildest for a long time. Thus Ahlmann fixed the date of departure from Narvik at June 15, which was very early for work on Nordaustlandet. It was vital to him to come up on the ice-caps before the melting away of the snow culminated; the experiences of Binney's expedition in 1924 dismayed him. Longyearbyen was visited on June 21, and the *Quest* left for Nordaustlandet on the same day. Nine dogs had been taken aboard—offspring from Roald Amundsen's south polar dogs.

The little isle of Moffen, off the north coast of Spitsbergen, was visited on Midsummer Night. Then the course was set for Murchisonfjorden—with some suspense. Would ice bar the way? But Hinlopenstretet was ice-free. On Midsummer Day the anchor was cast off Söre Russöya, and opposite to it, on the southern side of Murchisonfjorden, a small and low point of land seemed to offer a good site for a station. There was a good foundation to build a house upon, the ship would get protection, and the fresh-water supply was well provided for.

The land differed greatly from what they had previously seen from Spitsbergen. No high mountains or massifs existed. It was an area of small hillocks, which in this part of the fjord seemed rather colourless: grey limestone and black schist. To the east, they got a glimpse of Vestfonna, the nearest of the ice-caps of Nordaustlandet.

Already in the evening of Midsummer Day, all stores and equipment for the station had been brought ashore, and the foundation for the house was laid. Four days were then taken to complete the station, which received the name *Sveanor* symbolizing the Swedish-Norwegian co-operation.

Sledging party leaving Wahlenbergfjorden on 2 July 1931. (Ahlmann, H.W:son and Malmberg, S.: Sommar vid Polhavet.)

The Swedish-Norwegian Svalbard Expedition of 1931. Crew and scientific staff on board the *Quest*. Bottom row fr. left: Nr 1. Einar Christell, Nr 3. Captain L. Schjelderup, Nr 4. Hans W:son Ahlmann. Middle row fr. left: Nr 3. Håkon Mosby, Nr 4. Oskar Kulling, Nr 6. O. Staxrud. Upper row fr. left: Nr 4. Sigvard Malmberg, Nr 6. Backa Eriks-son, Nr 8. L. Rosenbaum (top left). (Ahlmann, H.W:son and Malmberg, S.: Sommar vid Polhavet.)

The sledging party home from the ice-caps of Nordaustlandet. From left: Staxrud, Ahlmann, Schmidt (above). (Ahlmann, H.W:son and Malmberg, S.: Sommar vid Polhavet.)

Sledging on the ice-cap in July 1931. (Ahlmann, H.W:son and Malmberg, S.: Sommar vid Polhavet.)

*The sledging tour over the ice-caps
of Nordaustlandet*

After a short visit to Longyearbyen—where the steward needed an operation at the hospital—the *Quest* left for Wahlenbergfjorden, in order to land the sledging party under Ahlmann. On July 2, the ship proceeded through the rotten ice in the fjord. The glaciological group was landed a little to the east of Palanderfjorden, on the southern side of the main fjord.

The first sledging tour over the ice-caps of Nordaustlandet had been carried out by A.E. Nordenskiöld and Louis Palander. This was early in the season, on June 1-15, 1873, before any melting of the snow had set in. The march had, however, been much impeded by low visibility due to fog and drifting snow. The ice was next visited by George Binney's expedition in 1924, when three sledging parties worked here.

One group under Binney himself had travelled, from Isispynten on the east coast of Nordaustlandet, westward to the inner part of Wahlenbergfjorden. The other two groups had travelled on Vestfonna to the north of Wahlenbergfjorden. These three marches had taken place during the last days of July and the first half of August, during a miserable summer and at the peak of the snow-melt. The weather had been full of foggy days, with generally awful conditions that were worsened by the need to cross dangerous areas with crevasses.

The probability of meeting with fog on the ice-caps of Nordaustlandet is very great at the height of summer. Humid air masses from the south and south-west may then flow for long periods over the ice-caps, leading to the formation of low-lying orographic clouds or fogs, which remain stationary as long as the flow continues. The sledging party of Ahlmann got its share of fog and melting snow—but in general the conditions were good, and they obtained a rather good idea of the region they traversed.

The three men had two sledges at their disposal, respectively with five and four dogs in front. Staxrud and Schmidt, who were trained dog-drivers, took care of the dogs, while Ahlmann—when travelling—went in front on skis and kept the course; the dogs then followed “automatically” in his track. The party had one tent, provisions for 45 days, and a total load of 380 kg.

The sledging party started at 17.00h on July 2. First they proceeded to the east of Palanderfjorden, up along the slope towards the Sörfonna, 500-700 m high. Soon a routine developed in their observational work: after they pitched a camp, the odometer was read—a wheel with a counter for determining the distance covered. Together with compass readings, this allowed “dead reckoning” analogous to that of

navigation. Meteorological observations were made, and not least important were the readings of the barometer and thermometer, since these gave the height a.s.l.

Before the morning start, a pit was dug into the snow as far down as possible with ice axe and spade—generally to a depth of about 2 m, where a layer of ice was found. Between this and the surface lay relatively thin layers of ice, which were interpreted as summer surfaces: previous snow at the surface that had melted and re-frozen. The snow between these layers should thus correspond to the net accumulation between the respective years' summers. Here it indicated a fairly small annual precipitation.

This was, however, a misjudgement by Ahlmann. The summer surface of the previous year was in fact situated at the relatively thick layer of ice at 2 m, where the digging generally was discontinued. The annual precipitation and the net accumulation were therefore actually *rather high*. The thin layers of ice corresponded to periods of mild weather occurring at other seasons.

The misjudgement is understandable: experience from the ice-caps of Nordaustlandet was lacking. Ahlmann's pupil, Valter Schytt, was able to correct this error 27 years later. As mentioned above, the precipitation is strengthened orographically on the windward side of the ice-caps. The temperature and the density of the snow at different depths were also measured in the pits.

July 4 began with fine weather, but then the fog appeared—cool, raw and disagreeable. It did not last long, but it gave the sledgers a foretaste of the conditions that generally prevail on the ices. As the fog lifted, a vast amphitheatre appeared to the north, sculpted in the ice-cap. It was a continuation eastward of Binney's Etonbreen, and was now named Eton Depression or Etongropa by Ahlmann (see also p. 90). Binney and Nordenskiöld had both passed through the area in foggy weather; to them it had been a nightmare of crevasses, and they had not gained any general view of the topography as Ahlmann had.

The fog returned, and the sledgers travelled eastwards, enclosed in a whitish mist. But the visibility improved after somewhat more than a day and a night, revealing that they were crossing a flat and horizontal expanse of snow. They had reached the central parts of Austfonna and were 500-700 m a.s.l. They had not seen any of the mysterious “canals” in the ice-cap, which Nordenskiöld describes in the report on his ice-march.

On July 8, the ice had begun to slope down towards the north. They were able to discern Foynöya to the north, but clouds were invading the sky, and the air

pressure was falling in spite of their descent down the ice slope. The wind increased to a full gale, and an ice-cold rain fell. They got soaking wet, and their clothes became covered by an armour of ice. It was time to turn back, and the course was set for the west—towards Murchisonfjorden. The ice-cap, too, now lay under a plating of ice, which to a certain extent facilitated the progress, since it could bear men, dogs and sledges.

On July 11 they again descended, but westward. The surface was ice, and the slope became ever steeper, increasing their speed. Finally they reached the edge of Austfonna, towards the ice-free valley which connects Wahlenbergfjorden in the south with Rijpfjorden in the north. At the time it was believed that Nordaustlandet was covered by one single large ice-sheet¹. This valley, Rijpdalen, was thus a geographical discovery—yet it caused extreme hardship for our sledgers. After 14 hours of hard toil on July 14–15, they managed to cross the valley, a flat labyrinth of brooks and pools of water. At some places they had to go through slush that was up to one metre deep. This region was given the name *Helvetesflya* (Hell Plain).

On the other side of the valley, they reached the edge of Vestfonna. They travelled up the slope of this ice-cap, and without any noteworthy incidents they reached its western side on July 18; in the distance they could see Murchisonfjorden. They had covered 335 km, and 15 km remained until Sveanor. Leaving the sledges and most of the equipment, they set out on foot across the snow-free foreland. Next day, the 19th, they reached the station, happy to have completed their sledge tour.

The sledging party had discovered that the supposed uniform ice-sheet on Nordaustlandet consists of three separate ice-caps: Vestfonna, Austfonna and Sörfonna. Vestfonna was separated from the two other masses by a broad ice-free valley, Rijpdalen. The topography of the ice-caps had also been investigated, notably the amphitheatre of Etongropa. Nothing like the “canals” of Nordenskiöld had been seen. The structure and temperature in the upper layers of the ice-caps had been studied, but the interpretation of the series of strata was later to be modified (see p. 552).

Scientific work at Sveanor and in the west of Nordaustlandet

The different land groups were now assembled at Sveanor, where the observation activity had gone on undisturbed since the departure of the *Quest* on July 2. Three times a day, Christell sent observations to the

weather centre at Tromsø, and received forecasts in return. He maintained daily radio contact with the *Quest* and, if necessary, with Göteborg Radio.

The ablation was measured continuously on a snow-field in the neighbourhood. The station had also made observations and recordings of wind, temperature and solar radiation. It was then possible to empirically relate the amount of snow which melted and evaporated to the radiation, temperature and wind. This was a first step towards a better understanding of the ablation term in the energy and mass balance of a snow-field or a glacier, the other term being the accumulation of snow.

The Kulling group (Kulling, Scholander and Skjelten) carried out excursions during the summer with their motor-boat, all over Murchisonfjorden and the land areas in its neighbourhood. They also travelled north along the coast as far as Nordkapp. Kulling managed to analyze the complicated Hecla Hook formation. It had to do with folding and compression of considerable Ice-Age deposits from old geological periods. He even discovered fossils immediately above these glacial deposits.

Scholander carried out floristic studies and collected chiefly phanerogams and lichens, but also mosses, fungi, parasites, and algae. The visit of Kulling, who came from the Swedish province of Västergötland, is commemorated by the many geographical names from that province which are now found on the map in the region of Murchisonfjorden, though in some cases slightly modified—such as Kinnberget, Kinnvika, Hunnberget, Billingen, Mössberget.

The scientific work of the land parties ended on August 9, when the *Quest* arrived after her voyage eastward.

The cruise of the Quest to Franz Josef Land and round Nordaustlandet

The voyage of the *Quest* after her departure from Sveanor on July 2 had, in many ways, turned out to be a most remarkable venture. To begin with, the Kulling group was landed at Wahlenbergfjorden. During the short time available here, Kulling obtained an interesting collection of Triassic fossils.

The *Quest* then returned to Sveanor with the Kulling group, and started upon her long and somewhat precarious voyage. Her course was set southward down Hinlopenstretet, and turned east along the south coast of Nordaustlandet.

The scientific work was mainly devoted to physical oceanography, in which Mosby was assisted by Rosenbaum and Malmberg. The programme was extensive: water samples were taken and the water temperature was measured at 103 hydrographic sta-

¹ Note, however, the observation from the dirigible *Italia* on May 18, 1928 (p. 425).

From the long sledge tour of A.E. Nordenskiöld in June 1873, over the ice-caps of Nord-austlandet. Chasms on the ice-cap to the east of Wahlenberg-fjorden as represented by Nordenskiöld. Compare with Ahlmann's verbal description p. 485. (A.E. Nordenskiöld.)

The station Sveanor of the Swedish-Norwegian Expedition of 1931 was situated on the southern side of Murchinson-fjorden. The station served as a base for scientific investigations in Nordaustlandet. It was also a radio station (middle left). (Ahlmann, H.W:son and Malmberg, S.: Sommar vid Polhavet.)

On the long oceanographic cruise of the *Quest* Kvitöya was visited. A concrete foundation was set up on Andréneset and a commemorative tablet with the names of the aeronauts, Andrée, Strindberg and Fränkel, was fastened to it during a short ceremony on 19 July 1931 (middle right and right). (Ahlmann, H.W:son and Malmberg, S.: Sommar vid Polhavet.)

tions. The salinity and temperature of the sea water were obtained from 0, 5, 10, 25, 50, 75, 100, 150 m and, below the latter depth, at every 50 m until the bottom.

Between Victoria Island and Franz Josef Land, the water temperature was about $+1^{\circ}\text{C}$ at the surface, but decreased with depth until a minimum of -1° to -1.7°C at 30 m. This was the arctic surface layer of the Polar Sea—the high temperature $+1^{\circ}\text{C}$ at the surface was merely due to the summer heating. Below 50 m the temperature increased with depth until $+2^{\circ}$ to $+3^{\circ}\text{C}$ near the bottom. This was relatively warm and saline Atlantic water, which spread below the cold and less saline water.

At most of the hydrographic stations, the pH value and the oxygen content were determined. Current measurements were carried out at three stations (see map p. 490). The aim was to determine the exchange of water between the Polar Sea and Barents Sea in the region between Svalbard and Franz Josef Land, where the Andrée expedition in 1897 and the shipwrecked *Italia* expedition in 1928 had witnessed a south-going current (p. 253). The oceanographic programme also included tidal observations at Sveanor.

The coast on the eastern and south-eastern side of Nordaustlandet consists of a vertical ice-cliff, 25–50 m high: a so-called ice-barrier. There exist, however, places where it is possible to ascend upon Austisen and Sörisen from the sea. After the *Quest* had rounded Cape Mohn, the ice headland in the south-east, a landing was made for the purpose of determining its latitude and longitude astronomically.

The east coast was then followed northward to Storöya at the north-east corner of Nordaustlandet. They met with ice, but it did not impede their progress at first. Near Storöya, troubles and hardships began on July 9, with a strong northerly wind, ice-fog and a strong current. These made the ice masses collect in the sound between Storöya and the ice-cliff of Nordaustlandet. The ship, however, found shelter on the lee side of the land ice.

On July 14 the weather improved, and they were able to steer east towards Kvitöya. Next day it rose like a white cupola above the sea's horizon. Kvitöya had not been visited very often since its discovery by the Dutch navigator Cornelis Giles in 1707. The island is often surrounded by pack-ice due to the current, which brings drift-ice and pack-ice from the Polar Sea through the waters between Nordaustlandet and Franz Josef Land. But since the previous year, 1930, the island had become well-known after the discovery of the relics of the Andrée expedition (p. 254). As mentioned above, this discovery was made by a Norwegian expedition with the sealer *Bratvaag* under Dr.

Gunnar Horn, and one of the discoverers, Severin Skjelten, was among the crew of the *Quest*.

The island is almost completely covered by an ice-cap, and bare ground is only found in the south-west and the north-west. The last camp of the Andrée expedition was found on the low and barren strip of land in the south-west, Andréeset. A commemorative tablet was now to be set up at the place of the camp, and Rosenbaum intended to fix the position of the island after its many "wanderings" on the map since its discovery. He also wanted to map the barren Andréeset.

The expedition was favoured by fine weather and absence of ice during practically all of the stay at the island, July 15–19. The concrete foundation with its tablet giving the names of the aeronauts and the year—*S.A. Andrée, Nils Strindberg, Knut Frænkel 1897*—was set up, and was inaugurated with a short ceremony on the 19th.

Then the *Quest* steered east, towards Franz Josef Land via Victoriaöya in an ice-free sea, where the ice generally blocks the passage. But a heavy swell and fog now delayed her progress. On July 24, near Franz Josef Land, the north-easterly wind increased. Next night, a full gale blew in combination with fog and drifting icebergs. It was a hard situation and, before returning to Murchisonfjorden, they deemed it necessary to give the ship an overhaul, above all to clean her boilers.

In Cambridge Fjord, in the shelter of Alexandra Island and Prince George Island, the expedition spent five memorable days in excellent weather. Some of those on board could go on excursions, Mosby and Rosenbaum could devote themselves to their specific tasks, and some of the crew were busy cleaning the boilers. Adding interest to these days, the large German dirigible *Graf Zeppelin* passed over the ship on July 27, and greetings were exchanged (p. 428).

The voyage back to Sveanor was planned to go north of Nordaustlandet, in order to let Mosby obtain data from this oceanographically almost unknown region. But there was a rather high probability that the passage would be barred by the polar pack, so it was by no means free of risks. They did meet with heavy polar ice, and for several days they were kept in fear of not coming through. On July 31 they reached their northernmost position, $81^{\circ}22'\text{N}$, to the north-west of Cape Mary Harmsworth. They visited Broch- and Foynöyane and also Karl XII Öyane.

The two former islands were especially well-known from the newspapers during the days of the *Italia* expedition in 1928 (see p. 440). At Brochöya, a Swedish and a Finnish airplane had managed to rescue the Italian Alpine rifleman captain Sora and his Dutch

companion, Van Dongen, just in time before the drifting ice surrounded the island. The two men had in turn been out to rescue the *Italia* men on the ice, but with sledges and dogs. When leaving, they had been forced to leave dogs and equipment on the island. Now at last the equipment could be brought back to the owners.

After passing Kapp Platen, the *Quest* proceeded in a virtually ice-free sea. On August 9 she anchored off Sveanor. She had been the only ship to succeed in circumnavigating Nordaustlandet in 1931. There followed three days of hard work; equipment, including the house, was taken aboard.

On August 12 the *Quest* left Murchisonfjorden and, after some supplementary observations on the west side of Hinlopenstretet, the course was set for Longyearbyen, where the hut was landed. On the 24th, the ship steered homewards. Tromsø was reached on August 28.

The Spitsbergen expedition of 1931 had been carried out according to plans. It was in all respects a happy and fruitful enterprise.

THE NORWEGIAN-SWEDISH EXPEDITION OF 1934 TO ISACHSENFONNA, SPITSBERGEN

The study of the mass balance—or mass budget—of a glacier is straightforward. The glacier's accumulation of snow and rime, collected on its surface layer by layer during the cold part of the year, is found by measuring the height of the snow surface relative to stakes fastened into the snow and/or ice. Knowing the latter's density, one can calculate the accumulation in terms of water. This amount depends upon the precipitation conditions and the distribution of the snow over the glacier due to wind and topography.

The glacier's ablation, due to melting of snow and ice as well as to evaporation, is also found from the stakes. But a complicating factor is that the water from the melted snow often percolates into the snow, where it later freezes and appears as bands of ice on the walls of a pit dug into the glacier. This refrozen water does not imply a loss or expense of the glacier, and corrections must be made for it.

The ablation is caused by a net income of energy to the glacier: in part radiation energy, in part heat transferred from or to the air by turbulence. The radiation energy is mainly solar radiation, both directly from the sun and by diffuse reflection from the sky and the clouds. Some, however, is infrared heat radiation emitted from the sky and clouds, and from the glacier surface and from surrounding objects and from the glacier surface. Of the incoming solar radiation, only 10–30% is absorbed by a glacier or ice-sheet, the rest being reflected diffusely. These amounts

can be measured with fairly robust instruments built for field use; the infrared "terrestrial" radiation from sky, clouds, and the glacier surface is, though, often calculated from empirical formulas.

The heat transfer by turbulence is a more intricate energy term to measure. This transfer is caused by eddy motions in the air. It is not due to the irregular motions of individual molecules like the heat conduction in solid bodies, but in both cases the transfer proceeds from warm to cold strata.

The turbulent heat transfer in the low layers of the atmosphere, say between the surface and a height of 5–10 m, is determined by measuring wind speed and air temperature at suitable heights, using an observation mast. By simultaneously measuring the air humidity, one can also determine the transfer of water vapour to and from the glacier surface: condensation and evaporation are further terms in the energy balance equation of the glacier.

The Spitsbergen expedition of 1934 was intended primarily to gather these data and to develop measuring techniques and theoretical methods for studying the results. Thus Ahlmann hoped to get an idea of the relative and absolute values of the energy terms which cause ablation—the radiation, turbulent heat transfer, condensation and evaporation. He wanted to know these characteristic properties for glaciers in different climatic regions.

The expedition's work required interdisciplinary co-ordination of research on glaciology, "meteorological" radiation and atmospheric turbulence. It involved close Norwegian-Swedish collaboration between scientists who worked independently in their respective fields, but with the shared aim of elucidating the problem of the mass and energy balance of a glacier. Ahlmann obtained help from his friend, the outstanding Norwegian geophysicist Harald Ulrik Sverdrup, and the two became co-leaders of the expedition. Each of them brought an assistant as well.

Ahlmann was responsible for the glaciological studies—principally observations of the mass balance. Sverdrup, who had already studied the energy exchange of the arctic pack-ice during the *Maud* expedition of 1918–25, took care of the studies of the turbulent heat transfer in the air, and of the heat conduction and temperature within the glacier ice and snow. Hilding Olsson, from the Swedish Meteorological and Hydrological Institute in Stockholm, made the radiation measurements. Sverdrup was aided in his observational work by J. Knudsen, a meteorologist from Bergen.

THE EXPEDITION THUS COMPRISED FOUR SCIENTISTS:
Swedish members

Hans W:son Ahlmann (1889–1974), Ph.D., leader of

Håkon Mosby, oceanographer and L. Schjelderup captain of the *Quest* visited Brochöya north of Nordaustlandet. (Ahlmann, H.W:son and Malmberg, S.: Sommar vid Polhavet.)

Hans W:son Ahlmann in 1949. A diplomatic career awaits him. The Norwegian-British-Swedish Antarctic Expedition is being fitted out. (Geografiska Annaler 1949.)

Hans W:son Ahlmann in 1931. His polar research career has just started. Photo: A. Häggblom Collection.

The steamer *Quest* of Bodö (above). (Ahlmann, H.W:son and Malmberg, S.: Sommar vid Polhavet.)

The voyage of the *Quest* in 1931 (left). (Ahlmann, H.W:son and Malmberg, S.: Sommar vid Polhavet.)

Vatnajökull in southeastern Iceland was found to be an ice-cap with a very high accumulation of snow and high rate of melting. This land-ice is situated right on the routes of the North-Atlantic cyclones. (Ymer 1937.)

the glaciological investigations.

Hilding Olsson (1904-73), B.Sc., meteorologist, responsible for the radiation measurements; assistant in the glaciological work.

Norwegian members

Harald Ulrik Sverdrup (1888-1957), Ph.D., leader of the studies of atmospheric turbulence and heat transfer.

J. Knudsen, meteorologist, assistant in the studies of atmospheric turbulence.

Hilding Olsson had been the leader in 1932-33 of the Swedish Polar Year station on Nordenskiöldfjellet (Chapt. 42).

The expedition members left Bergen with their equipment on June 10, and arrived in Longyearbyen the 16th. Then they were taken by the motor-cutter of the Norwegian mining-inspector to Fjortende Julibreen on the east side of Krossfjorden, north of Ny-Ålesund. For the transports from the fjord upward along the glacier, they used the 17 dogs of the Norwegian "sysselman" or governor of Svalbard, Helge Ingstad (b. 1899), the well-known author and traveler. He and two dog-drivers came with the expedition, to help moving the equipment along Fjortende Julibreen up to the flat ice plain Isachsenfonna.

Here the "headquarters" of the expedition was set up at a height of 850 m a.s.l. This place had been chosen because of the ideal conditions it offered for the planned investigations. Fjortende Julibreen had been recommended, as a suitable landing-place for the expedition, by Dr. Adolf Hoel, the head of Norges Svalbard- og Ishavs-Undersøkelser (or Norsk Polar-institutt, as it was renamed several years later). Fjortende Julibreen offered a comfortable "road" up to Isachsenfonna.

The expedition reached the glacier on June 19. The weather was excellent, and already on June 22 the prospective "headquarters" in the centre of Isachsenfonna was reached. Ahlmann, Olsson and one dog-driver arrived on the following day, having set up bamboo stakes-2.5 m long-on the glacier for measuring the mass balance. Helge Ingstad, the two dog-drivers and the dogs departed on that same day, but two dogs were left to be used for excursions on the ice.

The camp-located at 79°09'N, 12°56'E-was completed on the 24th, and next day the scientific observations were started. These have been described above, and some further details may be added. For one thing, the ablation was continuously measured not only at the "headquarters", but also on Fjortende Julibreen during three sledge excursions, where the two dogs were of great help.

Olsson measured the incoming solar radiation, the

duration of sunshine, and the albedo of the snow surface. Albedo (reflectivity) is here the relative amount of incoming solar radiation which is reflected from the snow surface. Sverdrup and his assistant were fully occupied with measuring wind speed and air temperature at specific heights. They used an observation mast 7 m high, and took hourly readings day and night. Besides, they measured the temperature in the snow and in the glacier ice, and carried out ordinary weather observations.

The observation activity proceeded without a break for 53 days, until August 16. On the 15th, the motor-cutter came to fetch the men, and they left Krossfjorden on the 20th. In general, they had been favoured by the weather and had worked according to plan. Sverdrup's method for determining the heat transfer from the air to a glacier was later used by several scientists-such as C.C. Wallén (b. 1917), on the Kårsa glacier near Abisko in Swedish Lapland, during the summers in their beginning of the 1940s.

THE SWEDISH-ICELANDIC EXPEDITION IN 1936-1938 TO VATNAJÖKULL, ICELAND Plans, members and equipment

Ahlmann had long thought of studying *Vatnajökull* in south-eastern Iceland. During 1924 and 1925, when he and the Icelandic meteorologist Jón Eythórsson worked together in Jotunheimen in Norway, they discussed an expedition to this huge ice-cap. With an area of 8700 km², *Vatnajökull* is the largest land ice in Europe.

Until 1934, Ahlmann had studied land ice in two arctic regions, situated at a high latitude, but still with a maritime climate. His intention had been to study glaciers in three regions outside Scandinavia. He now wanted a land-ice mass which was extreme in several respects: *Vatnajökull* in Iceland. It lay outside the Arctic, at lat. 64-65°N, and close to the predominant tracks of the North Atlantic cyclones. Its mere existence indicated a high accumulation, but the accumulation of snow and the ablation were still to surprise Ahlmann. The interesting results were gained at the cost of hardship caused by the extreme conditions.

The *Vatnajökull* expedition of 1936-38 was a joint Swedish-Icelandic enterprise, with financial help from the Swedish Society of Anthropology and Geography. The governments of both countries were extremely obliging to the expedition. Its leaders were Ahlmann and Jón Eythórsson.

THE MEMBERS IN 1936 WERE AS FOLLOWS:

Swedish members

Hans W:son Ahlmann (1889-1974), Ph.D., glaciologist, leader of the expedition.

Carl Otto Göran M:son Mannerfelt (b. 1913), un-

dergraduate, student of geography, assistant glaciologist.

Mac Lilliehöök, dog-driver and ski expert.

Icelandic members

Jón Eythórsson, meteorologist, co-leader.

Sigurður Thorarinsson (1912–83), undergraduate, student of geography.

Jón from Lang, assistant for practical work.

After the expedition, Mannerfelt worked in glaciology and glacial geology, obtaining his Ph.D. with a thesis on the melting stage of the inland ice in the mountains of Sweden and Norway. Sigurður Thorarinsson became a professor of geology and geography at the University of Iceland in Reykjavik, and an expert on volcanoes.

The equipment included four polar dogs, one Nansen sledge, and some “pulkas” (Lapp sledges) which were also used for sleeping. The tents were small, constructed to stand severe gales and heavy snowfall. A new type of provisions, *vacuum-dried food*, was brought and was found excellent.

A difficult approach

The Swedish members of the expedition left Stockholm on April 14. At Bergen they embarked S/S *Lyra*, together with the four polar dogs. They arrived in Reykjavik on April 20. The Icelandic authorities had placed the *Aegir* of the Coast Guard at their disposal, and she took them eastward to Hornafjörður in the south-east of Iceland, where they landed on the 25th. Already the next day they reached Hoffellsjökull, one of the eastern outlet glaciers from Vatnajökull. From here they had planned to start their conquest of Vatnajökull. But the sight of the “road” ahead was by no means comforting.

Their start was early in the season, as they wanted to find a glacier covered in the winter’s snow in order to determine the total accumulation before the snow began to melt. But it would have been best to come even earlier. Now there was a chaos of wild chasms, deep crevasses, and high ice-ridges, the latter being so narrow that it was almost impossible to balance along them. And the farther they went, the worse things became. The 1930s were a bad period for glaciers in Iceland, as in the world at large. However, the expedition’s ablation measurements had already been started, in the lower reaches of Hoffellsjökull, by Guðmundur of Hoffell, who lived in the neighbourhood.

There were three ice-falls to pass. Two of these were conquered with the help of 8 men from the district. But at the third, they had to give up the attempt and pitch a camp to study the situation. The

weather was generally bad, but now and then the sky cleared up temporarily. Swans and wild geese were migrating northward, and occasionally a lone scout came circling over them to investigate their intentions.

They found a way up on April 29. On the western side of the glacier, the crevasses were still bridged over by snow. Here it was possible to make a passage, and in the evening they could camp satisfied that all obstacles were overcome. The helpers now departed. Most of the equipment had been laid up behind and was to be taken up on Vatnajökull via Heinabergsjökull, south of their present position, for storage in a depot at Esjufjöll.

An experience of the snow on Vatnajökull

Everything looked hopeful, and they were sure of reaching the high plateaus of Vatnajökull as soon as next day. They did reach Camp V at 1200 m a.s.l., but were then stopped by bad weather. The camp was in a pass, which they called Djävlapasset (the Damned Pass). For more than two weeks they were forced to become familiar with the weather conditions and the snow accumulation on Vatnajökull. Their troubles, though, provided first-hand knowledge that was to stand them in good stead.

On May 3, Ahlmann wrote in his diary:

“The large sledge with our provisions is now buried under one and a half metres of new-fallen snow and, besides, under a wall of snow which has been thrown up from the tent of the ‘boys’ [Mannerfelt and Thorarinsson]. The wind is too hard for doing anything outside. The gale is heard like a waterfall or like the roar from a heavy express train at full speed. The barometer is falling. Only the ridges of our tent and the top ends of our skis reach out of the snow, covered by rime. A few reindeer skins are somewhat dry, but Thorarinsson’s sleeping bag is soaking wet and looks like a drowned cat.”

Next day it was possible to dig a pit in the snow, four metres deep, for studying the snow. Ahlmann comments:

“The results of our measurements were remarkable and we found much to ponder over. No doubt, the precipitation in this part of Vatnajökull is colossal and considerably larger than we ever could have dreamt of.

We were on a glacier quite different from any I had come to know previously. We made a rough calculation and got the result that the annual

precipitation in Djävlapasset must be about 4000 mm (of water)."

Their own food would last; it was more economical in use than expected. But the dog food would not. In any case, the tents and everything in them—men, clothes and sleeping-bags—had to be dried. Then there was the problem of Thorarinsson's feet, which were swollen; he had to be taken down to the settled country.

In darkness and rain Thorarinsson, accompanied by Mannerfelt and Eythórsson, went down to "civilization", while Ahlmann and Lilliehöök pitched camp at VI, soaking wet. The following two days, however, were fine and they managed to dry their belongings. After Eythórsson and Mannerfelt had arrived on the 11th, they continued upward again. Yet when they reached Djävlapasset, they ran into the same awful weather as before.

Once they got to Camp VII, just a few km further inland, they became storm-bound until May 17. On the 14th, Ahlmann wrote:

"The severe weather continued the whole night. Eythórsson was outside shoveling snow between 03.00h and 05.00h. It was Mannerfelt's and my turn at 08.00h. Not until five hours later—with breakfast included—was the camp fairly uncovered, but now the tents stood on the bottom of a pit, 2 m deep."

So it went on until 13h.00, when "it started to rain; the wind was strong all the time." Such had been the conditions for three days, and they had swung from better to worse before that. Ahlmann commented:

"If the weather goes on like this for another week, our situation will become really critical."

On May 15, it proved possible to move the tents some 50 m, to a place where the surface was flat. Digging up the equipment took much effort.

Brighter days and scattered members

On May 17 the sun appeared, and the men's captivity was over. But Lilliehöök's feet were very bad: he had got what the Icelanders call "cold-water freezing", and needed to return immediately to civilization. They could not use Hoffellsjökull any longer. The only way to get down was by Heinabergsjökull, and three days were required even to reach it. Luckily, the weather was now fine and the snow was good for skiing.

They passed through the outskirts of the high central plateau of Vatnajökull. They had expected to

find a single high plateau of ice, but instead there were a number of fairly flat domes, separated by depressions leading toward outlet glaciers in the north and south. It looked like a tremendous, smooth swell in an ocean of ice and snow. To the south they saw mighty lava massifs; yet in all other directions, snowy plains and domes extended without any limit. To the north were the volcanos Snæfell and Kverkfjöll, covered in snow. The men had an exhilarating feeling that they had at last reached the giant ice-sheet of their dreams, and that all their trials were over.

On May 19, they descended the steep slopes toward Heinabergsjökull. They discovered a black dot in the distance, which gradually turned into Thorarinsson, approaching them. Soon they reached their main depot, and were greeted by Jón from Lang.

This called for an explanation. During the period of rotten weather, Jón from Lang had been forced to remain in the settled country; but when the weather improved on May 8, he started out with 25 horses, carrying the provisions and other equipment of the expedition. The horses could not be used on Heinabergsjökull, so he packed a sledge with the most necessary provisions and intended to drag it the long way to Esjufjöll, which they had agreed upon as a site for their main depot. Then Thorarinsson appeared—with his feet almost cured—and reported that Ahlmann's party was coming to Heinabergsjökull first. Esjufjöll was therefore abandoned as a depot site, because the region near it was somewhat dangerous.

The expedition members had thus suddenly come together. And fortunately for the scientific work. Thorarinsson and Jón from Lang had started the measurements of the ablation already on May 9. They had now dug a pit down to a depth of 3.5 m. A few minutes later, Thorarinsson could inform Ahlmann from the bottom of the pit that he had reached the surface of solid ice. This zero-level of the snow accumulation was located more than 4 m below the present snow surface. As their camp lay below the accumulation limit of the glacier, the whole layer of 4 m of snow was doomed to melt away during the summer. Hence their observations from Djävlapasset were confirmed: they were in for quite a lot of snow digging in the near future.

On May 21, Eythórsson arrived after having accompanied Mac Lilliehöök to the safety of the settled country. And next day, Camp XII at 1100 m above sea-level on Heinabergsjökull was decided upon as their headquarters.

Successful investigations

The weather was fine—but for how long? It was essential to make clearer progress with the work. Jón from

Lang and Thorarinsson would stay at Camp XII and carry out an extensive observational programme: reading all the stakes between 800 and 1350 m a.s.l., besides making all the weather observations. The other men started their sledge tour to the central parts of Vatnajökull. They had got a rest, and they knew how much digging awaited them. May 24 and the following three days were to become the very best and richest in scientific results during the whole expedition.

Mannerfelt drove the large Nansen sledge, and behind came Ahlmann and Eythórsson, each with a pulka sledge. They had provisions for two weeks. They pitched Camp XIV at 1450 m a.s.l., where the character of the terrain and the height of the ice demanded a large pit in the snow. They were now in the central part of the high region of Breidabunga.

Next day, the 25th, was devoted to digging. From previous experience, they knew that the pit should have an opening of about 2 x 4.5 m. A staircase had to be dug downward, with small platforms at depths of 1.3, 2.0, 2.5 and 3.5 m. Naturally, the difficulty of digging increased with the depth. They worked with excitement to see the previous summer's surface, which would be marked by a layer of ice.

They were also anxious to find another important reference level: a surface marked with a layer of ash, which had spread across Vatnajökull during the eruption of the volcano Grímsvötn during Easter of 1934, about two years earlier. This volcano is situated in the western part of Vatnajökull, though near its centre and covered by it. Grímsvötn is one of the most active volcanoes on Earth. The men intended to dig until they reached the summer surface of 1935, and then bore downward to the ash layer of Easter 1934 (Easter Day = April 1).

The summer surface was found at 4.90 m. And at 3.00 m below the bottom of the pit, making 7.90 m below its opening, the drill entered a thin layer of black ash. To be on the safe side, they bored another half metre. Since the previous autumn, nearly 5 m of snow had thus accumulated, and the layer of ash provided a check on this value.

Next day, May 26, they reached Camp XV at 1320 m a.s.l., situated farther to the north. Before evening, they dug a pit and had time to study and note the stratification of the snow. On May 27, Ahlmann and Eythórsson went to station XVB at 1250 m a.s.l., some distance farther north. The surface sloped downward here; they were in the upper reaches of Brúarjökull in the north-east of Vatnajökull. A pit confirmed their assumption that they had descended into the melting zone of Vatnajökull: the glacier ice was reached already at 3 m.

On the 29th, they encountered strong northerly winds with drifting snow at Camp XVI, upon the ice-dome of Breidabunga. But on May 30, they were back at the headquarters of Camp XII. On June 3 the next sledging tour started, this time into the central region of Vatnajökull.

Eythórsson now remained at Camp XII, while Ahlmann, Mannerfelt, Thorarinsson and Jón from Lang made up the sledging party. As on the previous tour, they brought provisions for two weeks. On June 7, they were at the centre of Vatnajökull—as far from Kverkfjöll in the north as from Öræfajökull in the south.

From the ice-cap to the outlet glaciers

The work was now finished, with the last pit on the programme dug and measured. There remained a visit to Grímsvötn in the west, just a few hours away. But fog swirled around the party, and the air became "dense" to the west. Over the radio they heard that a Danish expedition under Niels Nielsen had left the area. Probably he had carried out investigations similar to those planned by Ahlmann. The barometer was falling, so they turned back to the depot, and reached it in the evening of May 9 after a hard march. The same evening, Mac Lilliehöök arrived in company with Skarphjeddin, their friend from the district.

The next three days were windy, and snow fell—recalling the conditions at Djävlapasset. But now they had plenty of food for both men and dogs, their ice-cap programme was successfully completed, and the results were interesting and valuable. Early in the morning of June 13, it cleared up and the weather became fine. Within 62 hours all their equipment was brought down along Heinabergsjökull to bare ground at 700 m a.s.l. Then the horses of Skarphjeddin carried the loads down to the coast.

On June 20, Thorarinsson and Mannerfelt went to Hoffellsjökull for a more detailed investigation than had been made upon their arrival. They stayed until August 15. Their research included careful measurements of the melting of the snow, the discharge of the glacial river, and the previous extension of the glacier. They also measured the glacier's movement, estimating it to be as much as about 700 m per year, which is extremely large and indicates a very great mass turnover.

Ahlmann and Eythórsson left the rest of the expedition on June 21. They travelled mainly by horse through the desert regions to the south of Vatnajökull. They met their wives at Skaftafell, and went on a tour westwards.

The glaciological investigations of 1936 were continued in the next two years by Sigurdur Thorarinsson.

His measurements concentrated on the Hoffellsjökull and Heinabergsjökull. Thorarinsson stayed in the district from June 20 to July 31, 1937, and from June 20 to July 17, 1938. During the former visit, the weather was just as bad as it had been in 1936.

THE SWEDISH-NORWEGIAN EXPEDITION OF 1939-1940 TO NORTH-EAST GREENLAND

Ahlmann's glaciological investigations around the Norwegian Sea until 1936 had been affected by the ocean. The time had come for a study of a glacier in a region less influenced by the sea—a region with a continental polar climate characterized by fairly low precipitation. Ahlmann chose a glacier called Vintergata, in the centre of Clavering Island in north-eastern Greenland at about 74°N. The climate in this region is very dry, with an annual precipitation of only a few hundred mm, and the summer weather is often fine with clear skies.

At the same time, another scientist was contemplating studies in this part of Greenland: the Norwegian medical student Kaare Rodahl (b. 1917). He planned investigations of arctic nutrition, especially the occurrence of vitamins; the rich flora and fauna of the region were a decisive factor in his choice. Ahlmann's stay would be limited to the summer; but Rodahl intended to winter, together with two Norwegian hunters, in a cottage at Revet, just west of Clavering Island.

Having heard of Ahlmann's plans, Rodahl offered to help him with the observations after he left Greenland for home. In any case, Rodahl intended to carry out meteorological observations in order to elucidate the causes of the rich flora and fauna. His observations would now also be of great value for the study of how the meteorological conditions affect the melting of snow and ice upon the glacier.

As a result, the expedition turned into a Swedish-Norwegian collaboration:

SWEDISH MEMBERS (DURING THE SUMMER OF 1939)

Hans W:son Ahlmann (1889-1974), Ph.D., glaciologist, leader.

Backa Erik Eriksson (1905-58), M.Sc., meteorologist and glaciologist.

NORWEGIAN MEMBERS (WINTERING)

Kaare Rodahl (b. 1917), medical student, making glaciological and meteorological observations, pursuing independent studies in arctic nutrition.

Henry Rudi, hunter, practical work.

Schölberg Nilsen, hunter, practical work.

The expedition left Ålesund, Norway, on July 15, 1939, aboard the Norwegian sealer *Polarbjörn*, under Captain Kristoffer Marö. Her course was initially

northward. Ny-Ålesund in Spitsbergen was reached on July 22, and then she turned west. It was intended to approach the Greenland coast at about 80°N, but not until 74°-75°N could the ship enter the ice and—on the 27th—steer for Cape Herschel, east of Clavering Island.

The equipment was to be landed at the bay of Leirevåg, on the northern side of the island. From there a valley leads up to the glacier, Vintergatabreen, which had been chosen for the investigations. The transports to the glacier would be aided by the two hunters and the dogs. However, to the north of the island, Young Sound was still ice-covered, so the ship had to proceed south of the island and unload the equipment at Revet to the west of Clavering Island. This was to be Rodahl's headquarters. Landing here was not easy.

The changed conditions led to some modifications of the programme. The base at Leirevågen had to be established with transports by motorboat from Revet. Then the equipment was carried up along the rather small Fröya glacier, chosen now for its location in the neighbourhood. The Vintergata glacier was thus given up. Time was short, as the *Polarbjörn* would return on August 15. They needed to work in the most effective way until then.

Backa Eriksson lived in a tent on the glacier at 450 m a.s.l., where he carried out meteorological observations and measurements from July 31. Ahlmann and Rodahl lived at Leirevågen, near the shore, and shared the work between them—Ahlmann making the measurements in the lower parts of the glacier, Rodahl in its upper reaches. Meteorological observations were also conducted at Leirevågen.

Ablation and accumulation were determined by reading the vertical position of the snow or ice surface against bamboo stakes. These had been set up in different parts of the glacier—which was 8 km long—from 300 m to 850 m a.s.l. The snow which had accumulated since the previous summer, or rather the part of it that remained after melting, was studied in pits.

The meteorological work aimed at differentiating between the ablation caused by radiation and that due to convection—turbulent heat transfer from the air. The low ablation values observed were ascribed to the strong *outgoing* radiation, which is a characteristic of high albedo and continental climate. The glacier movement was also studied, but scarcely any movement was noticed.

The *Polarbjörn* had got into trouble in the ice, and could not come to fetch them at the pre-arranged date, August 15. As the provisions were running low, the expedition moved to Revet on August 18 and

The glaciological expeditions and studies of Ahlmann from 1923–1939 surround the arm of the North Atlantic, reaching high up into the Arctic. (Ymer 1939.)

The small Fröya glacier on the north side of Clavering Island in North-East Greenland was characterized by low accumulation of snow (upper left corner) The Fröya Glacier was studied by Ahlmann in 1939 during his last Arctic expedition. (Ymer 1939.)

The Kebnekaise Massif with Storglaciären. Near the lower edge, Tarfala Valley. At a short distance to the right the glaciological station, Tarfala Research Station, is situated. Compare with photo p. 498. Photo: Per Holmlund.

awaited the ship there. When she arrived the next day, Ahlmann and Backa Eriksson left for home, while the Norwegian group of the expedition settled down for the winter at their main station, Revet. The ship reached Ålesund in the night towards August 31. The day after that, World War II broke out.

Concerning the expedition's results, Valter Schytt wrote in *Ymer* for 1980:

“...The three weeks which had been at Ahlmann's disposal were enough for him to state that the regression of the glaciers in dry East Greenland was as evident as in Iceland with its high precipitation. Everywhere the glaciers receded.”

Thereafter, Rodahl visited the Fröya glacier to read the stakes, and the data were sent by radio to Ahlmann in Stockholm. In this way it was possible to obtain both the accumulation during the cold season and the ablation during the summer season of 1940.

But the Germans attacked Norway on April 9, 1940, and Rodahl's last visit to the glacier took place on August 17. He then went by ship to Reykjavik, and from there to Scotland. He was later to be known as one of three men who were landed by airplane in the Polar Sea on March 19, 1952, upon the ice island T3 which, subsequently, was manned for geophysical observations by the Americans.

Interlude

The glaciological investigations on the Fröya glacier were the last in Ahlmann's series of studies on glaciers around the Norwegian Sea: in Jotunheimen, Norway; on the Kårsa glacier, Swedish Lapland; on Nord-austlandet and Spitsbergen in Svalbard; on Clavering Island in North-East Greenland; and on Vatnajökull in Iceland.

In 1939, World War II had guided Ahlmann's research work along partly new courses. He now found time to sum up his results, and he was able to devote more energy to his students—not least at social gatherings, which were mutually inspiring, after lectures and seminars. He also gave much attention to work for occupied Norway. However, he was looking forward to two enterprises:

1. To establish a glaciological station in the Swedish mountains, where one—or several—glaciers could be studied continuously and the results be related to the climate and its variation.
2. To bring about an expedition to the Antarctic after the war, with the aim of getting insight into the life, character and structure of inland ice and shelf ice in this climatically so extreme region—and their meteorological and climatological implications.

The glaciological station Tarfala in Swedish Lapland

The research station which Ahlmann had dreamt of during World War II materialized from 1946 onward. During reconnaissances in the field by Valter Schytt, the choice was made of Storglaciären, near the Tarfala Valley in the Kebnekaise Massif. An advantage was the easy access to this region.

Tarfala is located at 67°55'N, and the station site is 1130 m a.s.l.. The annual mean temperature is -3.9°C, and the mean temperatures of the warmest and coldest months of the year are +7° (July) and -13°C (January) respectively.

The annual precipitation is 950 mm, comprising 600 mm winter snow and 350 mm summer rain. In the Köppen climate classification system, Tarfala thus has a polar climate of tundra type.

The Storglaciären has shrunk and retreated ever since the beginning of the 1920s. Photographs taken in 1910 by the geographer Fredrik Enquist (see p. 480) show that the glacier had a much greater extent than now.

To begin with, the observation programme at Tarfala included only studies of the mass balance of the glacier. This meant that a snow inventory was made in May in different parts of the glacier; the winter accumulation was then determined. During the summer, the course of the melting away of snow and ice was followed. The “budget year” of the mass balance starts at the time when accumulation first exceeds ablation at the firn limit: it thus extends from the first snow-fall of the winter, through the ablation season of the following summer.

The measurements at Tarfala began with the “budget year” 1945–46 and are still going on, though new fields of research are being added to the routine observational work. The Tarfala station was very primitive during the first years of its existence, but gradually buildings were added for different purposes—accommodation, meals, laboratories, lecture rooms, and so on. International courses have been held here, the first in 1967. Several well-known polar scientists have acquired information and practical experience from the local snow and ice. The station was initially directed by Valter Schytt (1919–85) who, after his death, has been succeeded by the professor of physical geography at Stockholm University, Wibjörn Karlén.

Ahlmann's ambitions for a glaciological research station were amply realized in Tarfala valley in Swedish Lapland. His dreams of an expedition to the Antarctic were also to be fulfilled.

The Ice-fall glacier with terminal moraines, the Tarfala Valley and the glaciological station, Tarfala Research Station, at 1130 m a.s.l.
Photo: Per Holmlund.

The mass balance of Storglaciären, 1945–1990. The winter balance=amount of accumulated snow in the cold season. Summer balance=amount of melted and evaporated snow and ice during the warm season. Net balance = “winter balance” minus “summer balance”. (Department of Physical Geography, Stockholm University.)

44. THE NORWEGIAN-BRITISH-SWEDISH ANTARCTIC EXPEDITION 1949–1952

Background and organization

In 1943, forty years after the relief of the Nordenskjöld expedition of 1901–03, J.G. Andersson (p. 287) had started to write a book on the *Antarctic*, the old expedition ship. He had discussions with Hans Ahlmann, and urged the latter to revive the plans of 1911–14 for an Anglo-Swedish expedition to the Antarctic Peninsula (see p. 376). Andersson was glad to hear that Ahlmann had been thinking along the same lines for some time. However, the plans were destined to be changed somewhat, because of discoveries made in the Antarctic a few years earlier.

In the southern summer of 1938/39, the German catapult ship *Schwabenland*, commanded by Captain Alfred Ritscher, had been dispatched to the Antarctic. The ship carried two ten-ton Dornier-Wal seaplanes for air reconnaissance and for a photogrammetric survey of the land region around the Greenwich meridian. The expedition was favoured with good flying weather, and the flights were carried out practically according to plan. During seven long flights, a mountain region in the interior of Antarctica was discovered and photographed. Peaks, massifs and ranges protruded from the inland ice.

This region, which was named Neu-Schwabenland, was provisionally mapped by using a selection of the 11 600 photographs that had been taken—though without ground control, as no landings had been attempted. The photographs were of great interest in many respects, not least from the glaciological point of view. When the scientific results of the expedition became available in Sweden in 1943, they led Ahlmann to revise his plans: the newly found mountain region seemed to be a better area for research than the Antarctic Peninsula.

The coastal zone, beyond which the German discoveries had been made, had been visited by the Norwegians already during the 1930s—in connection with flights by Hjalmar Riiser-Larsen in 1929/30 and Viggo Widerøe in 1936/37. On January 4, 1939, the Norwegian Government had declared the antarctic land between the meridians of 45°E and 20°W to be Norwegian territory; it was given the name Dronning Maud Land.¹

Ahlmann found in 1945–46 that there was considerable interest in Great Britain in a joint expedition to Dronning Maud Land—as, of course, there was in Norway, partly for political reasons. National committees were formed in the three countries, and discussions took place in the following years to establish a workable plan and a scientific programme for the expedition.

The chairmen of the three committees were: in Norway, H.U. Sverdrup, divice chancellor of Norsk Polarinstitutt; in Sweden, Hans W:son Ahlmann; and in Great Britain, J.M. Wordie with L. Kirwan as executive divice chancellor. Sverdrup, whom we have already described, was to be the leader of the expedition. J.M. Wordie was at the time professor of geology at Cambridge. He had taken part in Shackleton's adventurous antarctic expedition with the *Endurance* in 1914–16. From 1919–29 he participated in six arctic expeditions—to Svalbard, Jan Mayen and North-East Greenland.

Norway was naturally most interested in an expedition to her own territory, and therefore accepted most of the costs, amounting to 75%, while Sweden and Great Britain shared the remainder equally. It was planned that the expedition should work from a base in Dronning Maud Land for two years, 1950–52.

Norway would also be responsible for the transports to and from the Antarctic. The expedition ship, the *Norsel*, had recently been built. She was an ice-breaking sealer of a new construction, with a diesel engine of 1200 hp. Captain Guttorm Jacobsen (b. 1911) of Tromsø was her commander.

The responsibilities for the scientific projects were divided up. Norway would deal with meteorology and surveying, Great Britain with geology, and Sweden with glaciology. However, a strict partition between nationalities and scientific programmes could not be maintained, as may be seen from the list of expedition members.

Norwegian members

John Giæver (1901–70), leader.

Nils Jörgen Schumacher (b. 1919), B.Sc., meteorologist.

Nils Roer (b. 1914), surveyor.

Egil Rogstad (1908–87), radio operator.

Peter Melleby (b. 1917), mechanic, in charge of dogs.

John Snarby (b. 1922), cook and steward.

British members

Gordon de Q. Robin (b. 1921), Australian, physicist (making seismic measurements of the ice-sheet thickness and upper-wind measurements), third in command.

Frederick Roots (b. 1922), Canadian, geologist.

Alan Reece (1921–61), geologist.

¹ The meridian 20°W was definitely settled in October 1939 after an agreement with Great Britain.

Committee leaders of the Norwegian-British-Swedish Antarctic Expedition, 1949–1952. From a meeting at Norsk Polar-institutt in May 1949. From left: L. Kirwan, Royal Geographical Society, H.U. Sverdrup, Norsk Polarinstitut, H. W:son Ahlmann, Stockholm University (Giaever, J. and Schytt, V.: Norwegian-British-Swedish Expedition 1949–1952.)

The *Norsel* is about to leave Antarctica, 20 February 1950. The wintering party remains. From Left: Robin, Quar, Roer, Schumacher, Wilson, Roots, Swithinbank, Rogstad, Ekström(below), Schytt, Liljequist, Snarby, Melleby, Giaever. Photo: Private collection of Valter Schytt.

Not shown in digital edition

Sledging tours in western Dronning Maud Land. From an advanced base with rich stores the sledgers investigated the mountainous regions of western Dronning Maud Land. (Giaever, J. and Schytt, V.: Antarktisboken.)

Not shown in digital edition

The voyages of the *Norsel*, 1950–1952. After leaving Cape Town on the first voyage the course was set S, and then W, to meet with the factory ship *Thorsbøvdi* in the Scotia Sea, then SE towards Maudheim. Before Maudheim was reached there was much roving about in the ice. (Giaever, J. and Schytt, V.: Antarktisboken.)

Charles Swithinbank (b. 1926), glaciologist.

Leslie Quar (1923-51), electrician, assistant radio operator.

Swedish members

Valter Schytt (1919-85), Ph.D. glaciologist, second in command.

Gösta H. Liljequist (b. 1914), B.Sc., meteorologist.

Ove Wilson (1921-81), M.B., doctor to the expedition.

Bertil Ekström (1919-51), mechanic.

After a year, John Snarby left the expedition and was replaced by Bjarne Lorentzen (b. 1900) from Norway. Two new men also then joined the wintering party: Stig Hallgren (b. 1925), a film photographer from Sweden, and John Jelbart (1926-51), a physicist from Australia.

The expedition's equipment was so extensive that part of it—including 60 dogs, three snow tractors (Weasels), spare parts, a drilling machine and five men—had to be transported south on the Norwegian factory ship *Thorshövd*.

With the Norsel to the Antarctic

The *Norsel* left Oslo on November 17, 1949. On her way south, she took aboard equipment at London and Cape Town. Also in London, some of the British members joined the expedition—as did a flying group from the Royal Air Force with two small Auster planes, which were mainly intended for reconnaissance of ice conditions and landing-places.

THE BRITISH FLYING GROUP CONSISTED OF:

Squadron Leader G.B. Walford

Flight Lieutenant K.M.H. Tudor

Sergeant P.D. Weston

Corporal W.B. Gilby

Corporal L.A. Quar, who in the Antarctic transferred to the land group.

The *Thorshövd* and her catchers were hunting in the Scotia Sea, about halfway between South Georgia and the South Orkney Islands, which meant a long detour to the west to reach her and get the rather bulky load transferred to the *Norsel*. The ship became heavily loaded and, to make matters worse, top-heavy; but the ice on the route to Dronning Maud Land was expected to calm down the sea.

The expedition had been advised to establish its base somewhere between longitude 50°E and 15°W. Selbukta near Kapp Norwegia had been especially recommended by Riiser-Larsen. The *Norsel* steered a south-easterly course after her separation from the *Thorshövd*. At first, she passed several open ice-fields alternating with open water; but nearer the continent

she met with heavier ice, and on the 22nd she entered dense frozen slush-ice, which was extremely tough. It was like sailing in frozen "porridge", and here, with full power, the speed of the *Norsel* was reduced to 1-2 knots or less.

In an attempt to reach the coast, the ship stayed in this area (about 69°S, 5°E) for several days. Finally it was decided to proceed south along the meridian through Kapp Norwegia, farther to the west. A reconnaissance with one of the Auster planes indicated that it might be possible to reach the coast that way. In the evening of February 3, the ship was stopped by compact and very heavy ice, which lay in front of Kapp Norwegia and farther south-west; but to the east there was a good deal of open water.

The coast was of the barrier type, with a vertical ice-cliff 20-40 m high. The next problem was to find a place to come ashore with all the equipment. A flight eastward, the following day, indicated that there were four "valleys" in the ice-coast which seemed to be usable for landing. A closer inspection on the 10th showed that one of the "valleys" had advantages. It was situated in the inner part of a bay in the barrier coast, where the shelf-ice surface sloped smoothly down to the sea and offered an excellent quay for unloading the ship.

The period February 4-10 had been spent "roving about" with the ship in the ice. Many participants were in a pessimistic mood—autumn was approaching and there was a risk that the expedition would have to return home. But now a base site was chosen about 2.2 km from the "harbour", at 37.5 m a.s.l., on the flat shelf-ice. Its position was later found to be 71°03'S, 10°56'W. The shelf ice was almost 200 m thick, floating in a sea with a depth of 400 m. The base was later given the name Maudheim.

The Maudheim base

The unloading and transport operations started next day, the 11th, and went on for eight days. Transport sledges were loaded directly with the ship's winches, and were dragged by the Weasel tractors—one sledge to each—up to the base site, where the goods were sorted in piles according to contents. With transportation still in progress, the house-building began.

The expedition possessed two houses—a third house had been left at home with some furniture, as there was no space on board. The houses had been constructed in Sweden, each with a floor measuring 8x8 m and a roof ridge 4 m high. Every man had a little cabin of his own. One of the buildings held the meteorological department, the radio station, the doctor's office and the photographic darkroom; the other building contained the kitchen, the dining-

room and the library. There was, moreover, a hut for the two diesel generators and the electric accumulators. For engineering work, the expedition had been presented with a big crate in which the airplanes were placed during the voyage with the *Norsel*.

The *Norsel* left on February 20. The house-building had by then proceeded far enough for the expedition members to get a roof over their heads, but the insulation material was yet to be installed, not to mention all the interior fittings. The boxes of equipment laid in piles round the buildings, and there was a risk that they would be buried in the snow during periods with strong winds and drifting snow. As soon as possible, the boxes were used as modules for the construction of a system of passageways and rooms, between and around the houses. The whole system was then covered with tarpaulins. In this way, the base was transformed into an enclosed unit, which would gradually be embedded in the snow and thus become protected from blizzards and severe cold. At the same time, all equipment was within easy reach.

The 44 remaining dogs of the expedition were, in their respective teams, chained along wires near the base. The dogs had suffered during their voyage down to the Antarctic, 16 had died. But these were offset by 24 pups, born in the winter; a passageway at the base served as a maternity ward, and as a ward for sick dogs.

Weather observations had started on February 22, but most other measurements and observations had to wait until the house-building was practically finished—in the middle of March. The weather during the landing operations and the house-building was remarkably good, but April 26 marked the beginning of a period with severe gales. This lasted until May 4, and then followed a storm with winds reaching 30 m/s on the 17th.

There were enormous amounts of drifting snow, and Maudheim became partly buried in the snow. A long dune formed on the lee-side of the base, towards the west-south-west; the winds had come from directions around east-north-east. This dune was exploited by digging out rooms for hydrogen production, and for filling the meteorological radiosonde balloons. The radio sounding had started on March 15, but had been much hampered by strong winds, before the accommodation in the dune became ready for use.

The Maudheim people got to know the drifting snow also from another aspect: the reduced visibility, due to an increase in the number of snow particles which became suspended in the air when the wind rose. The reduction in visibility was so pronounced that the greatest care had to be exercised in conditions with winds higher than 20 m/s. The table below indicates the average visibility, but may still overesti-

mate it in extreme situations. At Maudheim, a visibility of less than 2 m was observed once for a wind of full gale force (greater than 25 m/s).

<i>Wind speed</i> (m/s)	<i>Visibility</i> (m)
13	300
17.5	82
22	23
27	8
30	4

The weather in the winter of 1950 was extraordinarily fine. The polar night lasted from May 19 to July 24. It was twilight in the middle of the day, and during much of the time the northern sky was beautifully coloured orange and red, thanks to very thin cloud veils which were probably situated in the lower stratosphere. The lowest temperature observed was -46°C in the first winter, -47° in the second.

The turn of the months July/August was windy, with gales almost uninterruptedly for 11 days. The following period, too, was characterized by unsettled weather, but also by many fine days. In the spring of 1950, the surface of the snow reached to within half a metre from the roof ridge. The Maudheim people had now, more or less, become cave-dwellers—and so they were to remain “for the duration”.

Scientific work at Maudheim

The research started in the latter half of March, though the geologists and the surveyor would have to wait until the summer season of 1950/51 before they could begin their respective projects—there were no mountains near Maudheim, only snow and ice.

The meteorological programme was extensive. Weather observations were carried out every three hours, beginning at 00 GMT, but the 03.00h observation was omitted. These data were transmitted by radio to the South African weather service, to be forwarded. This material was to be used as a basis for a description of the weather and the climate, and as a background for other studies. With similar observations sent from South Africa, as well as those from factory ships in the Southern Ocean during the summer and from the Falkland Islands, it was possible to construct synoptic weather maps and forecast the weather with reasonable reliability.

Once a day, a *radiosonde ascent* was made. Hydrogen for filling the balloons was produced by means of aluminium pellets, caustic soda and water, and a high-pressure generator. The radiosondes were of the Finnish type. For determining the upper winds, a

The *Norsel* in Maudheim harbour, 19 February 1950. After eight days of toil the ship is unloaded, and most equipment has been transported to the station site. The ship left next day on 20 February 1950. Photo: Private collection of Valter Schytt.

Construction of Maudheim. The two dwelling-houses, the motor-generator-house and the workshop are roofed over. Passage-ways are built between the houses using packing-cases covered with tarpaulins. The base gradually became buried in the snow during blizzards. Photo: Private collection of Gösta H. Liljequist.

The *Norsel* berthed alongside the factory ship *Thorsbøvdi* with two whales as fenders, January 1950. 44 dogs, 3 weasel tractors, 15 tons of whale meat and five expedition members were transferred to the *Norsel*. (Gjaever, J. and Schytt, V.: Antarktishoken.)

Plan of the base Maudheim. A=dwelling-house, also housing radio, meteorology, dark-room and surgery. B=dwelling-house, also housing kitchen and dining-room. C= electric powerstation. D=workshop, E=glaciological boring-machine. (Gjaever, J. and Schytt, V.: Norwegian-British-Swedish Antarctic Expedition 1949-1952.)

small transmitter was attached to the balloon. In this way the position of the balloon in the air could be determined, independent of weather, by direction-finding with a so-called Rawin instrument. Previously only one series of radiosonde ascents had been made in Antarctica, at Little America in 1940. Schumacher was responsible for this project, but Robin carried out the upper-wind measurements.

Liljequist was responsible for a project dealing with the *energy exchange of the shelf-ice surface*: measurements of solar and terrestrial radiation that were received, lost and retained, and determinations of the turbulent transfer of heat mainly from the air to the shelf-ice surface. The aim was to determine the energy balance of the snow surface and its variation during the day and year. The project included many kinds of measurements and recordings, such as determinations of direct solar radiation, global radiation (from the sun and sky upon a horizontal surface), the albedo (reflectivity) of the snow surface, terrestrial (infrared) radiation, the penetration of the solar radiation into the snow, and recordings of wind and temperature by instruments attached at different heights along an observation mast 10 m high.

From the mast observations, one could derive the turbulent transfer of heat and many other factors, for example the wind and temperature variations with height and their mutual coupling. In fine winter weather, the temperature was often 15–20°C higher at the top of the mast than near the surface. The vertical temperature variation, as obtained from the radiosondes and from the recordings on the mast, also explained and supplemented the observations of the marked mirage phenomena that occurred.

The *glaciological* project under Valter Schytt consisted, in the winter half-year, of studies of the physical properties of the shelf-ice at Maudheim, and in the summer season of field work on the inland ice among the mountains.

Glaciological stakes were mounted around the base up to a distance of 4 km. These stakes were used to determine the accumulation of snow upon the flat shelf ice and its differential movements. A drilling machine was used to study the structure of the shelf-ice in the deeper layers. A depth of 45 m was reached in the first year, and 100 m in the second. The two glaciologists took samples of the firn ice, and installed electric thermometers at different depths. The temperature readings were then noted on a routine basis by the meteorologists.

A study of the ice cores from the drill was done in a cold-laboratory built from boxes in the snow. The separate ice crystals of the cores could be seen and photographed in the microscope by using polarized

light. Thus it was demonstrated how the grains in the firn of the upper layers turned into marked ice crystals, which increased in size with depth, until at about 60 m the layers consisted of ice—with the crystals closely packed. This metamorphosis took place at a temperature of about -17.5°C, which corresponds to the annual mean temperature of the air in the lower layers of the atmosphere at Maudheim.

The temperature in the shelf-ice varied over the year around this mean value, and the variation lagged behind with increasing depth, in perfect agreement with the mathematical theory of heat transfer by conduction. At the same time, the amplitude of the variations decreased with depth. At a depth of 10 m, it was warmest in the winter and coldest in the summer, but the amplitude of the variation here was only a few tenths of a degree C. By drilling down to about 10 m and measuring the temperature there, it is thus possible to obtain the annual mean temperature of the air to a few tenths of a degree. This is a good method for field studies of the distribution of the annual mean temperature of the air in a region covered by ice.

The upper layers of the shelf-ice were also studied by digging a shaft. Winter-snow and summer-snow could be distinguished on the walls of the shaft by their different grain sizes, the winter-snow with its smaller grains appearing whiter than the summer-snow with its somewhat larger grains. In this way the annual accumulation, here very nearly equal to the annual precipitation, could be determined for individual years, so that even climatological mean values for the annual precipitation were obtained. This is also a method which can be used in field work, but the snow-surface has to be flat over wide areas and the temperature below freezing in the summer. At Maudheim the annual accumulation of snow was found to be 70 cm, which corresponds to an annual precipitation of 380 mm (water).

The glaciological cold-laboratory and its photographic equipment were also used by Liljequist in connection with his studies of halo phenomena. When the phenomena were produced by ice crystals in the low layers of the atmosphere, it was possible to collect the crystals on a glass plate (thinly oiled) and photograph them in the cold-laboratory.

In the winter, Roer and Roots carried out *geomagnetic observations* in an igloo situated about 500 m from the base. Further, the expedition's doctor, Ove Wilson, made a *physiological investigation* throughout the entire stay at Maudheim, as well as before and after it, using the expedition members and himself as guinea-pigs. His aim was to find out the reaction of human beings to the severe antarctic climate. Blood tests were taken

each month, mainly to determine white and red blood-corpusele and blood-sugar values. Basal metabolism and weight were also measured.

The summer field season of 1950/1951

Judging from the German maps, the nearest mountains were estimated to lie some 300 km from Maudheim. To make a detailed investigation of that area possible, a large depot had to be established at some suitable place within it, using the three Weasels. The mechanic Bertil Ekström would therefore be essential to the success of the summer's field projects. But before any major depot could be established, a safe route to the mountains had to be reconnoitred by a sledging party, which would need some depots on the way. Thus, an extensive programme of preparation was required in order to start the scientific work among the mountains, see below.

Using the Advanced Base for support, the field parties investigated the mountain region around it. One of the aims of the glaciological group was to look for indications of any ice retreat or advance as signs of

a climatic variation. Their conclusion was that the inland ice, at least at present, is maintaining a status quo.

The main work of the surveying group was to establish ground control for the air photographs which were to be taken in the summer 1950/51 by a Norwegian flying group arriving with the *Norsel*.

A disagreeable summer, 1950/1951

In the winter, a polar traveller looks forward to the summer, with the sun shining bright in the sky and with agreeable temperatures. But the summer seldom turns out as it did in his daydreams. This was also the case at Maudheim.

The spring of 1950 had been windy, but there were also many fine days. The solar radiation had made itself felt from the middle of October: snow lying upon objects started to melt in spite of rather low temperatures. In fact, the direct solar radiation soon became as intense as in the Sahara Desert during the summer; the air was dry and there were few dust particles to reduce the intensity. Since 80-90% of the

<i>Apr. 3-14</i>	Reconnaissance east of Maudheim.	Sledge tour.
<i>Sept. 8-14</i>	Choosing a site for a "departure depot" 75 km to the east of Maudheim.	Sledge tour.
<i>Sept. 25-26</i>	Establishing the Departure Depot.	Two Weasels with a transport sledge each, load about 6 tons.
<i>Oct. 5 - Nov. 15</i>	Reconnoitring a safe route to the mountains and marking it with small flags, from Maudheim to the site of the Advanced Base, near the Nunatak Pyramiden about 300 km from Maudheim.	Sledging party consisting of Schytt (leader), Roots, Reece and Melleby. Supporting party escorting half the distance to the depot site.
<i>Nov. 20-28</i>	First Weasel transport to Advanced Base: 3 Weasels, each with one transport sledge. Total load ca 9 tons.	Roots and Ekström leaders.
<i>Dec. 4-8</i>	Second Weasel transport to Advanced Base: 2 Weasels, each with one transport sledge. Total load about 6 tons.	Roots and Ekström leaders. Seismic group (Robin and Liljequist) left the Weasel party at half the distance in order to measure the thickness of the inland ice.
<i>Dec. 18-19</i>	Start of the field parties: geological, surveying, and glaciological groups.

Sledging has started after many preparations. (Gjæver, J. and Schytt, V.: *Antarktisboken*.)

An overhaul of a weasel tractor ended in tragedy on 25 February 1951. During the trial trip the tractor was driven down the ice slope at the harbour due to low visibility. From left: Leslie Quar, John Jelbart, Bertil Ekström and Stig Hallgren. The former three drowned; Hallgren, a strong swimmer, reached an ice-floe and was rescued. (Gjæver, J. and Schytt, V.: *Antarktisboken*.)

Three leaders of the Expedition in January 1951. From left: John Gjæver, Maudheim, Antarctica, Harald Ulrik Sverdrup, Norsk Polarinstitut, Oslo, Guttorm Jacobsen, Captain of the *Norsel*, Tromsø. (Gjæver, J. and Schytt, V.: *Antarktisboken*.)

An eye operation at Maudheim. In the summer of 1950/51 the geologist Alan Reece got a stone splinter in an eye, while collecting rock samples in the mountains. He became blind in the eye. Later at the base the doctor had to remove the eye, assisted by the geologist Roots, the glaciologist Schytt (behind Roots), the photographer Hallgren and the radiooperator Rogstad (not in the picture). (Gjæver, J. and Schytt, V.: *Antarktisboken*.)

solar radiation is reflected from the snow surface, an object—or a man—receives up to twice as much solar radiation as in summer at middle latitudes.

One may therefore feel quite warm, despite low temperatures. The skin reacts if exposed too much; so do the eyes, which have to be protected with tinted glasses. The snow surface did not melt, but the sunlight penetrated into the snow and, when it was absorbed by embedded objects or particles, the snow near them melted or evaporated. In December, the huts and tarpaulins gave rise to considerable melting. Water stained the walls and ceilings in the houses, dripped in the passageways, and built up ice-stalactites from the “ground”, making everything quite slippery.

The base now became embedded in an armour of ice instead of porous snow, as had been the case previously. This affected ventilation in huts and passageways—especially during gales, when the entrances were closed. Harmful effects appeared gradually, and were noticed as a feeling of fatigue and a lack of initiative. The situation became more critical on Boxing Day, when a period of gales began and, besides, fumes from the diesel engines invaded the passageways and houses. The meteorologists were better off than the others at the base, as they had to stay outdoors at repeated intervals during the day.

On January 6, the *Norsel* arrived with stores for the station. On board the ship were Professor H.U. Sverdrup, the leader of the expedition, and a Norwegian flying group which was to photograph the mountainous regions.

THE FLYING GROUP CONSISTED OF THE FOLLOWING MEN, FROM THE WIDERØE FLYVESELSKAP IN NORWAY: Kaare Friis-Baastad, chief pilot.

Anders Jacobsen, pilot.

Josef Jensen, mechanic.

Walter Andreassen, mechanic.

Sigvard Kjellberg, aerial photographer.

The map of western Dronning Maud land was to be constructed on the basis of their photographs and of Roer's measurements for ground control. But the bad weather, which had begun on Boxing Day, continued. From the point of view of an aerial photographer, the weather was the worst possible.

With the ship came also representatives of the national committees and “observers”, among them Captain Reinhold von Essen of the Swedish Air Force who—as it turned out later—was to return in the following summer with a Swedish Air Force group. Among the passengers were the Swedish film photographer Stig Hallgren and the Australian physicist John Jelbart, who were to stay at the base over the winter.

On the 29th, a day before the ship left, a flight was made over the surrounding country, with Liljequist as passenger. The plane crashed on landing, but the pilot and passenger escaped without injuries—although the plane was severely damaged.

The Weasels had gone through a strenuous period in spring and early summer, during the long transports to the Advanced Base. They had also been used for transporting stores from the ship to Maudheim. They needed a rest and an overhaul. Ekström worked on one of the Weasels to get it into order, and on the night of February 23/24 a trial run was made. Ekström was the driver and the passengers were Hallgren, Quar and Jelbart. They followed a route towards the “harbour”. There were banks of mist locally over the shelf-ice, but over Norselbukta there was sea-smoke drifting inland.

In the reduced visibility, the Weasel was driven straight down the four-metre-high steep slope and into the water. Hallgren was a strong swimmer and managed to get hold of an ice-floe, but the others drowned. Rogstad, who was working with his radio, became anxious about the long absence of the group; he skied down to the “harbour” and was able to contact Hallgren.

Intense activity and hard work followed: one of the expedition's two boats was dug up and was dragged down to the “harbour” on two worn-out sledges. It slid down the steep slope was bailed out, and after a little rowing Hallgren was rescued.

The summer had been stormy; hard winds continued to blow in the autumn, and in the winter that followed. The sledgers returned from the mountains, and some of them took care of the remaining two Weasels. But the geologists Roots and Reece, and the surveyor Roer, were very late in coming. Not until May 30 did they appear, long after the sun had passed under the horizon at noon. There had been many days of worry at the base. This anxiety also concerned Alan Reece, who had become blind in one eye.

The second year, 1951-1952

The second year at Maudheim was in some respects like the first year, but in others it differed considerably. The autumn and winter, for instance, were more windy than in the first year. This meant increased difficulties for the meteorologists, especially in connection with the release of the radiosonde balloons, although it was partly compensated for by their greater experience and by improved arrangements.

The base was now completely buried in the snow, so the ventilation was not very good to begin with. But it was improved by means of vertical ducts, which reached above the snow and were mounted at differ-

ent places in the system of passageways. A new entrance to the base had also been opened. The best of all arrangements that winter was a blizzard-entrance, which eliminated the problems of coming out or in. It was simply a vertical ladder along the gable of the "radio house" A. On top was a cubical box, surmounted by a lid. The meteorologists especially appreciated this device.

The state of health at the base was good, but there was the problem of Alan's eye, which had been injured when he was collecting rock specimens in the mountains. A stone splinter had hit one eye with great force, causing blindness. The doctor was faced with a dilemma. The eye was inflamed and he had been advised by his professor in Sweden to operate—in other words, remove the eye. He had never performed an eye operation, nor did he have any experienced nurses or an assistant doctor at his disposal. He had to instruct and train his helpers: Roots as assistant doctor, Schytt as instrument-nurse, Hallgren as anaesthetist, Rogstad to take blood pressure and pulse, Liljequist to take notes and draw graphs. The operation was successful.

It was imperative to give Robin the resources to carry out his seismic measurements in the next field season. A long Weasel tour was planned by him, through the mountain region and southward onto the inland plateau. For that purpose he would need the two remaining Weasels and two transport sledges. Upon one of the sledges he built a tarpaulin "caboose" hut, to house the three travellers—Robin, Swithinbank and Melleby—and their seismic equipment. The measurements could be made rapidly at the different stopping-places, and the photographic recordings could be developed immediately after the measurements.

The seismic journey was fruitful. The party obtained a section with measurements which indicated a landscape beneath the ice similar to a Norwegian fjord and mountain region, with depths to 500–700 m below sea level. On the inland ice plateau, at latitude 74.5°S, the thickness of the ice was 2400 m, and the land beneath the ice was situated at 300 m a.s.l. These were the first reliable and systematic seismic measurements of ice thickness that had ever been made in the Antarctic.

The seismic measuring technique arrived at was to be of great value for similar measurements during the International Geophysical Year (IGY) in 1957–58 and later. Glaciological studies were also made. For instance, the annual mean temperature of the air, as measured in the ice, was found to be -30°C near Advanced Base and -40°C on the plateau at latitude 74.5°S.

On January 6, 1952, the seismic party was back at Maudheim, the other field parties having returned somewhat earlier. During the field work in the sum-

mer of 1951/52, nunataks in the northern part of the mountain region were visited. The sledgers found it interesting to observe how the climate turned milder as they travelled north toward the coast: almost every successive nunatak exhibited more lichens and patches of moss than the previous one.

Birds were seen among the mountains—snow petrels and antarctic petrels—and over the northern nunataks, flocks of more than a hundred individuals were noted. In addition, the seismic party observed a skua on the inland ice plateau at latitude 74°S. In the summer 1950/51, Wilson discovered two species of mites on the two northernmost nunataks. These mites were brought home alive and were found to be new to science.

The glaciologists had noted indications of a more severe glaciation than that of the present day. Observations of lichens on a number of very small nunataks showed, though, that there had not been any shrinking of the ice in *recent* years, at least not during the last few decades; the lichens reached just down to the snow surface.

The last summer, beginning in November, was favoured by very fine weather: clear sky, light to moderate winds, and temperatures just under freezing. A drawback, of course, was the dripping water in the base itself, with ice-stalactites and slippery passageways.

In the houses, walls and ceilings became even more stained than in the previous summer. The surface of the snow now reached about half a metre above the roof ridge.

The *Norsel* arrived on December 22, 1951, and moored along the fast-ice edge in the middle of Norselbukta. A group of six men from the Swedish Air Force under the leadership of Captain Reinhold von Essen were among the passengers.

MEMBERS OF THE SWEDISH FLYING GROUP, SUMMER OF 1951/52

Reinhold von Essen (1913–70), captain in the Swedish Air Force, leader of the flying group.

Olof Wijkman (b. 1917), pilot.

Curt Edin (1918–88), warrant officer, signaller and navigator.

Reinhold Nilsson (b. 1919), warrant officer, signaller and navigator.

Åke Hellström (b. 1917), mechanic.

Uno Jegestad (b. 1923), technician.

Helge Skappel, aerial photographer, of Wideröe Flyveselskap, Norway.

The Air Force group brought two aircrafts, a twin-engined Beechcraft 18-R and a small SAAB Safir, besides complete field equipment for radio commu-

nication with the planes. A cable was drawn from the "airport" to Maudheim and the meteorologists, making it possible to get up-to-date weather reports and advice. During the winter, Roer and Roots had constructed a map of the area to be overflown, in order to facilitate the planning of the flight tracks.

"Maudheim Airport", situated on the shelf-ice about 500 m from the previous "harbour", was in operation for 16 days. On eight of these days, long photo flights were made, covering the area which had been investigated by sledge and Weasel parties. No greater favours can be expected from the antarctic weather gods. This photographic work was all done by Helge Skappel. The mountain region which was photographed extended between longitude 30°E and 16°W, and from the coast to 74°S. The coastline from the Greenwich meridian to 21°W was photographed.

On January 8, 1952, "Maudheim Airport" was closed and the two planes were taken aboard. On January 15, a short ceremony was held at Maudheim, and a few hours later the *Norsel* left the Antarctic with the members of the Norwegian-British-Swedish Antarctic Expedition on board. The party left the ship at Very Cruz, Canary Islands, and arrived by passenger ship in Southampton on February 18.

With the exception of the Weasel accident, the expedition had been a happy and successful enterprise. The members got on well together. What they had gone south to do, they had now accomplished. They had obtained an abundance of valuable scientific results, and in the two geophysical disciplines of meteorology and glaciology—including seismic measurements—the results were of great benefit to the investigations which were carried out a few years later during the International Geophysical Year. These findings were published by Norsk Polarinstitutt in

the series *Norwegian-British-Swedish Antarctic Expedition 1949-52: Scientific Results*.

TEMPERATURE AND WIND AT MAUDHEIM, ANTARCTICA
(Lat. 71°03'S, long. 10°56'W, alt. 37 m a.s.l.)

	Monthly mean temperature, °C		Monthly mean wind speed, m/s	
	1950	1951	1950	1951
Jan.	—	-4.0	—	8.8
Feb.	—	-8.2	—	8.7
March	-12.2	-18.4	—	6.2
April	-21.2	-17.3	7.3	9.6
May	-23.2	-24.6	8.8	7.1
June	-27.5	-25.8	6.1	7.9
July	-30.5	-23.9	6.9	9.9
Aug.	-24.1	-28.0	8.2	8.1
Sept.	-22.8	-24.4	8.3	8.7
Oct.	-17.3	-19.3	7.0	8.8
Nov.	-10.9	-10.6	8.8	5.7
Dec.	-4.0	-6.3	6.8	4.9

Highest observed temperature in 1950 and 1951: ca. +0.1°C. Lowest observed temperatures: -46.0° (July) in 1950, and -47.0° (August) in 1951.

Highest wind speeds (hourly mean): 30.3 m/s (May) in 1950, and 30.4 (June) in 1951.

Note: In the summer season, the direct readings of temperature were made from an Assmann psychrometer in order to eliminate the strong radiation error. The values of highest observed temperature are also from Assmann readings.

The Swedish flying-group had good luck with the weather and the planned flights could be carried out in the mountainous inland as well as along the coast. (Gjaever, J. and Schytt, V.: Antarktiskboken.)

Maudheim and surrounding area, January 1951. A tractor track can be seen between Maudheim and the harbour 2.5 km away. Photo: Norsk Polarinstitutt.

GEOPHYSICS AND GEOSCIENCE AFTER 1952

45. THE INTERNATIONAL GEOPHYSICAL YEAR (IGY) 1957–1958

Historical background and plans

The two Polar Years, 1882–83 and 1932–33, were accomplished with an interval of 50 years. After 1933, remarkable developments occurred in technology and natural science—not least in the disciplines that belong to geophysics.

Once international relations stabilized after the upheaval of World War II, it was found appropriate to organize a third Polar Year as soon as possible. A leading motive was that it would now be possible to attack, among other things, the interior of the antarctic continent, as well as the upper atmosphere and perhaps even its fringes towards interplanetary space.

The first tentative ideas concerning a third Polar Year date from April 5, 1950, when a group of American geophysicists arranged an informal meeting with their British colleague Sydney Chapman (1888–1970), who was widely regarded as the most prominent geophysicist of those days. During the meeting it was suggested that the time had come for a new polar year, rather than waiting until the centenary in 1982. The geophysical disciplines had developed considerably and they should not be withheld the data that would result from this venture.

Those at the meeting were highly enthusiastic over the proposal, and it was agreed that Chapman and the American Lloyd Berkner should present the plan at the next meeting of the Mixed Commission on the Ionosphere, which was to be held in Brussels three months later. This commission decided to commend the plan to the scientific bodies which were included as members.

It was also decided to present the plan to the International Council of Scientific Unions (ICSU), where all the Commissions were represented together with the national Academies of Sciences.

In the autumn of 1951, the Executive Board of ICSU met in Washington D.C. A special committee was established to work with plans for a third Polar Year, and in the following year an invitation to take part in the “year” was sent to the nations involved.

The World Meteorological Organization (WMO) soon remarked that the scientific interest in this event was too heavily concentrated on the polar regions, and proposed—together with some other bodies—that the research should be world-wide. Chapman suggested that the name Polar Year should be exchanged for *International Geophysical Year (IGY)*, which was

ratified by the ICSU general assembly at Amsterdam in October 1952.

A Special Committee for the IGY had been formed. In July 1953, Chapman was made its president, Lloyd Berkner vice-president, and Marcel Nicolet of Belgium the secretary-general. These three scientists constituted the Bureau of the IGY. Later, two members were added: Vladimir Belousov of the Soviet Union, and Jean Coulomb of France. Thus the Special Committee included citizens of the four great powers: France, the United Kingdom, the United States and the Soviet Union. This group of five men directed the IGY from Nicolet’s office at Uccle near Brussels.

It was now decided that the IGY would extend over 18 months—against 13 months during the first and second Polar Years—from July 1, 1957 to December 31, 1958. This period would correspond with an expected maximum of solar activity. Besides, 25 years would then have elapsed since the second Polar Year. The prolonged observation period was also chosen with due regard to the activity in the Antarctic.

It was highly desirable that the Soviet Union should take part in the IGY—which would have failed otherwise. But the Soviet Union was not a member of the ICSU, so special measures had to be taken. It was mainly thanks to the Russian scientist Vladimir Belousov, a specialist on tectonics, that the road for Russian co-operation was paved.

It was desirable that China participate in the observation activity during the IGY. But there were two states called China at the time, and the People’s Republic of China did not want to join in the IGY when informed that Nationalist China would do so. Consequently, observations from a considerable part of the Earth’s surface were missing during the IGY.

By 1953, one year after the ICSU sent out the first invitation, twenty-two nations had set up national committees for preparing the observation activity. A deadline, May 1954, for submitting detailed national programmes was prescribed, in the hope of preparing a master plan for the entire Earth in advance of the IGY.

A number of important conferences were held for discussion of problems connected with the activity during the “year”: at Brussels in 1953, Rome in 1954, Brussels in 1955, Paris in 1955 (concerning the Antarctic), Stockholm in 1956 (concerning the Arctic), and Barcelona in 1956. From September 30 to October 4, 1954, a plenary meeting with the Special Committee for the IGY was held in Rome. Here it was decided, for example, that a scientific project should deal with “specific planetary problems of the Earth” to be included in the IGY programme.

These problems were defined at the Rome conference as follows:

- a) Problems requiring concurrent synoptic observations at many points, involving co-operation by many stations.
- b) Problems of branches of the geophysical sciences, whose solutions will be aided by the availability of synoptic or other concentrated work during the International Geophysical Year in other geophysical sciences.
- c) Observation of all major geophysical phenomena in relatively inaccessible regions of the Earth that can be occupied during the International Geophysical Year because of the special efforts made during that period, in order to augment our basic knowledge of the Earth and of the solar and other influences acting upon it.
- d) Epochal observations of slowly varying terrestrial phenomena, to establish basic information for subsequent comparison at later epochs.

The geophysical conditions to be studied were those in the Earth's interior, on its surface, and in its atmosphere and oceans, including the cosmic phenomena which influence those conditions. Therefore, many geophysical sciences were involved. The synoptic studies demanded routine observations from a very great number of stations. These observations had to be carried out at fixed intervals, and supplemented by continuous recording. The intervals could also be increased in number by arranging so-called *World Days*.

There existed three classes of such *World Days*, or periods of increased observation activity:

1. World Meteorological Intervals
2. Regular *World Days*
3. Special *World Days* or Periods of Alert

The *World Meteorological Intervals* consisted of 10 consecutive days in June, September, December and March, each containing a solstice or an equinox.

The *Regular World Days* consisted of 3 or 4 days which had been selected in advance at times "when things tend to happen"—at new moon, in periods with meteoric showers, at solar eclipse, near half-moon, and so on.

The *Special World Days* or *Periods of Alert* were determined when observations of the sun indicated that something "special" could be expected within the next few hours due to exceptionally high solar activity, such as geomagnetic storms or intense aurora.

However, observations could not be carried out in all parts of the globe, even during such a bold venture as the IGY. It was necessary to concentrate the efforts

to some special regions. Two regions stood out in this respect: the Antarctic and outer space.

Before the IGY, the interior of Antarctica was still practically unknown, let alone the geophysical conditions in this ice-covered continent. But since World War II, technological development had been very rapid, and man now possessed the technical tools for exploring these hitherto inaccessible regions on a grand scale. Strong icebreakers and large ice-strengthened freighters had become available; large airplanes for intercontinental traffic could be used to establish stations in the interior, and to maintain them there. Likewise, snow tractors made possible long journeys into the interior of the continent, either for purely scientific purposes or for transports of equipment. Thus, by a combined attack during the IGY, the secrets of the Antarctic would be solved to a great extent.

Planetary space was now also attainable. Towards the end of World War II, long-range V-2 missiles had been used by Germany against Britain. After the war, 69 of these missiles were brought to the USA and used, for example, to carry instrument payloads to high levels, reaching up to 186 km. An attempt during the Second Polar Year to study the upper atmosphere with the help of a rocket constructed by Professor Robert Goddard (1882–1945) had failed—yet the symbol chosen for the IGY was a satellite cruising round the earth. These dreams were to be fulfilled with the Russian launching of the first Sputnik on October 4, 1957.

Geophysical studies on a grand scale had been carried out in the Arctic from the ice in the Polar Sea since about 1950, by both Russians and Americans. It was vital to continue these observations. Stations existed all over the Arctic since the end of World War II, but in order to improve the network, temporary stations were to be established in some regions.

The meteorologists were eager to obtain sections through the atmosphere, from pole to pole, showing the thermal structure of the atmosphere and the flow of air in the same sections. Such sections could not be obtained everywhere on the globe; the observation activity had to concentrate on just a few. Moreover, the equatorial zone had been largely neglected in geophysics, not least within meteorology. It was decided that this zone would be the object of special attention during the IGY.

In summary, the programme gave priority to the following regions: planetary space, the Antarctic and Arctic, the equatorial zone, and three zones extending from pole to pole. The latter lay between longitudes 70° and 80°W (east coast of North America and west coast of South America), along longitude 10°E (Eu-

rope and west Africa), and along longitude 140°E (east Siberia, Japan and east Australia).

A series of conferences was held immediately before the start of the IGY, for instance in Stockholm on May 22–25, 1956, to coordinate the arctic research plans of nations bordering upon the Arctic.

One important conference was held at Uccle, Belgium, on April 1–4, 1957, and dealt with the exchange of data. A decision was reached to establish three centres: World Data Centre A would be located in the USA, and World Data Centre B in the Soviet Union, while World Data Centre C was to be subdivided between countries in western Europe, Australia and Japan.

The chief weather data archive would be at the headquarters of the World Meteorological Organization (WMO) in Geneva, Switzerland.

During the IGY, the sun was carefully watched from a number of stations, the idea being that any marked rise in solar activity would be followed by a rise in the observation activity, notably within geocosmic physics. So-called Special World Days would then be proclaimed (see p. 512).

The International Geophysical Year was the greatest research venture that has ever been attempted. The scientific personnel is said to have totaled 60 000 persons from some 60 nations. To this should be added the crews on board the ships, the flying personnel with ground service, and the many technicians, not to mention the personnel at home—members of committees, administrators, office personnel, and so forth.

It is difficult to obtain a clear and detailed general view of what actually happened during the IGY. So much went on at so many places that a review of the Geophysical Year must be very superficial. We cannot touch upon the many difficulties which were overcome or found insurmountable; there also occurred accidents and deaths, mental and physical strain, as well as aid and support from other people or expeditions.

The International Geophysical Year was a collective achievement: the individuals involved usually remained anonymous, whereas the scientific results shone with their scope and their richness of details. A basic theme was the effective application of technology in inhospitable environments, although ultimately everything depended on the individuals and their enthusiasm for the work. The IGY initiated a new type of polar exploration, more effective and less heroic than previously. It was a victory of co-operation over individuality—and this was both for the better and for the worse.

Sweden's role in the IGY

The planning of the observation activity was done by national IGY committees in different countries. The Swedish committee, attached to the Royal Swedish Academy of Sciences, had as its president the meteorologist Professor Carl-Gustaf Rossby (1898–1957). After his death in August 1957, the physicist Dr. Nicolai Herlofson (b. 1916) acted as president. The secretary was the meteorologist Dr. Bert Bolin (b. 1925).

At an early stage in the preparations, it was decided that the Swedish contribution to the International Geophysical year would consist of a scientific station in Svalbard, besides increased observational activity within Sweden and by the Swedish solar observatory at Capri, Italy. Discussions also led to Swedish-Finnish co-operation in Svalbard. Later, from December 1955, Switzerland joined the collaboration in Svalbard.

The three nations were to concentrate upon the following scientific disciplines:

Sweden

General meteorology: project leader Dr. Alf Nyberg (b. 1911).

Geocosmic physics (including cosmic rays, aurora and geomagnetism): project leaders Prof. Arne Sandström (b. 1905), Prof. Nicolai Herlofson (b. 1916) and Dr. Nils Ambolt (1900–69), respectively.

Atmospheric chemistry: project leader Dr. Erik Eriksson (b. 1917).

Finland

Aerology: project leader Dr. V. Rossi.

Tidal observations: project leader Prof. I. Hela (1915–76).

Switzerland

Atmospheric electricity and radioactivity: project leader Prof. Jean Lugeon.

A SCIENTIFIC STATION IN SVALBARD

At first, Longyearbyen had been tentatively proposed as a site for the station. But considerations on the local topography indicated that it was not very suitable for the purpose. Another suggestion had been the flat land near Kapp Linné at the mouth of Isfjorden. Here, however, Norway intended to carry out observations and, furthermore, Poland had chosen Hornsund in the south of Spitsbergen for her station. There remained the north of Svalbard.

In 1954 the meteorologist Gösta H. Liljequist was asked by the Swedish committee to become the leader of the Svalbard station, and to take care of the practical aspects of planning the expedition. One of the first problems to be settled was to find a suitable site for the Swedish-Finnish IGY station.

Liljequist was advised by Major Einar Christell to locate the station at Murchisonfjorden in the west of Nordaustlandet—preferably at the bottom of a small fjord, Kinnvika, on the northern side of Murchisonfjorden. Christell had been a member of the Swedish flying group for the rescue of the members of the ill-fated *Italia* expedition in 1928 (see p. 433). He had also spent the summer of 1931 on the southern side of Murchisonfjorden during Ahlmann's Svalbard expedition (p. 483).

The low and relatively flat land at Kinnvika seemed to offer good conditions for a scientific station. But it was naturally essential to inspect the place as soon as possible, to investigate a safe sea route to Kinnvika, to study the landing conditions, and to find the best ground for houses and huts near the landing-place, as well as a surface suitable for transports of heavy equipment from the sea to the station. Further, geomagnetic measurements had to be carried out in order to avoid a site with local magnetic disturbances. And finally, some alternatives to Kinnvika had to be studied in case of severe ice conditions in 1957.

The reconnaissance was carried out in August 1955 by G.H. Liljequist and V. Rossi—as representatives of the Swedish and Finnish commissions respectively—on board *M/S Minna* of Ålesund, under Captain Ingolf Rören. This ship was in the service of Norsk Polarinstitut, Oslo, to carry out hydrographical surveying and inspection of lighthouses in Spitsbergen waters, under Lieutenant Commander Kaare Lundquist of that institute. Time was also found to make the Swedish-Finnish reconnaissance possible.

A fine passage with deep water was located, leading from Søre Russøya right up to Kinnvika in the north of Murchisonfjorden, through waters that are otherwise treacherous due to rocky ridges—which creep below the sea surface or appear as either islands in the fjord or rocky outcrops on land. The landing-place was suitable for unloading equipment with small craft, either singly or in combination, as landing rafts. The huts and houses might be built on flat gravel beds a couple of hundred metres from the shore. From the landing-place, gravel “roads” led up to the prospective station site through an area with sharp flat pieces of dolomite standing almost vertical.

A hasty inspection showed that drinking-water was available. The flat, low land alternated with small hillocks. The surroundings were ideal for observational work, and Rossi's geomagnetic observations indicated that the planned geomagnetic measurements would not suffer from local irregularities in the geomagnetic field. Christell's recommendation had thus been a good one—but ice might prevent the expedition from reaching the place in the summer of

1957. Other station sites, therefore, also had to be looked for.

On the way back to the west coast, Nordenskiöld's station of 1872–73 in Mosselbukta was visited. The house was now a ruin, but the walls making up the kitchen and the small dining-room were still there, without the roof. This place could be used if necessary—but what a dreary site it would have been. Next to be studied was the south-eastern corner of Reinsdyrflya, near Worsleyhamna, and it too might be used. In addition, there was a potential site close to Ny-Ålesund, if the ice conditions in 1957 proved to be the worst possible, with the whole north coast blocked by ice.

The station site on Nordaustlandet was approved by the two national committees, and in the autumn the preparatory work could start in earnest. The different project leaders had special requirements; some of these were inconsiderable, but others had consequences for the planning and finances of the expedition. The cosmic ray project demanded a continuous electric power supply of 8 kW—which was later reduced to 4 kW—and no stops would be allowed, because the apparatus would then become untrimmed and recording intervals might be lost.

The electronics would heat the cosmic ray house, but sometimes the heating might become too intense, requiring outside air to be blown into the house; at other times the temperature might become too low, but could be increased automatically by electric heaters. It turned out that electricity was needed in all the aspects of practical and scientific work at the station. The demands of the cosmic ray project indicated that a reliable diesel-electric power station was a must, and preferably it should consist of two aggregates working in turn. The technician in charge would have a highly responsible position.

With the question of electricity resolved, it was time to consider the various houses, huts and pavilions. In this connection, due regard had to be paid to the fact that Hinlopenstretet, near which the station was to be established, was a notoriously windy spot. A building firm was found, with an interest in this somewhat uncommon construction work, and a representative of the firm had an open mind to the expedition's specific demands—Mr. C.G. Olsson.

Apart from electric power and housing, it was time to concentrate upon the many articles included in the equipment. The project leaders planned their own stores of instruments, as well as the houses and pavilions for instruments which were to be constructed by the building firm.

It was now December 1955, and at that time Professor Jean Lugeon, head of the Meteorological Serv-

ice of Switzerland, expressed his desire to join the expedition with a project in atmospheric electricity and radioactivity. During the Second Polar Year 1932–33, he had been the leader of a Polish Polar Year group on Björnöya.

The wintering party led by Gösta H. Liljequist

With the Swiss participation, the number of expedition members was increased by two persons, and the wintering personnel reached a total of 13. Of these, 8 were Swedish, 3 were Finnish and 2 were Swiss.

Swedish members

Gösta H. Liljequist (b. 1914), Ph.D., leader of the expedition, making meteorological observations.

Carl-Axel Bäckstedt (1921–87), radio operator, taking part in meteorological and aerological work.

Eric Dyring (b. 1930), B.Sc., responsible for the cosmic ray project, taking part in meteorological and aerological work; second leader.

Hans Engström (b. 1927), engineer, responsible for the electric power station and electric installations, workshop, tractor and boats.

Karl-Erik Heikkilä (b. 1932), engineer, responsible for the geomagnetic observations and for the technical details of the cosmic ray project. He supervised the practical outdoor work, and took part in the aerological work and geomagnetic observations.

Sven-Eric Molander (b. 1925), engineer, instrument technician, responsible for the aurora photography and the photographic darkroom; photographer to the expedition, participant in the aerological work, reserve cook.

Edgar Tollén (1925–89), electrician, cook and steward to the expedition, responsible for the kitchen, heat installations, washing machine, and stores of provisions. He took part in all kinds of practical work at the station, and carried out biological and geological observations.

Karl Erik Wärme (1920–60), chemist, responsible for the work in atmospheric chemistry, responsible for the firearms of the expedition.

Finnish members

Matti J.T. Aro (b. 1931), doctor to the expedition, conducting medical research, participating in the aerological work and the geomagnetic observations.

Ilmari Helimäki (b. 1928), B.Sc., meteorologist, responsible for the aerological work and the tidal observations, taking part in the weather observations.

Erkki Gröndahl (b. 1926), radiosonde technician, responsible for the technical details of the aerological work, taking part in this work and the meteorological observations; assistant radio operator.

Swiss members

André Junod (b. 1930), physicist, responsible for the investigations in atmospheric electricity and radioactivity.

Pierre Wasserfallen (b. 1932), electrotechnician, taking part in the work in atmospheric electricity and radioactivity, responsible for its technical and practical details.

Jean Brunner (b. 1932), physicist; he went with the expedition to Nordaustlandet, but had to return home on October 3 for reasons of health. He was replaced by Pierre Wasserfallen.

Liljequist had been an assistant at Bornö oceanographical station in south-western Sweden in 1937–38, followed by a post as meteorologist at the Swedish Meteorological and Hydrological Institute in Stockholm until 1958. He visited the polar regions on five occasions, the first two being study tours:

1945 Visit to Jan Mayen and Iceland in September–October on board the patrol ship *Honningsvåg* of the Norwegian Navy.

1947 A visit to Longyearbyen and Nordenskiöldfjellet, followed by a tour along the Spitsbergen west and north coasts with adjoining fjords. This tour was made with the mining inspector of Svalbard, Gunnar Aasgaard, on his official ship, the *Bremsnes*, to investigate the state of the hunters' huts, which had been unused since the withdrawal of the Svalbard population in 1941.

1949–52 Meteorologist of the Norwegian-British-Swedish Antarctic expedition to Dronning Maud Land.

1955 Reconnaissance in Spitsbergen and Nordaustlandet on board the *Minna* (hired by Norsk Polarinstitut) for the purpose of finding a site for a Swedish-Finnish (and subsequently Swiss) scientific station during the International Geophysical Year, 1957–58.

1957–58 Leader and meteorologist of the Swedish-Finnish-Swiss IGY expedition, 1957–58 working at the station Murchison Bay in Nordaustlandet.

The first transports to Nordaustlandet

As time passed, the demands for equipment and facilities tended to increase. The expedition planned in 1954, therefore, was not the same as what took place in 1957. Originally only a sealing vessel had been considered adequate for the transports to Nordaustlandet.

The Finnish research ship *Aranda* was to visit the Barents Sea in the summer of 1957, and the Finnish commission for the IGY arranged that this ship would

The first day in Nordaustlandet, July 1957. The Finnish marine research ship *Aranda* arrived as planned on July 15 at Kinnvika, northwest of Murchisonfjorden. The ship brought ca. 25% of the equipment and most of the expedition members. The photo shows a pause in the unloading operations, due to drift-ice from the inner parts of the fjord. Photo: Private collection of Gösta H. Liljequist.

The last hut in a series of 11 houses, huts and pavilions was set up on 13 August 1957. It was then possible to receive a Catalina of the Swedish Air Force with crew and scientists, the intention being to let the crew become familiar with Arctic environments, so they could be relied on in difficult situations (below). Photo: Edgar Tollén.

The dwelling-house under construction. The houses at Murchison Bay consisted of a strong framework, upon which blocks with heat-insulating material were fastened (above). Photo: Private collection of Gösta H. Liljequist.

The Swedish mine-cruiser *Älvsnabben* arrived on July 27 with the remaining 75% of the expedition equipment. The ship brought also scientists for setting up instruments and accessories. Photo: Private collection of Gösta H. Liljequist.

take some of the equipment, about 100 tons, to Svalbard. The Swedish Navy was to take the remaining 300 tons on the mine-cruiser *Älvsnabben*.

The leader of the oceanographical cruise with the *Aranda* was Professor Ilmo Hela, of the Institute for Marine Research in Helsinki, Finland. The *Älvsnabben* was commanded by Captain *Bengt* Gustav Gottfrid Lundvall (b. 1915), later to become Admiral and Head of the Swedish Navy. The *Älvsnabben* was to be accompanied by three large minesweepers, which would stay in northern Norway while the *Älvsnabben* was on her Svalbard tour. The group of ships was commanded by Commodore Sven Hermelin (1901–84).

With due regard to the normal ice conditions in the north of Spitsbergen, the date July 15 had been fixed for the arrival in Murchisonfjorden of the *Aranda*, with about 25% of the equipment—notably the reserve house, the sauna, the balloon-house for the radio soundings, and the house for the cosmic ray apparatus, besides three boats. It had been agreed upon that the main part of the expedition members would board the *Aranda* at Longyearbyen for passage to Murchisonfjorden. With the rest of the expedition equipment, the *Älvsnabben* would come to Murchisonfjorden about two weeks later, when the expedition was expected to have established itself somewhat on Nordaustlandet.

The *Aranda* reached Murchisonfjorden on July 15, and anchored in Kinnvika at 06.00h in the morning. After an inspection of the station site for determining where to place the different houses and huts, the unloading started. The weather was fine at first, and the equipment was taken ashore by the three motor-boats of the expedition, each towing one or two light military landing boats. During the first day, manpower was used for bringing the items from the boats to the safety ashore. It was an extremely hard piece of work.

During the night a gale arose from the south—straight into Kinnvika—and caused a rough sea, which barred any attempt to land equipment next day. The unloading operations were resumed in the night towards the 17th. The wheel tractor and its trailer were now landed, and sleds were made from logs of driftwood. With these the equipment could be transported to the station site, at a distance of 300 m over bare and stony ground. The weather was again fine.

The *Aranda* left in the morning of July 18, to resume her oceanographic investigations in the Barents Sea. The land party now entered upon a month of building activity. The *Älvsnabben* was to bring instrument personnel and project leaders who would set up complicated and delicate equipment. But to do so, they must be provided with lodging and with huts for

their instruments. Moreover, in the middle of August a Catalina seaplane of the Swedish Air Force was expected, and with the plane two scientists of a glaciological expedition under Valter Schytt would be coming. Four members of this expedition had already arrived with the *Aranda*.

THE VOYAGE OF THE *ÄLVSNABBen* TO NORDAUSTLANDET IN 1957

The *Älvsnabben* loaded expedition equipment in Karlskrona at the end of June and beginning of July. The intricate and difficult stowage was directed by Lieutenant Helbor Borre. The packages were many and diverse: apart from the 300 tons of equipment for the geophysical and glaciological expeditions, the ship brought equipment for the landing operations at Murchison Bay. To handle these operations, officers and men from the coast artillery were coming. There were also some representatives of the expedition, the national committees, and the building firm—besides the artist Roland Svensson (b. 1910) and representatives of TV and press.

Before starting upon her arctic cruise, the *Älvsnabben* paid a visit to Uddevalla on the Swedish west coast, where a meeting was held between the naval colleges of the Nordic states. On July 22 the ship left Uddevalla in company with three large minesweepers, *Ramskär*, *Landsort* and *Ulvön*, which together with the *Älvsnabben* made up the 2nd Squadron. The ships met with fresh headwinds along the Norwegian coast, where especially the minesweepers exhibited a frisky dance. Off Trondheim the minesweepers were detached; they were to visit harbours in northern Norway while awaiting the return of the *Älvsnabben* from Svalbard.

Captain Ragnar Thorén (b. 1895), a learned man on polar matters, gave lectures and informed the officers, men and passengers about the Arctic and its exploration. His father, Dr. Adolf Thorén (1852–1904), had taken part in a similar naval expedition during the first Polar Year as a naval surgeon.

The Arctic Circle was crossed on July 24, with a traditional ritual: the Sovereign of the Arctic Ocean attended by two “polar bears” paid a visit to the ship. Farther north, the wind died down. In the evening of the 26th, they reached Prins Karls Forland under favourable weather conditions: a calm prevailed and the air temperature was +6° to +7°C, while a metre below the water surface +7°C was also measured. The ship’s company and passengers enjoyed the passage along the coast of Dei Tri Isfjella, and at the north-western corner of Spitsbergen they could just see Virgohamna, from where Andrée had started his balloon flight in 1897. Everything was ably described by Captain Thorén.

The fine weather continued during the passage along the Spitsbergen north coast. Already here the ship crossed the parallel of 80° N. Soon the *Älvsnabben* rounded Verlegenhuken, the northernmost point of Spitsbergen, and entered Hinlopenstretet, where she was met by a strong southerly wind and a rough sea. All around the ship, whales were blowing—an occurrence not too common in the waters of present-day Spitsbergen.

For the route to the station Murchison Bay, the commander of the *Älvsnabben* had been supplied with a geological map, which indicated the route together with some readings of depths at submarine thresholds obtained from the echo-sounder of the *Minna* during the reconnaissance in August 1955.

On the evening of July 27, the *Älvsnabben* anchored in the inner part of Kinnvika. The wind was still fresh to strong, and the rather rough sea was not subdued by any type of breakwater.

From the ship, three houses could be seen some way from the shore, and on the shore were men launching a boat into the breakers. A party of four soon boarded the *Älvsnabben*. She had thus reached her destination. But one thing now worried those in command: the persistent wind, which might complicate the landing of the equipment.

Officers and equals on the *Älvsnabben*, July–August 1957

2nd Squadron

Sven Samuel Gustaf David Hermelin (1901–84), commodore, commander of the 2nd Squadron.

Henrik Lange (b. 1908), colonel of the coast artillery.

Ragnar Vilhelm Adalgot Thorén (b. 1895), captain

Carl Jan-Gunnar Jardal, captain.

Sven Gustaf Floryd, captain.

Nils Dellgren, naval engineer 1st degree.

HMS Älvsnabben

Bengt Gustav Gottfrid Lundvall (b. 1915), captain, commander of the *Älvsnabben*.

Göran Andreas Eriksson Bernström, commander, second in command.

Karl Georg Roland Rudnell, captain, navigation officer.

Göran Viktor Nordling, captain, gunnery officer.

Lennart Eriksson Torén, captain, 1st training officer.

Viktor Helbor Jonathan Borre, lieutenant, manoeuvre officer.

Karl Erik Harald Hedström, lieutenant of the coast artillery, training officer.

Gösta Greger Högström, lieutenant, safety officer.

Thomas Werner Öhrwall, lieutenant, training officer.

Bror Per Harald Stefenson, lieutenant, training officer.

Nils Gunnar Toremalm (b. 1923), naval surgeon 2nd degree, ship's doctor.

Lars Hjalmar Lundgren, lieutenant, narrator.

Unloading the Älvsnabben

When the ship arrived, the weather was fine, but a southerly wind had freshened and it increased during the night. Next day, there prevailed a fresh to strong wind and a rough sea. However, coast artillery men who had come with the ship began to build three piers at the shore in spite of the breakers. In the evening the piers, resting upon stone caissons, were completed.

In the night towards the 29th, the wind abated. Soon it was calm—and silent as if even the wind was waiting for the activity which would commence. But the landing of the equipment started gradually, and there were many preparations. Landing-rafts were made by placing platforms upon two or more landing-boats. Special vehicles were placed on top of these platforms and were loaded with equipment.

At the piers ashore, the two band tractors (Weasels) of the glaciological expedition and the wheel tractor of the station awaited the ferries. The vehicles were then dragged up to the station with their loads, which were laid up in depots or stores at suitable places. With some training, the procedure soon became most effective. The weather was good, and manpower was available from the ship. The land party and the three carpenters from the building firm now devoted themselves to construction.

Some of the project leaders had arrived on the *Älvsnabben*: Professor Arne Sandström in charge of cosmic ray, and Professor Jean Lugeon to study atmospheric electricity and radioactivity. So had instrument experts: Kjell Borg for geomagnetism and Matti Wilska for the radiosonde equipment. And all of them needed electric power—some immediately, others after a few days. The flooring of the power station was mounted, but the house could not be completed until the two diesel-electric generators had been landed. The house had to be built, so to speak, around the two aggregates.

July 30 was the hottest day that the expedition was to experience in Nordaustlandet. A maximum temperature of +11.3°C was noted. There were no winds or clouds, and the heat was oppressive. People were stripped to the waist. The equipment was pouring into the station site, and in the evening Lieutenant Borre, the leader of the landing operations, noted with satisfaction that 185 tons had come ashore.

The aerals for determining the upper winds were now mounted. Engström had got his two diesel-generator aggregates ashore and could supply the electric power. The receivers for upper wind and for

On the day of departure of HMS *Älvsnabben*, 1 August 1957. The expedition equipment had come ashore undamaged, the crew of *Älvsnabben* had a day of rest. A farewell dinner awaits on board, before the ship departs. From left: Captain Bengt Lundvall, commander of *Älvsnabben*. Colonel Henrik Lange, Swedish coast artillery, G.H. Liljequist of the Murchison Bay Station, Commodore Sven Hermelin, commander of the 2nd squadron, Captain Ragnar Thorén, Arctic expert. Photo: Private collection of Gösta H. Liljequist.

Map of Murchisonfjorden. A safe approach to Kinnvika and the station Murchison Bay is indicated by the names Arandasundet and Älvsnabbenrenna. (Liljequist, G.H.: *Arktisk utpost*.) Private collection of Gösta H. Liljequist.

Air photo towards the south showing the area around the station Murchison Bay. In the background Murchisonfjorden. Photo: Swedish Airforce.

the radio sounding were mounted—all in the open air. The balloon with attached instruments went up into the air, as a low cloud of mosquitoes hung in the air above the men at the radio receivers. Wilska made a radiosonde test, and the result was good.

By the evening of July 31, the whole 300 tons of cargo from the *Älvsnabben* had been unloaded. Everything had come ashore undamaged. The shore party cleaned up along the shore, but one pier was left to the expedition. The last task was to help the expedition members to raise their six monstrous radio masts. These were high and thick wooden spars, stayed with strong ropes, since the Swiss recordings of the bearings to thunderstorms—over a good part of the northern hemisphere—would have been disturbed by metal constructions.

August 1 was reserved for relaxation. Besides, it was the national day of Switzerland; the Swiss flag fluttered on the main mast of the *Älvsnabben* and, of course, at the station. At noon, a 21-shot salute to that country's honour boomed on board the ship. Among other ceremonies, the *Älvsnabben* was presented with a beautiful diploma painted by the artist Roland Svensson, who had come with the ship. It confirmed that she had passed beyond the latitude of 80°N.

After the salute there was a ceremony on board the *Älvsnabben*. The whole crew was assembled on the forecastle and the leader of the expedition thanked the ship's party for the invaluable help they had given. At the same time he gave a short summary of the contributions of the Navy to polar exploration. He also told of the Swedish expeditions which had specially visited Murchisonfjorden.

The programme of the *Älvsnabben* now called for a visit to Ny-Ålesund and to Longyearbyen. The passage along the Spitsbergen north coast took place in fine weather. But in the west, visibility was reduced by fog all the way to the mouth of Kongsfjorden. There the fog lifted and exhibited wonderful scenery of mountains and glaciers, for which this fjord is so renowned. The ship's party was warmly received by the management of the mine. Longyearbyen was visited on August 3–4 with an equally friendly reception.

The voyage home started in the evening of August 4. Björnöya was passed, and all were happy to see the island. The Arctic Circle was crossed on the 7th, and soon they met the three minesweepers which had spent the time in harbours in northern Norway. On August 13 the *Älvsnabben* reached Göteborg after a successfully completed mission. Here the commander of the ship received a telegram from Admiral Stig H:son Ericson, the head of the Swedish Navy:

"I congratulate the commander and the crew of HMS *Älvsnabben* on an exceedingly well-accomplished task in Spitsbergen, and I convey the gratitude of the Navy for the way in which everybody on board has upheld our traditions in the Arctic with zeal and satisfaction."

A scientific station is established

The *Älvsnabben* had left Kinnvika at 22.00h on August 1. At the station it was now most important to complete the dwelling-house or main building. This was an elongated (30 m long) building, orientated NNE–SSW, which was more or less parallel to the prevailing strong winds. On its eastern side was an annex containing the kitchen, a larder and the boiler for the central heating. In the northern end of the building were 14 cabins for the 13 expedition members, and a "sick-room". Adjoining the kitchen was the dining-room/living-room. The southern part of the house contained rooms for the radio station, radiosonde and radio-wind receivers, general meteorology, and atmospheric electricity, radioactivity and chemistry.

The erection of the main building demanded physical strength. Its walls consisted of blocks with heat-insulating material between the outer and inner sides. The blocks were heavy, some weighing 300 kg, but they made the assembly a speedy process. The three carpenters from the building-firm were excellent workers, and the building was finished on August 10. Until then, the men had slept in the reserve house, in the sauna and in houses for instruments, eating their meals in a large military tent.

Moving into the building was celebrated with a "house-warming" party, which was joined by members of the hydrographic expedition of Norsk Polarinstitut under Kaare Lundquist. The two ships *Minna* and *Sjövern* had arrived in the evening. The instrumental equipment could now be mounted relatively rapidly, and within a few days the observation activity was starting.

The radio station had begun to function on August 11, and the Murchison Bay station was no longer isolated. From August 15, the weather reports, made eight times daily, were sent to Tromsø via Hopen Island. The radio soundings and the upper wind measurements were initiated on the same day, with ascents twice daily at 00.00h and 12.00h GMT.

Meanwhile the remaining huts and pavilions were set up, and ultimately a little village had appeared on the flat land to the north of Kinnvika. The eleven buildings varied in size, from the 30-m main building to a small hut which held the rotating direction-finding frame for recording the bearings to thunder-

storms (electric discharges in the atmosphere) over much of the hemisphere. The other buildings were the reserve house, the electric power station and workshop, the Finnish sauna, the cosmic-ray and balloon houses, and the huts for atmospheric chemistry, aurora photography, geomagnetic recording, and geomagnetic absolute measurements.

The last of these huts was erected in pouring rain on August 13. Recalling that the expedition had arrived on July 15, one can see that the station was completed in less than a month. It had been hard work indeed.

A Catalina plane versus the weather

The Swedish Air Force had promised to send a Catalina plane to Murchisonfjorden for investigating the conditions in the area, in case a plane later had to be sent to the station. Accidents and severe illness might arise among the expedition members, requiring fast transport to a hospital in Sweden—and the Air Force had promised that a Catalina plane might be sent in such a situation.

It seemed vital to send a plane already now, after the radio station had been set up, in order to give the crew some experience in arctic conditions.

Besides, it was considered valuable to photograph Murchisonfjorden and the surrounding land from the air. The aerial photographs would be a help to the glaciological expedition in connection with the subsequent study of their observations. Moreover, it would be useful to give Professor Gunnar Hoppe and Valter Schytt a direct view from above of the specific characteristics of the land.

From August 11, when the radio station had begun to operate, the plane was expected any day. In a telegram the expedition was asked to supply information about places near the station, where the plane might find shelter in rough weather. No suitable places existed, and in reply the pilots were advised to use Longyearbyen as a refuge. But at 22.00h on the 16th, the plane arrived and anchored in Kinnvika off the station.

There were ten newcomers:

CREW OF THE CATALINA

Captain Olle Brunstorp (b. 1919), commander of the plane.

Sergeant Erik Wallner (b. 1920), second pilot.

Warrant Officer Ivar Gustav Klang (b. 1917), navigator.

Warrant Officer Bertil Carl-Gustav Wesslén (b. 1926), signaller.

First mechanic Nils Ivan Ånell (b. 1919).

Electrotechnician Sven Lennart Lindström (b. 1921).

Aeronautical technician Sven Ivan Andersson (b. 1922).

PASSENGERS

Gunnar Hoppe (b. 1914), Ph.D., professor of physical geography, Stockholm University.

Valter Schytt (1919–85), Ph.D., glaciologist, leader of the glaciological expedition.

Tore Hallén, journalist.

It was as if all the evil powers of the weather had gathered to make trouble for this plane. It began the next morning, when two men had gone aboard the plane to pump her dry. A fresh wind was blowing, and suddenly the plane started to drag without the men noticing. The plane was only 20–30 m from the shore cliffs before the men could start the motors, get clear and taxi to a sandy beach near the station. The plane was then placed just at the water line, with its wheels standing firmly on the bottom even when fierce breakers rose against the shore.

On the 19th, Storsteinhalvöya to the north of the station was investigated from the air, with Weston Blake of the glaciological expedition as observer. The weather was excellent, and the next aim was to make a photo flight over Murchisonfjorden and the marginal zone of Vestfonna, with Hoppe and Schytt as observers. But the wind had been increasing and, when the plane started, the sea had become so rough and the wind so strong that the plane could not get airborne. It just buried its nose in the sea when its speed was increased. Nor could the plane utilize its previous parking-place on the beach.

Thus another parking-place had to be found in the south of the fjord on the lee side of Kvalrosshalvöya. Radio contact was established every hour, and in the following night every three hours. In the early morning of the 20th, the wind speed at the station was measured as 20 m/s. When contact was established, the wind speed proved to be higher at the plane. The situation was not difficult, but from the plane they now requested radio contact every hour.

The ice dome of Vestfonna gave rise to waves in the atmosphere, indicated by the clouds, and the wind speed in the low layer fluctuated analogously. This was something the Kinnvika people were to experience repeatedly during the coming year.

In the evening of August 20, the plane was detected from the station, far away to the south in the fjord. The wind had increased again. Seamanship was needed now to handle the plane. The pilot steered obliquely against wind and sea at short intervals, managing to cope with the water while guiding the plane with the engines. The wind provided the power for transport.

By radio the pilot asked for a boat to be sent out. This could be done in spite of the breakers—but what could a little boat do to rescue the plane? The venture

The station Murchison Bay as seen from the north, 1957. The radio masts were wooden spars, in order to obtain undisturbed recordings of distant thunderstorms (spherics). Photo: Edgar Tollén.

The station seen from the west. In the background Kinnberget. Photo: Eric Dyring.

The main building of the station Murchison Bay. In a wing of the building are the kitchen, larder, and an installation for central heating. The wing adjoins the dining-room/sitting-room and from this latter room a corridor leads with entrances to the cabins of the personnel. At the other end of the building there are rooms for scientific work: meteorology, atmospheric electricity and radio activity, and chemistry, besides a darkroom and radio station. (Liljequist, G.H.: Arktisk utpost.)

The station site 1957. In the northeast the main building and to the south of this building the sauna and the motorhouse/workshop. To the west we find the house for cosmic ray studies, the balloon house and the aurora camera with pavilion. Far to the west there are the two huts for geomagnetic measurements. The smallest building at the base is the pavilion for the rotating aerial which records spherics. (Liljequist, G.H.: Arktisk utpost.)

was doomed to fail. Shelter was sought in a little bight, which the landing parties from the *Älvsnabben* used. Although Hoppe and Schytt were able to disembark, nothing more was possible. Nor did the sandy beach help matters. Attempts were made to drag the plane up onto it with the tractor, yet this was too weak a machine for a big airplane. What remained was to supply the airmen with sandwiches and hot coffee in thermos bottles. Then the plane steered south and disappeared from sight.

The station personnel relaxed, soaking wet. A few hours later, a radio message said that the plane had found a sheltered place at Selodden on the north side of Murchisonfjorden. Next day, the 21st, strong winds continued to blow. The airmen now asked for iron-bar levers, food and beer: the plane was stuck on the shore. Three men from the station walked across the intervening land—there were only 8 km between the plane and the station.

Next day, the 22nd, the wind was still fresh to strong, but apparently calming down. Only three men were staying at the plane, the others having returned to the station. When they left the plane, it was still stuck on the shore. However, later in the afternoon, it passed over the station on its way to Longyearbyen to refuel.

There were plenty of people at the station; they seemed to abound everywhere. Some had more than enough work to do, whereas others simply had to arm themselves with patience and let time pass by. The schedule now called for a photo flight over the neighbouring land, but for this purpose a clear sky and good visibility were essential.

The wind abated on the 23rd, only to be followed by low clouds, fog and mist. Nothing could be done but to wait, and the plane was still at Longyearbyen with three men. Bäckstedt had been sitting at his radio day and night. Others at the base were also overworked, and Tollén in the kitchen had been burdened by chores. Nevertheless, he got a man to take his place, and made an excursion into the surrounding country. He returned with the first report on polar bears, having seen two at a distance of about 100 m. This was invigorating to Tollén.

The Norwegian survey ship *Sjövern* arrived on August 23, and with her the Stockholm contact-man of the expedition, Walter Bischof. Kaare Lundquist, the leader of the Norwegian survey work, had much in common with Kjell Borg, who had now established the geomagnetic observatory at the station. Lundquist wanted to study the geomagnetic conditions in the Svalbard area, now that he could check his observations from the recordings at Murchisonfjorden and from the Polish station at Hornsund in southern

Spitsbergen. Besides, both Lundquist and Borg were anxious to obtain fresh data from the previous Polar Year stations at Kapp Thordsen and Sveagruvan, of 1882–83 and 1932–33 respectively.

The people who had stayed at the Murchison Bay station during the summer of 1957 may be summarized here. With the two ships, *Aranda* and *Älvsnabben*, several men had arrived who were to help the expedition in creating the scientific station of Murchison Bay.

Three carpenters were sent by the building-firm Vetlandahus to help the expedition members in the construction work:

Karl Ericsson, master builder.

Thorsten Pettersson, carpenter.

Erik Angel, carpenter.

With the ships had also come four instrument experts or project leaders, to help the members get the instruments mounted, tested and trimmed:

Kjell Borg, Swedish, for geomagnetism.

Jean Lugeon, Swiss, for atmospheric electricity and radioactivity.

Arne Sandström, Swedish, for cosmic ray.

Matti Wilska, Finnish, for radiosonde and upper-wind equipment.

In addition, the representative of the expedition in Stockholm, Walter Bischof, stayed for a time at the station.

The expedition's transport and housing facilities were also used by the glaciological expedition, which was organized and led by Valter Schytt. In the summer of 1957 a preparatory expedition of four men had worked in the area of Murchinsonfjorden and at the margin of Vestfonna, the westerly ice-cap of Nordaustlandet.

This group consisted of the following persons:

Weston Blake, American, leader of the group.

Erkki Palosuo, Finnish.

Anders Häggblom, Finnish.

Christman Ehrström, Swedish.

In part for photographing the region to be investigated by the glaciological expedition, a Swedish Catalina plane had been dispatched to Murchison Bay. As previously mentioned (p. 521), along with its crew of seven men, the plane brought Hoppe and Schytt, as well as the journalist Tore Hallén. Thus there were many persons staying at Murchison Bay in the summer of 1957.

It was late summer now; the autumn was nigh. The Catalina left at 10h on August 27, carrying Schytt, Hoppe, Hallén and Bischof. In excellent weather, the land area between Murchisonfjorden and Lady

Franklinbreen was photographed from the air. Then the plane proceeded to Longyearbyen to spend the night there. At 12.00h on the same day, the *Sjövern* arrived to fetch Sandström, Borg, Häggblom, Palosuo and Ehrström; she left at 18.00h.

Finally on the 28th, the *Minna* arrived to fetch the remaining summer guests—Lugeon and the three carpenters—except Weston Blake. The wintering party of 13 men, and Blake of the glaciological group, remained at the station. Until then, as many as 34 persons had been present, making the station resemble an overcrowded tourist station in the mountains, and in bad weather at that.

The “sysselman” had promised to visit the station with his official ship, the *Nordysse*, on about October 1. With the ship would come a new member of the Swiss group, as Brunner was forced to go home for medical reasons.

SCIENTIFIC WORK AT THE MURCHISON BAY STATION

The observation activity and a suitable routine of life were at last to begin in earnest. Here it is relevant to describe the station and surroundings. In the “village”, extending about 200 m from east to west, the dwelling-house, sauna, power station/workshop and reserve house lay towards the east. The western part contained the balloon house, chemistry hut, aurora pavilion and, farthest to the west, the two geomagnetic huts. These two latter huts were placed as far away as possible from the other huts, in order to avoid magnetic disturbances from the station and from people moving about there.

The different huts and houses were situated upon slightly domed, well-drained gravel “ridges”. Close to the main building was a small and shallow pond in the summer. The drinking-water of the station was then pumped from this pond to the kitchen; otherwise the water was fetched from a little lake about 2 km north-east of the station. The water in the pond originated from the plateau north of the station. It percolated through the gravel resting upon permafrost strata about 0.5 m below the surface, so the pond had no visible inlet or outlet.

The land was flat except for low hillocks or ridges. About 1 km to the east-south-east of the station was the dominant local mountain, Kinnberget. It was low, at 130 m a.s.l., but provided a magnificent view of the surroundings. To the west, the plain looked gloomy and dark-brown, yet the old strandlines gave a kind of artistic touch to the landscape—thanks to their smooth curves on the plain, caused by the land uplift. Below Kinnberget the dolomite rocks were highly weathered: a yellow colour characterized the landscape

here, and the ground was more or less sterile, giving the impression of a lunar landscape.

To the south extended Murchisonfjorden, with its many islands and islets. Beyond the mountains and hills south of the fjord, the western ice-cap of Nordaustlandet, Vestfonna, loomed like a vertical cliff of ice. To the north and north-west, Storsteinhalvöya was dotted with small lakes. There, the dominant embayment of Claravågen was more like a lake with a narrow outlet. In the south-west, Ny Friesland and part of its ice-cap formed the background to the windy strait of Hinlopen.

The surrounding country was an excellent miniature landscape in which to make excursions. Sedentary life at an observation post like Murchison Bay had to be balanced with refreshing outdoor activity. In the autumn of 1957, though, not much time could be spared for such journeys. The darkness was approaching rapidly, and much work still had to be done at the station.

Most of the scientific work consisted of observations, and much attention was devoted to the recording instruments. At first, neither the instruments nor the men had enough time for adjustment. These days were often trying: the observers felt that they had climbed onto a treadmill of labour. When to this were added the problems of troublesome instruments, as well as electric disturbances of various kinds, they had their hands full. Soon the work at the station functioned more or less by itself—but not always.

Atmospheric research

The aerological work governed life at the station to a much greater degree than any other project, because of its heavy demands for manpower—especially in connection with high winds, and during the Regular World Days and World Intervals, when four daily soundings were made instead of the normal two (see p. 512).

The end of a World Meteorological Interval, which contained 10 days with four soundings per day, was marked by an exhausted station personnel.

The Finnish Vaisala sounding system was used both for measuring temperature, humidity and pressure and for determining upper winds. The hydrogen for the balloons was produced with a low-pressure hydrogen generator using caustic soda, aluminium and water. The gas generator was placed in the balloon house, which was open along the ground to allow effective ventilation. The balloons, filled here too, were released from the inside of the house. The roof could be drawn aside, even in strong winds, although special precautions then had to be exercised. Sometimes a man lay on top of the wall as a “fender”. The

ascents were remarkably successful in spite of the high winds.

Electric sondes—recording electric field force, or electrical conductivity of the air—were occasionally connected with the ordinary radiosondes. In that case, the release became much complicated and could be attempted only in situations with light winds.

The Murchison Bay station belonged to the European and West African chain of radiosonde stations near longitude 10°E (see p. 512). This chain passed from the North Pole via Murchison Bay and the Norwegian stations of Kapp Linné, Björnöya and Bardufoss, all the way down to the South Pole.

Ascents were carried out twice a day, at 00h and at 12.00h GMT (01.00h and 13.00h EMT), and they lasted 2–3 hours each, excluding the study of the recordings. It was therefore found advisable to let the radiosonde work determine the time to be used and the routine to be followed at the station. The daily work started at about 10.00h GMT (11.00h EMT), just in time for the radiosonde personnel to have breakfast, and they went to bed at the end of the midnight radio sounding. Thus, relative to visitors from the outside world, the people at Murchison Bay were late risers and kept late hours.

A balloon ascent was easy to carry out in fine weather, but in situations with strong wind it could be harrowing. The balloon might burst during the release, or it might be blown downward and burst upon hitting the ground. Then everything had to start again from the beginning.

The weather observations were made eight times daily—every three hours at 00.00h, 03.00h, 06.00h, etc. GMT—but they took only about a quarter of an hour. The observers were scheduled on watch lists.

The Swiss projects included several studies in atmospheric electricity. The *electric field* and the *electrical conductivity* of the air near the Earth's surface were recorded.

Spherics (the atmospheric electrical disturbances from thunderstorms), the directions to thunderstorms, and the frequency of the disturbances were recorded. The *electric field* and *electrical conductivity of the free atmosphere* were recorded by sondes, released together with the radiosondes on a number of occasions. There were also recordings of the *atmospheric radioactivity*, but only near the Earth's surface.

Investigations in geocosmic physics

The IGY programme in geocosmic physics included observations of the sun, the ionosphere, geomagnetism, aurora, airglow and cosmic rays, among other things. At Murchison Bay geomagnetism, aurora and cosmic rays were observed.

The Earth is bombarded by flows of electrically charged particles—mainly electrons and protons, but also heavier particles—which are deviated by the planet's magnetic field, modified by the field which is created by the moving particles themselves. These particles come from both the sun and outer space, and they give rise to effects in the atmosphere. The flow becomes concentrated to a zone surrounding the geomagnetic poles, and causes light-phenomena in the upper atmosphere: the “northern lights” or *aurora*. Most of the latter occur in the *auroral zone* around the geomagnetic poles. Variations in the flow of particles create variations of the *geomagnetic variables*, especially in the polar regions; often the conditions in the ionized layers of the ionosphere are so much affected that radio communication becomes impossible. Finally, the particles with the greatest speeds give rise to secondary particles in the atmosphere due to collisions; these are observed as *cosmic ray* at the Earth's surface.

During the first Polar Year in 1882–83, there existed no theory concerning the nature of the aurora. But the observations gave an initial idea of the global distribution of the phenomenon. This proved valuable when the first theories were formulated, by Birkeland and Störmer in Norway, before the beginning of our century. Also during that Polar Year, the *geomagnetic* disturbances were studied from a number of stations, including those in the polar regions where such disturbances are most marked.

During the Second Polar Year in 1932–33, the investigation of the atmosphere up to some 20 km had become possible by means of radiosondes, and the conditions in the ionosphere began to be elucidated by studying the reflection of radio waves in the electrically conducting layers above 100 km. During the International Geophysical Year in 1957–58, scientists drew benefit from many new instruments which had been developed, not least for research on cosmic ray, the aurora and the ionosphere.

Frequently a phenomenon or quantity can be better understood by studying its variations, such as those in its distribution over the Earth, or with time in a particular place or area. For instance, studies of the aurora profit from a knowledge of its geographical distribution, changes with time, and intensity. To this end, so-called *all-sky cameras* were used during the IGY (see Fig. p. 532): the whole sky was photographed on 16-mm film once every minute, in suitable weather and light conditions. These photographs show no details of the structure of individual aurorae, but they indicate the general appearance of the phenomenon and its positions in the sky, helping us to determine its global distribution and variation with

Radio sounding from the balloon house during the polar night. Left: A calm prevails and the balloon can pass through an opening obtained by sliding the roof aside. Right: There is some wind and the man that holds the probe has to run a short distance to let the balloon reach some height and come free from the ground (top left and right). Photo: Private collection of Gösta H. Liljequist.

The "department" of atmospheric electricity and radioactivity, a Swiss project. André Junod (left) and Jean Brunner (far left). Photo: Private collection of Gösta H. Liljequist.

Ilmari Helimäki recording the radioprobe ascent, a Finnish project (left). Photo: Private collection of Gösta H. Liljequist.

Karl-Erik Heikkilä checks the cosmic ray apparatus of a Swedish project (far left). (Liljequist, G.H.: Arktisk utpost.)

Matti Aro measures the vertical component of the geomagnetic field force, a Swedish project (left). Photo: Private collection of Gösta H. Liljequist.

time. At Murchison Bay, a Stoffregen all-sky camera was used, set up in a small building whose roof could be opened to allow the whole sky to be photographed. Small lamps on two semicircular bows indicated height above horizon and azimuth. The camera made automatic exposures every minute.

The *geomagnetic observations* were carried out in two nonmagnetic buildings: a variation-house for the recording of geomagnetic variables, and an absolute-house where the recordings were checked 3–4 times per month. The recordings in the polar regions exhibit incessant fluctuations, instead of the even and smooth curves which are generally found in lower latitudes.

Murchison Bay was situated fairly far within the *auroral zone*. With the observations from the stations on Björnöya, at Tromsø, Kiruna and Stockholm, a valuable section through the auroral zone was obtained.

For studying the secular variation of the geomagnetic variables, the Svalbard stations of the first and second Polar Years were visited, and comparative measurements were carried out (see p. 523).

The position of the Murchison Bay station inside the auroral zone made it possible to elucidate the conditions in this unsatisfactorily investigated region, especially as a fairly dense network of auroral stations was now available. Even today, theories of the aurora are far from being definitive.

The auroral displays were different from those that are commonly described in the Arctic and the Antarctic as a smooth and homogeneous arc, which can be seen practically unchanged in some part of the sky. The displays at Murchison Bay were utterly erratic: a ray could be seen sweeping upward from the horizon, new rays were added to become a beautiful corona near the zenith where they met, and then all the rays rather suddenly disappeared. At other times, broad bands extended across the sky in an E–W or even N–S direction. Sometimes there were “curtains” to the south; often the sky was covered by a weak greenish or reddish veil of light. Although the auroral camera was automatic and photographed the whole sky, it did not operate in overcast weather, when Molander had to keep a sharp look-out to avoid missing displays.

Atmospheric electricity and radioactivity, and cosmic ray, were all recorded by automatic instruments, but these recordings had to be checked. The same was true of the geomagnetic observations, which were conducted in the two small nonmagnetic huts in the outskirts of the station. This meant that, during part of the way to the huts, the observer had to go without a gun—and there were polar bears to consider in the darkness.

Autumn activities

The summer of 1957 was a hectic time at Murchison Bay, and the station personnel had longed to devote themselves to their scientific duties. The end of the polar daylight occurred on one of the last days in August. Now it would be only a little more than seven weeks until the beginning of the polar night.

The weather in September was fine on the whole. The nights became dark very soon, but some excursions could be made: to Russöyane, where on Nordre Russöya the cross and the ruins of an old Russian hut were visited, and to Söre Russöya with its lagoon where, however, no traces of Russian hunting activity were seen.

On September 5–10, Blake and Tollén studied Lady Franklinbreen; and on September 22–24, Blake and Aro visited the region south of Murchisonfjorden up to Vestfonna, where the glaciological investigations of the previous summer had been made. They could not penetrate to the central parts of Vestfonna, as fogs/clouds covered the ice—but the accumulation stakes were read. The stay was shorter than they had intended, as a polar bear vandalized their camp and tent while they were on the ice-cap.

The “sysselman” of Svalbard, Odd Birketvedt, arrived with the *Nordsyssel* on October 2. It was dark and snowing, with low visibility. This would be the last visit enjoyed by the station until late spring.

October was a windy month. The wind was not very fierce, but it was persistent, and the speed often fluctuated in the same way as during the previous summer. The wind came from Kinnvika, and the droplets from the breakers covered the windows on the windward side of the dwelling-house with a sticky film of brine. The snow on the ground was blown away. This was experienced a number of times throughout the winter, so—at least in the beginning of the season—there was little “snow-light” to reduce the darkness.

The polar night

On October 20 the sun crept below the horizon at noon, and now the polar night had begun. The preceding days had been characterized by purple colours in the southern sky. For a month afterward, it was by no means dark in the middle of the day; twilight prevailed, a great help to the outdoor work. But for two months in midwinter, darkness ruled throughout the day, except when the sky was clear. A low strip of red colour, some 1–2° high, then rested upon the southern horizon. Then followed a month with twilight in the middle of the day, before on February 22 the sun reappeared over the horizon at midday, and the polar night was over.

There is no doubt that winter darkness has an influence on human beings. Here the most typical symptom was sleeplessness; the inmates lay in their beds simply hoping to fall asleep. In daytime, on the other hand, they felt tired and drowsy. Some people wanted to be left alone, some felt sympathetic, and others were mean. The symptoms in detail varied. An individual might be influenced for weeks, and then he usually recovered.

Matti Aro looked into the state of health of the expedition members. Once a week—on Saturdays—all men had a sauna bath followed by a rest. Often an ultraviolet lamp was used, and later in the evening delicacies and wine were served with the supper.

Life was not humdrum, thanks to the observation activity, which aroused the mind and kept it from dozing off. The men at the station were onlookers of the grand scenes and events of nature. Besides, they possessed all the advantages of electric power.

On November 19, a serious fire nearly broke out at the station. After supper Tollén had gone to the sauna to check his clothes in the washing-machine, but he returned a few minutes later with alarming news: the motor-house with the electric generators and workshop was on fire. It was in the nick of time, and the fire could be extinguished. The scientific work depended upon the availability of electric power. The exhaust-pipe had not been properly heat-insulated at its passage through the wall, and an overheating had taken place when a fresh wind died during the evening.

This event was a shock, and led to precautions against a recurrence. Naturally a reliable amount of rock-wool was applied round the exhaust-pipe. A "fire brigade" under Molander was set up, and a regular night-watch was established, rotating among the personnel. The night-watchman began his duties at 02.00h, when the radiosonde people usually finished their work. The most important or critical buildings were inspected every hour until 09.00h, when the cook started his preparations for breakfast. The critical buildings were the dwelling-house, the motor-house and the house for cosmic ray measurements. The inspection work included taking a deep breath to smell for any fumes from overheated electrical insulating material. Among other measures were observation and checking of the functions of instruments. It was a valuable routine in many ways.

Polar bears were occasionally in the neighbourhood or among the houses. The night-watchman therefore always carried a gun during his walks among the houses. A further important precaution was to switch off the electric power to the reserve-house. Besides, no open fire was allowed to be used there—only electric torches. The house then became a store

for provisions, clothes, sleeping-bags, stoves and other equipment. Thus life and work would not be entirely at the mercy of possible fire in the dwelling-house.

Christmas and New Year were celebrated in the traditional way, as was "Lucia Day" although a female beauty was missing. On the latter day a telegram was received, stating that Liljequist had been appointed professor of meteorology at Uppsala University, and the celebrations were extended.

The return of the light

In midwinter with an overcast, there was no difference between day and night as regards illumination—it was quite dark. With a clear sky it was possible to see an orange-coloured strip along the southern horizon up to 1° – 2° in the middle of the day. Above that strip, the sky was light bluish-green up to about 10° , followed by the dark night-sky.

In the middle of January, the twilight began to increase markedly in intensity, and the surrounding country could be discerned. Kinnberget was seen on the 14th and, on the 22nd, the mountains and the shores of Murchisonfjorden. On the 28th, visibility was extremely good and in the middle of the day it was possible to see mountains some 100 km away. On February 6, no stars could be seen owing to the twilight in daytime. On February 22, the sun reached above the horizon—one day too late because of clouds. This was the end of the polar night, and the Murchison Bay people enjoyed the sight.

During the first days of February, those at the station asked to be roused early in the morning in order to have time for a tour in the surrounding country before breakfast and the radiosonde work. When they returned, they were happy and invigorated from the exercise and by what they had seen and experienced. Matti Aro, the doctor of the station, had been told by his colleague at Longyearbyen that the worst time of the year was not the polar night, but the time of the sun's return: people were generally most affected then, and for the worse. This, however, was not the experience at Murchison Bay.

There is no doubt that everybody at the station enjoyed the season which began around the time of the sun's return. It was pleasant to renew acquaintance with the animal life, which now gradually appeared. Tollén was especially enthusiastic and, being free from routine work after he prepared coffee in the afternoon, he had ample time to study the fauna. During the year 1957–58, for instance, about 80 polar bears were observed—or traces of them—either among the huts or nearby. Most bears were seen in March and April.

The excursions in the surrounding country gave

Tractor transport about to leave for Vestfonna to make arrangements for Station West-Ice.

Photo: Private collection of Gösta H. Liljequist.

Station West-Ice, situated near the summit of Vestfonna. The station consisted simply of three caves in the snow (left). Photo: Private collection of Gösta H. Liljequist.

The dining-room/kitchen/larder of Station West-Ice. The temperature begins to rise in late spring. From left: Pierre Wasserfallen, electrotechnician, and Gösta H. Liljequist, leader of the expedition (below). Photo: Private collection of Gösta H. Liljequist.

the station personnel an idea of how poor in snow the land really was. With winds between south and east, the station was situated in the precipitation shadow of the ice-caps of Nordaustlandet. These winds occurred when cyclones passed between Svalbard and Norway. Besides, the snow was blown away and remained only in local depressions of the ground, or in the lee of some slopes or rock outcrops. Sometimes a 100% snow cover formed, but the next gale often blew it away. However, a north-west flow of air, which originated from the polar pack and had passed across open water before coming over land, frequently gave rise to rich snowfalls and a 100% snow cover—until the easterly to southerly winds returned, when the snow on the ground blew away.

Such were the experiences from 1957–58, when the weather was affected by the open sea—although the situation in 1958–59 was to be different. Moreover, the snow conditions which prevailed in 1957–58 were favourable to the reindeer. These were observed throughout the year in the neighbouring country or even at the station, where they sometimes were seen feeding almost like cows on a farm.

The winter was milder than normal, and Murchisonfjorden was practically ice-free until January 22, when it grew colder (-15° to -20°) and rapid freezing occurred. An observation from Kinnberget on the 28th showed that the entire fjord was now covered by ice. In Hinlopenstretet and farther north, the ice did not appear until occasionally in the latter part of the winter—mostly slush and pancake ice. In the middle of April, ice seemed to cover the Hinlopen strait all the way over to Ny Friesland.

On March 13, a Catalina plane of the Norwegian Air Force arrived, dropping five mail-bags on the fjord ice near the station. The personnel's isolation was thus broken. It was remarkable how fast everyone disappeared into the cabins after the mail had been distributed.

STATION WEST ICE

The meteorological observations at Murchison Bay revealed the weather and climate conditions near sea level, but it was of interest to ascertain the conditions on the ice-caps of Nordaustlandet—in the present case, Vestfonna. Thus, such a station was being contemplated in February. The stay on the ice would last only a fortnight, as dwelling-place caves in the snow were to be used.

This outpost, called *Station West Ice*, was an improvisation. One of the Weasels of the glaciological expedition would be used, and one of the “caboose” sledges. There was not much snow on the ground, as mentioned, so the route over the ice-free land be-

tween the fjord and the edge of Vestfonna had to be reconnoitred. The route followed by the glaciological party in the previous summer could not be used, as it was too stony.

A study of the aerial photographs from Norsk Polarinstitut indicated a potential route along a ravine on the north side of Celsiusberget. During two reconnaissances in the field by Molander, Heikkilä and Engström, an approach to Vestfonna was found along this ravine. It then passed across the small De Geerfonna until it reached Vestfonna. The party continued with the tractor up along the slope of the ice-cap, to see whether there were any crevasses and whether the route could be used for transports.

Station West Ice was established on March 28–30 by a party of five. Equipment was loaded both in the Weasel and in the “caboose” sledge. At the start, the weather had been fine; but coming near Vestfonna, the party met with strong katabatic winds and drifting snow. A course of about 120° was steered, and every 1–1.5 km the track was marked with a stake. In the bad visibility which prevailed, they passed the highest part of the ice and continued down towards Wahlenbergfjorden.

They stopped at an altitude of about 560 m a.s.l. The surface of the ice had been wind-packed on the upward slope, but here the snow was rather loose. The upper 5 cm consisted of a crust which, when walked upon, broke into floes roughly 0.5 m across. It was like the much-appreciated boyhood sport of jumping from one piece of floating ice to another. Apparently this crust was just rime, formed by the supercooled droplets of clouds near the surface in situations with winds about south.

The party stayed here until March 30, and had by then made a cave with two rooms: a kitchen/larder/dining-room and a radio station/atmospheric-electricity observatory. A ditch with vertical walls was dug, enlarged horizontally, and covered with a sloping roof of ice-blocks, which in turn were covered in snow. The entrance went through a cubical box with a lid on top. To reach the entrance from within, a staircase of snow was dug out from each room. Later a third room was added for sleeping. Immediately upon arriving at the site, a thermometer screen was set up to hold thermometers and a thermograph with 14-day recording.

During the stay at the ice-cap station, the temperature varied between -18° and -32° , and at times there blew a fresh to strong wind with snowfall and drifting snow. But the weather was by no means as bad as it was down at Murchison Bay, where a gale raged with very heavy snowfall. On the way back to the base on March 30, the glaciological stake profile from the summer of

1957 was visited, but only stakes on the slope could now be found.

On April 9, the Vestfonna party was transported to the ice-cap station by Engström and Gröndahl. It consisted of four men: Molander, Junod, Wasserfallen and Liljequist. The afternoon and evening were devoted to mounting instruments, and to digging a large cave for use as a sleeping-room. The weather was excellent with a light wind, a clear sky and a temperature of about -25°C .

THE OBSERVATION PROGRAMME WAS AS FOLLOWS:

Meteorology

- 1) Weather observations at 00.00h, 06.00h, 12.00h, and 18.00h, besides supplementary observations at 15.00h and 21.00h. The air temperature was also recorded.
- 2) Measurements of the albedo of the snow surface, both for the total solar radiation and for different parts of the solar spectrum, with the help of selenium photoelectric cells and colour filters.
- 3) Measurements of the global radiation with an overcast sky in relation to the clear sky radiation.
- 4) The penetration of the sunlight into the snow.
- 5) Measurements of the temperature in the upper 30 cm of the snow.
- 6) Taking samples of air for determining its CO_2 content.
- 7) Taking samples of snow for chemical analysis.

Glaciology

Digging a pit, about 4.5 m deep, for observation of the stratification of the snow and firn, as well as measurement of the temperature and density—the temperature down to about 6 m by boring from the bottom of the pit.

Atmospheric electricity

Measurements of the electrical conductivity and the potential gradient (electric field force) of the air.

The stay on the ice gave a rather good idea of the weather conditions here during the transitional period between winter and spring. The station had been established in the coldest part of the winter—in 1958—with temperatures down to a few degrees below -30°C .

During the stay at the station, the temperature increased gradually to -4°C . The weather was mostly stable, but there were a few days with gales raging, besides overcast days with light winds and fog.

On an average, the West Ice station was 2.7°C colder than Murchison Bay, which corresponds to a temperature decrease with height of 0.5°C per 100 m. This is the normal temperature decrease which, in climatology, is generally used for reducing mean temperatures to a certain reference level, generally

the sea level. In other words, the cooling effect of the ice-cap upon the flow of air should be slight.

The albedo of the snow surface was found to be 96–97% in the visible part of the solar spectrum, and with an overcast sky the albedo of the total solar radiation was measured as 89%. The selective extinction of solar radiation penetrating into the snow was not so marked as found in the Antarctic, and the colour of the light did not attain a clear blue colour—as in the Antarctic—but was a vapid greenish-blue colour.

The summer surface of 1957 was localized in the pit at a depth of 166 cm. With a mean density of 0.415 g/cm^3 , this corresponds to an accumulation of 690 mm (water equivalent) since the autumn or late summer of 1957—which should be compared with the 250 mm of precipitation at Murchison Bay, according to ordinary standard methods with a precipitation gauge. The high accumulation must be explained as due to orographic effects on the windward side of Vestfonna.

The density of the snow and firn varied irregularly with depth, from 0.38 g/cm^3 near the surface to 0.55 g/cm^3 at 3–4 m. The stratification above 166 cm—from the top of a thick layer of ice—was characterized by porous strata alternating with strata of clear ice. The temperature in the snow near the surface on April 11 was -28.2°C , and increased with depth to -3.2°C at 5.9 m. On April 22, a new temperature series was carried out. The temperature had now risen considerably near the surface, to about -10°C .

The station was occupied at the beginning of the polar day, and the colours of the northern sky were bright purple at midnight. There occurred halo phenomena—although with relatively few components—and mirages in the layers near the surface. Beautiful orographic cloud-formations were seen, and marked rime formations were created in situations with fog. It was characteristic that a local layer of mist nearly always rested upon the ice, often within a limited region, while visibility otherwise was good. With winds higher than 5 m/s, the drifting snow flowed over the surface like water in a rapid. The mountains of southern Hinlopenstretet, and those at the south side of Wahlenbergfjorden, could be seen. To the north, the ice sloped upward and the majestic mountains in the Nordkapp region were hidden from sight. To the west, the ice-cap surfaced arched into a smooth dome.

From the Schytt campsite back to the base

On April 9, the Weasel arrived to relieve the observers. Molander and Junod were to leave, and Dyring was coming instead, while Wasserfallen and Liljequist stayed on. Helimäki and Wärme were passengers.

The Stoffregen aurora camera. The whole sky was photographed on 16 mm film, each minute under suitable weather conditions. With small electric lamps fastened to bows the position of the aurora in the sky could be determined. This Swedish project was led by Sven-Eric Molander. (Liljequist, G.H.: *Arktisk utpost.*)

At the position where the Ahlmann Station was situated on the summit of Vestfonna, 16 April 1958. The little "object" in front of Hans Engström's left foot was the only thing left to mark the position of the Russian camp of the *Ob* expedition of 1956. Photo: Private collection of G.H. Liljequist.

Now and then polar bears visited the Murchison Bay Station. The huts for geomagnetic measurements were objects of their interest. The number of visits from polar bears at Murchison Bay is shown in the table. The staples indicate the number of bears actually seen each month over the year. The broken curve indicates the number when observed footprints or howling dogs are included. Photo: Edgar Tollén.

The weather was fine, and suitable for finding Valter Schytt's camp from the expedition with the Russian research ship *Ob* in September 1956, when he and a party had been landed by helicopter on top of Vestfonna (see p. 546). The most important circumstance was that Schytt had left glaciological stakes, with the help of which it would now be possible to interpret the series of strata in the snow—especially the summer surface of 1956. It was therefore important to find the camp.

Molander had reconnoitred, using Schytt's compass bearings: the camp was supposed to lie a few km towards the north-east, but Molander had not seen anything.

A new attempt was made on April 9 using the Weasel. It was possible to follow Molander's footprints while taking repeated bearings. The camp was found at last, but not much could be seen above the surface—24 cm of an aluminium stake, and a small pennant fastened to it. From a distance of 25 m, the place looked like a small irregularity in the snow surface. Near the stake and 2.5 m below the surface, the rolled-up Russian tent and a cooking apparatus were found.

The camp was now marked with two stakes, and a big snow cairn was built to guide the glaciologists. It was situated on top of Vestfonna, and became the main glaciological station in the summer campaign of 1958, when it was named the *Ahlmann Station*.

The work at Station West Ice continued according to plan during the following week. It was now getting warmer, -4° to -10°C , which was found most agreeable in combination with strong solar radiation. In the snow cave, the temperature was still around -15° , but the upper layer of the snow had become warmer. When the Primus lamp in the roof was burning, water dripped upon the table below, where it froze. The cave was no longer a pleasant and clean abode.

The station was evacuated on April 23, but the thermometer screen with its thermometers and thermograph would henceforth be handled by the glaciological party.

The first glaciological group arrives—with the birds
A telegram arrived from Valter Schytt, stating that the Norwegian Air Force had promised to send a Catalina plane to Murchison Bay with five men of the glaciological expedition. A landing-strip some 1200 m long and an ice thickness of 1 metre were asked for. Schytt was worried about whether he could come up in time. So was the station personnel, for the ensuing mild weather was making the ice worse. A new telegram arrived: the landing-strip should be marked and, if there were large "sastrugis" or snow dunes, the

station personnel was asked to level the surface with a Weasel.

An acceptable strip had been found in innermost Kinnvika, west of the station, but it deteriorated as the days passed before the arrival of the plane on May 8. The marking of the strip was made with eider skins, rotten potatoes and other garbage from the kitchen. The landing was successful. The captain of the plane was Odd Haabet, the same man who had delivered mail to the station in March.

The glaciological party consisted of the following persons:

Valter Schytt, glaciologist, leader.

Weston Blake, American, glacial geologist.

Stig Rune Ekman, responsible for the seismic measurements of the thickness of the ice-caps; radio operator to the party.

Erkki Palosuo, Finlander, glaciologist and ice-expert.

Bertil Johnsson, mechanic.

The group had the reserve house at its disposal from then on, during the summer.

The glaciological party was now to travel over the ice-caps of Nordaustlandet for a month (in reality three weeks). Measurements of the snow accumulation and of the thickness of the ice-caps was foremost on the programme. During the rest of the summer, special investigations would be carried out on Vestfonna and in its marginal zone, including the ice-free country. In June a group of four more men was to come by ship.

The party started on May 13, with two Weasels dragging two sledges. Each evening Murchison Bay was in radio contact. This was for reasons of security, but the glaciological party was also given the correct time for astronomical determinations of position.

On May 14, the day after the glaciological party left, the weather changed dramatically. The wind shifted from SE to NNE–NNW, and kept this direction until the 24th. The sky was covered with stratocumulus or stratus clouds, and every day snow fell at temperatures of about -10°C . It was more like winter than it had been in the previous winter months. The change marked the prelude to a very bad summer, and this was felt strongly after the favourable weather conditions which had otherwise prevailed in the spring. The end of May was also overcast, but the temperature rose to between 0° and -5°C . These conditions prevailed during the first half of June, though with somewhat higher temperatures, and the ground was then snow-covered to 15%. After the 16th, the snow started melting and became coarse-grained, and the first flowers emerged.

On June 15 the *Nordsyssel*, with the "sysselman"

Odd Birketvedt, arrived and moored along the ice-edge off the station. The station received some extra equipment and a reinforcement of two men, who were to help Wärme with the chemical work during the summer: Stig Fonselius, M.Sc., and Bogdan Kviescinsky, a chemical engineer.

On June 29 the *Minna* arrived, bringing the reinforcement for the glaciological expedition:

Rolf Bergström, geologist.

Staffan Tengnér, chemist.

Anders Häggblom, geologist and geographer.

Paavo Sääpänen, limnologist.

The glaciological party of five under Schytt had already arrived at Murchison Bay in the night towards June 27. Since the 13th, the party had travelled over the ice-caps of Nordaustlandet. The weather had been very bad at times, but the scientific work was successful. This expedition was now up to full strength, and the second stage of the glaciological investigation could start.

It should be noted that a British ornithological expedition also came with the *Minna*, and was to be landed in the inner part of Wahlenbergfjorden. The visits of the *Nordysse* and the *Minna* had been favoured by beautiful weather. Ever since the return of the sun in February, birds had been observed at the station or in the neighbourhood—first ivory gulls, glaucous gulls, kittiwakes, terns, Arctic fulmars and snow buntings, and from the middle of March, eiders, auks, black guillemots, dunlins, and so on. The eiders gathered in groups of 50–100 individuals at the edge towards open water.

The reindeer had not been seen in May, but in June they appeared at the station, this time with newly born calves. They often grazed near the houses, as fearless as ever. They were also grazing in the relatively rich vegetation under a small bird-cliff on the north side of Murchisonfjorden. On the ice in the fjord, seals crept up through their holes, and from the top of Kinnberget it was possible to count some 200 individuals. Near the station, walrus were observed a couple of times.

Excursions

During the spring and summer, a number of excursions or tours were undertaken, largely to relieve the personnel from their captivity at the station. On April 25, Molander and Heikkilä, with four dogs and two pulkas, left the base to travel eastward across Vestfonna. But they were surprised by katabatic winds and had to spend two days in a snow bivouac on the slope of the ice. Their equipment got soaking wet, and they decided to return to the station.

Backa-breen to the south of Murchisonfjorden was

visited three times in the summer, partly to take snow samples for chemical analysis. Celsiusberget was visited on April 30, and the signal of the Arc-of-Meridian expedition of 1898–1902 was re-established, the intention being to fix the position of the station by triangulation, using some other existing geodetic points.

There was undoubtedly a marked difference between the southern and northern sides of Murchisonfjorden, at least in the outer parts of the fjord. In July when the northern side was practically free of snow, the southern side was still covered to 30% by deep snow in the area between Backabreen and Sveanor (the station site of Ahlmann in 1931). As regards animal life, too, the south side seemed to be poorer.

Two men stayed on Depotöya for some days to study birds. Another party of two walked along Lady Franklinbreen and along the edge of Vestfonna, ending up at Sveanor via Backa-breen. Finally, a group of three went by motorboat to the mouth of Wahlenbergfjorden, but were prevented by ice from penetrating into it. There were also visits to Söre Russöya, Krossöya and Depotöya.

Ice and break-up

At the beginning of July, the people at Murchison Bay had an indication of what could be expected later in the summer. Fog or misty weather had prevailed for some days, but on July 6 visibility improved. It was now discovered that the northern approach to Hinlopenstretet was blocked by pack ice, which had come drifting from the north two days previously—according to information obtained later on. The *Minna* and the *Sjövern* reported by radio that the whole north coast from Biscayerhuken eastward was blocked. The little *M/S Havella* with tourists on board had become shut up in Sorgfjorden just opposite Murchison Bay.

This was indeed a bad omen after several years of good ice conditions to the north of Svalbard. From Kinnberget it was possible to obtain a good idea of the distribution of the ice. The ice was strong and dense, and reached the islands in the mouth of Murchisonfjorden. From there it stretched across Hinlopenstretet—apparently unbroken—right up to Ny Friesland. The Hinlopen proper was, as far as could be seen, practically ice-free.

During the following days, the ice became more open and drifted toward the western side of Hinlopenstretet and toward Verlegenuken. On July 14 it was nearly ice-free, but for some isolated floes or strings of ice. The last of the winter fast-ice in Kinnvika drifted out of the fjord on July 8, and on July 15–18 the ice in central Murchisonfjorden broke up. But new ice

Map of northwestern Nordaustlandet and Hinlopenstretet. The positions of some scientific stations are given; viz. Murchison Bay, the Ahlmann Station, Station West-Ice, the British station of A.R. Glen, 1935-1936 and the German Station of W. Dege, 1944-1945. (Liljequist, G.H.: Arktisk utpost.)

American and Russian scientific stations drifting with the ice in the Polar Sea during the International Geophysical Year 1957-1958. Stations marked A and B were American stations, those marked NP4 and NP7 were Russian. (Liljequist, G.H.: Arktisk utpost.)

returned, and in Kinnvika there collected an ice field of strong and piled-up floes with a breadth of 500–1000 m.

The sky was mostly covered by dense clouds in July, with misty or foggy weather, and often sleet or rain. On July 13 and 16, the electric light was on almost throughout the day. The first days of August, though, were sunny with winds about south-east. But on the 5th, the wind changed to NNW, and thenceforth it stayed between west and north. Because of orographic effects, the sky became covered with low clouds, and at times precipitation fell, from rain to snow.

On August 4 the *Sjövern* with Kaare Lundquist anchored off the station. She was on an expedition for carrying out geomagnetic measurements. On board were three members of the Polish IGY expedition at Hornsund, among them the leader, Dr. S. Siedlecki. During the winter and spring, the two IGY stations, Murchison Bay and Hornsund, had corresponded over the radio. Another passenger was Arvid Moberg, a newspaperman from Luleå, Sweden, and deeply read in the history of Spitsbergen.

The *Sjövern* left next day, and with her went Liljequist. During the spring and summer he had received several appeals to come home, considering his new assignment. The ship's route passed via Hinlopenstretet, Heleysundet, Sörkapp, Hornsund (with a visit to the Polish station), Kapp Linné, Longyearbyen and Ny-Ålesund.

The Älvsnabben arrives

About August 10 the glaciological expedition returned—in different groups—after completing diverse field work. The packing of equipment was going on and was finished on August 20. The *Älvsnabben* would come to fetch them: she had left Göteborg on August 17 and was expected at Murchison Bay on the 23rd. Her commander was Captain Sven Österman, and the commander-in-chief of the squadron, Commodore Willy Edenberg (1910–1990), was also on board.

Also on the ship were Professor Lugeon, the head of the Swiss group, and Kjell Borg, the geomagnetician. Both had been to Murchison Bay in the summer of 1957. Furthermore, a group of four men was coming to replace the party which was now leaving for home. This group included Walter Bischof, who had organized the new expedition. He was to stay at the station for a few weeks and introduce the newcomers to their work.

However, on the 20th, the arctic pack-ice came drifting from the north-west and again blocked practically the whole north coast as far as Amsterdamöya in the west. When the *Älvsnabben* reached the north coast on the 22nd, she managed to get as far as

Verlegenhuken, but here she came to a sudden stop. From Kinnberget at Murchison Bay, it was possible to see the ship on the horizon through binoculars.

She proceeded to Ny-Ålesund, where help was promised by Kaare Lundquist and the "sysselman" for Svalbard, Odd Birketvedt. An ice reconnaissance indicated that it would probably be possible to make an exchange, using the *Minna* and *Nordsyssel*. Personnel and equipment were transferred from the *Älvsnabben* to the two Norwegian ships in Smeerenburgfjorden, and in the evening of August 29 they entered the southern side of Murchisonfjorden. A SSE gale was raging, though; the southern part of the fjord had got rid of the ice, but the two ships could not be unloaded at the station.

The gale had, however, given rise to open water off Ringertzöya, and along the coast to the west of the station. Both ships therefore proceeded to this foul stretch of coast and, after the gale had calmed down in the afternoon of August 30, the unloading and loading of equipment began. The tractors shuttled between the station and the landing-place, which lay about 2 km west of the station. This work lasted until 03.00h on the 31st. A few hours later, the *Nordsyssel* went to the north-western corner of Spitsbergen, where the *Älvsnabben* was waiting: on board were the Murchison Bay personnel of 1957–58, and the glaciological expedition. Only those who were to instruct the newcomers stayed on; they were taken aboard the *Minna* on the 31st, to be forwarded to the *Älvsnabben*. The ice had by then started to drift toward the coast.

The personnel of the two expeditions was transferred to the *Älvsnabben* on September 1, and the cargo later at Ny-Ålesund. Already that evening, the *Älvsnabben* left for Tromsø, where she arrived on September 3. The president of the Arktisk Forening in Tromsø, Fritz Oyen, had arranged the transport onward. On September 6 the two expeditions arrived by railway in Stockholm, hale and hearty. At Murchison Bay, the observation programme was maintained on a reduced scale for another year.

PROLONGED OBSERVATION ACTIVITY IN 1958–1959

From a manuscript by Lars E. Andersson

During the spring and summer of 1958, the thoughts of the people at Murchison Bay were occupied with the question of whether the station would be closed at the end of the summer, or whether the observations were to be continued for another year. The latter option had been discussed since the summer of 1957. Arne Sandström, project leader for cosmic ray, and Walter Bischof, the contact man, were keen on a continuation, and they kept the station informed

about the proceedings at home. Yet this information was by no means optimistic at first: the committee which had been set up for the purpose lacked money.

Everything was uncertain, but finally in the beginning of July 1958 a message was received, saying that the station was to continue for another year with a personnel of four and with a reduced programme. The leader would be Ivar Klang, one of the *Älvsnabben* crew of the previous year. The *Älvsnabben* would come to Murchison Bay with the new group and its equipment, and carry the "old group" back to Scandinavia. Lists of equipment were sent by radio to Bischof and his office in Stockholm—along with advice on various matters.

He had little time for definitive preparations, but the personnel was chosen:

Ivar Klang (b. 1917), warrant officer in the Swedish Air Force, leader of the group, radio operator, making meteorological and geomagnetic observations.

Sam Hagberg, engineer, responsible for the electric power station, workshop and heat installation; he assisted in the meteorological and geomagnetic work.

Pierre Wasserfallen, a Swiss member of the 1957–58 expedition, electrotechnician, making measurements in atmospheric electricity and radioactivity.

Lars E. Andersson, student of technology, responsible for the observations of cosmic ray and aurora.

The programme during 1958–59 would be reduced, though the observations and measurements of cosmic ray, geomagnetism, aurora, and atmospheric electricity and radioactivity were to go on as in the previous year. In meteorology, the weather observations would be reduced to four times a day, at 00.00h, 06.00h, 12.00h and 18.00h; recordings of global radiation and sunshine were to be made, but the radiosonde programme would be given up altogether.

The exchange of personnel and equipment on August 30–31 has been described above. Walter Bischof stayed with the new men in order to assist them at the beginning, until the latest connection by ship—the *Nordsyssel*—on September 21. At first, the new personnel were occupied with transporting equipment from the landing-place to the station, not least oil drums. The *Älvsnabben* had loaded 330 barrels for the expedition, mostly diesel oil. However, due to the problems with the ice, only about 110 barrels could be landed on Nordaustlandet. In addition, 50 barrels were left at the station by the previous group. During the wintering, this amount of oil proved to be quite inadequate (see below).

The transport of oil drums from the landing-place

to the station was carried out with utmost care, because of the rough terrain and the surface of sharp stones. As long as most of the oil was stored so far away from the station, it was essential that the means of transport were in good condition. After the oil barrels had come to the right spot, time could be found to collect and convey driftwood for the sauna.

Human life and animal life

The party soon established its routines. The station personnel was small, so it was impractical to arrange a regular night-watch. Hence the station was unguarded for 2–3 hours in the morning. At other times, there was always a man at work—making observations or measurements, preparing meals, attending the radio station, and so on. Lunch was served at 13.00h and dinner at 20.00h. The men alternated as cooks, for one week each time.

There was no doctor in the group, but Klang was trained in nursing. However, no need arose for his aid in that respect. As for the mental influence of the winter darkness, the men had their share of slight depressions, but these seem to have been fairly rare. L. Andersson considers

"...that darkness and isolation meant less than the prolonged periods of strong winds. These were indeed most trying."

The return of sunlight was, of course, enjoyed. On February 22, the sun could be seen for the first time; on March 28, there was daylight also at night; and from April 21, there was midnight sun. This was an agreeable season with long periods of fine weather.

No animal life existed at or near the station during the winter, except for a visit by a bear on January 16. The next visit did not occur until April 16, and only 15 polar bears were observed over the year. Some of these bears were intrusive, and one was shot after placing himself on the roof of the dwelling-house just above the entrance. The party brought very little fresh meat from Sweden, so they greatly enjoyed the meals obtained from a young bear, which they shot and prepared with due regard to possible trichinae.

The first bird of the year was an ivory gull. On March 23, Andersson and Wasserfallen observed an owl in the terrain at Mössberget, north-west of the station. Andersson writes:

"With the greatest probability it was a Snowy Owl. It is unbelievable to a layman that a bird of prey can find food in such an environment. Possibly it visits the slaughter-places of the bears to find remains of killed seals."

The ice conditions were anything but favourable. On April 8, open water could be seen far to the north; but on April 26, no open water could be seen from Kinnberget, except at the outlet of Claravågen to the north-west of the station, probably caused by tidal currents.

In Hinlopenstretet, the first open water of the year was noted on May 10—just a narrow lane northward from Sorgfjorden.

In the autumn they observed flocks of reindeer, counting 10–15 individual animals. But after the winter, reindeer were rare, only about six animals being seen altogether. Seals were seen in Murchisonfjorden at the end of April. The glaucous gull was observed on April 1, and then almost daily. On May 3 the men saw common kittiwakes, snow buntings, and a species of auk.

Weather and oil

Svalbard is situated between the ice-covered Polar Sea and the more or less open expanses of the Barents Sea and northern Norwegian Sea. Svalbard is thus influenced by mild and humid air masses from the open seas to the south or south-west. But in some years the cold air masses of the Polar Sea, and of the polar pack-ice itself, are displaced southward. Everything here depends on the general circulation in the atmosphere. The Svalbard climate is therefore maritime and mild in some years, while in others it is cold and somewhat continental. The first year at Murchison Bay was generally mild with very little ice, yet the second year was cold and the north coast was blocked by ice. A very sharp “boundary” between these two extreme weather types occurred in the beginning of July 1958.

The meteorological conditions during the observation period of 1958–59 may, in many respects, be compared with the conditions during the wintering of the Swedish Arc-of-Meridian expedition in 1899–1900 at Sorgfjorden, situated straight across Hinlopenstretet from Murchison Bay. (Compare the Tables on pp. 346 and 539). The very cold late winter at Sorgfjorden in 1899–1900 corresponded to the cold winter in 1958–59 at Murchison Bay. Noteworthy were the mild autumn and early winter in 1957–58; this part of the year was also characterized by strong and persistent winds.

Both winterings were markedly affected by the ice-caps of Nordaustlandet. With the prevalent S–E winds in 1957–58, the station lay in the precipitation shadow, with little snow which was often blown away. With the occasional NW winds in 1957–58, the low land of Storsteinhalvöya exercised an influence due to increased friction when the air flow came over land: the air had to rise, causing cloud formation and

snowfall. This was especially because, during the passage of the air across the open sea which then existed to the north, water vapour and heat were added to the low layers—the air had become labilized. In such situations, the snow resembled flour and led to a sharp deterioration of visibility. In the microscope, the snow proved to consist of frozen cloud droplets, which had collected on ice crystals.

In 1958–59, there were often winds from northerly quarters, but the snow precipitation differed considerably. The pack-ice then extended, from the polar pack of the central Arctic, right up to the coasts of Svalbard.

Turning to indirect effects of the weather, we have mentioned that the store of oil at the station was low, because of complications during the landing operations. The personnel tried to economize as far as possible. For the central heating and the diesel, they gradually also used paraffin oil. But finally, on May 1, they were forced to stop the operation of the station as regards the electrical instruments and apparatuses. Oil remained until mid-July for radio communications twice a week, and for heating and cooking. It was an advantage that the dwelling-house during this time was mostly covered in snow—the heat insulation was good.

On June 22 the *Nordsyssel* paid a visit—the first after the winter. She had met with severe and troublesome ice conditions on the way. Between Ringertzöya and the land, there was now mostly open water; but to the west of the island lay thick drift-ice. The gaps between the floes were frozen over, yet with treacherous and partly snow-covered rifts and openings, which led to many involuntary cold baths and even to a “swimming party”—when the station personnel with a boat tried to reach the ship, which was staying about 500 m off Ringertzöya. The station now received mail and some provisions, but the 25 barrels of diesel oil which were destined for the station had to be left on board the *Nordsyssel*.

Evacuating the Murchison Bay station

The observations at the station had already ceased to a great extent, and now the equipment had to be packed for transport home.

A group of six people was to come up and help the station personnel with this work. It consisted of: Eric Dyring, physicist, leader, member of the 1957–58 party.

Lars Dahlgren, meteorologist.

Gunnar Holmner, chauffeur.

Zahm Ottosson, technician.

Anna Greta Holmner.

Anna Greta Svensson.

The group travelled to Spitsbergen on the Norwegian passenger steamer *Lyngen*. At Virgohamna it was transferred with packing-cases to the *Minna*, which was to take the group to Murchison Bay. However, the *Minna* had to battle against ice: Hinlopenstretet was reached after four days and a half, but along the eastern side of the strait there was drift-ice, which prevented a landing. Instead, the *Minna* got the *Nordsyssel* to take over the task. The two ships met at Norskøyane, and the *Nordsyssel* managed to advance and land the new group, as well as to take some of the instrumental equipment aboard for transport to Switzerland.

After some measurements for cosmic rays and geomagnetism, the packing started. There was fast-ice in Kinnvika, and still in the last days of July great parts of Murchisonfjorden were covered by ice. Apparently the landing-place opposite Ringertzöya would have to be used this time too. The land transports of the equipment were planned accordingly. The wheeled tractor with a trailer, and one of the band tractors with a sled, were used. The frozen soil was now thawing and, in particular, the wheeled tractor got stuck repeatedly.

For transport between the landing-place and the ship, two boats with outboard motors were used, besides military landing boats which were towed in tandem. These boats were flat-bottomed and could

be loaded while standing on slips. For very heavy pieces of equipment, the party used the crane which was mounted on the wheel tractor. The launching was then performed in traditional style, though without champagne.

August 7 was the last hectic day on Nordaustlandet. The scientific station of Murchison Bay was now abandoned, and secured against the attacks of weather. Some equipment was left in the reserve house for anyone in future who might get into distress on Nordaustlandet. Next day there remained one heavy load to take aboard—the wheeled tractor with a weight of 1700 kg, which was too much for the winches of the two ships. Gunnar Holmner worked the last of his wonders on Nordaustlandet: with a few assistants and some monkey-wrenches, he managed to divide the tractor into two parts, which could be handled.

Both ships steered west, the *Minna* to make measurements along the north coast of Spitsbergen, the *Nordsyssel* to take the Swedish expedition members and equipment to Longyearbyen, where they arrived on August 9. Next day they boarded the Norwegian collier *Ingerfem*, bound for Hammerfest.

The two years of observation activity at Murchison Bay were completed, and the last expedition members returned to their homes. They were healthy and happy—like the personnel of the 1957–58 expedition—and none had suffered any injuries during the stay on

TEMPERATURE AND WIND SPEED AT MURCHISON BAY,
lat. 80°03.5'N, long. 18°15'E. August 1957–July 1959

	Monthly mean temperature, °C			Mean wind speed (m/s) at 10 m above the ground		
	1957	1958	1959	1957	1958	1959
Jan.	–	–11.2	–23.6	–	7.4	3.4
Feb.	–	–15.8	–20.5	–	6.3	7.5
March	–	–18.2	–22.1	–	5.7	4.8
April	–	–13.6	–13.5	–	4.1	4.3
May	–	–4.3	–6.0	–	6.2	4.5
June	–	–0.3	–0.5	–	4.3	5.2
July	–	+2.3	+1.9	–	4.3	4.1
Aug.	+3.7	+1.1	–	4.9	5.2	–
Sept.	–0.1	–3.4	–	5.0	4.8	–
Oct.	–0.9	–8.4	–	9.1	5.9	–
Nov.	–8.0	–13.2	–	8.6	6.8	–
Dec.	–14.4	–18.5	–	6.3	5.6	–
Highest Temp (°C)	(Aug. 1957 – July 1958) =			+9.1 (Aug 1957)		
"	(Aug. 1958 – July 1959) =			+8.5 (July 1959)		
Lowest Temp. (°C)	(Aug. 1957 – July 1958) =			–31.6 (March 1958)		
"	(Aug. 1958 – July 1959) =			–40.3 (March 1959)

Scientific stations in the Arctic and the Subarctic during the International Geophysical Year, 1957-1958. (Liljequist, G.H.: Arktisk utpost.)

Scientific stations in the Antarctic during the International Geophysical Year, 1957-1958. The Antarctic Convergence separates the cold Antarctic waters south of the convergence from the warmer Subantarctic to the north. Often this oceanic front is taken to define the extension of the Antarctic regions. The stations Vostok, Amundsen-Scott (The South Pole) and Byrd were situated on the inland-ice and at height of 3420, 2880 and 1515 m a.s.l., respectively. The first two stations indicate a remarkably severe climate with annual mean temperatures of -55.4° and -48.9°C , respectively.

Nordaustralandet. Their experiences had been more troublesome than those of the previous group, but all had ended well.

THE INTERNATIONAL GEOPHYSICAL YEAR IN THE ANTARCTIC

While the International Geophysical Year 1957–58 was intended to embrace the whole Earth—or rather, chosen regions of it—the greatest attention was paid to Antarctica, and rightly so. At the time, this continent was virtually unknown in its interior. The geophysical conditions were of special interest because of their ideal nature. Here a land of continental extension is covered by a thick inland ice mass situated almost symmetrically round the South Pole. Moreover, it is surrounded by oceans almost free of land until high up into middle latitudes.

In sum, the region constitutes a vast scientific laboratory with the most simple conditions imaginable: a uniform land surface of snow and ice with a very high reflectivity for solar radiation, in the midst of wide oceans that are very little disturbed by the land masses of the Southern Hemisphere.

For added simplicity, there is polar night in the winter and midnight sun in summer, and—as regards geocosmic physics—the geomagnetic pole lies within the region.

Man now possessed the technical facilities to carry out extensive scientific research here: strong ice-breakers and ice-strengthened freighters, large long-distance planes, new and effective instruments for the investigations, snow tractors for extensive travels into the interior of the continent. Further, the experiences and scientific results gained by the Norwegian-British-Swedish Antarctic Expedition in 1949–52 were to be of great value to the campaigns in the Antarctic during the IGY of 1957–58.

Twelve nations were most directly involved in the IGY Antarctic research, although later a few more nations became interested. Among these twelve were *Chile, Argentina* and *South Africa*, all three being Southern Hemisphere states; and the *USA, Great Britain, Norway* and *USSR*, all having Arctic and/or Antarctic territories.

The following three nations took part in the activity in the Antarctic for more special reasons. *France* possessed scientifically strategic islands in the Southern Ocean—Kerguelen, Crozet and New Amsterdam—besides Adélie Land on the continent. *Japan* had interests in the antarctic whaling industry. *Belgium* had sponsored the expedition with the *Belgica* in 1897–99 (see p. 362).

During the first and the second Polar Years, only two stations had been occupied in the Subantarctic,

and none in the true Antarctic. In 1882–83, France worked at Cape Horn, and Germany in South Georgia. In 1932–33, Argentina occupied stations in the South Orkneys and in South Georgia.

But during the IGY in 1957–58, about 40 stations were established within the land and sea regions encircled by the Antarctic Convergence—the boundary separating cold and less saline water masses to the south from warmer and more saline water masses to the north.

Biologically these two regions constitute different worlds of fauna and flora. In the Antarctic Peninsula with off-lying islands, a dense network of stations was established, in some cases with stations only a few kilometres from each other. These stations served political rather than scientific considerations. The positions of the different stations can be seen from Fig. p. 540.

The American and Russian contributions in the Antarctic were outstanding. These states possessed the technical facilities, besides experience from the Arctic. At the coast, the USA had the main base McMurdo, and the USSR the base Mirni. From these, the interior of the continent could be investigated and scientific stations established—notably the American ones, Amundsen-Scott at the South Pole, and Byrd in the interior of West Antarctica. The Russians established, among others, the station Vostok near the South Magnetic Pole in the interior of East Antarctica. This station had an utterly extreme continental climate of very low temperatures and scant precipitation, and was situated at a height of about 3400 m a.s.l.

From stations along the coast and inland, long traverses were carried out, elucidating the physical features of the inland ice and the land below it, as well as the conditions in the atmosphere above.

The International Geophysical Year activity was prolonged. Already in September 1957, a special committee for the purpose had been created in Stockholm: the *Special Committee for Antarctic Research, SCAR*. Its first meeting was held at The Hague on February 3–5, 1958, and laid the foundations from which the committee has developed.

At the same time, the name of the committee was changed to *Scientific Committee on Antarctic Research*, still abbreviated SCAR. It had one delegate from each of those states which were actively engaged in antarctic research, and one delegate from each of a number of scientific unions: the IGU, IUGG, IUBS and URSI (International Geographical Union, International Union of Geodesy and Geophysics, International Union of Biological Sciences, and International Scientific Radio Union) (see further p. 581).

THE INTERNATIONAL GEOPHYSICAL YEAR IN THE ARCTIC

The activity in the Arctic during the IGY did not awaken the same interest as that in the Antarctic. The entire Arctic now possessed a fairly dense network of meteorological stations. The Canadian Arctic Archipelago, which had been the last region without a satisfactory network, had been provided for at the end of, and after, World War II. Here the observation activity could easily be enlarged to meet the demands of other geophysical disciplines.

During the two polar years 1882–83 and 1932–33, the Polar Sea had been devoid of any stations—although, during the preparations of the latter polar year, the establishment of such a station had been discussed. In April 1941, two Russian planes had landed on the ice in the Polar Sea. Scientists on board the planes had carried out geophysical observations, after which the planes had lifted to look for a new landing-place, where new observations were made, and so on. This was a method hitherto not attempted. It offered hopes of supplying considerable scientific information within a reasonable time.

Previously, ships specially built for the purpose had drifted with the ice and served as scientific stations, beginning with the Norwegian ships *Fram* and *Maud* in 1893–96 and 1922–24 respectively (see p. 149 and 408). In May–June 1937, the Russians had established a station, *North Pole 1*, at the geographical North Pole with a quartet of four-engined airplanes. The station with its personnel of four men drifted with the ice toward north-east Greenland, and later with the East Greenland current, until—at about 71°N—the expedition could be relieved on February 19, 1938. In 1950 the Russians continued the polar activity which had

been tested before, and in the beginning of, the war.

After World War II the Americans made flights over the Polar Sea, among other things for meteorological purposes. Their radar screens revealed large massive areas of ice, which proved to be floating ice-islands similar to antarctic tabular icebergs. Later studies showed that these originated from shelf-ice off the north coast of Ellesmere Island. In March 1952, a small group under Lt. Col. J.O. Fletcher was landed on one of these islands, called T-3; and in June, meteorological observations were started there.

The Americans had thus found a safe platform from which various observations could be carried out—that is, safer than the floes of sea-ice. The ice-islands generally followed the drift in the anticyclonic vortex, which prevails in the Polar Sea in the American sector of the Arctic. In some cases the ice-islands might slip out into the East Greenland current and be lost. In the Russian sector, on the other hand, the main drift is generally directed toward the gap between Spitsbergen and Greenland, near which the floes of ice become rafted and hummocky, or else split. A station on the sea-ice has to be evacuated before this happens.

During the IGY, four stations were operated on the ice in the Central Arctic, two by the Russians and two by the Americans. They were, respectively, North Pole 6 and North Pole 7, and Station A and Station B (the famous T-3). Their drift, and the beginning and end of their operation, are given in Fig. p. 540. It should be noted that Station A was situated on an ice-floe, whereas Station B was on an ice-island. The Russians also had one of their stations, North Pole 6, on an ice-island, but North Pole 7 was situated on a floe. Both of the stations operating from the sea-ice experienced trouble with it.

The *Nordsyssel*, official ship of the governor of Svalbard, visits the Murchison Bay Station as first ship of the season, 15 June 1958. (Liljequist, G.H.: Arktisk utpost.)

46. THE GLACIOLOGICAL EXPEDITIONS OF VALTER SCHYTT

Stig *Valter* Schytt (1919–85) was a pupil of Hans W:son Ahlmann, who inspired him to take up studies and research within glaciology. He was also given opportunities to devote himself to glaciological field work in different parts of the world, notably the polar regions and the mountains in Swedish Lapland, for which he was remarkably suited—scientifically, mentally and physically.

Schytt was engaged in glaciological field work from about 1945 until his death in 1985, either in the polar regions or among the Swedish mountains—and at the writing desk when studying his observations. His preparations included work at the glaciological station Tarfala in 1945–49. This station, situated in the Kebnekaise Massif in Swedish Lapland, had been founded on the proposal of Ahlmann in 1945. The post as “managing director” was earmarked for Schytt, and here he worked throughout his final years (compare p. 497).

Schytt was attached to the Department of Physical Geography at Stockholm University during the whole of his active life, since undergraduate days. He was a physical geographer specializing in glaciology. He disputed for his doctor’s degree in 1958 and was appointed lecturer in the same year. His chance to carry out full-time research in glaciology was secured in 1963, when he was awarded a professorship in the subject by the Swedish Natural Sciences Research Council.

Schytt’s visits to the polar regions are summarized below:

- 1949–52 Glaciologist and second in command of the Norwegian-British-Swedish Antarctic Expedition to Dronning Maud Land (see Chapt. 44).
- March 1954 A visit to the Canadian Arctic for the specific purpose of investigating the possibilities of carrying out snow studies from the air.
- Summer 1954 Glaciological studies near the American air base at Thule in north-western Greenland.
- 1956 A visit to North Greenland waters and Svalbard on the Russian icebreaker and research ship *Ob*. An adventurous but most valuable visit was paid to the summit of Vestfonna, the western ice-cap of Nordaustlandet. This visit was a preparation for the glaciological expedition which Schytt was planning for 1957 and 1958.
- 1957 A short visit to the Murchison Bay IGY station

in preparation for the activities of his glaciological expedition in the summer of 1958.

1958 Leader of the Swedish glaciological expedition working on the ice-caps of Nordaustlandet and in the region of Murchisonfjorden.

1966 Co-leader, with Professor Gunnar Hoppe, of the large glaciological expedition of Stockholm University. The expedition worked in eastern Svalbard from the base Murchison Bay, which had been established by the IGY expedition of 1957–58. This base is often referred to as Kinnvika.

1972 A visit to Deception Island in West Antarctica for stratigraphic studies in a glacier, whose layers had become accessible due to volcanic activity a few years previously.

1980 Scientific leader of the Swedish expedition YMER–80, with the icebreaker *Ymer*, in celebration of the 100th anniversary of the passage of the *Vega* along the North-East Passage.

The first years (1945–49) of field work at Tarfala supplied Schytt with rich experiences, which he could build upon when he planned his glaciological work for the Norwegian-British-Swedish Antarctic Expedition in 1949–52 (Chapter 44). His scientific work at the base Maudheim and among the mountains of western Dronning Maud Land became pioneering, and served as models for other investigations in the following years, not least during the International Geophysical Year in 1957–58.

TO THE CANADIAN ARCTIC AND GREENLAND IN 1954

The years just after the expedition of 1949–52 were naturally devoted to studying the data which had been collected during the two years in the Antarctic. However, Schytt had an interlude of travel.

In 1953–54 he served as a visiting professor at Northwestern University in Evanston, Illinois. And in March 1954 he was given the opportunity to travel by air over a great part of Canada for the purpose of investigating the possibilities of carrying out snow studies from the air.

The first leg of his air travels brought him from Winnipeg to Churchill on the west side of Hudson Bay,

“...where the tree limit practically comes down to the shore, while the village itself is situated on open tundra. From the airplane it is difficult to see where the tundra terminates and the sea-ice begins; everything is white and vaguely outlined.”

From Churchill he travelled back to Winnipeg, and from there westward over the interminable prairies to Edmonton in Alberta. The itinerary of the flight then went north via Fort Smith, Hay River, Norman Wells and finally to Aklavik in the delta of the mighty Mackenzie River. The last leg, from Norman Wells to Aklavik, took place on board a single-engined Norseman plane running between the two places once a week.

The flight gave him a good picture of the natural conditions in the Subarctic when approaching the Polar Sea to the north, with marked Quaternary deposits which, thanks to the sparse vegetation, were seen extremely well from the air. A week's stay at Aklavik showed him many of the problems which arise in a village, situated in the flat delta land, due to the permafrost and its thawing in the upper layers during the summer.

In the summer of 1954 Schytt was occupied with glaciological investigations on the Greenland inland ice, near the American air-base Thule in north-western Greenland. These studies were carried out under the auspices of the *Snow and Permafrost Research Establishment of the US Army (SIPRE)*. Schytt was the leader of a field party working here, including a young student who carried out the meteorological observations: Weston Blake Jr., who was to become a valuable expedition companion of Schytt's in coming years. The investigations were directed towards finding the origin of ramps as opposed to cliffs at the edge of the inland ice.

When Schytt came home to Sweden, preparations for the International Geophysical Year 1957–58 were going on, but there was no place for glaciology. However, he started to prepare an expedition of his own and, though means for such an enterprise were missing to begin with, a possible solution emerged. In 1955 it was decided that the Swedish-Finnish-Swiss IGY station would be located at Murchisonfjorden in the west of Nordaustlandet, Svalbard, within easy reach of the ice-caps of this island. It would therefore be possible to reduce the costs of a glaciological expedition to Nordaustlandet, as the problem of transports could be overcome. Besides, there were the advantages of using the station as a rallying point, as well as the chance to use the facilities and manpower at the station. The expedition's finances were arranged later on.

THE RUSSIAN EXPEDITION WITH THE *Ob* IN 1956

Background and members

In May 1956, an IGY conference was held in Stockholm to coordinate the arctic research plans of those nations which bordered upon the Arctic. A happy event was that the conference was attended by several prominent Russian scientists. In the glaciological working-group, Schytt presented his plans concerning a glaciological investigation of the ice-caps of Nordaustlandet. He was then invited by the head of the Glavsevmorput (p. 149), V.F. Burkhanov, to take part in an arctic expedition with the icebreaker and research ship *Ob* to the seas around Svalbard. He was also promised a visit to Nordaustlandet and its ice-cap, and a few days' work there in preparation for his glaciological expedition.

Besides Schytt, two other Scandinavian scientists were coming: Erik Eriksson (b. 1917), an atmospheric chemist of Stockholm University, and Nils Jörgen Schumacher (b. 1919) of the Meteorological Institute, Oslo, a member of the Norwegian-British-Swedish Antarctic Expedition in 1949–52. Eriksson intended to study the regional distribution of the CO₂ content of the air, and its content of dust and salt particles; Schumacher planned to carry out radiosonde ascents to supplement his observations from Maudheim in Dronning Maud Land.

The *Ob* was an icebreaker of 7500 hp, built in Holland together with two sister ships, the *Lena* and *Yenisey*. These served as freighters along the North-East Passage, while the *Ob* was specially equipped for scientific research.

The commander of the *Ob* was Captain Inyushkin. The staff of scientists and their assistants on board counted 44 persons, of whom 12 were women. They represented a number of scientific disciplines: oceanography, meteorology, hydrochemistry, geology, hydrobiology, microbiology, and so on. The scientific leader was Leonid Balakchin, an oceanographer from the Arctic and Antarctic Institute in Leningrad. The second scientific leader was J. Gakkel, a geographer with many arctic expeditions behind him: the discovery of the Lomonosov Ridge at the bottom of the Polar Sea is usually ascribed to him.

The three Scandinavian guest-scientists embarked the *Ob* in Stockholm, and on August 8 the ship started upon her scientific mission. The Russian mining village Barentsburg in Spitsbergen near the mouth of Isfjorden was visited on August 14–15, and on the 16th the *Ob* steered westward along the parallel of 78°N, to make observations in physical oceanography and to study the marine fauna and flora. The geologists under Nikolai Belov, who had previously inves-

Valter Schytt, 1919–1985. Photo: Private collection of Anna-Nora Schytt.

Not shown in digital edition

Stratification in the uppermost layers of snow, firn and ice, on the summit of Vestfonna. The summer melting of the snow in the surface layers creates problems. The melt water percolates downwards and spreads horizontally on cold strata of snow where it refreezes to form ice layers in the otherwise mostly coarse-grained snow. With experience these ice layers can be interpreted and may be distinguished from the summer surfaces in the snow. A dating is also obtained by spreading a dye on the snow surface and later determining its depth in the snow. See the position of the dye layer of September 1956 found in the summer of 1958. Note: The thick black lines are strata of ice resulting from the spring melting and refreezing. (Geografiska Annaler 1964.)

In the summer of 1956, Valter Schytt was invited to take part in a scientific cruise onboard the Russian ice-breaker and research vessel *Ob*. At the time Schytt planned for a glaciological expedition to Nordaustlandet, Svalbard. The *Ob* met with several untoward events but these events were in fact, favourable for Schytt in his planning and in the scientific outcome of his own expeditions of 1957 and 1958. The map shows the route travelled by Schytt. Note that the tour from Nordaustlandet to Franz Josef Land went by air, first by helicopter, later by twin-engine airplane. (Ymer 1957.)

A group from the *Ob* – including Schytt – was in September 1956 landed on the summit of Vestfonna, Nordaustlandet, but unsuitable weather conditions resulted in a longer stay than planned, more than two weeks instead of one day, besides a crashed helicopter. The five men on Vestfonna were ultimately relieved by the polar pilot Moskalenko in his twin-engine plane, which was sent up from Moscow. The scientific outcome of the two weeks on Vestfonna provided Schytt with a key to the unexpected mass balance of the ice-caps of Nordaustlandet.

tigated the bottom sedimentation in the central areas of the Polar Sea, carried out similar observations now.

In the Greenland Sea

On August 18, two days after the departure from Barentsburg, the first ice was met with. It was rather scattered, but there was a marked ice blink ahead, which indicated more dense ice fields. Next day the sea was 70–80% covered with ice, most of it flat and one year old, generally 2–3 m thick.

Nearer Greenland, the ice became more open, and along the coast was a coastal lane quite free of ice; but they observed a great number of tabular icebergs resembling those in the Antarctic. On the request of Schytt, the ship approached the north-eastern headland of Greenland, Nordostrundingen, to within 7 nautical miles. Shelf-ice of a type similar to those in the Antarctic was observed here. It is, however, not connected with the large inland ice of Greenland; the ice-cap of Nordostrundingen is a geographically isolated ice-cap. The great concentration of tabular bergs was explained by the fact that they were grounded upon the submarine ridges which occur in this region. It should be noted that this area had never before been visited by ships—all previous ice observations had been carried out during sledge expeditions and from airplanes.

The *Ob* proceeded north from Nordostrundingen, but at 82°56'N it was found desirable to turn back because of heavy ice. There were more important things to do than butting against the ice. Instead the ship proceeded east towards Spitsbergen, now between the parallels of 79° and 80°N, and on September 4 they were back in Spitsbergen; but strong winds now prevented oceanographic research. The *Ob* steered towards Nordaustlandet, where Schytt was to get a few days for his glaciological work.

To the summit of Vestfonna on Nordaustlandet

On the 6th, two attempts were made by helicopter to reach the summit of Vestfonna, the western ice-cap of Nordaustlandet, but the weather prevented it. However, they flew with the helicopter over Lågöya and observed reindeer and enormous amounts of driftwood, and also over the prospective site of the Swedish-Finnish-Swiss IGY station at Murchison Bay.

Next day, September 7, the weather was better, and it was possible to land on the summit of Vestfonna. After the landing, the clouds dissolved and Schytt was surprised to find that as much as 40 cm of loose, newly fallen snow covered the ice-cap. Above it the surface was studded with frost flowers, which had grown to a height of several centimetres, pointing toward the north from where the wind had blown lately.

The helicopter carried out three sorties to the summit, and in the evening several people were assembled at this desolate place: the three Scandinavians, Balakchin, an interpreter, a meteorologist, a trainee glaciologist, a film and instrument man, and the whole helicopter crew. Before evening, Schytt had completed his glaciological programme connected with the visit. Eight electric thermometers were placed at as many depths in the firn between 3 m and 10 m; at the same time, the borings provided him with a core of the firn and ice between these depths. This core was to be delivered to the cold-storage room of the *Ob*, to be forwarded to Stockholm. Schytt and his assistants had also dug a pit down to a depth of 3.4 m, where he could study the stratification and the structure of the snow, firn and ice. Finally he had raised an accumulation stake 4 m high.

Next morning—September 8—a few attempts were made to land with the helicopter in the ablation region of the ice-cap, near its edge. The low visibility forced the helicopter crew to give up the attempts and return to the summit. The weather was deteriorating and it was deemed necessary to evacuate the camp on the summit. Three men could go by the first helicopter transport—besides the helicopter crew. Five men were left to be fetched as soon as possible—Balakchin, the young meteorologist and the three Scandinavians—but there was no interpreter among them.

An adventurous sojourn on an ice-cap

The stay on the ice-cap was to be longer than planned. It turned out later that the pilot, after delivering his three passengers to the ship, decided to use an advanced base on Lågöya, where he could await improvements in the weather. However, he set his craft on the relatively thin ice on a lake, believing it to be snow resting on land. The ice broke under the weight of the helicopter, which capsized and sank in part. One man managed to open a window, dive into the water and crawl up on to the tail, where he could open a door and help the others out. This was in the nick of time, as one man had become unconscious by then. The crew had retrieved their emergency transmitter and could send SOS signals to inform the ship.

The crash took place at 14.00h on September 11, and the SOS signals were transmitted at 18h. At 23.00h, a relief party of seven men left the *Ob*; and at 09.00h on the 12th, it reached the helicopter crew. Two days and nights after the crash, everybody was on board again. Special measures now had to be taken to get the people on Vestfonna safely back to the ship. The helicopter was damaged beyond repair where it lay.

The men on the ice-cap had no radio and did not

know why the helicopter failed to return. There was unsuitable weather for any landing on the ice-cap on September 9 and 10, but the men on the ice could hear the helicopter during both days. On the 11th the weather improved in the evening, and the men started to wonder why the helicopter came only when the weather was bad.

On the 12th the weather was fine, and in the afternoon a twin-engined plane appeared. It dropped a message to them: the helicopter had crashed on Lågöya about 40 km to the north-west, but the crew was safe and sound and was making for the ship. A short while later, they got another message: Moscow had decided that the party should be evacuated by air; the polar-pilot Moskalenko was on his way to Franz Josef Land, where skis were to be mounted on his plane; he would come as soon as time and weather permitted.

So now they had only to wait. They had previously discussed an eventual march down to the coast, which was estimated to take three days. This had to be weighed against the fact that their position on the ice-cap was known, but nobody would have any idea of their whereabouts on the coast, nor would it be easy to distinguish them from the bare ground or the rocky background. So they stayed put. Schytt writes:

"We had a large and roomy tent, we had good clothes and sleeping-bags and—at least to begin with—we had a good store of fuel and plenty of food. I had brought with me one of the new and handy propane stoves from Primus. When the four gas bottles I had brought were empty, and these went quickly with the great consumption during the two first days, we changed to the Primus paraffin stove which I had as a reserve. But my fuel was for 3 men and 8–10 days, and on September 11 the paraffin too was finished. Now we had to change over to a Russian petrol stove, which we would not take into the tent because of the fire hazard. All cooking had to be done outdoors, and from then on it was rather cold in the tent; especially the drying of wet clothes was ineffective. The temperature outside varied between -1°C and -13°C , and indoors it was probably between $+5^{\circ}$ and -10°C ."

For Schytt in particular, these days on the summit of Nordaustlandet were valuable, in that he had ample time to get to know the glaciological conditions which prevail here. Again we cite him:

"The snow surface was covered with a thick layer of fog-frost, and during our stay we observed

beautiful examples of the enormous formation of the fog-frost which occurs here. During one single night an aluminium tube, 2 m high and 2.5 cm wide, became surrounded by 8 cm of fog-frost, and my accumulation stake grew thicker and thicker as the days passed. It makes one inclined to believe that the fog-frost represents an important contribution to the net accumulation. However, I do not believe so. In a small pit, which had been dug through the newly fallen snow, I could clearly distinguish 5 layers of fog-frost similar to that at the surface. They were all marked, but I am sure that they made up less than 10 percent of the accumulation here.

Our snow thermometers had ample time for indicating correct values. It emerged that the cold of winter (since the preceding summer) had already reached a depth of 1 m. From 1 m to 7 m the snow had a temperature of 0°C , but below 7 m negative temperatures made their appearance again.

While we waited for our evacuation, we dug a pit 7 m deep. The extremely thick layers of ice indicated a strong summer-melting and a subsequent intense refreezing farther down in the firn. Between 5.5 and 6.0 m, for instance, we passed through a layer of ice which was 45 cm thick, and if I had not expected such layers, I would have believed that we had reached down to the pure, solid glacier ice. However, below this layer of ice the firn was loose and coarse-grained, and differed little from that at depths between 1 and 1.5 m. Here is a region of great interest for studies of the formation of the glacier ice; the conditions differ much from those prevailing in temperate and high-polar glaciers.

The annual stratification was not quite unambiguous, and I prefer to wait another year before mentioning how large an income the ice-sheet has, but we could now take samples of the snow on either side of the conjectured summer surfaces. These samples will be analyzed in Stockholm. Other samples of the snow were intended for chemical analysis.

We had ways of whiling away the time, but it should not be denied that we would rather have seen that our stay did not turn out quite so long."

To the relief of the party

In the morning of September 21 the reconnaissance plane arrived, and the party on the ice was informed that Moskalenko had got orders to start from Nagorskaya, the small polar village and airfield on the nearest island in Franz Josef Land. The party pre-

pared a fine airstrip, and at about 10.00h Moskalenko landed his twin-engined plane.

"Suddenly there was a great crowd on the ice."

They had to pack rapidly and load the plane with their possessions, but some equipment was left behind—the tent, the cooking apparatus, and great amounts of food. At about 12h on September 21, the plane started for Nagorskaya. Perhaps Schytt was the only one in the party of five who wanted to come back to the summit of Vestfonna.

The rest may be summarized briefly: they spent two agreeable days at Nagorskaya. In the night towards the 24th, the *Ob* arrived to fetch them, then proceeded south. The Scandinavian guests were landed in Göteborg on September 29. To Schytt the expedition had been of great importance in his future scientific work. However, the crash of the helicopter affected the research programme of the *Ob* unfavourably. But in the following year, 1957, the investigations in the northern waters of Svalbard could be continued by the *Lena*, the sister ship of the *Ob*.

One may well ask whether any attempts had been made from Swedish and Norwegian side to assist the group on Vestfonna. In fact, the Norwegian "sysselman" Rynning Tønnesen organized a relief expedition with the *Nordsyssel*. A sledging party of three under him was landed at noon on the 19th at Brageneset at the mouth of Wahlenbergfjorden, from where an easy approach leads to the central parts of Vestfonna. The sledgers returned at 01.00h on the 21st, without having found the party on the summit. After a rest, they started again at about noon the same day. They did not know that Moskalenko had by then landed with his plane on Vestfonna.

In Stockholm, preparations for a rescue expedition by air were started on the initiative of Dr. Carl Mannerfelt. A group of three—consisting of Professor Gunnar Hoppe, the meteorologist Gösta H. Liljequist, and Carl M:son Mannerfelt—launched into hectic activity in the forenoon of September 21. Not much was known at the moment: the Norwegian sledging party had returned in the night after their first tour without having found the camp. The missing group might have marched down to the coast; their store of food and fuel might be running out. In that case there was a great probability that they had marched for Kinnvika in the north of Murchisonfjorden, the prospective site of the IGY station of Sweden, Finland and Switzerland. Else, of course, they might still be in the camp waiting for a plane. In any event, relief by air was deemed necessary.

The Swedish Air Force was contacted, as was the

Swedish Foreign Office. One plane was available, a Catalina, which at the moment was at Ronneby in southern Sweden. But it had to pass an overhaul, and because of the long flight there must be double crews. Finally it was decided that the plane should be ready to start from Stockholm on the 23rd, with Liljequist as a passenger. However, at about 17.00h on the 21st, a message arrived to report the successful relief flight of Moskalenko. So the preparations which had started in Stockholm could be called off. It had been a matter of scarce information.

47. THE GLACIOLOGICAL SVALBARD EXPEDITIONS OF 1957 AND 1958

Plans and expedition members

It was long uncertain to what extent the prospective glaciological expedition under Valter Schytt would be realized. Finances had to be applied for, from both scientific funds and private firms, in Sweden and in Finland. A definite programme could not be formulated until the day when the Swedish Army promised to place two Weasel band tractors at the disposal of the expedition.

The plan for the investigations on Nordaustlandet contained the following separate studies:

1. An investigation of the mass balance of the ice-caps, meaning the annual incomes and expenses in the form of snow accumulation and melting/evaporation;
2. A study of the temperature conditions in the firn and the ice, and the influence of temperature upon the formation of the glacier ice;
3. A seismic investigation of the thickness of the ice-caps;
4. An investigation of the glacial history of Nordaustlandet.

During the Swedish-Norwegian Svalbard expedition of 1931, Ahlmann had studied the mass balance on Nordaustlandet. His studies had subsequently served as a model, notably during the British expedition of 1935–36 under A.R. Glen. The values, though, seemed unexpectedly low, and the logical consequence was that the ice-caps of Nordaustlandet should be more or less *passive*.

These ice-caps are of a type referred to as sub-polar glaciers: the meltwater in summer percolates into the snow, where it refreezes. This fact called for studies of the temperature conditions in the ice and snow and

firn over the year. The studies of the mass balance of the ice-caps also required investigation of the thickness of the ice and its geographical variation.

The glacial history can be derived from knowledge of previous strandlines, through radiocarbon datings of driftwood and whale bones found at different heights a.s.l., and from the bottom sediments of small lakes at different heights a.s.l. By determining the age of the bottom sediments, with the help of the radiocarbon method, the glacial events in Nordaustlandet may be compared with those in north-western Europe (see further p. 555).

SCHYTT COLLECTED A NUMBER OF SCIENTISTS AND TECHNICIANS FOR ATTACKING THE PROBLEMS:

Stig *Valter* Schytt (1919–85), Ph.D., glaciologist and leader of the expedition.

Rolf Bergström (b. 1934), B.Sc., assistant glacial geologist, Uppsala University.

Weston Blake Jr. (b. 1930), glacial geologist, responsible for the studies in glacial history, from the Department of Geology at Ohio State University in Columbus, Ohio.

Hans Christman Ehrström (1935–87), medical student, assistant scientist, Stockholm.

Stig Rune Ekman (b. 1931), Master of Engineering, seismologist, responsible for the seismic investigations and for radio communications, from the Department of Physical Geography at Stockholm University.

Anders Häggblom (b. 1931), geographer and geologist, making studies of sediment cores from inland lakes, of Helsinki University, Finland.

Bertil Johnsson, mechanic, Sweden.

Erkki Palosuo, Ph.D., sea-ice glaciologist, making crystallographic studies of various types of ice, from the Institute for Marine Research in Helsinki, Finland.

Paavo Seppänen, limnologist, making chemical and biological studies of lake water, from Helsinki University.

Staffan Tengnér, chemist, investigating the salt content of snow and firn, from the Royal Institute of Technology in Stockholm.

The expedition was international: of its 10 members, 6 were Swedish, 3 were Finlanders and 1 was from the USA. It worked in Nordaustlandet during two summers, in 1957 and 1958. During the first summer, a group of four was occupied with preparatory work and reconnaissance. They also took care of the equipment which had been sent up to Nordaustlandet for the expedition. The principal investigations of the glaciological expedition were to be carried out in the summer of 1958. Preparatory scientific work had also

been carried out in 1956 during Schytt's visit to the summit of Vestfonna (see p. 546).

THE FIRST SUMMER IN THE FIELD 1957

The glaciological group arrived on July 15, 1957, with the *Aranda*, which also carried the Swedish-Finnish-Swiss IGY expedition.

THE GROUP CONSISTED OF THE FOLLOWING (COMPARE THE LIST ABOVE):

Weston Blake, Jr., leader

Erkki Palosuo

Anders Häggblom

Christman Ehrström

The time just after their arrival was devoted to sorting out the equipment. For transports in Murchisonfjorden they had a light boat, specially constructed to be dragged across ice-floes where progress was otherwise impeded. This boat had an outboard motor. Their initial aim was to find a suitable route to the edge of Vestfonna south of Murchisonfjorden. They found such a passage at the bottom of Snaddvika, south-west of Celsiusberget.

From here it was easy to reach the edge of Vestfonna, where they were to carry out observations of snow accumulation and measure the snow and ice temperatures at a number of points along a line eastward. The slope of the ice-cap was fairly steep here, which with winds between S and E gave rise to strong katabatic winds down the slope. Their base at Vestfonna was therefore given the name *Vindheim* ("Wind Home"), and a small lake nearby at the edge of the ice was called *Vindvatnet* ("Wind Water"). At the campsite they built a stone wall, in whose lee they pitched their tent when visiting the place.

Due to the strong winds, the snow accumulation was small; and roughly 20 cm below the surface, the glacier ice was found. In consequence, the temperature conditions in the snow/ice were quite different here from those in the central area of the ice-cap (compare p. 531).

Along the route to Vindheim and on both sides of Snaddvika, there were a great number of small or tiny lakes at various heights a.s.l. For the investigations of the glacial history of the area, these lakes would be of great value. But not many observations were carried out in 1957, as the time was too short and the route used was too rough for band tractors. A reconnaissance for a suitable tractor route, from the fjord to the ice edge and up towards the central higher reaches of Vestfonna, was made in the spring of 1958 by people from the IGY station of Murchison Bay at Kinnvika (p. 530).

Valter Schytt and Gunnar Hoppe stayed at

The glaciological group, which intended to measure the thickness of the ice-sheets and their stratification, had to arrive fairly early in the season to avoid strong melting. This group was transported by a Catalina plane of the Norwegian Air Force which landed near the Murchison Bay Station on 8 May 1958 (above). Photo: Private collection of Gösta H. Liljequist.

Weston Blake Jr, b. 1930. Glacial geologist, Ohio State University, USA. Member of the Swedish expeditions of 1957, 1958 and 1966 (left). Photo: Private collection of Gösta H. Liljequist.

For transport on the ice-caps the glaciological expedition used two band tractors (Weasels) and strong sledges. These tractor sledges were transported to Nordaustlandet by the *Älvsnavben* in 1957. The ice-cap group started its investigations on 13 May 1958. (Eripiainos Terrasta 1960.)

Murchison Bay during August 16–27, to acquaint themselves with the research area. They had come on a Catalina plane of the Swedish Air Force (see p. 521). Moreover, the regions near and at Murchisonfjorden were to be photographed from the air. Unfortunately the weather gods were exceptionally ungracious on this occasion.

On August 27, three men in the glaciological group went with the *Sjövern* to Longyearbyen, for passage to Norway. That same day, Schytt and Hoppe left on the Swedish Catalina. Only Weston Blake remained at the Murchison Bay station, to study the structural ground in the neighbourhood. On October 2, he was fetched by the *Nordsyssel*.

*The glaciological investigations in
the summer of 1958*

The ice-cap group arrives

For the summer season of 1958, the travels and research on the ice-caps had to be conducted as early as possible, in order to avoid the worst effects of the snow-melt. A crucial area would be Rijpdalen between Vestfonna and Austfonna/Sörfonna. This valley is not covered by land-ice and becomes disagreeably wet in summertime (compare Ahlmann's description, p. 486).

The ice-cap group would thus need to reach Murchison Bay by plane in the spring. The expedition already had its heavy equipment stored at the IGY base, such as two snow tractors, two transport sledges, tents, and provisions. The group of Quaternary geologists and limnologists, who were mainly to work in the ice-free land areas off Vestfonna, would come later by ship. Schytt had managed to obtain air transport to Murchison Bay through the generosity of the Norwegian Air Force. The flight was to be made with a Catalina plane.

In the latter half of April, a telegram arrived at Murchison Bay. Schytt asked the station personnel to arrange a suitable airstrip on the sea-ice, where the Catalina might land. The ice thickness must not be less than 1 m, and the length of the strip should preferably be at least 1200 m.

ON MAY 8, THE PLANE LANDED WITH THE FOLLOWING EXPEDITION MEMBERS:

Valter Schytt, leader, glaciologist and "navigation officer".

Weston Blake Jr., glacial geologist.

Stig Rune Ekman, responsible for the seismic measurements of the thickness of the ice-caps and for radio connections, notably with the Murchison Bay base.

Erkki Palosuo, glaciologist and ice expert.

Bertil Johnsson, mechanic.

The group was accommodated in the reserve house at the station, and could use it for the rest of the summer.

The IGY personnel had reconnoitred a route to the central parts of Vestfonna. On Vestfonna the way had been marked by stakes, which also served as accumulation stakes. The prospective Ahlmann station on the summit of Vestfonna (the campsite of 1956) had been found and marked with a snow cairn. Some glaciological observations by the group from the IGY station had also been made at the temporary West Ice station, which was at work in April 1958 some four kilometres to the south-west of the Ahlmann station (see p. 530). There was, though, one uncertain point. The weather had been fairly warm lately, and the snow cover had deteriorated on the route to Vestfonna.

The investigations on the ice-caps of Nordaustlandet

The glaciological group started on May 13 with two Weasels and two transport sledges. They followed the same route as the Murchison Bay group had used in March and April. It passed the meteorological station West Ice (560 m a.s.l.) before reaching the Ahlmann station (622 m a.s.l.), which was the campsite in September 1956 during the Russian *Ob* expedition. This route was used repeatedly in the spring and summer of 1958. Most of the observations of accumulation, ablation, ice temperature and ice crystals were carried out here, only a few being made along the stake line of 1957.

On the 18th, the search for the old base stake at the Ahlmann station started, with the help of a sketch map of the camp from September 1956. The stake was found next day, but it had been broken—probably due to the tremendous formation of rime on the stake itself and on the guy ropes, combined with high winds.

On May 14, the weather changed drastically. The wind turned from SE to directions between NNE and NNW, which persisted until the 24th. Snow fell, and at Murchison Bay the temperature decreased to about -10°C . It was full winter and the glaciological group received a proper share.

Owing to the strong winds with falling and drifting snow, the studies of the stratigraphy within the snow had to be postponed till the 20th. A pit was then dug down to 4.45 m. The density and the temperature of the snow, firn and ice were measured at depth intervals of 10 cm, and the character of the layers was noted. It was highly important to find the snow surface from September 1956. A red dye had then been spread upon the snow surface at the camp. In this way a reference surface had been obtained for later investigations. The September surface of 1956 was now found at a depth of 210–212 cm; and it was

possible to identify the course layers making up the summer surface of 1956, which in September 1956 lay at a depth of 39–47 cm. Now it was found at 232–234 cm below the surface.

The snow between two summer surfaces will thus indicate the net accumulation of the snow which has fallen during the time between the two summers—with due regard to the fact that some snow is melted to be refrozen lower down. From the pits which were dug in 1956 and 1958 at the Ahlmann station, it was possible to determine the snow accumulation during the five preceding years, 1953–57.

The table below gives the main stratigraphic data from these pits. The second column gives the depth of the summer surfaces of 1957, 1956, 1955, and so on, below the summer surface of 1958. Hence the figures indicate the accumulation from respective summers till 1958.

Knowing the density of the snow, firn and ice in the different layers, the accumulation is obtained in grams per cm², which is the water equivalent—or approximately the annual snow precipitation in cm. In other words, at the Ahlmann station, the annual accumulation would correspond to a precipitation of more than 700 mm per year. So the ice-caps of Nordaustlandet cannot be in the passive state, as believed before the expedition (compare p. 485).

The layer of dye from September 1956 was found in 1958. It served as a reference level, and helped in identifying the summer surfaces in the pits. Furthermore, with the stratigraphy of the Ahlmann station at hand, it would be possible to identify the summer surfaces of 1956 and 1957 all over the ice-caps of Nordaustlandet. This would allow determination of the snow accumulation and its geographical distribution all over these ice-caps.

In 1931, Ahlmann had obtained a net accumulation of only 63 mm of water. This should be compared with the value that was now obtained by Schytt for the

Ahlmann station, about 700 mm, and higher still farther east, roughly 1000 mm. As mentioned elsewhere, Ahlmann had mistaken the ice layers—formed by percolating meltwater that spread horizontally before refreezing—as representing layers from the previous autumn or summer. In fact, Ahlmann had stopped digging at the pronounced ice layer which marked the previous summer, believing it to be the glacier ice—while the less pronounced ice layers above, from other times of the preceding year, were viewed as summer surfaces. Valter Schytt's stay on top of Nordaustlandet in September 1956 had indeed presented him with a key to the glaciological work in 1958.

While the stratigraphic studies were going on at the Ahlmann station, the seismologist Stig Rune Ekman was testing his seismic equipment. Reflection shooting was to be used. Test shootings at the Ahlmann station showed that good reflections could be obtained with the seismometers placed along a line, 10 m apart, using shot distances of 10–50 m and charges of one cap to about 0.3 kg of dynamite, all depending upon conditions. At the Ahlmann station a good refraction profile was also obtained.

The group of five men left the Ahlmann station on May 29, with two Weasels and heavily loaded sledges. They also had two dogs and pulka sledges, to be used as lifeboats in case the Weasels broke down, but mainly for scientific instruments and observation books. During most of the traverses, they would navigate like sailors on the high seas—using geo-navigation with the help of a magnetic compass and the odometers of the Weasels, besides astronomical navigation with the sun and a Kern DKM2 theodolite.

In this way the position of the camps would be fixed within about 0.5 nautical mile. The altitude a.s.l. was obtained from three Paulin aneroids and from simultaneous barometer readings at Murchison Bay, though

THE ACCUMULATION OF SNOW AT THE AHLMANN STATION, NORDAUSTLANDET 1953–1958

<i>Summer surfaces Depths (cm) below the summer surface of 1958</i>		<i>Annual accumulation in individual years, as measured along the walls of the two pits of 1956 and 1958</i>		
	<i>cm</i>	<i>"Year"</i>	<i>Diff. (cm)</i>	<i>Water equivalence, g/cm²</i>
1958	0	1957–58	106	59
1957	106	1956–57	126	60
1956	232	1955–56	175	91
1955	407	1954–55	143	72
1954	ca. 550	1953–54	102	74
1953	65	Mean value:		71 g/cm ²

the latter readings were used only at their campsites. Every evening they obtained time signals from Murchison Bay during the ordinary radio contact, which was upheld mainly for the sake of security.

On their tours they made snow studies in pits, and seismic shooting was carried out at intervals of about 5 km. A minimum demand was to get the last winter's accumulation of snow, but if time permitted a more detailed investigation of the stratigraphy would be made.

Leaving the Ahlmann station on May 29, they travelled ESE, stopping every 5 km for glaciological observations and seismic shooting. During the two weeks at the Ahlmann station, they had developed a technique for interpreting the stratification in the snow and firn, and for the seismic determinations of the thickness of the ice-caps. It was gratifying to know that everything now functioned.

Rijpdalen (Rijp Valley) had to be crossed before the intense melting started, as the Weasels would hardly be able to manage the water and slush which then prevails, making the crossing of the valley a horror to the traveller—as Ahlmann had experienced (p. 486). Since these conditions might occur on their way back, they were always pressed for time and they often had to compromise. On the outward journey they passed the valley, now snow-covered, on June 2 at temperatures around -7°C .

They climbed upward with the tractors along a fairly steep slope of Austfonna (East Ice), keeping the same course ESE. A few kilometres from the edge of the ice, they stopped at Station 3 on Austfonna (see p. 554). Then they steered toward the central part of Austfonna, where at Station 7 an ice thickness of 576 m was measured, the highest value which they measured in Nordaustlandet. The ice-cap here reached an altitude of 784 m a.s.l., and the glacial bed of underlying rock was at 208 m a.s.l.

In the surroundings of this station, they carried out measurements at 9 points, lying in a square with each side equal to 2 statute miles (3.2 km). The maximum values obtained were: ice thickness 576 m, altitude of the ice-cap 798 m a.s.l., altitude of the glacial bed 285 m a.s.l.

From Station 11 they turned toward Sörfonna on a south-westerly course, and spent June 6–10 measuring here. Next they returned in their tracks—and beyond—to Station 22, which they reached on June 15. The course was set for Kapp Laura in the north-east corner of Nordaustlandet, where they arrived on June 17. Before they attained the central part of Sörfonna, the temperature had been around -10°C . But on the tour from here to Cape Laura the temperature prevailed near 0°C or, on some occasions, a few degrees

below, and the wind was mostly fresh.

From Kapp Laura they retraced their tracks to Station 28. They now made a detour northward to the previous Station 7, where on the outward journey they had measured the thickest ice. They had thus completed their measuring programme on Austfonna. Vestfonna remained—and the passage across Rijpdalen, which had been considered a potential menace during the stay on Austfonna and Sörfonna. They carried out their last measurements on Austfonna on June 20, and on the 23rd they started the measurements on Vestfonna at Station 42. On the 26th they were back at the Ahlmann station, and in the night towards the 27th they reached Murchison Bay.

During the rest of the summer, July 8–August 3, seismic measurements and glaciological measurements and observations were made on Vestfonna, now along tracks radiating from the Ahlmann station. The air temperature was mostly between 0°C and $+2^{\circ}\text{C}$, and the summer melting was going on. The sections A, B, C and D (see p. 554) give an idea of the topography of the ice-cap, the bedrock below it, and the thickness of the ice. We cite Stig Rune Ekman:

“The basis for previous estimates of ice thicknesses in Nordaustlandet was the morphological assumption of the existence of large plateaus under the ice-caps, and these plateaus were believed to reach approximately 400–450 m a.s.l., as inferred from the height of the ice-free land outside the ice.

Our measurements give an entirely different picture. The sections in Figs. p. 554 show that nowhere along the profiles does the sub-glacial rock reach a higher altitude than 400 m. The bed rather seems to have a gently undulating surface, with valleys and ridges; and as far as we can judge, this statement is valid for all three ice-caps.”

At Station 7, in the region where they measured the greatest ice thickness on Austfonna, they made a careful investigation of the topography of the ice and bedrock, and of the ice thickness. They measured at nine stations defined by a square 2 miles (3.2 km) on a side, as mentioned above. Distances were measured with the Weasel mile-meter, and pressure with Paulin altimeters. It emerged that the topography of the ice surface and of the bedrock did not show any agreement here (see Fig. p. 557).

The predominant winds in the winter are within NE and S, and high accumulation of snow should therefore be expected on the slopes which face these directions. The eastern and south-eastern parts of Nordaustlandet are heavily glaciated, while to the

Map showing the topography of the ice-caps on Nordaustlandet. Note the three ice-caps: Vestfonna, Austfonna and Sörfonna, and the ice-free valley which penetrates the ice-sheet. Note also the bare land on the leeside (N-NW) and the ice-covered land areas on the windward side (S-E). (Ymer 1955.)

Not shown in digital edition

The western ice-sheet on Nordaustlandet-Vestfonna. On the summit of Vestfonna the Ahlmann Station was established in 1958 just at the position of the Russian camp during the Ob expedition in September 1956. WI marks station West Ice of the Murchison Bay group in April 1958. Dots mark the tractor route which was used by the Murchison Bay group.

The glaciological tractor tour in 1958, to measure the thickness of the ice-caps and to study the stratification of the snow and ice in the upper layers. Numbered points mark the places, where measurements were carried out (left). (Geografiska Annaler 1971.)

Sections of the altitude (m a.s.l.) of bedrock and ice surface. The sections can be identified from Fig. above (Geografiska Annaler 1971.)

north and north-west much ice-free land occurs. The snow accumulation during the cold season of 1957 until June 1958 is seen from table p. 552, where in the central parts of Austfonna/Sörfonna an accumulation as high as 70–75 g/cm² was measured, corresponding to 700–750 mm water. On Vestfonna, 60 g/cm² (600 mm water) was measured in the central parts. The obtained values differ in order of magnitude from the reports of previous researchers. On the slopes facing the opposite directions, SW to N, strong catabatic winds will blow away the collected snow and, more or less, leave the true glacier ice quite near the surface.

In the glaciological investigations, measurements of the temperature of the snow/firn and ice were included. Fig. p. 557 gives the results of temperature measurements from the central part of Vestfonna—from the Ahlmann station and from Station West Ice near it. The temperature series of 11-4-1958 was obtained in the coldest part of the winter 1957/58, whereas the series of 3-8-1958 was measured towards the end of the summer of 1958, when the melting snow and the percolating and refreezing water had heated the upper layers of the snow/firn to 0°C.

In the marginal *ablation zone* of the glacier, the meltwater cannot penetrate into the glacier ice and the transfer of heat takes place by *heat conduction*. The temperature variation over the year occurs around the annual mean air temperature, which here is near -10°C (compare p. 539). At a depth of about 10 m, the temperature is near 0°C in the cold accumulation area (here the centre of Vestfonna), but is equal to the annual mean temperature of the air, -10°C, in the warmer ablation area, which at first seems a paradox.

Investigations in the late summer of 1958

The Weasel party of five men had reached Murchison Bay in the night towards June 27. On June 29 the *Minna* arrived, bringing the remaining four members of the expedition: Rolf Bergström, Anders Häggblom, Paavo Seppänen and Staffan Tengnér.

The whole glaciological expedition was now assembled, and the second part of the summer's investigations was to start. There still remained observations and measurements to do on Vestfonna, notably those of accumulation and ice thickness. Much of the work would now concentrate on glacial geology and limnology, studies of the salt content of the snow and firn, and crystallographic studies of the snow, firn and ice of Vestfonna. The work would be done largely in the ice-free land between Vestfonna and Murchisonfjorden and on the west side of Lady Franklinfjorden.

Of special interest were the investigations to be made, from different starting-points, by Weston Blake and Anders Häggblom. The former used finds from

raised beaches for studying the land uplift during the last 10 000 years. The latter took advantage of small inland lakes at various altitudes a.s.l. By taking cores from the bottom sediments of the lakes, it would be possible to determine *where* in the core the present lake had separated from the sea to become an inland lake, and *when* the ice had disappeared in the area.

THE EXPEDITION WAS NOW SPLIT UP INTO FOUR GROUPS, WITH DIFFERENT SCIENTIFIC AIMS AND RESEARCH AREAS:

Schytt, Palosuo, Johnsson: Snow and ice studies on Vestfonna.

Ekman, Tengnér: Seismic profiles over Vestfonna; investigations of the salt content of the snow.

Blake, Bergström: glacial features and raised beaches outside present Vestfonna.

Häggblom, Seppänen: limnological studies, including investigations of bottom sediments from lakes in the ice-free land between Vestfonna and Murchisonfjorden.

Raised beaches

Raised beaches are common in the ice-free coastal zone of Murchisonfjorden and Lady Franklinfjorden. Here they are often found in series from the sea level up to altitudes above 100 m a.s.l. From these beaches, driftwood as well as whale bones and shells were collected, and were later dated by the radiocarbon method to determine the rate of the land's uplift since it had become entirely or partly ice-free.

Most of the driftwood consists of logs about 10 cm in diameter and 1–2 m in length. The collected samples of driftwood were partly buried in well-preserved beaches, indicating that the logs had once floated ashore at a time when the beaches were forming. Analogously, the whale bones were deposited soon after the whales had died, and their carcasses were washed ashore to be partly buried in the shingle of the beaches. As for the shells of molluscs, great care should be exercised in avoiding those which, by some means, have been transferred from another level than where they were found.

The samples can be dated with the radiocarbon method when brought home. The levels where they were collected, of course, were determined in the field. It is thus possible, for different regions, to construct a diagram showing the land uplift versus age, yielding information on how the uplift has varied during the past 10 000 years. The preliminary curve from the region of Murchisonfjorden is given in p. 564; a similar curve from the Billefjorden region in Spitsbergen published by R.W. Feyling-Hanssen and Ingrid Olsson. It is remarkable how the uplift from high rates during the first two thousand years after

about 10 000 years BP (before the present) gradually declines to about zero in our days.

Lake studies

In the ice-free land between Murchisonfjorden to the north and Vestfonna to the south, a great number of small lakes lie at various altitudes. Along the route used by the glaciological group in 1957, to get from Murchisonfjorden to the campsite Vindheim at the edge of Vestfonna, there are several easily accessible small lakes, which were suitable for investigations in limnology and glacial geology. The lakes can be seen in Fig. p. 557, and in the attached table are given their names, altitudes a.s.l., and maximum depths.

The thermic classification of lakes according to Yoshimura (1936) contains five classes of lakes. Of these, three are present in the Arctic:

Temperate lakes: surface temperature in the summer above $+4^{\circ}\text{C}$, during the winter below $+4^{\circ}$; two circulation periods occur, in the spring and in the autumn.

Sub-polar lakes: the surface temperature remains above $+4^{\circ}\text{C}$ only for a short time in the summer, and there are two circulation periods, in late spring and in early autumn; there is a relatively short period without ice.

Polar lakes: the surface temperature remains below $+4^{\circ}\text{C}$ throughout the year; the lake is free of ice only for a very short period, or not at all; circulation occurs only during some summers.

Among the lakes in the investigated area, only two can be classified as polar: Wulffvatnet (no. 23) and Rundvatnet (no. 22). Both have temperatures below $+4^{\circ}\text{C}$, namely about $+1.2^{\circ}\text{C}$ in August 1957 and about $+1.0^{\circ}\text{C}$ in July 1958; both lakes were then ice-covered. Except for a few very small lakes near sea level, all other lakes were sub-polar. The lakes near the edge of the ice-cap were found to be practically sterile.

The investigations were preferably carried out from the ice, so only a few measurements and observations could be made in the mild summer of 1957. The summer of 1958 was cool, enabling the main part of the investigations to be made from the ice. The routine began with a sounding of the depths; a sketched map was drawn and the depths were noted here, as well as the type of bottom. The temperature and pH value of the water were measured—and also, with a Secchi disk, the transparency of the lake water. Samples of plankton were obtained with a fine-meshed plankton bag net. In 1957, sedimentation cores were obtained with a home-made piston core sampler; but in 1958 a Kullenberg piston core sampler was used, allowing cores with a length of 140 cm to be taken.

The aim of the investigations was to obtain undisturbed cores from lakes near the present sea level and at the edge of the ice-cap, Vestfonna—and at intermediate levels. It was hoped to obtain important data concerning the glacial history, and the rise, of the ice-free land between Vestfonna and the inner part of Murchisonfjorden. Limnic peat layers in the sediment could be investigated as to age and sedimentation rate, using the radiocarbon method. Studies of diatoms, pollen and other organic matter in the cores gave information on the ecological environment of the region during the history of the lake.

The land area between Vestfonna and Murchisonfjorden was once covered by an ice-sheet, as indicated by erratic blocks and glacial striae. During the retreat of the ice-sheet, depressions and basins were gradually exposed and changed into lakes. When this happened can be determined by noting a change from marine fauna and flora into a limnic one, or from a sedimentation without organic matter to one with it—the latter revealing when the lake basin got rid of the land ice. The lake Trippvatnet, which now lies at 5.2 m a.s.l., has been a freshwater lake for the past 5 000 years, during which time the rate of the land rise seems to have been very slow. The lake Krystalvatnet (62 m a.s.l.) has been a freshwater lake throughout its existence, without any marine stage. None of the investigated lakes beyond its altitude, up to 200 m a.s.l. (Wulffvatnet), show any marine influences.

The glaciological expedition completed the field work in the first half of August 1958. In separate groups, the members returned to the Murchison Bay station on about the 10th. The *Älvsnabben* was due on August 23. However, the pack-ice changed the plans, and not until the 30th and 31st was it possible to leave Murchison Bay. On September 6 the expedition arrived in Stockholm (see p. 536).

Studies of the ecology of Arctic birds 1962–1967

Also to be mentioned are the Lund University Svalbard Expeditions during the 1960's, when three expeditions from the Department of Zoology were dispatched to Svalbard under the leadership of Sten Larsson (1962) and Ingemar Ahlén (1964, 1967). The scientific work was dominated by the study of breeding ecology of eider and duck populations and their adaption to arctic conditions. During the first expedition, 1962, observations were carried out at Reinsdyrflya at the northern coast of Spitsbergen. In 1964 and 1967, bird populations on Prins Karls Forland and at Kongsfjorden were studied. Sven-Axel Bengtson, well known for his pioneer ecology studies in Iceland at Lake Myvatn, was a member of the 1967 expedition.

Topography of the bedrock (solid lines) and of the ice-cap (broken lines). Obtained from measurements along the sides of a square with sides equal to two statute miles (≈ 3.2 km), and with one statute mile (≈ 1.6 km) between the points of measuring. Measurements were made in a region, where the highest values had been found. Note that the topography of the ice-sheet and of the subglacial rock do not agree. (Ymer 1971.)

Temperature ($^{\circ}\text{C}$) in the lower reaches of Vestfonna—in the ablation zone. Note that the temperature in the deep layers is about -8° , against about 0° in the upper reaches of the ice-sheet. The temperature -8° corresponds to the annual mean temperature of the air. In the ablation zone the ice-sheet consists of glacier-ice (right, below). (Eriipainos Terrasta 1960.)

Temperature ($^{\circ}\text{C}$) in the snow, firm and ice, in the upper reaches of Vestfonna. Broken curves of 11 and 22 April 1958 representing the coldest part of the year, were obtained at Station West-Ice situated 4 km from the Ahlmann Station from where the rest of the data were obtained. Note that percolating melt water makes the temperature equal to or near 0°C in the upper layers of the late-summer curve (August 3).

Map of the inner part of Murchisonfjorden with the bare land between the fjord and the northern edge of Vestfonna. The glaciologists had one of their camps, Vindheim, near Lake Vindvatnet (22 on the map). Wulffvatnet (27) was named after Thorild Wulff, the botanist who was on the point of drowning here in 1899. Both lakes are practically sterile. Anders Häggblom, of the 1957 and 1958 expeditions, took sediments from the bottom of the lakes at various altitudes above sea level and could determine whether and when the lakes had separated from the sea. He also determined whether and when the ice-sheet disappeared. (Ymer 1971.)

48. THE VERIFICATION OF A PREVIOUS ICE-SHEET OVER SVALBARD, THE BARENTS SEA AND NORTH-WEST EUROPE. EXPEDITIONS OF STOCKHOLM UNIVERSITY 1964–1969

Origins of the research

Under the leadership of Professor Hans W:son Ahlmann, the Department of Geography¹ at Stockholm University developed from about 1930 into a Swedish centre of glaciology—and of polar research. Its interest, until 1955 or so, focused mainly upon studies of existing glaciers and inland ice masses, notably their mass balance and dependence on existing climatic and meteorological conditions. From around 1950 onward, the research also concerned the structure and physical properties of glaciers, ice-caps and inland ice, beginning with the pioneering work of Ahlmann's pupil Valter Schytt in the Antarctic.

Ahlmann left his professorial chair in 1950 to become the Swedish ambassador in Norway. After a transitional period, he was in 1954 succeeded by Gunnar Hoppe (b. 1914). Hoppe's specialties in physical geography were glacial morphology and glacial geology. These subjects led him to investigate the stages when the inland ice of the latest Quaternary Ice Age—the Würm or the Weichsel—was disappearing in northern Sweden. Later he concentrated on the problems of the previous extent of the land ice in northern and north-western Europe, and in the European sector of the Arctic. It may be added that Hoppe was provicé chancellor in 1966–74, and vice chancellor in 1974–78, of Stockholm University.

Valter Schytt, who worked at the same department throughout his active life (until 1985), had taken his doctoral degree in 1958, after which he became a lecturer. In 1963–70, he was assistant professor of the Swedish Natural Science Research Council and with his duties at the Department of Physical Geography. In 1970 he was appointed professor of glaciology.

Gunnar Hoppe retired from his chair on January 1, 1981, and was succeeded by Gunnar Östrem and then in 1985 by Wibjörn Karlén (b. 1937), also specializing in glacial morphology and glacial geology, as well as in climatic variations and polar research.

For years after the glaciological expedition to

Nordautlandet in 1957 and 1958, there had been a lively debate concerning whether ice-free areas had existed along the coasts of Norway, where plants and animals might have been able to sustain life during the Weichsel Ice Age. Gunnar Hoppe and Erik Bergström, both of the Department of Physical Geography in Stockholm, argued against such a hypothesis of ice-free refuges with a favourable climate. The discussion gradually widened through the proposal of a working hypothesis: the large ice-sheets over Scandinavia, the British Isles, and Svalbard might have been united into a single large ice-sheet, also embracing the Barents Sea—and possibly even Novaya Zemlya and Franz Josef Land.

The expedition of 1957 and 1958 had ascertained, from studies of the land uplift in western Nordautlandet, that this region was freed of a vast ice-sheet beginning more than 10 000 years ago. These results had been obtained by collecting driftwood, whale bones, and shells from old shorelines, which now lie at heights from near sea level up to almost 100 m a.s.l., and by dating the samples with the radiocarbon (C^{14}) method. Investigations in small lakes at various heights gave information on the time when the ice had melted away from the area and the first organic matter appeared in the lake sediments. The latter method thus consisted of studying the bottom sediments in the lakes considered (compare p. 556).

To verify the probable existence of a continuous ice-sheet in north-western and northern Europe, and in the Barents Sea and Svalbard area, these methods had to be combined with studies of the glacial deposits and glacial striae. Glacial morphological data from eastern England, and indications from the bottom topography in the North Sea, seemed to indicate that the British ice-sheet had been connected with the Scandinavian ice. The hypothesis of a mighty ice-sheet covering the Barents Sea did not seem unrealistic, as this sea is fairly shallow with a mean depth of only 200–300 m. Besides, relative to today's level, the sea was more than 100 m lower during the peak of the Weichsel, corresponding to the amount of ice which then rested on land.

From about 1960, the scientific aims of the Department of Physical Geography of Stockholm University turned towards this question of a hypothetical large ice-sheet in north-western Europe and in the Barents Sea and the Svalbard region.

Several expeditions were therefore dispatched to the following regions:

1964 Shetland Islands, where a group of six worked during July–August under the leadership of Gunnar Hoppe.

1965 Björnöya, where a group of five worked in May–

¹ From 1955 the Department of Physical Geography.

June. The expedition was led by S.R. Ekman, and its scientific leader was H. Hyvärinen of Helsinki University.

1965 Hopen Island in the Barents Sea, where a group of three, with A. Häggblom as leader, worked during August 15–September 11. Despite trouble from severe ice conditions, the expedition obtained valuable scientific results. It was also forced to spend a week at Kapp Linné, Spitsbergen, which yielded further useful finds.

1966 The Svalbard Expedition of Stockholm University carried out investigations in the northern and western parts of Nordaustlandet, along Hinlopenstretet and farther southward to Heleysundet, in Kong Karls Land and along Wijdefjorden, and southward along Dicksonfjorden. The expedition's mobility was due to cooperation with Norsk Polarinstitut, which supplied sea transports while the Swedish group supplied air transports with helicopters to Norwegian field parties. The expedition comprised 18 scientists or scientific assistants. To it was attached a force of 3 helicopters and 10 officers and men from the Swedish Army. Valter Schytt was operational leader of the expedition; he and Gunnar Hoppe were its scientific leaders. The geophysical station of 1957–59 at Murchison Bay (often called Kinnvika) was used as a base for the field operations.

1967 In August, Gunnar Hoppe visited Grimsey, situated north of Iceland, and also the very small island Papey off the eastern coast. His investigations here showed that the ice sheet of Iceland had been more extensive than hitherto believed.

1967 Peder Knape and Peder Björklund, members of the expedition of 1966, visited Edgeöya and made investigations in glacial geology and history at Tjuvfjorden and Diskobukta.

1969 Peder Knape, Peder Björklund, Olle Melander and Bengt Almquist carried out investigations in glacial geology and history at Tempelfjorden and in southernmost Spitsbergen, from near Sörkapp and northward along the west coast to the Hornsund region.

THE EXPEDITION TO THE SHETLAND ISLANDS IN 1964

The first of these investigations of the extent and glacial history of the hypothetical ice-sheet was directed to the Shetland Islands, which had probably been situated in the western outskirts of the ice-sheet.

The expedition consisted of the following men, the first three being attached to the Department of Physical Geography at Stockholm University:

Gunnar Hoppe (b. 1914), Ph.D., physical geographer, leader of the expedition.

Bo Strömberg, Ph.D., physical geographer.

Anders Häggblom (b. 1931), B.Sc., geographer and geologist, making studies of sedimentation cores in lakes.

Stig Rune Ekman (b. 1931), Master of Engineering.

Magnus Fries (b. 1917), Ph.D., professor of the College of Forestry, Stockholm, pollen analyst.

Christman Ehrström (1935–87), doctor and scientific assistant.

The expedition worked in the Shetland archipelago during July–August 1964. The ice movement was studied by observing glacial striae and roches moutonnées. From these observations it was possible to determine the ice-front at different periods. The archipelago was entirely covered by ice during the Weichsel. For the latter stages of the Weichsel, it was found that the ice flowed radially outward from the centre of the archipelago, toward the ocean surrounding the islands. The remains of this ice-flow look fresh and must be attributed to the *last* stages of the Weichsel Ice Age; at present an exact dating does not seem to be possible.

There are, though, other ways to date the disappearance of the ice, notably by taking up and dating sediment cores from the bottoms of lakes. Preferably the cores should reach through the sediments down to the underlying till or glacial clay. The disappearance of the ice from the area will be marked in the core by a change from inorganic to organogenic strata—and the latter can be dated by the C^{14} method. The evidence indicates that the ice disappeared more than 10 000 years ago, in some cases even a few thousand years more. This corresponds with the Alleröd time of the Pleistocene—or somewhat earlier—and thus with the conditions in south-western Norway.

Uplifted strandlines are missing in Shetland. This may be explained by a masking of the land uplift with a simultaneous rise of the level of the Earth's oceans, due to the melting of the large land ice masses. When the ice disappeared on Shetland, the sea surface was several tens of metres lower than at present, a fact which is illustrated by the occurrence of peat in the bottom layers of the sea around the archipelago. Datings of peat from depths of 8–10 metres here have given an age of about 6 000 years B.P.

The deglaciation of the Shetland Islands was influenced to a high degree by the sea: the ice was attacked by the ocean which surrounded the archipelago, and the retreating ice front became more or less parallel with the curves showing the depth in the vicinity of the islands. The flow of the ice was directed towards

Gunnar Hoppe, b. 1914. Professor of Physical Geography at Stockholm University. Scientific leader of a series of expeditions dispatched by the university to verify the existence of a Weichselian ice-sheet over the Barents Sea and the Svalbard regions.

Photo: Department of Physical Geography, Stockholm University.

The large Svalbard expedition of 1966 made immense use of helicopters and ships for transporting both cargo and personnel. This was possible thanks to close co-operation between Stockholm University and Norsk Polarinstitutt. The photo shows the *Nordssyssel*, official ship of the Norwegian governor, and a helicopter of the Swedish Air Force. (Forskning i Arktis.)

Simplified map showing transport routes of equipment and personnel by helicopter and by ship during the expedition of 1966. (Forskning och Framsteg nr 2, 1966.)

the ice front, more or less radially outward from the centre of the archipelago. The connections with Scotland and Norway became severed, and the Shetland Islands had a distinctive glaciation from then on.

Indications of a somewhat older ice flow from the east were also found by the expedition. This flow probably indicates an ice movement from Scandinavia and a connection with its ice.

THE EXPEDITION TO BJÖRNÖYA IN 1965

The second expedition which was dispatched by the Department of Physical Geography, Stockholm, worked on Björnöya in May–June 1965. The transport to the island was arranged by Norsk Polarinstitut in the *Nordsyssel*, and on Björnöya the group was helped in all ways by the personnel of the radio station.

The expedition consisted of the following:

Stig Rune Ekman (b. 1931), Master of Engineering, leader of the expedition.

Hannu Hyvärinen, Ph.D., Department of Quaternary Geology, Helsinki University, scientific leader of the expedition.

Åke Fleetwood, Master of Engineering, making limnological observations.

Per Söderman, geographer.

Peder Knape, geographer.

The expedition had the same approach to the problem as did the investigation of the Shetland Islands in the previous year. The work concentrated on taking up sediment cores from 18 lakes situated at levels between 10 and 100 m a.s.l., see map in Fig. on p. 564. (For a description of the island, see Chapt. 29). These lakes had depths of 2–5 m, except Ellasjöen which was 14 m deep.

During the stay of the expedition on Björnöya, the ground was snowy and the lakes were covered with thick ice. Besides, the expedition was favoured with extremely fine weather. All this was a great advantage for travels and transports over the island—in the present case, over the low-lying flat region in the north and north-west. Two light snow-vehicles had been supplied from the Swedish Army, which made the transports very effective.

The sampling could be carried out from the lake ice. Generally a light piston sampler of the Livingstone-Vallentyne type was used; but at one station, Ellasjöen, heavier equipment was tried—a Kullenberg sampler with a winch and a 5-m sample tube. Detachable plastic tubes with a length of 120 cm were used with the Livingstone sampler, while for the Kullenberg sampler the cores had to be taken out of the tube, wrapped in aluminium foil and packed in special

storage tubes. Everything was done in the field. The aim was to take the samples in the centre of the sedimentation within each basin, in order to obtain complete stratigraphical sections.

Except in a few lakes with large fluvial contributions, the thickness of the sediments was found to be 1–3 m, and the basal sediments consisted of sandy and clayey gravel with angular pebbles. The main part of the sediments was found to be silty muds. The change from the basal silts to the muds—the transition from inorganic to organic deposition in the lakes—marks the beginning of *non-glacial conditions* on the island. A date of 10 000 years BP is proposed for this change.

The basal sediments of mineral contents from the area mark the melting stage of the ice. The northern lakes, which are far from the mountains and at a low level, necessarily contain less of the mineral in the sediments; instead there is a rich flora of lacustrine (freshwater) diatoms. The lakes in the northern part of Björnöya were therefore lying above the sea level during the final stages of the deglaciation. C^{14} dating “suggests” an advanced Late Glacial age for these events.

The expedition found that the shoreline in Postglacial times must have been below the present level of 10–20 m, at least as far as the stratigraphic record goes back. This is in accordance with the fact that no distinct marine terraces younger than the latest glaciation are present on the island. Björnöya is situated in the marginal zone of the Barents Sea shelf. Therefore it must also have been in the margin of a presumptive Barents Sea ice-sheet. The orientation of the glacial striae indicate a radial flow of the ice from the centre of the island. This should characterize a local glaciation of the island, but these striae may only indicate the final stage of the glaciation. It is possible that the isostatic land upheaval was inferior to the eustatic rise of the sea level—the rise conditioned by the water from melted ice which was added to the oceans.

THE EXPEDITION TO HOPEN IN 1965

The island of Hopen, which belongs to the Svalbard archipelago, lies all by itself in the Barents Sea about 100 km to the south-east of Edgeöya. In this respect the island will play a key role in a study of the glaciation of Svalbard and the Barents Sea.

The island is rather small and possesses a marked and characteristic configuration: it is 37 km long, but its breadth is less than 2 km; it consists of a series of plateaus with passes in between. Iversenfjellet in the south is the highest mountain, reaching to about 370 m a.s.l. Geologically the island consists of shales and sandstones from the Mesozoic. It has no lakes or

ponds, and much of its shoreline is steep rock. Off some of the passes, one can approach the island and its high central parts. The island is situated on a submarine platform with depths of some 100 m or less, which is a part of the Barents Sea shelf and includes Björnöya and Spitsbergen (see Fig. p. 564).

Hopen is often difficult of access due to fog, severe ice conditions, swell and shoals. It was discovered already in 1596 by the Dutchman Jan Cornelisz Rijp, and later in 1612 or 1613 by the English—when it was named *Hope Island*. In the following years it was placed at various positions on the maps. Among visits in later years may be mentioned approaches by Payer and Weiprecht, on the cutter *Isbjörnen* of Tromsø in 1871 during reconnaissance for the final expedition of 1872–74, which led to the discovery of Franz Josef Land. Nathorst with the *Antarctic* reached the island on June 22, 1898, but he could not land because of a heavy swell; two days were set aside for a mapping and investigation of the island (compare p. 268).

Not until 1924 was a first investigation of Hopen carried out by the Norwegian inspector of fishery, Thor Iversen, on visits of a few days' duration in July and August 1924. A map was produced and collections were brought home. Norwegian hunters have wintered on the island, and in 1944–45 the Germans had a meteorological station on the island at the end of World War II. This station was taken over by Norway.

Hopen had not been photographed from the air in 1957, when the Swedish Catalina plane was on her way home from the Swedish-Finnish-Swiss geophysical station of Murchison Bay with Schytt and Hoppe on board. A planned photographing of the island had to be given up owing to unsuitable weather.

THE SMALL EXPEDITION GROUP WHICH WAS TO VISIT HOPEN IN THE SUMMER OF 1965 CONSISTED OF THE FOLLOWING PERSONS:

Anders Häggblom (b. 1931), M.Sc., Department of Physical Geography, Stockholm University.

Henrik Österholm, M.Sc., Department of Geography of Helsinki University.

Peder Björklund (b. 1942), undergraduate.

The expedition left Norway on July 31 on board the *H.U. Sverdrup* of the Norwegian Navy, but now operated by Norsk Polarinstitutt. However, the ship failed to reach Hopen because of ice, and the expedition was taken to Kapp Linné, Spitsbergen, to await more favourable ice conditions. This delay resulted in a week of investigations on shorelines near Isfjord Radio at the mouth of Isfjorden.

Finally on August 15 the expedition could be landed on Hopen by the *Nordsyssel*. The investigations con-

centrated on the southern half of the island—in the area south of Thorkelsenskardet. Due to the heavy ice and rough topography, the northern part of the island was more or less unattainable in the time available to the expedition.

As the bedrock of the island consists of shales and sandstones, weathering and erosional processes have reduced the chances of finding glacial striae. Since no lakes exist on the island, the investigations were reduced to seeking and studying elevated shorelines for determining the land uplift. These studies indicated that the island must have been covered by a very considerable ice-sheet. Erratics have been found on the island, but below the highest shoreline, and they may have been transported by icebergs. Hence they cannot be used for a discussion of the glacierization of Hopen Island.

The elevated shorelines, common on Hopen, have been observed and described previously. They are best developed near the passes and in the southernmost part of the island. At other places the slopes are too steep to permit such small land-forms to survive, not least because of solifluction or landslide, which in some cases has deformed the shorelines. The highest marine limit is uncertain, but strandlines situated higher than 60 m were observed.

For the dating, only driftwood and whale bones were used, both occurring frequently. The driftwood changed its character at heights of 6–7 m: below that, it gave the impression of having been handled by man; higher up, it did not seem to have been worked, and often consisted of whole stems with branches and roots. Whale bones, too, occurred from near sea level upward. In the material which was chosen for C^{14} dating, 12 samples could be used for the dating. They show a close relationship between height a.s.l. and age, within the respective intervals of about 55 m and 10 000 years (see Fig. p. 564).

It should be remembered that these heights refer to the present sea level. As mentioned above, the level of the Earth's oceans had meanwhile risen owing to the melting of the Earth's land ice during the Postglacial. The real uplift of the land was thus greater, but this can be corrected for, revealing that the uplift of Hopen during the latest 10 000 years has been at least 90–100 m. The ice-sheet which covered Hopen must therefore have had a quite considerable thickness. The land uplift at Murchisonfjorden, as determined in 1958, is also shown here (Fig. p. 564). There is a marked difference between the two curves: the *rate* of the uplift was considerably smaller at Murchisonfjorden than at Hopen during the latest 8 000 years or so. But the ice-sheet covering both regions must have been very thick.

The severe ice conditions forced the expedition to leave Hopen in great haste on September 11, aboard the Norwegian patrol ship *H.U. Sverdrup*. All samples had to be left on the island, but these were fetched by a ship coming with stores to the weather station a few weeks later.

The results of the expedition may be summarized as follows. The investigations of the land upheaval indicated that Hopen must have been covered by a thick ice-sheet. The upheaval caused by the melting ice-sheet had been about 55 m during the latest 10 000 years when referred to the present sea level, and 90–100 m relative to the sea level of 10 000 years BP, which is the real or isostatic uplift. Remarkably, the upheaval is still going on, in contrast to the conditions at Murchisonfjorden, where the *rate* of the uplift is now insignificant.

In addition, the week spent by the expedition at Kapp Linné supplied valuable data on the land uplift in western Spitsbergen (see Fig. p. 564).

THE SVALBARD EXPEDITION OF 1966

Plans, equipment and members

After the investigations on the Shetland Islands, Björnöya and Hopen, it remained to study the traces of the Barents Sea and Svalbard ice-sheet in its central parts—in Nordaustlandet, on Kong Karls Land, and at some places in Spitsbergen. These studies would thus cover a substantial area, where sea-ice might hinder, delay or even prevent observations at important places. Both sea and air transports would be needed, as would a large scientific staff.

The transport problem was especially demanding. A base had to be established as a centre of operations for the different groups of scientists. It would also serve as a base for the aircraft, which were to transport the scientists to and from their respective research areas. For this purpose, helicopters would usually be needed because of ice obstructions, and in view of the time available. Further, expedition equipment and personnel would have to be transported by ship all the way to and from the base. The expedition should therefore have a ship or two—and a few helicopters, also for the sake of safety.

A base station existed already in the centre of the research area, at the station of Murchison Bay (also called Kinnvika) from the days of the International Geophysical Year in 1957–58; it would still come in handy.

The Swedish Army placed three helicopters with personnel at the expedition's disposal. By an agreement with Norsk Polarinstitut, the expedition was guaranteed ship's transports in exchange for air transports to the scientific groups under the Polarinstitut.

This arrangement proved to function satisfactorily for both parties.

The expedition was financed with a grant from the Swedish Natural Science Research Council and the King's Fund (Gustaf VI Adolf) as the first contributions, followed by grants from other funds and contributions from various firms. A decisive factor for the realization of the expedition, though, was the very great courtesy of the Swedish Army.

The expedition comprised 28 persons, 10 of whom made up the accompanying helicopter force. The expedition had been planned and organized by Gunnar Hoppe and Valter Schytt, and the latter acted as operational leader in the field. The members came from Sweden, Finland, USA, Canada and the Soviet Union. Close co-operation was maintained with Norway.

EXPEDITION MEMBERS:

Gunnar Hoppe (b. 1914), professor and head of the Department of Geography in Stockholm, organizer and scientific co-leader of the expedition.

Valter Schytt (1919–85), professor, operational leader, scientific co-leader, glaciologist.

Mikhail Grosswald (b. 1921), Ph.D., from the Geographical Institute of the USSR Science Academy, Moscow.

Henry Billeström, undergraduate.

Peder Björklund (b. 1942), undergraduate, member of the Hopen expedition of 1965.

Weston Blake Jr. (b. 1930), Ph.D., from the Geological Survey of Canada. Member of the glaciological expedition of 1957 and 1958.

Stig Rune Ekman (b. 1931), Master of Engineering, member of the glaciological expedition of 1957 and 1958, the Shetland expedition of 1964, and the Björnöya expedition in 1965.

Åke Fleetwood, Master of Engineering, member of the Björnöya expedition in 1965.

Fred Goldberg (b. 1943), student of technology.

Hannu Hyvärinen, Ph.D., from the Department of Geology and Paleontology, University of Helsinki, member of the Björnöya expedition in 1965.

Peder Knape, B.Sc., geographer, member of the Björnöya expedition in 1965.

Olle Melander (b. 1944), undergraduate, geographer. Erkki Palosuo, Ph.D., Institute of Marine Research, Helsinki, member of the glaciological expedition of 1957 and 1958.

Chriss Schlitter (b. 1930), Swiss-American, cook.

Bo Strömberg, Ph.D., geographer, Department of Physical Geography, Stockholm.

Lars Westman, B.Sc., botanist.

Pentti Vähäsarja, M.Sc., from Finland.

Henrik Österholm, M.Sc., Department of Geogra-

Not shown in digital edition

Map of Björnøya showing lakes investigated (marked black) and travel routes. Note the very great number of small lakes on the island, except in its southern part. In 1965 scientific work was dominated by taking and investigating samples of bottom sediments from a number of lakes. Björnøya was situated in the marginal zone of the Barent's Sea ice-sheet. (Geografiska Annaler 1968.)

Map of Svalbard showing regions, which were investigated by expeditions dispatched by Stockholm University in 1964–1969 and also investigations carried out by the expeditions of 1957 and 1958 under Valter Schytt. Note: investigated regions are marked in black on the map. (Svensk Naturvetenskap 1971.)

The figure shows the land upheaval observed in the Svalbard area by expeditions dispatched from Stockholm University. As seen from these curves the isostatic land rise—i.e. the upheaval of the land was about 55 m during the last 10 000 years. But the rate of the upheaval varied within the period, notably at Murchisonfjorden. (Svensk Naturvetenskap 1971.)

Lines isobases of equal land rise within the same period of time, the past 6 500 years. A reasonable assumption is that the uplift increases with the thickness of the ice-sheet. It also depends upon whether the uplift has been obtained in the marginal zone or from a more central position of the ice-sheet. The inference from the isobases seems to indicate that a marked ice-sheet was situated with its central parts over the Barents Sea, Franz Josef Land and the southeast of Svalbard. The data from Franz Josef Land were obtained from Dr Michail Grosswald, Moscow.

phy, Helsinki University, member of the Hopen expedition in 1965.

It should be noted that Dr. Mikhail Grosswald had carried out glaciological research in Franz Josef Land, tackling problems similar to those which the Stockholm University expedition would now study. His presence on the expedition was therefore of great value.

MEMBERS OF THE HELICOPTER GROUP:

Captain Berndt Hasselrot, commander of the group, pilot.

Sergeant Torsten Frick, pilot.

Sergeant Gunnar Krulle, pilot.

Staff Sergeant Ove Lundberg, pilot.

Ingvar Yngve, ordnance technician.

First army technician Levi Bäckström.

Army technician Harry Brandt.

Army technician Göran Hylendahl.

Army technician Urban Sundbom.

Two military physicians, Anders Carlström and Göran Karner, took care of the health of the expedition members, each for half of the time the expedition was in the field.

The helicopter group had three helicopters—a large Agusta Bell and two Alouettes. The tasks of this group were not limited to flying; they did most valuable work in making the base station of Murchison Bay an agreeable dwelling after its abandonment for seven years. They also took part in the field work.

Proceeding to Murchison Bay

The members of the expedition assembled at Harstad in northern Norway during the first days of July. On July 4, they embarked the collier *Binney* destined for Longyearbyen, where they arrived in the night towards July 7. After hectic work unloading the *Binney* and loading the *Nordsyssel* of the "sysselman" (governor), the expedition left already the next night at 01.00h. On board were now 12 expedition members with a good part of the equipment, including some of the 300 barrels of fuel for the helicopters.

Their destination was the previous scientific station of Murchison Bay from the International Geophysical Year of 1957–58, which would become their base station. However, severe ice was encountered north of Spitsbergen, and during the following days the *Nordsyssel* was involved in a futile fight against the ice near the isle of Moffen. Ice reconnaissance was asked for. The sealer *Signalhorn* had now arrived with another six expedition members and more equipment.

Meanwhile the helicopters were assembled at

Longyearbyen. Among other things they had been equipped with floats for reasons of safety, as many of the flights were to pass over open sea or drift-ice. In consequence their loading capacity and speed decreased, and the consumption of fuel increased.

On July 7, all three helicopters left Longyearbyen for Van Keulenfjorden to the south of Longyearbyen, where two Norwegian geological groups were to work. Gunnar Hoppe and Bo Strömberg were among the passengers. They now got a good opportunity to study the remarkable moraine landscape on both sides of the fjord in front of Nathorstbreen.

When they returned to Longyearbyen, the helicopter group received new tasks. One helicopter flew in the afternoon of July 10 to the *Nordsyssel* to carry out ice reconnaissance; another helicopter established a depot at Wijdefjorden and returned to Longyearbyen. On the 10th, the two remaining helicopters flew to the Murchison Bay station (Kinnvika). That day too, personnel and equipment were transported by the helicopters over the 75 km which separated the *Nordsyssel* from the base at Kinnvika.

The ice situation improved and, in the night towards July 12, the *Signalhorn* managed to reach Kinnvika. But 2 km remained to the station, so a second and shorter airlift had to be made. The Murchison Bay station was found to be in a good state, and could easily be arranged for housing the many new visitors. There were, besides the Swedish expedition, groups from Norsk Polarinstitut. One of these, a topographic group, stayed at the base and was often brought into the field by the helicopters.

The field groups

The scientific investigations were to be carried out by groups in distinct regions. They would be taken there by the helicopters, and could communicate with the base by radio. On July 13, a British-Norwegian group of botanists was taken to Brennevinsfjorden, and then followed the transportation of the groups of the Swedish expedition. These transports went on during the whole of the 13th. Late in the night towards the 14th, all groups were in their respective places.

THE GROUPS AND THEIR OBJECTIVES ARE SUMMARIZED BELOW:

The Strömberg group was led by Bo Strömberg, physical geographer, and included Peder Knape, Peder Björklund and Olle Melander. Its studies were to be carried out along Hinlopenstretet, on Kong Karls Land and along Wijdefjorden and Dicksonfjorden. Ice movement and shorelines were to be examined, starting near Svartberget (see Fig. pp. 560 and 564).

The Blake group, led by the Quaternary geologist Weston Blake, included Henrik Österholm, Lars

Westman and Henry Billeström. It was landed at the eastern side of Lady Franklinfjorden. Following up Blake's investigations during the glaciological expedition of 1957 and 1958, the group was to cover as much as possible of shorelines and ice movement on the north coast of Nordaustlandet (see map, p. 564).

Both of the above groups were to work in about the same way, studying uplifted shorelines and glacial morphology (including glacial striae, roches moutonnées).

The Palosuo group consisted of Erkki Palosuo, ice expert, as its leader, and Pentti Vähäsarja. They were landed on the western slope of Vestfonna to study ice structure.

The Lake group comprised Hannu Hyvärinen, Quaternary geologist, as leader, and Åke Fleetwood. They worked in the neighbourhood of the base, and the composition of the group varied. The bottom sediments were to be studied in some lakes. The aim was to determine the pollen "rain" over the area during the Postglacial.

The field work

Once the research groups reached their areas, they moved about on foot. When work was completed in one area, a group was taken by helicopter to the next field station, and so on. This proved to be a most effective procedure.

The Strömberg group in the southern research area

On July 13 the Strömberg group had been transported to the southernmost part of Hinlopenstretet, where they were to look for rock outcrops with glacial sculpture. Such a stoss-and-lee topography with glacial striation would enable them to determine the direction of the movement of the ice-sheet. They found good examples of these outcrops near the summit of Svartberget (150 m a.s.l.) and in the surroundings down to Mariebreen in the south-east.

Two ice motions could be derived, one from the SE, the other from between NE and E. The former was definitely oldest, and marked the movement of an ice mass which must have covered the whole of Hinlopenstretet. Islands in southern Hinlopenstretet indicated the same direction of ice flow. However, as Strömberg pointed out, these observations do not necessarily indicate a *vast* ice-sheet. The younger striae were probably formed at a late stage, when the ice-caps and the glaciers had an extension which did not differ materially from that of today.

To verify the hypothesis of a vast ice-sheet covering the Barents Sea, a visit to Kong Karls Land was

essential. On July 17 the *Signalhorn* had come to Murchison Bay with additional equipment, and that evening the ship proceeded south, taking the Strömberg group to Kong Karls Land. Radio and radar made it possible to find the group, but then troubles began in the form of heavy ice. Kong Karls Land could not be reached, and the group had to be landed at Torellneset, with a heavy load of aviation fuel for the helicopters. The ship then returned to Murchison Bay.

The stay at Torellneset proved relatively short, though somewhat disagreeable due to fog and high winds. On July 21 the weather had improved, and the group could be transported by air to Kongsöya. This was a delicate task because of the low range of the helicopters, which needed repeated refuelling. However, at 18.00h the helicopters landed at Kapp Koborg on Kongsöya near a small hut, and at 22.00h their crews were back in Murchison Bay after completing the mission. They were filled with enthusiasm over the rich vegetation they had seen on the island. But they had not experienced other characteristic conditions on the island—polar bears, solifluction which make excursions difficult, fogs, hard winds, and so on.

Mere glacial striae did not reveal any previous existence of a vast ice-sheet in the region. The glacial sculpture which they found might as well have been connected with a local glaciation of modest extent. Besides, such a glaciation might have been recent, eventual traces of an older glaciation having been removed by weathering of the rock surfaces.

However, a study of the raised beaches and their uplift could give indications. It emerged that the land upheaval had been 36 m during the previous 7 000 years. There were traces of uplifted beaches up to 100 m a.s.l. on Kongsöya, and up to 122 m a.s.l. on Svensköya. But dating with the help of driftwood and whale bones could not be done for heights above 35 m. The curve showing the relation between age and uplift indicates that the uplift has not died away; it still goes on. The land uplift therefore indicates that Kong Karls Land must have been covered by a vast ice-sheet. The more direct evidence, glacial striations and stoss-and-lee topography, was neither for nor against the hypothesis of a *vast* ice-sheet having covered the islands.

Field work was carried out during ten effective days. During this time the western part of Kongsöya was investigated satisfactorily. Moreover, helicopter visits could be paid in the neighbourhood: to Rundisen in the eastern part of the island, to Lyckholmsöya in the south, and to the north point of Svensköya. Characteristic are the basalt plateaus which cover the islands in some areas, though basalt occurs at lower

levels too. Otherwise the islands consist of sediments from the Jurassic and Cretaceous. These are highly weathered, and so is the basalt, which of course is unfavourable in a hunt for glacial striae.

The leader of the group, Bo Strömberg, was to leave the base Murchison Bay on the *Signalhorn* by August 4 at the latest. When this date was approaching, fog prevented helicopter flights and it was impossible to start until the 3rd. The helicopters then met with fog at Bråswellbreen in the south of Nordaustlandet, so they had to spend the night on the ice cap. Meanwhile the *Nordsyssel* was on her way to Kong Karls Land with a polar-bear research group, yet she had to turn back when barely 8 nautical miles from Svensköya. In the afternoon of August 4, the fog lifted somewhat to allow a flight to Kongsöya, and at 20.00h the helicopters were back at Murchison Bay. Strömberg had just enough time to board the *Signalhorn*.

It should be noted that Knape, a member of the Strömberg group, visited Wilhelmöya in the southern part of Hinlopenstretet together with Schytt and Grosswald. They travelled by helicopter southward, as far as the north point of Barentsöya, whence they returned with good scientific results.

A few days after the return of the Strömberg group to the base at Kinnvika on August 4, the remaining three members in the group set out on a long tour, which carried them to Longyearbyen and home. They used a light boat, specially built for handling in ice. The programme was the same as during their previous investigations.

They visited Lomfjorden and Sorgfjorden, rounded Verlegenhukken in a rough sea, and proceeded south along the eastern side of Wijdefjorden, until they reached Mittag-Lefflerbreen in the south. Here they stayed waiting for the helicopters, which were to pass on their way to Longyearbyen after completing tasks in Nordaustlandet.

From here the group and its equipment—including the boat—were flown over land to the north end of Dicksonfjorden. Then the group continued the investigations, along the eastern side of the latter fjord. At Kapp Thorsden they steered south across Isfjorden to Longyearbyen.

The Strömberg-Knape group had enjoyed a long and successful field season. They arrived in Stockholm on September 10, later than the other members of the expedition.

The Blake group in the northern research area

Before 1966, the most detailed investigations on ice movements in Nordaustlandet had been carried out by Weston Blake in 1957 and 1958.

His studies were, though, limited to the regions of

Murchisonfjorden and Storsteinhalvöya, including the western side of Lady Franklinbreen.

The Blake group now intended to examine the north coast of Nordaustlandet and its fjords, beyond the area which had previously been investigated by Blake. Shown here (Fig. p. 564) are the areas studied in 1966 by Blake and a member of his group, Österholm. Practically the whole northern coast was covered, as well as the western part of Storsteinhalvöya (region A). From the map can also be seen positions of the campsites of the group. As with the Strömberg group, the stay at each site lasted a few days, and for the transfer between sites helicopters were employed.

Sometimes the helicopters were also used in the search for striae and raised beaches. The observations of the ice movement were gathered from a close study of the sculpture of exposed roches moutonnées; studies of the till fabric and of erratics were also resorted to. The magnetic declination indicated no irregular disturbances in the region: the values agreed with the information on hydrographic charts. The most important contributions of the Blake group were the studies of uplifted strandlines.

In some areas the weathering of the rock caused great difficulties. This was especially true at high altitudes, where few striae therefore were observed. Most striae were found below the highest observed marine limit, about 100 m a.s.l., so they indicate ice movement close to the edge of the ice. The pattern of these ice movements will therefore generally reflect the retreat of the ice.

Observations on the summits and ridges in the northernmost parts of Nordaustlandet showed that the island must have been completely covered by an ice-sheet. Considering that the depths in the sea to the north are low—less than 200 m as far as about 70 km from the land—it seems reasonable to suppose that the ice-sheet reached so far from the coastal zone, if precipitation was fairly rich.

The three men in the group had worked their way systematically eastward. After arrival in Rijpfjorden a boat, specially built for passing among ice, was transferred to them by a helicopter. In this way it became possible to investigate Prins Oscars Land. However, northerly winds had now driven the ice towards the land, preventing them from coming farther east with the boat. But the helicopters helped Blake and Österholm to extend the investigation still further—to about 25°E on the north coast, and to the inner part of Wahlenbergfjorden and to Sjuöyane.

The studies thus covered almost the entire coastal zone of northern Nordaustlandet, besides the ice-free connection between the north coast and Wahlenbergfjorden, namely Rijpdalen. The observations to the

east of Prins Oscars Land are too few, though, to give a detailed picture of the retreat of the ice in this area.

The pumice level

The land uplift during the last few thousand years may also be determined more directly, in some regions, by observing the so-called *pumice level*. In Svalbard, as well as in certain regions of northern Europe and Canada, a narrow zone with a relatively rich occurrence of pumice stones is visible at some height a.s.l. along the coast.

The pumice was once washed ashore in connection with heavy volcanic eruptions, probably in Iceland or perhaps on submarine mountain ridges on the bottom of the Polar Sea. In regions with a land uplift, this pumice level will now lie some way *above* the present sea level, thus indicating the eustatic land rise since the eruption. The latter can be dated by radiocarbon tests of driftwood and whale bones found in association with the pumice.

The height of the pumice level depends on its position in relation to the previous ice-sheet. It may be located either in the central area or at the outskirts, at a high or low level respectively. The so-called upper *pumice level* in Svalbard is found to have been formed 6500 ± 500 years ago.

Studies of the pumice level and its height a.s.l. were among Weston Blake's methods for investigating the land uplift in Nordaustlandet. The upper pumice level was discovered at 14 m a.s.l. on Brageneset at the mouth of Wahlenbergfjorden, and at 8 m in Murchisonfjorden, indicating a probable increase of the ice thickness towards the south-east. On the north coast of Nordaustlandet, the following values were obtained: at Zorgdragerfjorden, 12 m; in the inner part of Rijpfjorden, 19–20 m. This means a southward increase in the rate of the land rise, and in the thickness of the ice-sheet.

The Lake group

The Lake group had its "headquarters" at the base of Murchison Bay. From there, the members were taken by helicopter to the lakes which they planned to study (see Fig. p. 560). These lakes were situated in the area of Murchisonfjorden, on Lågöya, and in north-western Ny Friesland to the south of Mosselbukta. Some of them were studied as regards the occurrence of pollen in the sediments:

- Trullvatnet, at inner Murchisonfjorden by the foot of Celsiusberget (altitude 1 m a.s.l.).
- Lake on Söre Russöya, near the western summit of the island (altitude 38 m a.s.l.).
- Ströen, in north-western Ny Friesland (altitude about 14 m a.s.l.).

Here the lakes are denoted S 7, S 16 and S 28 respectively. Cores were taken at depths of 3–4 m.

At the base

Those expedition members who were more permanently stationed at the base often also devoted their time to field work—either studying on their own or assisting the field parties. Hoppe, Schytt and Grosswald, and the two doctors, visited the field parties and took part in their investigations. Hoppe and Schytt made separate studies in the region of Murchisonfjorden, and Fleetwood diligently took water samples for his physical-limnological studies of the lakes in northern Svalbard.

The Murchison Bay base was often visited by groups of scientists—both Norwegian and Russian—and by Norwegian authorities.

Around August 22, the field parties were returning to the base. It was time to pack equipment and collections, and on August 27 the *Signalhorn* left Murchison Bay with part of the expedition on board. The helicopters with their crews followed, passing by Wijdefjorden.

At Longyearbyen the former men boarded the Norwegian patrolship *Andenes*, while the latter personnel, with helicopters, went on a collier.

It had been a successful expedition favoured by the weather. A vast Barents Sea ice-sheet from the Ice Age had begun to emerge from the field observations and studies, and was no longer a mere hypothesis. This large expedition of 1966 was followed by a number of small, and even tiny, expeditions to regions suitable for supplementing the results until then. The research areas of these expeditions as regards Svalbard can be seen from Fig. p. 564 (see also the summary, p. 559.)

A vast ice-sheet of the Weichsel Ice Age

The expeditions of the Department of Physical Geography in Stockholm were principally aimed at collecting scientific material to prove whether Svalbard and the Barents Sea had been covered by a vast ice-sheet during the Weichsel glaciation. Opinions in the scientific world were both for and against such a hypothesis, but their ideas had built upon feeble facts, to say the least.

In summary, the problem was attacked by several means:

1. A study of the land uplift and its variation with time in different parts of Svalbard (see p. 564).
2. Determinations of the movement of the Weichsel ice-sheet obtained from observations of glacial striae on roches moutonnées.
3. Studies of the sediments in lakes.

A large ice-sheet gives rise to a subsidence of the earth crust, which later becomes a land uplift—during and after the disappearance of the land ice. It is reasonable to assume that a vast and thick ice-sheet ought to create a considerable rise of the land, while at the margin of even a vast ice the uplift should be less and die away more quickly than in the central regions of the ice.

An important component of the investigations would therefore be to obtain land-uplift curves within the Svalbard and Barents Sea regions. The curves or data from Murchisonfjorden, Kapp Linné and Björnöya may be viewed as “stations” which were situated in the marginal zone of the hypothetical ice-sheet. The curves from Murchisonfjorden indicate a rapid uplift in the beginning of the Holocene, about 10 000 years BP. The rate of the land uplift then gradually approaches zero in recent years, in striking contrast to the remaining curves which represent stations fairly close to the centre of the hypothetical ice-sheet.

A tentative representation of the land uplift during the last 6 500 years in the Svalbard and Barents Sea region is given in Fig. p. 564. Curves with equal land uplift—isobases—have been entered in order to show the approximate extension of the ice-sheet, which may be inferred from the findings of the Stockholm University expeditions. The land uplift is referred to the present sea level. The melted ice from the ice-sheets of the Earth during the Postglacial was added to the oceans, whose surface therefore rose; hence a correction must be added to the directly observed values of the land uplift to obtain the real isostatic uplift.

In conclusion Gunnar Hoppe will be cited here:

“It is evident that the strongest land uplift has taken place over the south-eastern parts of Svalbard and/or over neighbouring parts of the Barents Sea. For that reason a most important conclusion is clear: the isobases give a definite indication of a large arctic ice-sheet.

The next question presents itself immediately: has this ice-sheet been in direct contact with ice-sheets in northern Europe and on Novaya Zemlya? This is a presumption which lies near at hand, considering that the Barents Sea is shallow and that, consequently, it must have been dry land to a large extent during the last Ice Age. Confirmation of this inference has, though, not been obtained as yet...

Certainly it will be possible to proceed by making further studies in the archipelagoes and on the northern sides of the continents. It is

equally evident that many of the answers will in future be derived from the bottom of the sea, both by studying its morphology in detail and by taking sediment cores. There are vast arcs of terminal moraines off north-western Spitsbergen, as well as extensive drainage systems which resemble drainage patterns on the bottom of the Barents Sea. This will give just an indication of the possibilities which exist.

International co-operation on a broad basis seems here to be exceedingly important.”

49. STUDIES OF RUSSIAN HUNTING ACTIVITY IN SVALBARD DURING THE 18TH CENTURY

*HANS CHRISTIANSSON'S NORDIC
ARCHAEOLOGICAL EXPEDITIONS IN
1955 AND 1960*

In the middle of the 16th century, England and Holland embarked upon investigations in high northerly latitudes for the purpose of finding a sea-route north of the continents of Eurasia and America to the Far East and its riches. In this way they hoped to avoid control by Spain and Portugal on the routes passing south of the large continents.

During such a venture in the north, Willem Barents, a Dutchman, discovered the north-western parts of Svalbard in 1596. A British seafarer and explorer, Henry Hudson, visited Spitsbergen in 1607. He was struck by the very rich animal life—whales, walruses and seals—and his reports on these conditions awoke the economic minds of the British, contrary to what the reports of Barents' men had done at first in Holland.

From about 1610, Spitsbergen became a centre of intensive whale hunting, where England was followed by Holland and Denmark—the latter claiming Spitsbergen as part of Greenland—and by the Basques and others. Different nations established stations at suitable places, where they could extract oil and other products from the whales. The Dutch had their main base, Smeerenburg, on Amsterdamöya in the north-west corner of Spitsbergen. In the summer, when the hunt was going on, Smeerenburg became almost a small town—although this may be exaggerated according to the latest investigations in the field. The other nations had, of course, bases of their own. To begin with, whale bones were most coveted, but soon the

blubber came foremost. Foundations for big cauldrons were built, to extract oil by boiling the blubber.

The whale hunting grew boundless—in our days one would say that it degenerated into ruthless exploitation—and the consequences appeared. The whales decreased in number, and they avoided the Svalbard seas. The Dutch were the first to take action and search for new hunting “grounds”. This was done from about 1640, but the hunting continued, on a lesser scale, until the end of the 17th century. The whales were facing extermination, yet some hunting continued throughout the 18th century.

Around 1700 the Russians began hunting in Svalbard, though not for whales. They were mainly interested in fur-bearing animals and walrus, the latter for tusks. The best furs are obtained in the winter, so the hunters had to winter in Spitsbergen—unlike the whale hunters, who were active in the summer. The Russian hunters were dispatched by economic societies and by monasteries in northern Russia, mainly from the White Sea region. Generally teams of 20–30 men were sent. They had very good equipment and brought, for example, prefabricated huts. They usually stayed for one or two years in the region they had chosen.

In the 19th century, Russian huts—or hunting stations—could be seen all over Spitsbergen. The huts were described by the polar travellers and scientists of those days, such as Keilhau from Norway in 1827, and K. Chydenius of Torell’s expedition in 1861. In some cases, ruins of huts were casually investigated, for instance by Swedes like Carlheim-Gyllensköld in 1898 (see p. 338) and De Geer in 1882 (see p. 197). But on the whole, no specialists carried out investigations. The Russian hunting activity prevailed until about 1850.

Sometimes the hunting teams returned home in good health; yet great tragedies occurred, with several hunters dying. Regrettably, no accounts exist of the life and work of the hunters. Most of them were apparently illiterate; besides, their life was hard and did not permit any leisure occupations. But we know that disasters took place during some winterings, even if others turned out well. Occasionally the remains of implements and huts tell a tale about the hunters’ way of life. The big Russian crosses near the hunting stations still give evidence of their religious sentiments, for example in Murchisonfjorden.

Around the beginning of the 19th century, the Norwegians began hunting seals in Svalbard waters, an activity which was to make Hammerfest and later Tromsø the “capital” of the Arctic Sea. These sealers did much to make the Arctic regions known, through both their own explorations and their practical assist-

ance to polar travellers and research workers. At the next turn of century, the mining industry appeared, while the hunting activity by wintering parties or sealers declined—notably after World War II.

From the mid-19th century onward, the Spitsbergen archipelago was the classic polar land and the object of comprehensive scientific polar research. Yet Svalbard was a no-man’s-land until 1920, and only since that year—or rather 1925—has the archipelago belonged to Norway, with some restrictions. This subject has been related previously (see p. 396). Thus the history of Svalbard begins with its discovery by Barents in 1596, and has been dealt with, mostly in terms of the hunting activity, in Conway’s book *No Man’s Land* of 1906.

However, doubts linger as to whether man has an even earlier, pre-Barents history in Svalbard. Old Icelandic annals supplied sailing instructions for a route between Iceland and Svalbard. Here Svalbard is supposed to refer to a northerly land visited by hunting expeditions. The *Landnamabok* states that

“...from Langanes on the north-east side of Iceland there are four days of sea [sailing] to Svalbard [situated] to the north in Havsbóttn.”

On a ship making 9 knots, such a voyage would be possible if Svalbard means present-day Spitsbergen with its islands, considering the good sailing properties of the Norse ships of that time. The Icelandic annals also noted that Svalbard was discovered in 1194.

The “Carta Marina” (1539) of Olaus Magnus from Sweden is also discussed in this context. It shows an island or peninsula, Grutlandie Pars, to the north-east of Iceland in “Mare Glacialis”. Moreover, driftwood was marked there along the eastern and the southern coasts. This may indicate that Spitsbergen was known in Scandinavia even before its discovery by Barents in 1596.

We should also recall the scientific results of the expeditions of Stockholm University to Svalbard and the Barents Sea. A vast ice-sheet over the region was then made likely. The land uplift, after the melting of the ice-sheet during the Postglacial era, was determined by these expeditions to have taken place during the past 5 000–10 000 years. Probably an archipelago existed in the Barents Sea during part of the Postglacial, and possibly remains from the Komsa culture of northern Europe or an equivalent culture are to be found in present-day Svalbard. At that time, hunting in Svalbard should have been excellent in the sea as well as on land.

THE EXPEDITION OF 1955

In the beginning of the 1950s, Hans Christiansson, an archaeologist of Uppsala University, launched the idea that Spitsbergen may have had pre-Barents settlers, perhaps even as early as the Stone Age. In 1955 he managed to organize an expedition to look into the matter.

His programme had two main aims, the second being a "safe card" in case the first bore no fruit:

1. to ascertain whether Spitsbergen had been visited by man before its discovery by Barents in 1596;
2. to investigate the remains of hunters' huts from the 17th and 18th centuries.

THE EXPEDITION BECAME A SCANDINAVIAN ENTERPRISE, WITH MEMBERS FROM SWEDEN, NORWAY, DENMARK AND FINLAND:

Hans Christiansson (b. 1916), Ph.D., Sweden, archaeologist, co-leader and initiator of the expedition.

Paul Simonsen, Norway, curator and archaeologist, co-leader of the expedition.

Helmer Tegengren, (1904–74), Ph.D., professor, Finland, ethnologist.

Georg Nellemann, B.A., Denmark, ethnologist.

Oluf Olsen, Denmark, museum assistant.

Torlef Markusen, Norway, mechanic and factotum (Norw.: *altmuligman*).

Paul Simonsen was attached to Tromsø Museum, which was to obtain all collections from the expedition. Called *The Culture-Historical Expedition to Spitsbergen in 1955*, it stayed in Spitsbergen from July 22 until August 27.

The summer of 1955 in Spitsbergen was characterized by bad weather with hard winds and rain. As a result, all long tours of reconnaissance were cancelled, meaning that the expedition's first aim was abandoned. Instead all work was concentrated upon excavating a large Russian hunting station, which was called Russekeila. It lies to the west of Grönfjorden near the mouth of a little river, Linné-elva, at its outflow into Isfjorden (see, Fig. p. 574). This was a happy choice, and proved to yield very good results—far better than could have been expected. In consequence the men had to devote practically all their time and energy to the work at Russekeila. Still their work was delayed by the gales, which also damaged the tents in their camp.

The Russekeila hunting station consisted of a number of houses, which had been built close together. All of these had been provided with flat roofs covered by clay. From an archaeological point of view, this was an advantage: when the houses col-

lapsed, things inside became well protected from the weather and climate, thanks to the roof and its clayey layer.

The hunting station seems to have been used as late as the 1760s and 1770s, according to the markings on some objects. The station consisted of a central building with an area of 5 x 5 m², a bathing-hut, a smithy, a storehouse, and a few other rooms whose use is unknown. Near the wall of the central building, it was possible to discern four cultural layers, partly with sand in between. However, at other places the layers had been destroyed due to reconstructions of the buildings. In the three upper layers were found bricks for stoves and hearths. The whole establishment was assumed to originate from the 18th century, except possibly the lowest layer.

The houses had been well built, and the windows had possessed panes of glass and mica, besides shutters. The buildings were apparently shipped to Spitsbergen ready-made and assembled there. It is known that the Russians used to man their stations with 20–30 men and for periods of 1–2 years. Moreover, a small cemetery was found with about ten graves. Two of these were investigated in 1955 and proved to contain two bodies, wrapped in simple pieces of cloth.

Among the implements found were leather and shoes in great amounts, shoe-hay, shoe-fittings, tools for skin dressing, spears for bear hunting, fish hooks, combs of different kinds, clay lamps, quantities of potsherds, cooper's tools and materials for barrels. Iron objects were few, but old-fashioned chessmen were numerous.

As mentioned, there was not much time to search for prehistoric objects. Nothing was found that could be ascribed with certainty to prehistoric settlers—although, as Christiansson points out, Spitsbergen must have been an ideal land for a prehistoric "nation" of hunters.

THE INTERDISCIPLINARY EXPEDITION OF 1960

The expedition of 1955 had been successful and had supplied valuable information on the living conditions of Russian hunters in Spitsbergen, which cannot be gained properly from the literature. Much work remained to be done at the research area, calling for a new expedition. Christiansson and his co-workers managed to obtain the necessary funds for this purpose in the summer of 1960.

The expedition worked in close contact with Tromsø Museum, which was to receive the culture-historical material collected by it. This time, however, no expedition member was Norwegian. The

Hans Christiansson, b. 1916 (front row, left) Archeologist at Uppsala University, Sweden. Leader of archeological expeditions to Spitsbergen in 1955 and 1960.

Christiansson's two expeditions to Spitsbergen in 1955 and 1960 had two principal programmes: 1) An attempt to elucidate whether the Spitsbergen archipelago had been visited by man before its discovery by Barents in 1596, i.e. whether it possessed a pre-Barents history. Here the Icelandic annals deal with a land Svalbard which is said to have been discovered "in 1196 in the north of Havsbotn". No remains from such early periods were found. 2) In order to have a "safe" card in the expedition programme a study of Russian hunting stations was also to be included. The studies of Russian hunting activity in the 18th century, i.e. after Barents discovery of Spitsbergen, were interesting and successful, notably at the Russian hunting station called Russekeila, situated at the mouth of Isfjorden. The picture shows the excavation of the kitchen-midden at the station.

(Arctic, vol 14, June 1961.)

Excavation of the Russian hunting station Russekeila, dating from the 18th century, facing west. (Arctic, vol 14, June 1961.)

expedition was split up into two groups, one with eight members under the leadership of Christiansson working at Russekeila, and a Finnish group with three members under Professor Tegengren working at Trygghamna on the north side of the Isfjorden mouth.

THE MEMBERS WERE:

The Russekeila group under Christiansson

Hans Christiansson (b. 1916), Ph.D., archaeologist, leader of the group and of the expedition.

Torsten Berglund, undergraduate, Quaternary geologist and botanist.

Lars Florin, M.Sc., cultural historian, public relations adviser.

Peter Manecke, undergraduate, archaeologist, ethnologist.

Michael Müller-Wille, German, undergraduate, Quaternary geologist and archaeologist.

Erik Norling, B.Sc., Quaternary geologist, curator.

Anders Norrby, M.B., doctor to the expedition.

Johnny Scavenius, Danish, undergraduate, curator, osteologist.

The Trygghamna group under Tegengren (the "Finnish group")

Helmer Tegengren (1904–74), Ph.D., professor, ethnologist, leader of the group.

Johan Snellman, M.A., ethnologist.

Nils Storå, M.A., ethnologist.

Six expedition members were Swedish, three were Finnish, one Danish and one German; the total number of participants was eleven.

The working conditions in 1960 were very good: the weather was fine. Besides, the so-called *Polar barracks* at Kapp Linné had been placed at the expedition's disposal by Norsk Polarinstitut. Thanks to the weather, the search for pre-Barents remains, which had been cancelled in 1955, could now be carried out in the area between Isfjorden and Bellsund—from Grönfjorden via Kapp Linné to Kapp Martin. The expedition stayed in Spitsbergen from July 20 until September 3, except the Finnish group which stayed till September 5.

The Russekeila hunting station had been placed on a flat terrace covered by vegetation, about 7 m above the sea level at high tide. The houses stood near the edge of the terrace, which sloped rather steeply towards the shore. In 1960 a large "kitchen-midden" was found here. It extended all the way from the station, along the slope, where it reached 15–17 m from the water at high tide and 2 m above the sea surface. High winds, probably combined with sea-ice shove, had covered the lowest 2 m of the midden with a 30-cm thick layer of gravel and cobblestones. Since the midden lay under a luxuriant coating of moss, it

apparently received no additions after the Russians left the place—in the middle of the 19th century at the very latest, when the Russians discontinued their hunting in Spitsbergen.

Research at Russekeila

The scientific work at the hunting station was done by three groups:

Excavation of the kitchen-midden: Müller-Wille, leader, assisted by Florin and Manecke.

Investigations of the house foundations: Manecke.

Excavation of the burial ground: Scavenius and Norrby. Excavating the kitchen-midden was difficult due to the permafrost; only the uppermost 10 cm were thawed. Two shafts, 2 m broad, were dug from the top to the base of the midden. It was found that the midden was about 1 m deep on top, but only a few cm at the foot. At a few places it was possible to come down to intact sand. The material which had been thrown away was largely preserved, thanks to the deep-freezing. Among objects of interest were a semilunar dish, a crucifix, ornamented birch-bark boxes, several game pieces, articles of clothing, hunting implements, earthenware vessels, and animal bones.

The investigation of the house foundations supplied some details of interest to architectural history. Measurements were made, and it was ascertained that the whole establishment very probably originated from the 18th century.

At the burial ground, situated about 200 m east-south-east of the station, 20 skeletons were found lying alone or in groups of 2, 3 and 7. They were wrapped up in simple bast cloth and had shoes or high boots on their feet. Most of the men had enameled pectoral crosses lying upon their breasts.

The skeletons were later investigated by Professors Bo Ingelmark and Björn Hedegård of the Department of Anatomy at the University of Göteborg. They found the skeletons to be in an excellent state of preservation. All were male, and the average age was estimated with fair confidence as 25 years with a range of 18–35 years. The height of the dead hunters varied between 150 and 186 cm, with a mean of about 165 cm. It is noteworthy that the three youngest in the group were among the tallest.

Finally we may cite the medical investigators:

"Suspicious signs of C-avitaminosis were seen in only one skeleton. The pathological findings in the skeletons do not indicate the main causes of death. However, the positions of the skeletons in the burial place seem to indicate some endemic

disease among the Russekeila settlers during a hunting season, but the skeletons may also constitute the total deaths of several hunting expeditions."

Additional studies

The Finnish group under Tegengren investigated a Russian hunting station at Trygghamna in the north of Isfjorden. It had previously been considered a monastery—but the investigations indicated that, like the Russekeila station, it had been devoted to hunting. According to Tegengren, this station originated from the 18th century; a coin from the mid-18th century was among the finds. The programme of the expedition of 1960 also included a search for pre-Barents cultural remains. As the weather was now excellent, a fairly extensive search could be carried out for a week, August 14–21. It covered the westernmost part of the peninsula between Isfjorden and Bellsund—from Grönfjorden via Kapp Linné southward to Kapp Martin. However, nothing was found that can be ascribed with certainty to the pre-Barents era.

Besides the archaeological and ethnological work, studies were made in Quaternary geology to obtain an idea of the environment in the research area during the Postglacial. These were pollen-analytic investigations at heights between 3 and 50 m. Samples were also taken for radiocarbon dating. The studies were carried out by Norling in order to learn the plant-ecological conditions in the area during different stages of the Postglacial. To establish a connection with these pollen investigations, the present-day flora in the Kapp Linné–Russekeila region was studied.

It should also be mentioned that about 100 birds

were ringed by Berglund and Norling—outside the expedition programme. Furthermore, the observations at the kitchen-midden indicated that the land rise during the last 100–200 years must have been small, or even zero or negative (compare the results from the glaciological expeditions of 1958 and 1966, pp. 555 and 559).

SUMMARY

The finds from the expeditions of 1955 and 1960 are kept at Tromsø Museum. These expeditions were quite successful, and Christiansson had opened up a new area of research in Spitsbergen, which others have pursued. A Dutchman, Louwrens Hacquebord of the University of Groningen, led expeditions in 1979–82 to study the activity at the Dutch whaling stations during the 17th century, notably at the station of Smeerenburg on Amsterdamöya. Recently the Danish Natural Museum has been studying the Danish whaling station which was used on Dansköya in the early 17th century.

Russian archaeologists, too, have turned their attention to culture-historical research in Svalbard. Russian hunting stations have been mapped and excavated, and supplementary studies have been made at Russekeila by Russians and Norwegians in co-operation. Moreover, since 1988, the rich archaeological collections from Russekeila, obtained during the expeditions of 1955 and 1960, have been under final investigation by Tromsø Museum in consultation with Christiansson.

The surroundings of the Russian hunting station Russekeila. In the upper part of the map is the station with huts, drawn black, and a kitchen-midden sloping towards the fjord. To the east-south-east from the station a burial-ground was found, with 20 well-preserved skeletons. (Arctic, vol 14, June 1961.)

Map of Murchisonfjorden, Nordaustlandet, showing the position of two Russian crosses on N. Russöya and on Krossöya. On the former island there are also remains of a small Russian hut. (Arctic, vol 14, June 1961.)

50. WITH AN ICEBREAKER IN THE POLAR SEA. THE EXPEDITION YMER-80

Planning and preparations

The greatest historical achievement in Swedish polar exploration is no doubt the voyage along the North-East Passage by the ship *Vega* in 1878–79. The triumphant completion of this expedition of A.E. Norden-skiöld also involved a circumnavigation of the entire continent of Eurasia. On April 24, 1880, the long voyage of the *Vega* ended in Stockholm.

At the festival meeting of Kungl. Örlogsmannasällskapet (the Royal Naval Society) on November 11, 1976, a member, Captain Bertil Daggfeldt, proposed that the pending centenary of the *Vega* expedition might be celebrated by sending one of the Swedish State icebreakers through the North-East Passage, so to speak in the wake of the *Vega*. The voyage home could then suitably be taken along the North-West Passage, which would complete a circumnavigation of the central Arctic.

Those at the meeting were highly enthusiastic, not least the head of the Swedish Navy, Vice Admiral Bengt Lundvall (b. 1915). In 1957 he had visited Svalbard as commander of the mine-cruiser HMS *Älvsnabben*, which had carried most of the equipment of the Swedish-Finnish-Swiss IGY expedition to Nordaustlandet. The possible dispatch of a new arctic expedition deeply inspired everyone present.

However, a mere "jubilee celebration" could not give cause for a large-scale polar enterprise. This would have to be justified by the scientific research which such a voyage entailed. The expedition thus had to be planned partly by representatives of the scientific community, notably members of the *Royal Swedish Academy of Sciences* and the *Swedish Society of Anthropology and Geography*. In this way a high standard of research would be guaranteed.

THE FIRST MEETING OF THE ORGANIZING COMMITTEE FOR THE EXPEDITION WAS HELD ON DECEMBER 22, 1976, AND ATTENDED BY THE FOLLOWING MEMBERS:

Royal Swedish Academy of Sciences

Professor Frans E. Wickman, president.

Professor Alf Johnels.

Chief Librarian Wilhelm Odelberg.

Swedish Society of Anthropology and Geography

Carl M:son Mannerfelt, Ph.D., president.

Professor Gunnar Hoppe.

Professor Valter Schytt.

National Administration of Shipping and Navigation

Lennart Johansson, director general.

Captain Agne Christensson, director of the ice-breaking service.

Royal Naval Society

Vice Admiral Bengt Lundvall, president.

Major General Bo Varenus.

Commodore Bo Granath, secretary.

Captain Bertil Daggfeldt.

THE MEETING RESULTED IN THE FOLLOWING RECOMMENDATIONS:

1. The centenary of the navigation of the *Vega* along the North-East Passage in 1878–79 should be celebrated in a dignified way by sending one of the Swedish icebreakers through the North-East Passage and by taking advantage of the opportunity to carry out research of great scientific value.
2. Three associations—the Royal Swedish Academy of Sciences, the Swedish Society of Anthropology and Geography, and the Royal Naval Society—were to investigate the necessary requirements for such an expedition.
3. The expedition should be Swedish and under Swedish command and leadership.
4. Efforts should be made to have foreign scientists join the expedition, notably from the Soviet Union, the USA, Canada and the Scandinavian countries.
5. The working title of the expedition would be YMER-79 (for explanation see below).
6. The expedition plans should be officially announced on Vega Day, April 24, 1977.

With this meeting an important step had been taken towards realizing the plans. However, there was still a long and cumbersome way to go. In January 1977, a letter was sent to scientific institutions and scientists who were assumed to be interested in the expedition. They were asked to submit proposals for scientific projects and their motivations, if they wished to take part in the enterprise.

A total of 33 answers were obtained before the next meeting of the Organizing Committee on February 18, 1977. These answers justified the dispatch of an arctic expedition.

The route of the expedition was to pass over the Siberian shelf throughout the whole length of the passage along Siberia. Freedom of the oceans had ceased to exist here, and it was necessary to ask Soviet authorities for permission to pass along the route. A desire was also expressed to obtain co-operation with Soviet scientists and scientific bodies. However, no answer was received.

Time passed, and finally it became apparent that the start of the expedition would have to be delayed one year, from 1979 to 1980. Furthermore, a new

research region had to be chosen, which was easy enough: Svalbard with seas extending to Franz Josef Land in the east and to northern Greenland in the west and, of course, the ice-covered Polar Sea in the north and the Barents Sea in the south. Land parties were to work in Svalbard and, if possible, also in northern Greenland. The new plans led to close co-operation with Norsk Polarinstitut (the Norwegian Polar Research Institute).

The scientific outcome of the expedition would now be greatly increased. The research region was no longer restricted to the continental shelf, but would include wide areas of the deep basins of the Polar Sea, not least of value to marine geology, geophysics and zoology/botany. The main exchange of cold and warm water masses between the Arctic Ocean and the Atlantic takes place both west and east of Svalbard, and this circumstance would be of specific interest to the oceanographers.

Instead of letting the route of the icebreaker settle the scientific programmes, these would determine the ship's route. After World War II, the Swedish State had procured a fleet of six strong icebreakers from the Wärtsilä shipyard in Helsinki, Finland. Among these ships, three were of the large type of 22 000 hp and 13,290 displaced tons: the *Ymer*, *Atle* and *Frej*. In April 1979, the Swedish Parliament ruled that an icebreaker should be placed at the disposal of the expedition. But not until August 1979 did the Ministry of Shipping decide that the *Ymer* should be sent north. This was indeed a popular decision: a ship named *Ymer* had been connected in 1876 with Nordenskiöld's expedition to the Yenisey River, and from 1881 onward the journal of the Swedish Society of Anthropology and Geography was named *Ymer*. These facts explain the designation of the planned expedition of 1980, namely YMER-80.

Funds for the expedition had already been delivered or promised, so the planning and preparations could begin. The *Ymer* was transformed into a research vessel, able to act effectively as a platform and a base for scientific research.

Two helicopters were included in the equipment for carrying scientists to their research areas, for landing and fetching them with their equipment, for reconnaissance and so on.

Valter Schytt was designated scientific leader of the expedition. His planning was assisted by a secretariat under Hans Dahlin. Bengt Lundvall—now retired—became operative leader of the expedition; officially the Government placed him at the disposal of his successor in the Navy.

Captain Anders Billström was designated commander of the *Ymer*. He possessed considerable expe-

rience with ice-breaking as commander of an icebreaker in the north of the Baltic.

The scientific programmes had been provisionally defined at a rather early stage. But they now had to be reshaped, with detailed specification of the equipment, scientific instruments, and personnel. Moreover, the route of the *Ymer* would have to be decided at least provisionally. The ship was to cover two "legs", in part for different scientific purposes and with different workers on board. The changed plans resulted in more extensive research programmes, primarily due to the fact that the deep sea would be included.

The scientific staff amounted to 119 scientists and technicians. Of these, 76 were Swedish and 43 non-Swedish, representing 9 different nations: Sweden, Denmark, Finland, Norway, Great Britain, Canada, Luxemburg, the USA and West Germany. The research comprised 60 projects and the expedition was highly interdisciplinary. Few of the expedition members were initially conscious of the great advantage of having results and data available from other investigations on board.

As mentioned, land parties would be working in selected areas. These parties contained 29 scientists and assistants. Finally, the expedition included a film photographer, three artists, an author and two public-relations men, totalling 7 persons.

The names of everyone on board the *Ymer* are given in the cruise report published by the Royal Swedish Academy of Sciences in 1987: *Expeditionen YMER-80. En slutrapport* (see List of References).

THE MAIN SCIENTIFIC DISCIPLINES ON BOARD THE YMER WERE:

Physical oceanography, 9 scientists.

Sea-ice studies, 6 scientists.

Chemical oceanography, 14 scientists.

Geology (on board), 12 scientists.

Biology (on board), 25 scientists¹.

Atmospheric research, 15 scientists.

Physical geography and Quaternary geology, 3 scientists¹.

Naval engineering, 6 scientists.

THE LAND-BASED PARTIES WORKED IN THE FOLLOWING DISCIPLINES AND GEOGRAPHICAL AREAS:

Geology, Svensköya, 3 scientists.

Biology, Kongsöya, 5 scientists.

Physical geography and Quaternary geology, Nordaustlandet, 9 scientists.

Glaciology, Storöya, 4 scientists.

Glacial meteorology, Kongsöya, 8 scientists.

¹ One scientist is entered both in the *Physical geography and Quaternary geology group* and in the *Biological group* (on board).

THE VOYAGE OF THE ICEBREAKER *YMER* IN 1980

The *Ymer* left Stockholm on June 24, 1980. Much work had to be done to make the icebreaker ship-shape, as a considerable part of the equipment arrived during the last few days. On the voyage along the Norwegian coast, the heavy equipment for deep-sea investigations in geology and biology was tested. The results were not very good in some cases, so modifications had to be made at Tromsø, where the ship stayed from June 30 until July 3. Most of the scientific staff came aboard here.

The first leg, June 24–August 6, 1980

This cruise was largely devoted to *oceanographical* and *marine biological* investigations. Further, land parties were to be transported to their respective research areas. The investigations on board the *Ymer* were mainly restricted to the seas east and north of Svalbard.

The ship left Tromsø on July 3, and passed Hopen Island on the 4th. Scientists were landed at Kongsöya and Svensköya on July 5–6. On the 8th, four glaciologists were landed at Storöya to the north-east of Nordaustlandet. A group of three landed at Glenhalvöya on the 10th, and on the 12th a group of six landed at Prins Oscars Land, the latter two regions being situated in the north of Nordaustlandet. With these operations completed, it was time to start the marine investigations without disturbance by "irrelevant events".

The course was set north-north-eastward into the Polar Sea, where 82°22'N was reached¹. The depth was 3920m. The scientific work was not entirely satisfactory: the large deep-sea winch caused troubles, and the echo-sounder ceased to function when the ship passed through the ice. The latter device was gradually improved. The winch, too, was put right—but not until August 22. This slowed down the deep-sea investigations and reduced the scientific harvest.

Next the *Ymer* steered south-east. The ice conditions had been found worse than expected, especially near land. However, they were still good enough to satisfy the biologists. Near Kvitöya, the *Ymer* steered due east toward Franz Josef Land. After passing longitude 32° E, she had entered the Soviet sector of the Arctic—and then the working environment suddenly changed. Through diplomatic channels, the expedition asked for Sovietic permission to carry out some marine biological and marine geological studies inside the 200-mile limit north of Franz Josef Land. However, the answer was negative.

The investigations were therefore reduced to oceanography, atmospheric chemistry and biological inventory work. At long. 50°E, the ice became very heavy and the ship's speed was reduced to only 1 knot. The course was set northward until about 82°N, where it was changed to west. The northernmost position reached here was 82°31'N.

At about long. 40°E, the ship steered about south until roughly 80°N. The oceanographers happily obtained a fine profile of temperature and salinity data, which indicated a bottom current of very saline water. The current flowed from the shelf north of Franz Josef Land, down into the depths of the Polar Sea. Previously such a current had been supposed to exist, but only on the basis of theoretical considerations. Now the flow was proved to exist by direct observations.

On July 29 the *Ymer* reached Kvitöya, and the opportunity was seized to visit the last camp of the Andrée expedition. Almost everybody on board the *Ymer*, about 100 persons, assembled at the place.

The first cruise of the *Ymer* was drawing to a close. It remained to fetch the land parties on Glenhalvöya and Kongsöya, which was done on July 30–31. There was also an oceanographical profile to be taken. This extended eastward along latitude 79°20'N, from Kongsöya to the neighbourhood of south-western Franz Josef Land. The *Ymer* then proceeded southward via Hopen Island and Nordkapp to Tromsø, where she arrived on August 6.

The second leg, August 9–September 24, 1980

Nearly the whole scientific staff of the first leg left the ship in Tromsø; only nine persons stayed to take part in the second leg. Fresh groups of scientists embarked the ship: the *marine geological* groups under Kurt Boström and Jörn Thiede. The *biological* group had now been reduced from 19 to 6 persons. The studies of the deep-sea biology had been successfully completed. What lay ahead were studies of plankton and polar bears, and the routine of carrying on the biological inventory work.

The *Ymer* left Tromsø on August 9. This time too, the route passed near Hopen Island, where Gunnar Hoppe and Valter Schytt took the chance to land and check some observations on glacial striae, which had been made by the Stockholm University expedition of 1965. Some of the scientists on Kongsöya were exchanged on August 11, and next day—with strong winds and low visibility—the station on Storöya was closed.

The ice conditions north-east of Nordaustlandet had deteriorated considerably since the previous visit of the *Ymer*. The ship worked hard to make headway

¹ This should be compared with the northern extreme of the *Sofia* in 1868, namely 81°42'N.

and reach Glenhalvöya and Prins Oscars Land, where land parties were to be fetched. At the same time, Gunnar Hoppe could be given opportunities to verify some observations.

The ice conditions improved markedly as the ship moved westward. After passing Kapp Platen, she met with open sea and beautiful weather, making August 13 a memorable day. The ship then steered north to get an oceanographical profile over the shelf and the deep-sea plain. On August 16, sediment cores were obtained at 82°30'N, 18°41'E—about the same position as on the first leg, but at a depth of 3250 rather than 3920 m. Next day they reached the eastern off-shoot of the Yermak Plateau, which was of value to the geologists: it was a safeguard against the effect of bottom currents of ooze upon the sedimentation on the bottom. By coming up on local “bottom-hills” this disturbing sedimentation can be avoided.

On August 18, the last land-based scientists were taken aboard by helicopter from Prins Oscars Land and Sjuöyane. And on the same day, 14 men went by helicopter to the IGY station of Murchison Bay at Kinnvika. The buildings at the station were found in a remarkably good state, considering that they had been abandoned since 1959. During this time, several expeditions and visitors had made use of the station in summertime.

Gunnar Hoppe, Wibjörn Karlén and Anders Häggblom intended to carry out some special studies to supplement their previous research on the land upheaval, now with the help of photographs.

On August 19–21, the King of Sweden, Carl XVI Gustaf, paid a visit to the *Ymer* and to the IGY station at Kinnvika. He studied the scientific activity on board, and also went to see the Dutch archaeological expedition working at Smeerenburgfjorden in north-west Spitsbergen.

The *Ymer* proceeded to Longyearbyen for an exchange of scientific personnel; 13 persons left and 9 new scientists boarded the ship. In the night towards August 22, the *Ymer* started her westerly cruise to northern Greenland, during which it was hoped to reach a high latitude and to penetrate into scientifically unknown waters north of Greenland. The deep-sea winch, which had caused so much worry, had been overhauled, and from then on it functioned properly.

The oceanographers intended to take hydrographic series in the interesting region between Spitsbergen and Greenland, where the main exchange of water occurs between the Atlantic and the Polar Sea. The marine geologists planned to study the rift zone between Spitsbergen and Greenland, which is probably still active. Sediment cores were to be taken and attempts made to collect rock samples by dredging.

All this meant, however, that the oceanographic series would have to be temporarily discontinued for a few days at about longitude 0°.

Peter Wadham of the Scott Polar Research Institute in Cambridge, England, intended to make detailed observations on the local formation of vortices, which are created in the sea between the drift ice and the open ocean—that is, between relatively cold and warm water. Generally such a vortex is found near the Greenwich meridian in this region. He had previously observed such vortices here. A vortex was now found, and was located more closely from a helicopter.

The currents in this vortex were studied with the help of four small buoys bearing radio transmitters. These could be activated with the ship's radar, and the position of the buoys could be followed by the radar. The buoys were first placed at the corners of a square, whose deformation with time could thus be determined. Moreover, by taking a great number of hydrographic series within an area of 4000 km², it was hoped to obtain a good idea of the mechanism behind the formation of this vortex. One of the buoys drifted 16 nautical miles in 24 hours, but the others drifted much less far.

It might also be noted that current-meters were left off the Greenland coast, yet they were never found, probably due to the ice.

Near Nordostrundingen on Greenland, Christian Hjort—a Quaternary geologist of Lund University—was given opportunities to study the glacial geology of the coastal zone between Holms Land and Nordostrundingen, during a long helicopter tour.

Previously, during the field seasons 1970, 1971, 1972, 1973 and 1976, Christian Hjort and his assistants carried out similar studies in East Greenland. During 1970–1972, the area between Kong Oscar Fjord and Kejser Frans Joseph Fjord was covered. In 1973, work in Hudson Land and on Hold with Hope was carried out, and further, in 1976, on Hochstetter Foreland and Shannon Island. In 1979, Christian Hjort worked together with Sven Funder from Denmark in North Greenland—in Peary Land and in the area south of Independent Fjord.

The YMER-80 expedition paid also a short visit to the Danish station Nord. Of interest in this region were the many icebergs, and the very strong sedimentation upon the sea-ice of airborne dust coming from Peary Land, which is extremely poor in snow.

There had lingered hopes on board the *Ymer* that it would be possible to penetrate toward the northwest from Nordostrundingen. However, the ice did not allow this and—as had been the case with the *Ob* in 1956—the *Ymer* had to turn back. The ice situation had

Bengt Lundvall, b. 1915. Admiral of the Swedish Navy, operational leader of the expedition with the Swedish icebreaker *Ymer* in 1980 (left). Photo: Marinstaben.

The YMER-80 expedition. –*Ymer* breaking ice. On the bridge. In the galley. In the engine room (right). Sketches by Gösta Werner.

The icebreaker *Ymer*, built in Helsinki, Finland, by the ship-building company Wärtsilä. Sweden possessed at the time three icebreakers of the same strength, 22 000 Hp. Photo: Sjöfartsverket.

The *Ymer* proceeding in the ice. In front Ross's gulls. Chromo lithography by Gunnar Brusewitz.

Not shown in digital edition

The two cruises of the *Ymer* in 1980. The first, June 24–August 6. The second, June 24–September 24. The second cruise is more weakly marked than the first one. (Expeditionen YMER-80, En slutrapport.)

also deteriorated rapidly, and the ship had great difficulty finding a way out of the ice.

The marine geologists had been prevented from working by the observation periods of other scientists on board, and they worried that their scientific programme would become a failure. Moreover, their long wire with the Kullenberg piston sampler broke just when they had started to work again on September 2—resulting in a loss of 4000 m of wire, and of the valuable piston sampler. But next day a 6000-m reserve wire was transferred to the winch, and the geological work could start anew.

On September 8, the *Ymer* reached Longyearbyen to land some of the personnel. It was now early autumn, and the mountains were covered in snow. The ship initially steered north. Norwegian current-meters were taken aboard north-west of Spitsbergen, and later Swedish current-meters north of Nordaustlandet. The ice was, however, more severe than earlier in the summer, and the geologists obtained no observations from the deep-sea plain north of eastern Nordaustlandet.

It remained to fetch the current-meters in the area north of Franz Josef Land. Then the ship steered south via Kong Karls Land, where the glaciologists and meteorologists were taken aboard. The oceanographers got a new profile of hydrographic series, not far from that obtained earlier in the summer. Finally, the geophysicists were in a position to study the geology of the bottom of the continental shelf in the Barents Sea by using seismic methods.

On September 24, the *Ymer* reached Tromsø; and on October 1, she was back in Stockholm.

SOME COMMENTS

The icebreaker *Ymer* had successfully carried out her high Arctic mission in spite of the fact that she had been designed for the ice in the Baltic. Her weak points—if one may say so—were her hull in the waterline below the bridge-house, and her bottom-plates which had received several dents in severe ice situations.

The *Ymer* has two propellers in the fore and two in the stern. There had been much discussion about the advisability of using fore-propellers; the arctic icebreakers are generally not equipped with these. However, the fore-propellers of the *Ymer* functioned well and did not suffer any damage.

The ship has five diesel aggregates, each consisting of a diesel motor and an electric generator, the latter being connected to an electric motor rotating a propeller. Most of the time when the ship worked in the ice, 2–3 aggregates were in operation, while 4 operated during 5% of the time. The ship rarely had a

speed less than 2–4 knots. Maximal power was never taken out, considering the slight increase in speed as opposed to the greater risk of damage upon the hull.

We cannot enter here into a discussion of the scientific work and the results which were gained. The reader is referred to the reports of 1981 and 1987 (see List of References).

The YMER-80 expedition marks the beginning of a new epoch in Swedish polar research. With few exceptions, the initiative in organizing and dispatching previous expeditions had come from private sources and/or civil scientific institutions, and in most cases they had been financed by private persons or funds. The Swedish State, though, and notably the Navy, had often helped with transports and equipment. King Oscar II also supported expedition activity, both as a private person and as head of the Swedish State. However, the expedition activities during the Polar Years—or Geophysical Years—were initiated through diplomatic channels and conducted by scientific academies or societies in various countries.

The YMER-80 expedition had been proposed and initiated by representatives of the Swedish Navy, notably Captain Bertil Daggfeldt and Admiral Bengt Lundvall. Later the Royal Swedish Academy of Sciences, the Swedish Society of Anthropology and Geography, and some scientific institutions took care of the scientific planning. But behind them all were the resources of the state—as well as financial help from many funds, some very large.

Never before had Sweden been in possession of so many and such strong icebreakers, among them three of 22 000 hp. With an icebreaker as strong as the *Ymer*, the deep-sea basins of the Polar Sea will be attainable.

Equally important is the fact that an icebreaker can serve as a movable *platform* for the numerous scientific investigations involved, especially in the polar pack-ice. Thus the scientific groups can be offered electric power, mechanical and navigational facilities, winches and laboratories. Furthermore, the scientists can bring containers in which the instruments are already mounted, so that everything is ready for use soon after the container has been placed on the deck of the icebreaker.

As regards Swedish polar research, the YMER-80 expedition also marks the introduction of a new type of polar expedition.

In this connection it should be remembered that the Russians have made use of icebreakers as scientific platforms, ever since they started to utilize the Northern Sea-Route effectively during the interwar period of 1918–39.

Also noteworthy are the scientific cruises of Rus-

The Swedish Antarctic research station Svea in Heimefrontfjella, Dronning Maud Land. Svea, erected in January 1988, was the first station built in this area. Photo: Olle Melander.

The *Stena Arctica* berthed along the edge of the Riiser-Larsen Ice, when unloading building materials for the Swedish research station Wasa, Dronning Maud Land, December 1988. Photo: Olle Melander

The Swedish research station Wasa on the nunatak Basen ($73^{\circ}03'S$, $13^{\circ}25'W$) in Vestfjella, Dronning Maud Land, was completed in January 1989. The size of the station is 200 m^2 which means that 10–12 persons can live here for long periods. It is designed for “summer periods” but with some minor modifications it can be used as a winter station in the future. The small building to the right is the generator hut. The buildings stand on legs to prevent them from becoming snowed over during blizzards. Photo: Dag Hangum.

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On top wandering Albatross. Below details of other species of albatross. From the sketch-book of Svererik Jakobsson, artist to the expedition SWEDARP (Swedish Antarctic Research Programme) 1988/99.

sian icebreakers in the summers of 1955–58 (see p. 545), to roughly the same regions as those of the *Ymer* in 1980.

A POSTSCRIPT: THE DECADE AFTER YMER-80

Thanks to the *Ymer* expedition, interest in polar research increased markedly among Swedish scientists, politicians and the general public. There arose a demand for a central organization to deal with the communication between scientists, within the country and abroad, in matters of polar research. Although Sweden had not previously possessed any such organization, the Organizing Committee which had been created to plan and conduct the *Ymer* expedition in 1980 may be viewed as the nucleus of such an organization during its five years of work. The experience gained in this time was extremely valuable for the next step: establishing a central organization for continuous research work in the polar regions.

In June 1981, the *Polar Research Committee* of the Royal Swedish Academy of Sciences was founded. It comprised representatives of natural sciences with varying relevance to polar research. At first the Committee had 13 members, of whom 11 were scientists; later the number was slightly decreased. There were also a chairman and a secretary, and at times an adviser on international law.

From 1981–84 Ragnar Edenman, previous governor of Uppsala County, served as chairman. He was followed by Professor Gunnar Hoppe. Others have served as secretaries: Solgerd Björn-Rasmussen, Göran Rudbäck and Dick Hedberg.

THE TASKS OF THE POLAR RESEARCH COMMITTEE ARE:

1. To initiate and promote Swedish polar research, and to collect information and spread knowledge of the polar regions;
2. To function as a reference group for the international scientific co-operation concerning the Arctic and Antarctic

A further development was the establishment on July 1, 1984, of the *Polar Research Secretariat*. This is a government authority—though small—and is housed in the premises of the Royal Swedish Academy of Sciences. Its tasks are to organize polar expeditions, to initiate and promote Swedish polar research, and to inform on polar activities. On questions of science and research, the Secretariat acts in close co-operation with the Polar Research Committee. Professor Anders Karlqvist, a member of this committee, has been in charge of the Secretariat since it was founded.

The recent development and organization of Swedish expedition activities in the Antarctic are due to the existence and aims of the *Scientific Committee on Ant-*

arctic Research (SCAR). The foundations of SCAR were laid in Stockholm in September 1957, and its first meeting was held at The Hague, Netherlands, on February 3–5, 1958.

It was stipulated that the 12 states which had been actively engaged in scientific research in the Antarctic during the International Geophysical Year 1957–58 should be represented (see p. 541) as well as some international scientific unions.

The 12 member states signed a treaty in Washington D.C. on December 11, 1959. Its formal ratification was announced at a meeting in Canberra, Australia, in 1961. The *Antarctic Treaty* was supposed to preserve the environment in the Antarctic and to secure of free scientific research in the region.

The treaty applies to regions within the 60th parallel. In short:

The Antarctic is dedicated to peaceful purposes only; its use for military purposes is restricted.

International co-operation in scientific research and exchange of personnel, information and results are promoted.

Nuclear explosions and disposal of radioactive wastes are prohibited in the region, but peaceful and scientific use of atomic devices is permitted.

No member nation need renounce its claims or previously asserted rights to claims, but there is freedom of operation anywhere about the continent; yet such operations shall not form a basis for new or extended claims during the time the treaty is in force.

In plain language, the Antarctic Treaty should serve as an instrument for avoiding an international “scramble” for natural resources in the Antarctic.

The treaty provides for new member states wishing to take an active part in Antarctic activities. As regards Sweden, its main polar research has been devoted to the Arctic, but two successful expeditions have previously worked in the Antarctic: the Swedish Antarctic Expedition of 1901–03, and the Norwegian-British-Swedish Antarctic Expedition of 1949–52.

On April 24, 1984, Sweden deposited its instrument of accession to the Antarctic Treaty. Sweden then became an *associated* member state of SCAR. It should be added that this accession is open to member states of the United Nations. In September, 1988, Sweden became a full member state of SCAR—and a *consultative* and a part of the Antarctic Treaty.

Since 1987, Sweden has dispatched annual expeditions to Antarctica to work more or less within the same regions as the expeditions of 1901–1903 and 1949–1952, viz the Antarctic Peninsula—with adjacent islands—and within western Dronning Maud

Land. Furthermore, South Georgia has been included in the research in close collaboration with British Antarctic Survey. During the last few years Swedish research workers have also returned to Greenland, Svalbard and Nordaustlandet with small summer expeditions.

Finally, in 1991, a large arctic expedition with the Swedish icebreaker *Oden* was dispatched to the Polar Sea (Arctic Ocean) to co-operate with the German

research vessel *Polarstern* and the American coast guard icebreaker *Polar Star*. On September 7, 1991 the *Oden* and the *Polarstern* were the first western ships ever to reach the North Pole.

We polar travellers of olden times marvel at the resources, and the technical wonders, which continue to benefit the polar workers of today. We wish the new generation of research workers good luck and success in their investigations.

International Arctic Ocean Expedition 1991. On September 7, 1991, the Swedish icebreaker *Oden* and the German research vessel *Polarstern* were the first western ships ever to reach the North Pole. The return tour took both ships into an area north of Greenland which no vessels had visited before. The Fig. shows the cruise track of the *Oden* and the *Polarstern* with noon positions indicated. Key to the tracklines: *Oden* alone=filled triangles, together with *Polarstern*=unfilled triangles.) Map: Göran Liljeström.

The *Oden* is one of the world's most powerful conventional icebreakers. The short and blunt bow design concentrates all ice-breaking to a small section of the hull which reduces friction and increases the ships ice-breaking capability. During the International Arctic Ocean Expedition 1991 the *Oden* was assigned the research programmes for oceanography and marine chemistry, biology, atmospheric chemistry, remote sensing, sea ice and ship technology. Photo: Lisbeth Johnsson.

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SVALBARD PLACE-NAMES

A list of geographical terms obtained from the list published on pages 37–38 in *The Place-names of Svalbard. Skriften om Svalbard og Ishavet, nr 80, Norges Svalbard- og Ishavs-Undersøgelser, Oslo, 1942.*

Norwegian	English
austre, aust	eastern, east
bekk(en)	brook, rivulet
berg(et)	mountain, hill
bre(en), pl breane	glacier
bukt(a)	bay, bight
by(en)	town
dal(en)	valley
elv(a)	river, stream
fjell(et), pl fjella	mountain, hill
fjord(en)	fjord, firth
fly(a)	barren ground, level or undulating in the mountains, fairly extensive.
fonn(a)	snowfield or plateau glacier
gruve (gruva)	mine, pit
halvøy(a)	peninsula
hamn(a)	harbour, haven
hang(en)	hill, hillock
holme(n) pl holmane	islet, holm
huk(en)	hook (in the meaning head-land or mountainous cape)
hytte (hytta)	hut
högd(a) pl högdane	hill, height
jökel(en)	glacier (glacier tongue)
kamm(en)	ridge
kolle(n)	hill (more or less rounded)
moréne(moréna)	moraine
nes(et)	naze, point
nordre, nord	northern, north
odde(n)	point, cape
pass(et)	pass, defile
pigg(en) pl piggane	pointed mountain peak
pynt(en)	point
rev(et)	reef
sjö(en)	sea, also lake
skard(et)	pass
skjer(et) pl skjera	skerry, rock
slette(sletta)	plain, level land
stret(et)	strait
stein(en) pl steinane	stone, rock
strand(a)	strand, shore
sund(et)	sound, strait
söre, sör	southern, south
tange(n)	point (low), sandy spit
tind(en)	peak
topp(en) pl toppane	peak, summit
urd(a)	scree, slope of loose stones

varde(n)	cairn (as landmark)
vatn(et) pl vatna	lake
vestre, vest	western, west
vidde (vidda)	level or undulating ground of large extension
vik(a)	creek, cove
våg(en)	small usually protected bay
Å(a)	brook, river
Öy(a) pl öyane	island
Öyr(a)	gravelly plain; low-lying level land

Russian	English
boloto	swamp
bol'shoi, bol'shaia,	
vol'shoe	large
brod	ford
buchta	bay
chernyi	black
gora	mountain
gorod	city
guba	bay
kamen	rock
khrebet	mountain range
krasnyi, krasnaia, krasnoe	red, beautiful
kriazh	mountain crest
liman	lake, bay, fjord
malyi, malaia, maloe	small
more	sea
nizhnyi, nizhniaia, nizhnee	lower
nizmennost'	lowland
novyi, novaya, novoe	new
ostrov, pl ostrova	island
ozero	lake
pik	top
poluostrov	peninsula
proliv	sound, strait
reka	river
sever, severnyi,	
severnaia, severnoe	north, northern
srednii, sredniaia, srednee	middle
staryi, staraia, staroe	old
ust'	mouth
velikii, velikaia, velikoe	large
verkhonii, verkhniaia,	
verkhnee	upper
vyshnii, vyshniaia, vyshnee	
vostok, vostochnyi,	high
vostochnaia, vostochnee	east, eastern
yug, yuzhnii, yuzhniaia,	
yuzhnee	south, southern
zaliv	bay
zapad, zapadnyi,	
zapadnaia, zapadnoe	west
zemlia	land

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Abbreviations:

KVA = Kungl. Vetenskapsakademien = Royal Swedish Academy of Sciences.

SSAG = Swedish Society of Anthropology and Geography.

Ymer is the Journal of the SSAG.

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