NORGES SVALBARD- OG ISHAVS-UNDERSØKELSER
LEDER: ADOLF HOEL

SKRIFTER

Nr. 85

THE DOWNTONIAN AND DEVONIAN VERTEBRATES OF SPITSBERGEN. VIII.

THE ENGLISH-NORWEGIAN-SWEDISH EXPEDITION 1939.
GEOLOGICAL RESULTS

BY
SVEN FØYN AND ANATOL HEINTZ

WITH 3 PLATES AND 18 TEXT-FIGURES

OSLO
I KOMMISJON HOS JACOB DYBWAD
1943

RESULTS OF THE NORWEGIAN EXPEDITIONS TO SVALBARD 1906—1926 PUBLISHED IN OTHER SERIES

(See Nr. 1 of this series.)

The results of the Prince of Monaco's expeditions (Mission Isachsen) in 1906 and 1907 were published under the title of 'Exploration du Nord-Ouest du Spitsberg entreprise sous les auspices de S. A. S. le Prince de Monaco par la Mission Isachsen', in Résultats des Campagnes scientifiques, Albert Ier, Prince de Monaco, Fasc. XL—XLIV. Monaco.

ISACHSEN, GUNNAR, Première Partie. Récit de voyage. Fasc. XL. 1912. Fr. 120.00.

With map: Spitsberg (Côte Nord-Ouest). Scale 1 : 100 000. (2 sheets.) Charts: De la Partie Nord du Foreland à la Baie Magdalena, and Mouillages de la Côte Ouest du Spitsberg.

ISACHSEN, GUNNAR et ADOLF HOEL, Deuxième Partie. Description du champ d'opération. Fasc. XLI. 1913. Fr. 80.00.

HOEL, ADOLF, Troisième Partie. Géologie. Fasc. XLII. 1914. Fr. 100.00.

SCHETELIG, JAKOB, Quatrième Partie. Les formations primitives. Fasc. XLIII. 1912. Fr. 16.00.

RESVOLL HOLMSEN, HANNA, Cinquième Partie. Observations botaniques. Fasc. XLIV, 1913. Fr. 40.00.

A considerable part of the results of the ISACHSEN expeditions in 1909 and 1910 has been published in Videnskapsselskapets Skrifter. I. Mat.-Naturv. Klasse. Kristiania (Oslo).

ISACHSEN, GUNNAR, Rapport sur l'Expédition Isachsen au Spitsberg. 1912, No. 15. Kr. 5,40.

ALEXANDER, ANTON, Observations astronomiques. 1911, No. 19. Kr. 0,40.

GRAARUD, AAGE, Observations météorologiques. 1913, No. 1. Kr. 2,40.

HELLAND-HANSEN, BJØRN and FRIDTJOF NANSEN, The sea west of Spitsbergen. 1912, No. 12. Kr. 3,60.

ISACHSEN, GUNNAR, The hydrographic observations. 1912, No. 14. Kr. 4,20.

With chart: Waters and anchorages on the west and north coast. Publ. by the Norw Geogr. Survey, No. 198.

HOEL, A. et O. HOLTEDAHL, Les nappes de lave, les volcans et les sources thermales dans les environs de la Baie Wood au Spitsberg. 1911, No. 8. Kr. 4,00.

GOLDSCHMIDT, V. M., Petrographische Untersuchung einiger Eruptivgesteine von Nordwestspitzbergen. 1911, No. 9. Kr. 0,80.

BACKLUND, H., Über einige Olivinknollen aus der Lava von Wood-Bay, Spitzbergen 1911, No. 16. Kr. 0,60.

HOLTEDAHL, OLAF, Zur Kenntnis der Karbonablagerungen des westlichen Spitzbergens. I. Eine Fauna der Moskauer Stufe. 1911, No. 10. Kr. 3,00. II. Allgemeine stratigraphische und tektonische Beobachtungen. 1912, No. 23. Kr. 5,00.

HOEL, ADOLF, Observations sur la vitesse d'écoulement et sur l'ablation du Glacier Lilliehöök au Spitsberg 1907—1912. 1916, No. 4. Kr. 2,20.

VEGARD, L., L'influence du sol sur la glaciation au Spitsberg. 1912, No. 3. Kr. 0,40.

ISACHSEN, GUNNAR, Travaux topographiques. 1915, No. 7. Kr. 10,00.

With map: Spitsberg (Partie Nord-Ouest). Scale 1 : 200 000 (2 sheets).

GUNNAR ISACHSEN has also published: Green Harbour, in *Norsk Geogr. Selsk. Aarb.*, Kristiania, 1912—13, Green Harbour, Spitsbergen, in *Scot. geogr. Mag.*, Edinburgh, 1915, and, Spitsbergen: Notes to accompany map, in *Geogr. Journ.*, London, 1915.

All the above publications have been collected into two volumes as Expédition Isachsen au Spitsberg 1909—1910. Résultats scientifiques. I, II. Christiania 1916.

As the result of the expeditions of ADOLF HOEL and ARVE STAXRUD 1911—1914 the following memoir has been published in Videnskapsselskapets Skrifter. I. Mat.-Naturv. Klasse.

HOEL, ADOLF, Nouvelles observations sur le district volcanique du Spitsberg du Nord. 1914, No. 9. Kr. 2,50.

Expeditions of TH. VOGT 1925 and 1928:

STØRMER, LEIF, Downtonian Merostomata from Spitsbergen. — Skr. Norske Vid.-Akad I. Mat.-Nat. Kl. 1934. No. 3. Kr. 3,00.

The following topographical maps and charts have been published separately:

Maps:

Bear Island. 1 : 25 000. 1925. Kr. 10,00.

Bear Island. 1 : 10 000. (In six sheets). 1925. Kr. 30,00.

East Greenland. Eirik Raudes Land from Sofiasund to Youngsund. 1 : 200 000. 1932. Kr. 5,00.

NORGES SVALBARD- OG ISHAVS-UNDERSØKELSER
LEDER: ADOLF HOEL

SKRIFTER

Nr. 85

THE DOWNTONIAN AND DEVONIAN VERTEBRATES OF SPITSBERGEN. VIII.

THE ENGLISH-NORWEGIAN-SWEDISH EXPEDITION 1939.
GEOLOGICAL RESULTS

BY
SVEN FØYN AND ANATOL HEINTZ

WITH 3 PLATES AND 18 TEXT-FIGURES

OSLO
I KOMMISJON HOS JACOB DYBWAD
1943

A. W. BRØGGERS BOKTRYKKERI A/S

Contents.

Previous Work and Progress of the Expedition.

Earlier expeditions to the Devonian areas in Spitsbergen were chiefly geological ones, and the fossils, as a rule, had not been collected by specialists. The experiences, however, of previous expeditions conducted by Stensiö (mostly to the Triassic regions), and by Vogt (to the Devonian areas), and the Danish expeditions to Greenland, have shown that paleontologists working in the field are more competent to discover and collect valuable paleontological material than the geologists. It had, therefore, already long ago been planned, both in Stockholm and Oslo, to arrange an exclusively paleontological expedition to Devonian areas in Spitsbergen. As the most valuable paleontological collections previously had been made in Raudfjorden (1910, 11, 25, 28) and partly in Wijdefjorden (1912, 25, 28) and Billefjorden (1917, 25, 28), it was natural, as the main working field of the expedition, to choose the Wood Bay Series — the mightiest Devonian deposits in Spitsbergen —, especially as the fossils found in 1912 in Woodfjorden comprised many interesting pieces.

The English-Norwegian-Swedish (E.N.S.) Spitsbergen Expedition during the summer of 1939 was the result of an intimate collaboration between the British Museum (Natural History), London, the Paleozoological Department of the Riksmuseum in Stockholm, and the Paleontological Museum in Oslo. The initiator, and the one who accomplished most towards its realization, was Professor Dr. Erik A:son Stensiö, Stockholm. For several years he had plans of starting an expedition, and, partly in collaboration with Dr. Errol I. White, London, and Professor Dr. A. Heintz, Oslo, he worked out the program.

The expedition was financed by all the three countries. The trustees of the British Museum (Natural History) had granted 1000 £, the Swedish Government and private donors 30 000 Swedish Kroner, and finally the Norwegian Funds (Forskningsfondet and Varekrigsfondet) 10000 Norw. Kroner. It was decided that not more than 4 scientists should take part from each country. The list of the members of the expedition was as follows: Prof. Dr. Stensiö (Stockholm), the leader of the expedition; Dr. White (London), chief of the English

party; Prof. Dr. Heintz (Oslo), chief of the Norwegian party. Dr. Moy-Thomas (Cambridge), Dr. Brough (Edinburgh) and Mr. Croft (London) — members of the English party. Amanuensis Jarvik (Stockholm) and Amanuensis Wängsjö (Uppsala) — members of the Swedish party; Lektor Cand. Real. Føyn (Kongsberg), and Stud. Real. Aarhus (Oslo) — members of the Norwegian party. Dr. Delle (Riga) also took part in the expedition. Mr. Andreassen, a fisherman, was engaged as assistant in Tromsø (Fig. 1). The E.N.S. expedition freighted its own ship — M/S "Heimen" of Tromsø (Fig. 2), Captain Lars Jakobsen, with a crew of 10.

"Heimen" left Tromsø on the 30th of June with 6 of the members, while the other 6 went with S/S "Lyngen" from Tromsø on the following day. Both parties arrived in Longyearbyen, Adventfjorden, on the 3rd of July. The first object was investigations at Dicksonfjorden. One party, consisting of Stensiö, Brough, Croft, and Andreassen, was landed on the 5th of July in the southern part of the fjord to collect Triassic fossils, the rest of the expedition camped below Mount Lykta on the east side of the inner part of the fjord, and began at once investigating the Devonian deposits belonging to the Wood Bay Series, which is excellently exposed in this place. After a few days Stensiö's party moved to the west side of the inner part of the fjord to investigate the Devonian deposits there.

On the 13th of July the whole expedition left Dicksonfjorden, and, after a short visit to Adventfjorden, left for Woodfjorden. On the north coast of Spitsbergen the fog was so thick that it prevented us from finding Woodfjorden, so we were forced to wait not far from the west point of the Reinsdyrflya (Reindeer Peninsula). Some of us went ashore and found that the red Wood Bay sandstone here was strongly compressed. On the 17th of July, in spite of heavy fog, we arrived in Bockfjorden, where the following 3 days were spent in collecting fossils in the deposits on its south coast. Two or three parties worked independently at various parts of the coast.

From Bockfjorden we went straight to the very bottom of Woodfjorden working on both sides of the fjord until the 26th of July. We kept head-quarters onboard ship, and every morning three parties left the ship to investigate the coast, the mountains, and the side-valleys. As a rule the three parties were as follows: 1st party: Stensiö, Brough, Croft, Andreassen. 2nd party: White, Moy-Thomas, Jarvik, Aarhus. 3rd party: Heintz, Føyn, Wängsjö, Delle. In the last days of July one party was landed not far from the very point of Gråhuken (Heintz, Føyn, Jarvik and Delle), while the rest of the expedition went with the "Heimen" to Liefdefjorden making investigations on Pteraspistoppen and the neighbouring mountains.

On the 2nd of August the party at Gråhuken was taken up by the "Heimen", which with all members onboard started for Wijdefjorden.

Fig. 1.

Members of the Expedition in Vestfjorden (7-8-1939). From left to right: Stensiö, Wängsjö, Andreassen, Føyn, Delle, Moy-Thomas, White, Heintz, Aarhus, Brough, Jarvik, Croft. (Wängsjö phot.).

Fig. 2.

M/S "Heimen" in Raudfjorden. (Føyn phot.).

An unusually strong wind prevented us from going to the bottom of Austfjorden, as originally planned, and forced us to cast anchor at the very bottom of Vestfjorden. Here the red sandstone of the Wood Bay Series is beautifully exposed, and during the next two days we investigated and collected fossils on both sides of the fjord as far north as Kartdalen. Continuously bad weather prevented us from going to Austfjorden, and we made only two short trips to the coast further north (by Sjettedalen, Andredalen and Vatnedalen). Only small collections were made here.

After a short visit to Bockfjorden to meet the S/S "Lyngen", with which one of the members of the English party, Dr. Brough, was forced to leave us to get earlier back to England, the "Heimen" sailed on the 10th of August to Raudfjorden. Here we collected fossils in the localities so well known from earlier expeditions (Frænkelryggen and Ben Nevis). We left Raudfjorden on the 12th of August, and went back to Isfjorden, where we arrived in Adventfjorden on the 14th. On the following day we came to Skansbukta and collected Triassic and Carboniferous fossils there. From Skansbukta we visited Billefjorden and made two short trips to the west side of the fjord, collecting some fossils in the Devonian beds. The following day, the 18th of August, was spent in Mimerdalen in visiting a few of the fossil-localities there.

The 20th and 21st the greater part of the expedition (Mr. Croft and Aarhus were left in Adventfjorden collecting Tertiary plants) spent in Ekmanfjorden, investigating the Devonian deposits on the east side. Here a very valuable collection of fossils from the Wood Bay Series was brought together. On the 22nd the three last members of the English party (Dr. White, Dr. Moy-Thomas and Mr. Croft) had to leave Spitsbergen by the S/S "Lyngen", owing to the very strained political situation in Europe. The rest of the expedition spent the last days of August visiting various parts of Isfjorden, collecting fossils from the Triassic, Jurassic, Cretaceous, Tertiary, and also Carboniferous marine fossils. We left the Adventfjord on the 29th by the "Heimen", arriving at Tromsø on the 1st of September.

As a result of the expedition a large collection of different fossils was brought together, the greater part consisting of Devonian fossils, especially from the Wood Bay Series. Valuable collections from the Red Bay and Wijde Bay Series, however, were also made. In addition must be mentioned the collections of Stegocephals, fishes, and Ammonites from the Triassic, Jurassic, and Cretaceous, the Brachiopods from the Carboniferous, and the Tertiary plants. All this material is to be distributed among different specialists, in the first instance to members of the expedition, for description.

The geological part of the work during the expedition was done by N. Delle and the authors of the present paper (S. Føyn and A. Heintz).

As the chief task, however, was to collect fossils, the geological investigation was made in connection with the fossil-hunting only, thus necessarily being of a more or less casual character. The preliminary determination of the fossils has mostly been done by Heintz.

In this paper we shall shortly discuss the geological results obtained during the expedition in the Devonian area, but must point out that they cannot be regarded as an exhaustive description of the geological conditions in the districts we visited. The paleontological part of this paper is written by A. Heintz, the geological by S. Føyn. The authors are very much obliged to N. Delle for his kind and valuable assistance during the field-work.

In this place we want to express our best thanks to Norges Svalbard- og Ishavs-undersøkelser in Oslo and its leader Adolf Hoel. This office has with its great experience concerning the organisation and supply of Arctic expeditions helped us in all possible ways. We must also mention the air photographs of Spitsbergen which the expedition obtained from the Svalbard office. They were of great support, especially in the geological work done by the authors.

Finally we wish to express our most cordial thanks to the leader and initiator of the expedition, Professor Dr. E. A:son Stensiö, and to all our other companions. The preliminary work which Professor Stensiö had undertaken to realize the expedition and to supply it in the best way was enormous. His inexhaustable energy, enthusiasm and brilliant spirits made the work easy and pleasant for us all. This interesting expedition remains for us as a most glorious example of a real international collaboration, where representatives of different nations worked together for the good of the whole, under the leadership of a man who was at the same time a comrade to each of us.

The Downtonian and Devonian Areas of North Spitsbergen. Previous Investigations.

The Downtonian and Devonian deposits of North Spitsbergen form a down-faulted area, which to the east and west is limited by NS running faults (Fig. 3; Pl. I). In the west there are two faults: the first running along the western shore of Raudfjorden and further southwards, the second from Breibogen (= Broad Bay) to Liefdefjorden, Bockfjorden and further southwards in the direction of Ekmanfjorden. The block between these two faults consists of sediments of uppermost Downtonian and Dittonian age ("The Red Bay Series"), resting unconformably on the metamorphic Hecla Hoek rocks. As the block dips to the west, the Hecla Hoek rocks occur along the second fault.

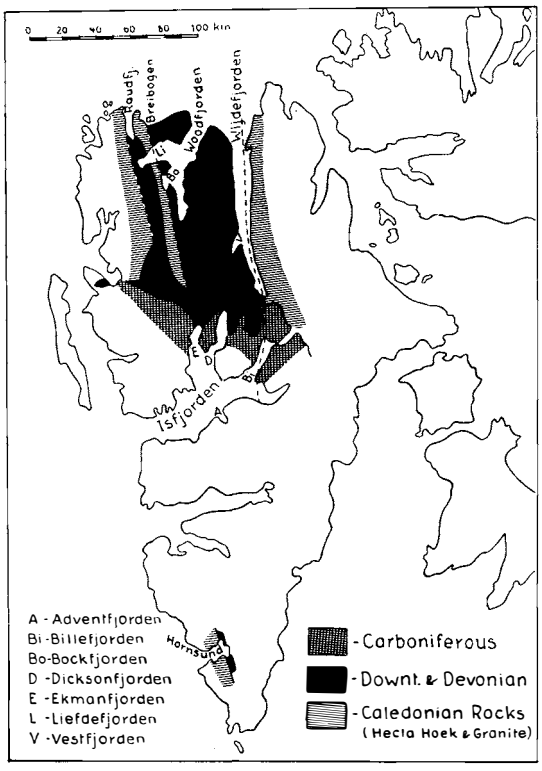


Fig. 3.
Map showing the distribution of the Downtonian and Devonian deposits in Spitsbergen.

The eastern fault runs along Wijdefjorden, and continues into Billefjorden on the north side of Isfjorden. The block between this eastern fault and the second western fault consists of rocks of Devonian age. Only near the faults to the west there are small areas with deposits of the Red Bay Series (Liefdefjorden, Bockfjorden and Sigurdfjella at the head of Woodfjorden). In this Devonian area there also occur volcanic rocks, which, according to A. Hoel (1911, 14, 1.), are partly of Cretaceous, partly of Quaternary age. The Devonian area extends westwards to Kongsfjorden (Kings Bay), and southwards to the innermost parts of the northern branches of Isfjorden (Ekmanfjorden, Dicksonfjorden, and Billefjorden). The Devonian is here covered, unconformably, in some places by the Culm, in others by the Upper Carboniferous.

In addition to this large Devonian area in the north, there is also a smaller one, around Hornsund. It was, however, not visited by the E. N. S. expedition.

Fossils proving the Devonian age of the rocks were for the first time found by Malmgren and Nordenskiöld at Liefdefjorden in 1868. In 1870 Nathorst and Wilander found fragments of Devonian fishes on the west coast of Billefjorden, and in 1882 Nathorst discovered that Devonian fishes were abundant both in the inner part of Dicksonfjorden and in Mimerdalen. During the Swedish Arctic Expedition of 1898 the Devonian fossils were collected at Gråhuken, and finally in 1899 Tschernichew and De Geer discovered the Devonian area at Hornsund (Nathorst, 1910). During the Monaco Expedition of 1906, conducted by Isachsen, Staxrud discovered fossils of Downtonian age on Pteraspistoppen, between Raudfjorden and Liefdefjorden (Hoel, 1909, 29). The following year Hoel found Lower Devonian fishes at the inner end of

Woodfjorden (Hoel 1909, 29). Further collections and geological investigations in Raudfjorden, Woodfjorden and Wijdefjorden were made chiefly by Hoel and Holtedahl, during the expeditions of Isachsen in 1909 and 1910, and during those of Hoel and Staxrud in 1911 and 1912 (Hoel, 1913, 29). In 1917 Stensiö made collections and geological investigations in Mimerdalen and Billefjorden (Stensiö 1918, 1, 2). In 1924 Høeg crossed the Devonian area between Dicksonfjorden and Wijdefjorden (Lid 1929). The expeditions of Vogt in 1925 and 1928 had as their special task to study the Downtonian and Devonian deposits in north Spitsbergen (Vogt 1926, 29). The geological investigation and collection of fossils was made in Raudfjorden, Dicksonfjorden, Wijdefjorden, and Billefjorden (Mimerdalen). The geological results of Vogt's expeditions are not yet published, with the exception of a short abstract of a communication read at a meeting of the Geological Society of London in April, 1938 (Vogt 1938) and a paper about the cannel coal from Spitsbergen (Vogt 1941). A more detailed publication from Vogt is awaited with great interest. Finally it must be mentioned that Schenk in 1936 carried out geological researches on the peninsula between Woodfjorden and Wijdefjorden (Schenk, 1937).

On the basis of investigations in 1911—12 and a preliminary determination of the fossils collected, made by Kiær (Kiær, 1916), Hoel and Holtedahl (Holtedahl 1913, 14) proposed dividing the Downtonian-Devonian deposits in North Spitsbergen into the four following series (Pl. I):

The Wijde Bay Series.
The Grey Hoek Series.
The Wood Bay Series.
The Red Bay Series.

Orvin in his last paper about the geological history of Spitsbergen (1940), proposed to alter these names into Norwegian ones — Wijdefjord Series, Woodfjord Series, Gråhuk Series and Raudfjord Series. The authors do not agree with Orvin in this alteration. They find that the names for the geological series, which have been internationally used for nearly 30 years, cannot thus be changed only because the geographical names of the localities have been translated into Norwegian. These names have been used in all paleontological and geological Spitsbergen literature which has appeared in Norway since 1913 (e. g. Hoel, 1914, 29, Holtedahl, 1925, 26, Heintz, 1929, 35, 37, Kiær, 1916, 30, 32, 35, Quenstedt, 1926, Stensiö, 1927, Vogt, 1941 etc.) and further in all papers printed abroad, discussing the geology or paleontology of Spitsbergen (Holtedahl, 1913, 14, Heintz, 1934, King, 1925, 34, Stensiö, 1918, 26, 32, Säve-Söderbergh, 1934, 41, Schenk, 1937, Vogt, 1938 etc.). Also in both the reviews on the geology of Spitsbergen, published by

Nathorst (1910) and Frebold (1935), the original English names have been used. Taking these facts into consideration we prefer to keep the old names, finding the new ones proposed by Orvin less satisfactory.

The Red Bay Series was originally determined as belonging to Downtonian. Later (Heintz, 1937, Vogt, 1938) it was regarded as belonging to the upper part of Downtonian and Dittonian.

The age of the Wood Bay Series was determined as being Lower Devonian. This opinion is still maintained by later investigators, with the only difference that the Wood Bay Series is regarded as belonging to the lower part of Lower Devonian (Stensiö, 1927, Heintz, 1929, 37, Vogt, 1938). The age of the two other series is more uncertain. Originally the Grey Hoek Series was regarded as being probably of Middle Devonian age and the Wijde Bay Series as Upper Devonian. Since then other views have been suggested. Thus Stensiö (1927) and Heintz (1929) regarded the former as being of upper Lower Devonian or lower Middle Devonian. Later Quenstedt (1926) and Heintz (1937) determined it as being upper Lower Devonian, and Vogt (1938) was of the same opinion. The age of the Wijde Bay Series was also determined very differently. Thus Stensiö (1927) regarded it as probably being Upper Devonian, but older than the upper Devonian Ursa sandstone (Bear Island). Heintz (1937) classed it as being of middle Middle Devonian, and Vogt (1938) (who proposed the new name Mimer Valley Series) as upper Middle Devonian. Finally Schenk (1937) regarded the Wijde Bay Series as upper Lower Devonian to lower Middle Devonian. As shall be discussed later, however, Schenk has certainly mistaken the name proposed before, and regarded a part of the Grey Hoek Series as Wijde Bay Series.

The paleontological collections have been studied by different specialists. The first investigation and determination was made by the late J. Kiær (1916). He continued later the studying of Heterostraci, and published four papers (1927, 30, 32, 35; the two latter papers edited by Heintz). E. A:son Stensiö has studied the Crossopterygians (1918 2, 3), Pteraspids (1926), Cephalaspids (1927) and Anthiarchi (1931); A. Heintz various Arthrodira (1929, 1, 2, 34, 35, 37). Quenstedt has treated the Lamellibranchiates (1926), and Solle (1935) the Ostracods. Finally Wängsjö (1938) has described a new Benneviaspis, and Nilsson Anthiarchi (1941).

The geology and stratigraphy of the Devonian deposits on North Spitsbergen have been treated by Nathorst (1910), Holtedahl (1913, 14, 26, 1), Hoel (1909, 13, 14), Stensiö (1918), Schenk (1937) and Heintz (1937). A general review of the geology of Spitsbergen has lately been given by H. Frebold (1935), giving a complete bibliography. Recently an excellent paper has been published by Orvin (1940).

Woodfjorden.

(Pl. I; Pl. II, Fig. 1 and 2.)

Of the three series into which the Devonian of Spitsbergen is divided, the Wood Bay Series is by far the mightiest; its thickness is greater than that of the Grey Hoek and the Wijde Bay Series together. With regard to extension, it makes up the major part of the Devonian area of North Spitsbergen (Pl. I). Mostly being intensively red, its sandstones distinguish it easily from the other series and make it visible at a great distance.

In Woodfjorden the Wood Bay Series is complete, and both its lower and upper limits can be studied. During our 17 days' investigation in Woodfjorden ($^{17}/_{7}$–$^{3}/_{8}$) we succeeded in dividing the whole series into three divisions and mapping their extension along the shore (Pl. III).

We were uncertain as to what names we should choose for these divisions: should we name them after the most characteristic guide-fossils, or after the localities where they are most distinctly exposed. The names based upon the guide-fossils have many advantages, but also some drawbacks, as many of the fossils are not yet described, and many names of already described fossils will have to be changed as they are not in accordance with the international rules of nomenclature. Thus it is preferable to use a geographical terminology, especially as the names of the various parts of the Red Bay Series are also based on the geographical distribution of the deposits (Frænkelryggen Division and Ben Nevis Division). We have thus chosen the following names for the three divisions of the Wood Bay Series, from the oldest to the youngest (Pl. II; Pl. III).

1) Kapp Kjeldsen Division, after a point of that name between Bockfjorden and Woodfjorden.
2) Lykta Division, after the mountain in Dicksonfjorden.
3) Stjørdalen Division, after a valley on the east side of Woodfjorden.

Each of these three divisions is characterized by a group of guide-fossils, some fossils of one group may, however, also occur in another division. With our present knowledge of the stratification and of the fossils it is therefore impossible to draw distinct limits between the various divisions, and we have thus to reckon with the presence of transitional zones.

In appearance all three divisions have certain characteristics making it possible to distinguish them more or less accurately at a distance. A mountain-side in the Stjørdalen Division has an intense purple colour, and an even surface. In addition the uppermost part of this division is easily recognizable by a zone of a yellowish-grey limy

sandstone, 20—40 m in thickness. Above this there follow some layers of red sandstone covered conformably by the grey rocks of the Grey Hoek Series. This transitional zone can be seen at several points between Kapp Auguste-Viktoria and Scott Keltiefjellet, for instance in the valleys Stjørdalen and Verdalen. In contrast to the Stjørdalen Division, the two lower divisions are more brownish-red, and the surface is slightly more rough and irregular owing to a richer content of thick sandstone beds and a more frequent occurrence of grey-coloured beds.

Especially in the uppermost part of the Kapp Kjeldsen Division grey-coloured sandstones occur abundantly; thus as a rule this zone, which in Woodfjorden is more than 100 metres thick, is easily recognized in the mountain-side by its paler colour. This zone we regarded as the upper limit of the Kapp Kjeldsen Division.

The Fauna of the Wood Bay Series.

The fauna of the Wood Bay Series is partly very rich, but at the same time quite uniform; the fossils in some parts occurring very abundantly, while in others they may be totally absent. Only seldom have fossiliferous horizons continuing uninterrupted for any longer distance been observed. As a rule the fossils occur quite locally. The state of preservation varies, mostly being fairly good. In some localities especially fine fossils have been found, such as complete Pteraspids, Cephalaspids with well-preserved endocranium, and others. In other parts, on the contrary, only isolated plates or fragments of fossils occur. In one and the same horizon parts with a very rich fauna may interchange with completely empty ones. In some places deposits of many hundred metres seem to be almost without fossils.

The fauna in the Wood Bay Series consists, as a whole, mostly of Ostracoderms, Arthrodirs, and Crossopterygians. Of invertebrates only Ostracodes were collected in a few localities.

Of the Ostracoderms the Pteraspids are represented by a number of forms. As none of these forms has hitherto been described, we shall only mention a few of the most characteristic types. *Giganthaspis* (Fig. 4, A, B) (a name proposed by Kiær for a large Pteraspid, with dorsal shield about 15—20 cm) occurs abundantly in the Kapp Kjeldsen Division. The shield is flat, very thin, with relatively broad, flat, and even ribs (Fig. 4, B). The sensory canals are indistinct. As a rule only isolated plates, such as dorsal and ventral shields, or rostral plates, have been found. Another unusually abundant and characteristic Pteraspid is *Doryaspis* (Fig. 5, A, B, C). This form, first described by Lankaster (1884) and later by Woodward (1900) as *Pteraspis nathorsti*, was by Kiær referred to a new genus, *Doryaspis*, because its structure is quite different from that of the typical *Pteraspis*. Kiær, however, did not

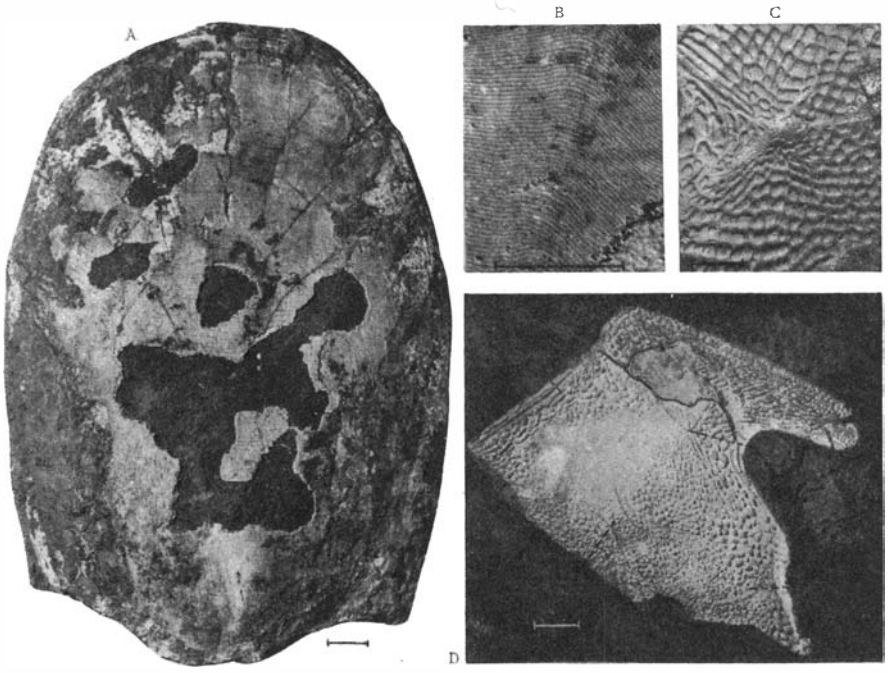


Fig. 4.

The guide-fossils from the Kapp Kjeldsen Division: A — *Giganthaspis* sp., dorsal shield. B — *Giganthaspis* sp., sculpture. C — *Arctaspis* sp., sculpture. D — *Arctaspis kiæri* Htz., ventral shield (C and D after Heintz, 1929). Scale: The lines on the figs. is like 1 cm.

give any complete description of it. Lately White (1935) mentioned and depicted a single shield from Spitsbergen. Most common are isolated, relatively flat dorsal shields and strongly curved ventral shields. But also complete specimens have been found, a few ones during Vogt's expedition in 1925, later a large number during our expedition. The most characteristic feature of this relatively small form (dorsal shield about 7—8 cm) is the sculpture, which consists of two sets of lines, — one concentric line parallel to the outside margin of the shield, the other radiating from the hind median part of the shield (Fig. 5, C). The crossing of these lines gives the sculpture a very characteristic outline. The complete forms show that the rostral plate is unusually narrow and long (about 5—6 cm), the orbital plates are large, and the dorsal median spine is absent; the lateral spine, however, is enormously developed. The tail is covered by relatively thick, quadrangular scales. Many different species of *Doryaspis* are without doubt represented in the Wood Bay Series. Perhaps they later on may allow one to make a more detailed division of the middle part of the series into single horizons. At the present, we can only state that *Doryaspis* is a perfect guide-fossil for the Lykta Division of the Wood Bay Series. So far

as could be determined it occurs only in this division. A few more uncertain specimens have however been collected in other parts of the Wood Bay Series.

Finally we must mention a very small form of which we know only isolated dorsal and ventral shields. It measures between 1 and 1.5 cm, and has a very coarse sculpture of concentrically arranged ribs. In some deposits of the Kapp Kjeldsen Division it occurs very abundantly.

Cephalaspids are also quite abundant, but so far none of them can be regarded as especially good guide-fossils. As is known, Stensiö (1927) has described the following species of *Cephalaspis* from the Wood Bay Series: *Cephalaspis watneliei* St., *C. oblongus* St., *C. isachseni* St. (all from Kapp Kjeldsen Div.), *C. acuticornis* St., *C. borealis* St., *C. lata* St. (probably from Kapp Kjeldsen Div.), *C. høegi* St. (Lykta Div.), *C. laticornis* St., and *C. brevicornis* st. (probably Lykta Div.). Further Stensiö has mentioned 9 indeterminable specimens from various parts of Woodfjorden. He has described a new genus *Boreaspis* (*B. rostrata* St.) based on 2 cephalic shields found in the Wood Bay Series. They were collected in the lowest part of the Kapp Kjeldsen Division (West of Vonbreen (=Hoffnung Glacier)). On Vogt's expedition 1928 a number of new specimens were found in the Wood Bay Series. The collections made in 1939 consist of a number of Cephalaspids, mostly large forms, corresponding to the earlier described forms which were also mostly large ones. None of the new forms have hitherto been determined or described, but in all cases it is evident that the new collection contains a number of new species. *Boreaspis* appears to be a very common form in the Wood Bay Series, occurring mostly in the two lower divisions (Kapp Kjeldsen and Lykta). In the Stjørdalen Division only uncertain fragments were found. *Boreaspis* often appears in a great number of species, many different specimens being represented, from very small ones (about 1—1,5 cm) to relatively large ones (about 3—5 cm). It seems very likely that, when the whole material has been described, some of the species will prove themselves to be good guide-fossils. In addition to the typical *Boreaspis*, other forms, probably belonging to new genera related to *Boreaspis*, were found. In the lowest part of the Kapp Kjeldsen Division also *Benneviaspis* appeared (Sigurdfjella, 1939). As is known, this form was previously only known from the Red Bay Series and the Dittonian in England. The investigation of this material has been left to Dr. Wängsjö, Uppsala.

The most common group of Arthrodira, represented in the Wood Bay Series, is the Phlyctænaspids, earlier named "Acanthaspids". As Heintz mentioned in 1937 the name "*Acanthaspis*" cannot be used, being already preoccupied for certain insects (1843). The name of the order "Acanthaspida" must accordingly be altered. In 1937 Heintz

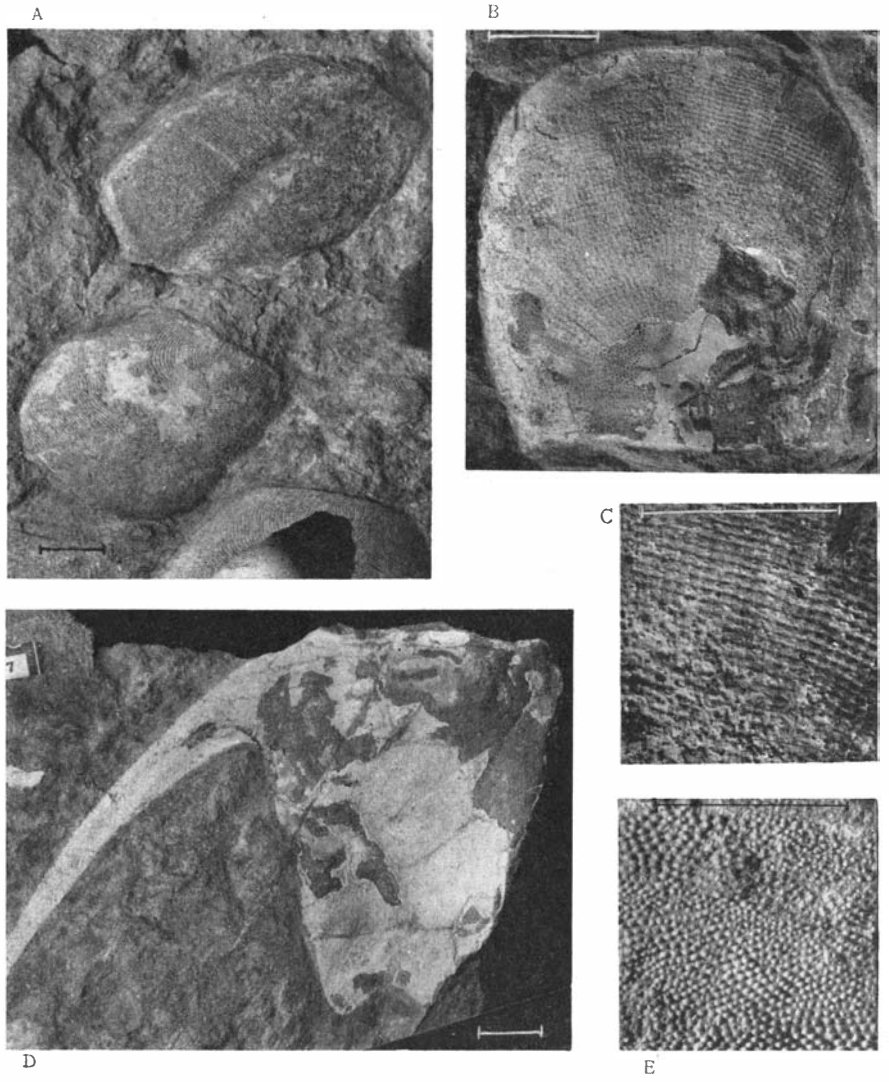


Fig. 5.

The guide-fossils from the Lykta division. A *Doryaspis nathorsti* (Lank.), one dorsal shield (above) and two ventral shields (below). B — *Doryaspis* sp., ventral shield with finely preserved sculpture. C — *Doryaspis* sp., sculpture. D — *Arctolepis* (= *Jaekelaspis*) *lewini* Htz., ventral shield. E — *Arctolepis decipiens* (Wd.), sculpture (D and E after Heintz, 1929).
Scale: The lines on the figs. is like 1 cm.

used the name "Arctolepida", corresponding to the name *Arctolepis*, proposed by Eastman in 1908 for the forms from Spitsbergen which Heintz in 1929 named as "*Jaekelaspis*". The name "*Jaekelaspis*" must accordingly be changed into *Arctolepis* Eastman, but the name of the whole order may better be derived from *Phlyctœnaspis*, a Canadian form described as early as 1890 by Traquair.

A number of Phlyctænaspida was described from the Wood Bay Series by Heintz (1929, 1, 2). The new and very rich material collected in 1939 gives a more complete picture of the structure and distribution of these interesting Arthrodirs. The forms earlier described are as follows:

Arctolepis decipiens (Wd.), *A. lata* (Htz.), *A. lewini* (Htz.), *A. longicornis* (Htz.), *A. brevis* (Htz.), *A. solnørdali* (Htz.), and *Arctolepis* sp. As mentioned above these forms were originally described by Heintz as "*Jaekelaspis*". But this name must be dropped in favour of the older name, *Arctolepis* Eastman. The *Arctolepis* forms (Fig. 5, D, E) are all characteristic of the Lykta Division, but closely related forms occur, without doubt, both in the upper part of the Kapp Kjeldsen Division and in the Stjørdalen Division. The new material consists of a number of new species.

Arctaspis forms are represented in former collections by 6 species: *A. kiæri* Htz., *A. holtedahli* Htz., *A. hoeli* Htz., *A. minor* Htz., *A. maximus* Htz., and *Arctaspis* sp. A number of new species will be added to this list, when the description of the new material is issued. The *Arctaspis* forms (Fig. 4, C, D) are excellent guide-fossils for the Kapp Kjeldsen Division, the characteristic sculpture of the shield making even the most minute fragments definable (Fig. 4, C).

Eleganthaspis reticornis Htz. is probably related to the *Arctaspis*, forms. New specimens of this form have not been found, but may occur in the Kapp Kjeldsen Division.

Heintz has previously described as *Svalbardaspis* different head-shields of Phlyctænaspida, which were found without connection with the body carapace. The rich new material is sure to reduce this group, and prove that many of the "*Svalbardaspis*" heads belong to body-carapaces described under other names (for inst. *Arctolepis*, *Arctaspis*, and others). Up to the present the following *Svalbardaspis* species have been described: *S. typicus* Htz., *S. rotundus* Htz., *S. polaris* Htz., *S. angulatus* Htz., and *S. stensiöi* Htz. Naturally none of the *Svalbardaspis* forms can be regarded as guide-fossils — in fact the genus *Svalbardaspis* comprises only quite occasional forms.

The same is the case with the genus *Monaspis*, also comprising various forms, which hitherto have not been differentiated with full certainty. This genus will probably disappear or be strongly diminished, when the new material from 1939 has given us a better knowledge of the various forms from Spitsbergen. 5 different species have hitherto been described: *M. giganteus* Htz., *M. minutus* Htz., *M. acuticornis* Htz., *M. borealis* Htz., and *M. hornsundi* Htz. Among these forms are some relatively small ones with narrow spines, often more or less strongly curved (*M. acuticornis*, *M. borealis*, *M. minutus*). A number of corresponding forms have now been collected from the different parts of the Stjørdalen Division. It appears that these forms must be regarded as guide-fossils for this division.

One new type, known from the earlier collections, is found in great numbers. It is a relatively large form, with short, round MD plate, and large head. The sculpture is very characteristic, consisting of more or less concentrically arranged tuberculated ridges, and there is a peculiar pattern of the sensory canals on the head. There can be no doubt that this form, which Heintz (1937) has mentioned as "*Rotundaspis*", is identical with *Actinolepis*, recently described by Gross (1940) from the *Heterostius*-deposits in the Balticum. According to Gross' figs., it is also obvious that the AVL+SP+IL fragments which Heintz described (1929, 1) as "*Plataspis*", must be regarded as body-plates of the same form. *Actinolepis* is probably characteristic of the upper part of the Lykta Division.

Fragments of other types of Arthrodirs, belonging to the Brachythorasia, occur quite abundantly in the Wood Bay Series, but are as a rule only represented by smaller fragments or indeterminable plates. Some, however, are large and thick, indicating the presence of large or even very large Arthrodira. Only a few fragments could be determined as belonging to the family Homosteidæ and possibly to the genus *Homostius* or closely related forms. One fragment belongs to the genus *Angarichthys*, a form earlier only known from Siberia (Obručev 1927). Some fragments of *Heterostius* have also been collected. The occurrence of typical *Homostius* and *Heterostius* is mostly limited to the uppermost parts of the Stjørdalen Division (grey layers), while *Angarichthys*- and *Homostius*-like forms were found as low down as in the Lykta Division. As a whole, it is evident that the Arthrodira play a very great part in the fauna of the Wood Bay Series.

No certain remains of Acanthodii, other Elasmobranchii, Chondrostei or Dipnoi are hitherto found in the deposits from the Wood Bay Series. Reversely the representatives of the Crossopterygii occur quite abundantly, but are limited to the so-called "*Porolepis*" type. The rectangular scales of this type occur in all sizes and forms in a great number. A number of jaws and head-fragments, partly with well preserved neurocranium, have been collected in 1939. Dr. Jarvik, who is going to describe these forms, supposes that the name "*Porolepis*" represents a number of very different forms, only showing a resemblance in the shape of the scales and in the sculpture of the surface.

The Lower Limit of the Wood Bay Series.

While the borders between the single sub-divisions of the Wood Bay Series are somewhat indistinct, it is possible to indicate the lower limit fairly exactly, petrographically as well as faunistically. The contact with the underlying Red Bay Series is hitherto known in three localities: the south side of Liefdefjorden, west side of Bockfjorden, and south

side of Sigurdfjellet west of the head of Woodfjorden. The first and last localities were discovered by A. Hoel (1914). It is, however, only at Vonbreen (= Hoffnung Glacier), south of Sigurdfjellet that we can state with certainty that the Red Bay Series is normally covered by the Wood Bay Series. The contact is found at the foot of Sigurdfjellet about 5 km from the fjord (Fig. 6). The layers generally dip towards the south-east, slightly near the fjord, gradually becoming steeper further west. The lowest part of the Kapp Kjeldsen Division consists of red sandstones resting conformably on the greyish-green sandstones, which on the top, contain layers of quartz-conglomerate. These lower red layers have a relatively rich and peculiar fauna, and may prove to be a separate sub-division. Especially characteristic of these layers is a comparatively large and flat Pteraspid, which systematically no doubt lies near to the large Pteraspids from Ben Nevis in the Red Bay Series. They have a rather coarse sculpture and are to some degree reminiscent of *Doryaspis* from the Lykta Division, but probably without being closer related to the latter. A number of small and large Cephalaspids were likewise found, and especially abundant were the small or somewhat larger *Boreaspis* forms. (We may add that both specimens of *B. rostrata* St. were collected here in 1911). Also *Benneviaspis*, a typical Red Bay fossil, was found here in 1939.

In the greyish-green division only a few fossils were found. From this place, however, we have fossils from Hoel's expeditions in 1910 to 1912. The fossils collected by Hoel and by us are quite identical, mainly being represented by a peculiar, narrow, relatively small *Pteraspis* sp. with a large and flat, almost rectangular rostral division. In addition some shields of *Homaspis nitidus* (Kiær) were found here. The same form is also known from Ben-Nevis; *Homaspis* is in reality a guide-fossil for this division, leaving no doubt that the grey layers belong to the Red Bay Series.

The thickness of the greyish-green sandstones may amount to a couple of hundred metres. To the west occurs a red-brown coarse conglomerate without any distinct stratification. It consists of quartzite and gneiss. The conglomerate evidently belongs to the Red Bay Series. Unfortunately we could not ascertain whether the grey sandstones normally rest upon the conglomerate. The conglomerate is farther west separated by a faultline from the metamorphic Hecla-Hoek rocks.

Bockfjorden. On July 27th we went ashore on the west side of the middle part of Bockfjorden. A full account of the geological conditions there would require a far more thorough investigation, we shall therefore confine ourselves to give a summary only of the observations made during our short stay.

Already at a distance our attention was drawn to the red colour of the rocks in the shore-section at the point of the headland (loc. No. 5

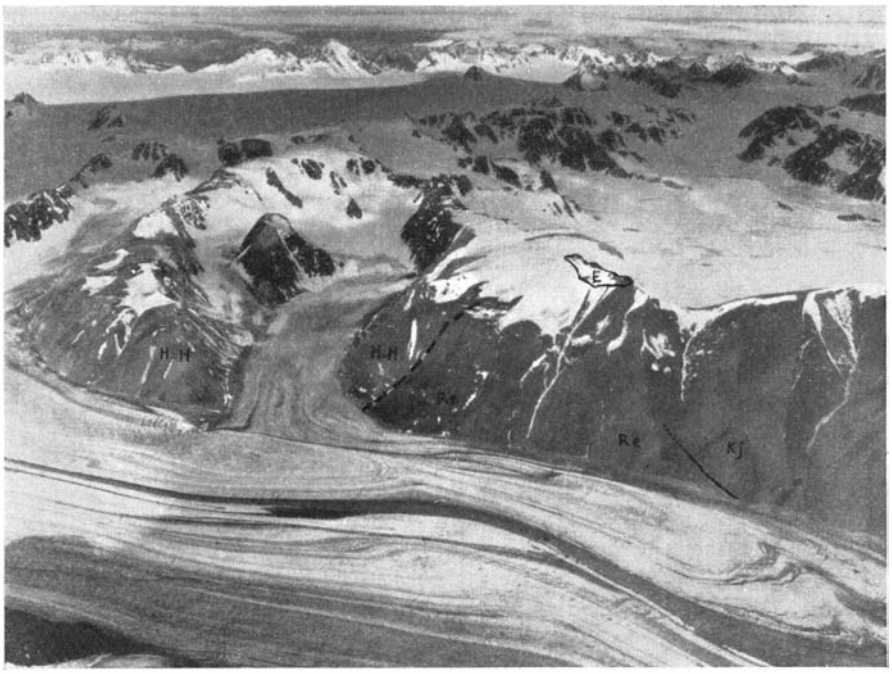


Fig. 6.

Vonbreen (= Hoffnung Glacier) and Sigurdfjellet seen from the south. One can see the limit between the Red Bay Series (Re) and the Kapp Kjeldsen Division (Kj) of the Wood Bay Series, and the fault between the Red Bay deposits and Hecla Hoek (H.H.). E — the volcanic mass at the top of Sigurdfjellet (Norges Svalbard- og Ishavs-undersøkelser. Air photograph No. 010).

on the map in Fig. 7). We found fossils, but they gave no indication as to what series the strata belong to. Further south (loc. No. 1) there are greyish-green sandstones with beds of conglomerate; scanty fossils in the grey sandstones show that these strata belong to the Red Bay Series. At loc. No. 2 we found a coarse red conglomerate similar to those common in the Red Bay Series. All three localities lie on the shore, separated from each other by covered areas. The position of the layers does not indicate the sequence of the rocks. Further, all these localities are separated from the greyish-green sandstones forming the eastern slope of Germaniahøgdene. According to its appearance, the latter surely belongs to the Red Bay Series. In the north-eastern corner of the mountain-slope (loc. No. 3) there is a precipice consisting of flatlying, red beds. These rocks are bounded towards the greyish-green sandstones by a fault, which has the direction N 25 W. The red beds contain fossils belonging to the Wood Bay Series, more exactly to the undermost beds of the Kapp Kjeldsen Division, found near Vonbreen on Sigurdfjellet. Fossils from the same part of the division were also

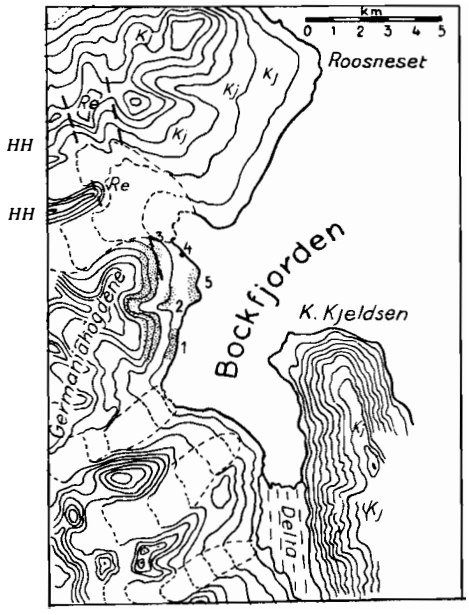


Fig. 7.

Map of Bockfjorden. Kj — Kapp Kjeldsen deposits. Re — Red Bay deposits. HH — Hecla Hoek deposits. Localities 1 and 2 — Red Bay deposits. Localities 3 and 4 — basal layers of the Kapp Kjeldsen Division. 5 — probable Red Bay deposits.

found in detached pieces on the shore (loc. No. 4).

The beds of the localities Nos. 1 and 2 and of the mountain slope thus belong to the Red Bay Series; the beds of loc. No. 3 to the undermost part of the Wood Bay Series, while the age of the beds of loc. No. 5 is unknown. More faults are probably present.

Between Bockfjorden and Liefdefjorden two borderlines can be clearly seen from Bockfjorden: the one separating the red Wood Bay beds from the grey Red Bay beds, and the other the grey Red Bay beds from rocks of a yellowish colour (probably Hecla Hoek). The last-mentioned border cuts the outermost part of the ridge north of the glacier north of Germaniahøgdene. The border appears there as a steep line in the mountain-side (Fig. 7).

The West Side of Woodfjorden.

(Pl. II, Fig. 2.)

From Liefdefjorden and inwards the west side of Woodfjorden consists of strata belonging to the Kapp Kjeldsen Division. The layers largely have a dip of 10—20 degrees towards the SE. In the section along the fjord from Kapp Kjeldsen to Sigurdfjellet the layers are seen as fairly horizontal lines, with only slight undulations, in some places interrupted by faults. About half-way up the mountain-side a stripe of greyish green sandstone is seen in the otherwise red rocks; towards the south, in Risefjella, this stripe wedges out. In the mountain-block north of Risefjella it is cut by three faults, further north of the Halvdandalen it disappears.

The Thickness of the Kapp Kjeldsen Division.

In the mountains along the west side of Woodfjorden the easily distinguishable, pale zone of the Kapp Kjeldsen Division is not visible, thus the sequence here does not represent the youngest layers of the Kapp Kjeldsen Division. This is also the case with Grevefjellet south of Vonbreen. In the mountain-side south and south-east of the head of the fjord the uppermost paler layers are present, and, judging from the dip, their continuation seems to have been just above the present top of Grevefjellet. Further, the layers in Grevefjellet seem to correspond approximately to the layers in Sigurdfjellet, the dip being the same (slightly towards SE) and no fault-line of any great dimension seems to run between these mountains. The sequence in Grevefjellet thus represents almost the whole Kapp Kjeldsen Division. In these nearly flat-lying strata we therefore have a possibility of measuring their thickness by the altitude of the peak. As the peak is 1200 m above sea level, the thickness of the Kapp Kjeldsen Division can be estimated at 1000—1500 m. As guide-fossils for the Kapp Kjeldsen Division can be mentioned different *Giganthaspis* and *Arctaspis* forms (Fig. 4).

The East Side of Woodfjorden Inside Kapp Auguste-Viktoria.

(Pl. II, Fig. 1, B.)

The mountain-sides along the fjord consist for the greater part of red rocks of the Wood Bay Series. The layers, as a whole, dip towards SE, the inclination being 10—25°. Owing to numerous faults, however, constantly older and older beds are met with, southwards towards the head of the fjord, the block south of the fault plane being always relatively raised. The faults are very distinctly seen where the mountain-side consists partly of the Wood Bay Series, partly of the Grey Hoek Series (Fig. 9), and also when the faults cut the uppermost pale zone in the Kapp Kjeldsen Division (Fig. 8). It would have been interesting to map the exact course of at least some of these faults, but time did not allow it. We had to content ourselves with drawing them as they were seen in the mountain-sides along the fjord (Pl. II, Fig. 1, B) and in the large valleys, Verdalen and Stjørdalen (Pl. II, Fig. 1, F, G). There seem to be two systems of fault-lines, one with a direction about W-E (or a little S of E), the other directed about N-S (or a little E of S). The first-mentioned system corresponds to the direction of the outer part of the valleys Verdalen and Stjørdalen; these valleys have probably been formed along fault-lines. The second runs parallel to the large faults limiting the whole Devonian area in North Spitsbergen. By closer studies more faults may be found than those marked on the map and on the section.

Fig. 8.

Scott Keltiefjellet on the East coast of Woodfjorden. E — volcanic rocks at the top of the mountains. Gr — Grey Hoek deposits. Kj — Kapp Kjeldsen deposits (the upper pale zone is limited by . . . . . line). Ly — Lykta deposits. St — Stjørdalen deposits. - - - - - - Faults. x — the point where Delle and Føyn started the climbing of Scott Keltiefjellet. 1 — Tavlefjellet. 2 — Purpurdalen. 3 — Wijdefjorden.
(NSIU. Air photograph No. 437.)

The Thickness of the Lykta-Division.

Delle and Føyn climbed up the steep mountain-side to the western-most part of the lava-plateaus in Scott Keltiefjellet (Fig. 8 x). The altitudes were measured by a large aneroid barometer. The decline of the strata is largely 10—15°, towards SSE. The layers in the lower part of the mountain-side belong to the Kapp Kjeldsen Division; here *Gigantha-spis* was found. The pale zone is located between 215 and 335 m above sea-level. No guide-fossils were found in it. On top of these layers comes a zone of rather thin-bedded red sandstone. At 475 m above sea-level begins a more coarse-bedded part of the sequence, containing *Arctolepis decipiens* and *Doryaspis*. A comparatively rich horizon was discovered about 840 m above sea-level. The lower limit of the lava was met with at 990 m above sea-level. (At 950 m above sea-level were two lava-dykes).

Fig. 9.

Sørlifjellet on the East coast of Woodfjorden. Verdalen to the left, delta from Stjørdalen to the right. In the background Wijdefjorden. One can see from left to right Vatnedalen 1 (on the map erroneously called Vassdalen), Andredalen (2) and Forkdalen (3). E — volcanic rocks at the top of Sørlifjellet. Gr — Grey Hoek deposits. Ly — Lykta deposits. St — Stjørdalen deposits. - - - - Faults.
(NSIU. Air photograph No. 443.)

Thus 600—700 m of the Lykta Division are present here. The continuation of the layers upwards must be studied somewhere else, for instance about 5 km further north. If we had known exactly where the uppermost layers in the described section were located in the sequence, we could have given the thickness of the whole Lykta Division. With our present knowledge of the sequence, however, we cannot exactly determine it, but we suppose that not more than a couple of hundred metres are lacking in the section studied, which thus includes the main part of the Lykta Division. Accordingly the thickness of the division should be between 600 and 900 m. As guide-fossils must be regarded the different species of *Doryaspis* and *Arctolepis* (=*Jaekelaspis*) (Fig. 5).

The Thickness of the Stjørdalen Division.

As seen on Pl. II, Fig. 1, B this division was observed several places in the mountain side, and we estimated the thickness to about 500 m (Fig. 9). As guide-fossils may be mentioned the smaller Phlyctænaspids with curved, thin spines. A better knowledge of the fauna may reveal other guide-fossils.

The thickness of the whole Wood Bay Series thus lies between 2000—3000 m. Hoel and Holtedahl previously reckoned it as being 3000 m.

The East Side of Woodfjorden from Gråhuken to Kapp Auguste-Viktoria.

(Pl. II, Fig. 1, A; Pl. III.)

The outer part of the Andrée Land (the peninsula between Woodfjorden and Wijdefjorden (Pl. I; Pl. III)) consists mainly of grey sandstones and black arenaceous shales belonging to the Grey Hoek Series. In the upper parts of the valleys which open out into Mushamna and Jakobsenbukta (Pl. II, Fig. 1, E), rocks of the Wood Bay Series are also seen. The layers rise towards the interior of the peninsula, and the yellowish grey and red uppermost layers of the Wood Bay Series appear normally below the Grey Hoek Series. From a distance we also observed other areas with red rocks along the middle of the peninsula, these areas presumably having been raised by faults. Time did not allow us to map the last-mentioned areas.

The strata in the outer part of Andrée Land are rather strongly folded. The shales have a cleavage, which is most often inclined in relation to the bedding planes. The folding axes run approximately NS. This stronger folding may be due to the rocks being more yielding, but we find it more probable that the folding pressure has actually been stronger here than in the inner part of the fjord. We observed the same sort of cleavage on the north side of Reinsdyrflya, where the rocks belong to the Wood Bay Series.

As the folding axes are NS, the section along the fjord will largely show the inclination of the folding axes. They appear to be fairly horizontal. Irregularities in the section may be due to the direction of the folding axes not quite coinciding with the coast, but forming an acute angle to it. This is the case between Jakobsenbukta and Kapp Auguste-Viktoria.

Especially strong folding is seen in Jakobsenbukta, where the strata are almost vertical (Pl. II, Fig. 1, E). A steep position of the strata is, however, common all along the shore outwards to Gråhuken (Pl. II, Fig. 1, D).

Owing to numerous faults in the inner part of Woodfjorden we might expect faults in the outer part of the peninsula also. It is, however, difficult to observe faults in the Grey Hoek Series, as this series neither shows great variations in colour nor at the present can be divided into zones on a faunistic basis.

The Fauna in the Grey Hoek Series.

The Grey Hoek Series is mostly very poor in fossils, and those which occur are often badly preserved on account of the secondary cleavage of the rocks. The fauna consists chiefly of lammelibranchiats, gastropods and ostracods, while fish-remains occur seldom. In addition plant-fragments have been recorded from different parts.

Quenstedt (1926) described the following molluscs: *Ctenodonta* ex. aff. *Maureri*, *Nucula* sp., *Montanaria* sp., *Myalina nordenskiöldi*, *Myalina (Nathorstella) semiplicata*, *Avicula (Leptodesma)* sp. *Bellerophon (Bucanella)* sp. and *Palaeotrochus* aff. *praecursor*. Solle (1935) mentioned ten new species of Ostracods. A number of fossils collected on Vogt's expeditions, both of lammelibranchiats and ostracods are, however, not yet described.

The fish fauna has been better investigated. It consists almost exclusively of different forms of Arthrodira. First the Phlyctænaspida (= Acanthaspida) are represented by at least five species: *Huginaspis brøggeri* Htz. and *Mediaspis problematica* Htz., *Arctolepis* sp. (= *Jaekelaspis* sp.) and two different *Monaspis* sp.

Petalychtida are represented in the Grey Hoek Series by at least one species of *Lunaspis: L. arcticus* (Htz.)

Of other fishes only some *Porolepis*-shales were discovered in Grennadalen, Woodfjorden, and also some poorly preserved fragments of other Crossopterygians.

Wijdefjorden.

(Pl. I; Pl. II, Fig. 3; Pl. III.)

We spent 7 days investigating Wijdefjorden (from 3/8 to 10/8). First we visited Vestfjorden making collections on both sides as far north as to Kartdalen along the W-side. Later on we investigated Sjettedalen (Sixth Valley), Andredalen (Second Valley) and Vatnedalen (Lake Valley).[1] All the excursions were short and more or less casual. During the preparation of geological maps and sections, the air photographs from Norges Svalbard- og Ishavs-undersøkelser were of very great value rendering still more help here than was the case in other and better investigated districts.

[1] On the map and sections (Pl. II; Pl. III) erroneously called Vassdalen.

East Side of Vestfjorden and Gråkammen.

The mountains along the fjord and valley itself consist of red deposits of the Wood Bay Series (Fig. 10). The layers are mostly situated more or less horizontally, with a dip about 5—10° towards the south. According to the fossils collected here, the greatest part of the deposits belong to the Lykta Division. Two more or less EW-running faults can distinctly be seen in the mountain-sides. The one more to the south runs through Hagendalen. Lowest in the mountain-side south of this fault one can see the uppermost parts of the Kapp Kjeldsen Division, formed of greyish green sandstones with some red zones. Here the guide-fossil *Arctaspis* was collected. Around Frøysneset the dip increases as the layers form an anticlinal between Frøysneset and Kapp Petermann. This anticlinal, however, displays a somewhat irregular arrangement of the layers. At Frøysneset *Arctaspis* was also collected. The deposits in the anticlinal are reminiscent of those in the uppermost zone of the Kapp Kjeldsen Division, but, owing to a more common presence of the greenish layers, display a somewhat paler colour than in Woodfjorden, and are thicker.

A more continental character of both the Kapp Kjeldsen and the Lykta Divisions seems more distinct in Vestfjorden than in Woodfjorden. The conglomerates containing pieces of shale and sandstone are more common. Ostracods *(Leperditia)*, which were relatively common in all parts of the deposits in Woodfjorden, were not found at all in Vestfjorden.

The highest point on the peninsula is called Gråkammen. One may see, even at a long distance, that the grey deposits on its top lie conformably on the yellow-coloured zone, which forms the top layer of a brilliantly red series. Even without fossils one can at once determine that we here have to do with the deposits of the Grey Hoek Series lying on the uppermost part of the Stjørdalen Division. And the fossils collected here by Vogt's expedition in 1928 completely confirm this opinion. In the grey limestone 775 m on Gråkammen was found exactly the same fauna as the one we collected in the innermost part of Jakobsendalen. It consisted of large Arthrodira, *Homostius* and *Heterostius*, isolated *Porolepis* scales, besides lammelibranchiats, Ostracods, and Gastropods.

To the east the purple and grey layers on Gråkammen are limited by a NS running fault, which is distinctly seen from the sea north of Kapp Petermann. Judging by their appearance the deposits E of this fault belong to the upper part of the Kapp Kjeldsen Division. The fault is very distinct also in the air-photographs (Fig. 10).

Fig. 10.

East coast of Vestfjorden. Farthest to the right Bryndalen. The top above it — Gråkammen (Gr.). The valley to the left — Jørgensendalen. Below it — Tysneset. Farthest to the left Frøysneset is partly seen. In the background — Austfjorden. Gr — Grey Hoek deposits. Kj — Kapp Kjeldsen deposits. Ly — Lykta deposits. St — Stjørdalen deposits. - - - - - Faults. (NSIU. Air photograph No. 081.)

Judging by the position of the layers, the Stjørdalen Division deposits below Gråkammen, hardly lie concordant on the Lykta Division deposits, which form the sides of the valley. Probably the Gråkammen deposits and those below it form a sunken block, which thus also from the west must be limited by a fault. Unfortunately we had no time to investigate this matter.

West Side of Vestfjorden.

(Pl. II, Fig. 3, A; Pl. III.)

The mountain-sides along the fjord are formed of the layers of the Lykta Division. Guide-fossils, *Doryaspis* and *Arctolepis* (=*Jaekelaspis*), have been collected in great numbers in some of the localities. We may especially mention a horizon on Errol Whitefjellet named after a member of the expedition, Dr. E. I. White. Here an unusually rich layer was discovered, and hundreds of *Arctolepis* and *Boreaspis*, and some complete *Doryaspis*, were collected. The layers dip moderately towards the south (ca. 10—15°). In the inner part of Landingsdalen one can see the uppermost, pale-coloured layers belonging to the Kapp Kjeldsen Division. We may thus assume that there runs a fault along the Landingsdalen.

West Side of Wijdefjorden North of Vestfjorden.

(Pl. II, Fig. 3, B, C; Pl. III.)

The south side of Kartdalen consists of horizontal layers of the Lykta Division. It seems probable that there runs a fault along the valley, as its north-side is formed of strongly red layers with yellow-grey zones on the top — in other words by the upper part of the Stjørdalen Division. The dip is 25° towards the north.

The transition from the Wood Bay Series to the Grey Hoek Series is seen farther north, along the shore between Kartdalen and Sjettedalen. The layers dip towards NE. In Wijdefjorden the yellow-grey zones on the top of the Stjørdalen Division pass directly into the grey-black layers of the Grey Hoek Series, without the red passage-beds between them as is the case in Woodfjorden.

In Sjettedalen about 5 km from the sea, we observed red layers lying below the grey ones with strike N 40° W, and dip about 25° towards NE. In the same district a fault was observed with direction about N 20°W.

Along Purpurdalen there certainly runs a fault, as in the furthermost part of the valley the Grey Hoek layers are placed on the south side and the uppermost layers of the Wood Bay Series on the north side. In the innermost part of the valley the mountains are formed of red sediments. From the ship we could see, according to the colour of the deposits, that even so old layers as the uppermost parts of the Kapp Kjeldsen Division were represented here. Between Purpurdalen and Skamdalen (Short Valley) one can see a distinct fault running in an E-W direction. The marked difference in colour makes this fault especially conspicuous.

In Skamdalen the conditions seem to be very clear. The layers rise in an inward direction, and the strongly red layer can be seen on the north side of the valley, normally covered by Grey Hoek layers.

Fig. 11.

Tavlefjellet on the West coast of Wijdefjorden. E — volcanic rocks at the top of Tavlefjellet. Gr — Grey Hoek deposits. Wi — Wijde Bay deposits. X — Scott Keltiefjellet on the East coast of Woodfjorden. (NSIU. Air photograph No. 044.)

The Wijde Bay Series.

(Fig. 11, 12; Pl. I; Pl. II, Fig. 3, B, C, D, E; Pl. III.)

The deposits belonging to the Wijde Bay Series form a stripe about 25 km long and about 5 km broad along the shore from Tavlefjellet (The Table Mountain) (Fig. 11) to Vatnedalen (Lake Valley) (Fig. 12; Pl. I; Pl. II, Fig. 3; Pl. III). The stripe is parallel to the direction of the folding-axis, which here runs about NS and forms a syncline. On the cross-sections from Andredalen and Vatnedalen (Pl. II, Fig. 3, D, E) one can see that the layers dip towards E (Fig. 12, 13). The Wijde Bay Series as a whole consists of grey sandstones, which can be distinguished from the Grey Hoek Series by their somewhat lighter colour. At present it is impossible to point out any special layer which might be regarded as the limit between these two series, as the time for investigations in the field was too short. The limit on the map is therefore made by way of an estimate. The fossils which allow us to divide the Wijde Bay Series from the Grey Hoek Series were found mostly along the shore south of Andredalen.

The Fauna of the Wijde Bay Series.

As pointed out by Heintz in 1937, three earlier expeditions have collected fossils from the Wijde Bay Series (Hoel in 1912, Vogt in 1925 and 28). But as a whole the number of fossils from these parts

Fig. 12.

West coast of Wijdefjorden seen from South to North. 1 — Vatnedalen. 2 — Vogtdalen. 3 — Gråhuken. 4 — Reinsdyrflya. Gr — Grey Hoek deposits. Wi — Wijde Bay deposits. . . . . The approximate limit between the Grey Hoek and Wijde Bay deposits. (NSIU. Air photograph No. 061.)

of Wijdefjorden is scarce, and the fossils themselves are mostly represented by isolated scales, plate-fragments, and the like.

The Psammosteid fragments must be regarded as the most characteristic fossil for the Wijde Bay Series. At present they cannot be determined more in detail, but they all belong, so far as can be seen, to one and the same type. Psammosteid fragments were earlier known

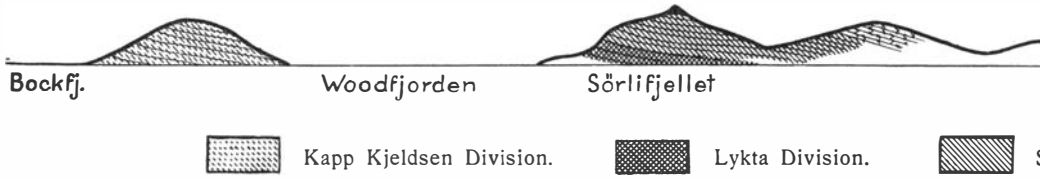


Fig. 13. Section across the Devonian

both from Vatnedalen and Andredalen, and we also found them in the same localities. Especially one specimen, found in debris in a small stream running somewhat south of Andredalen, is of considerable interest. It consists of a number of quite large fragments of Psammosteid plates, inbedded in ferrugineous rock, very similar to those known from the Fiskekløfta locality in Mimerdalen, Billefjorden. The corresponding deposits were later discovered in situ higher up on the mountain-side south and north of Andredalen.

Fig. 14.
Shield of a fish, probably belonging to the Pteraspidomorphi. Ca. × 0.75. Short section south of Andredalen. Collected on Th. Vogt's expedition 1925.

Scales of Crossopterygians, belonging to Rhizodontids, are probably also characteristic of the Wijde Bay Series. Smaller, round scales of this type were earlier collected from different localities, belonging most probably to the Grey Hoek Series. Thus, for instance, in 1925 on the highest point of Hugindalen a number of small scales of this type were collected by Vogt's expedition (1925). We found some uncertain fragments in Jakobsenbukta and Jakobsendalen and in the innermost part of Verdalen. The Rhizodontid-scales found in Wijdefjorden near Andredalen are however much larger, similar to those in Fiskekløfta, and were partly imbedded in the same ferrugineous rocks. From the Wijde Bay deposits are also known large Crossopterygian teeth very similar to those known from Fiskekløfta.

From the same layers between Vatnedalen and Tavlefjellet are also reported three fragments of Anthiarchi, which according to Nilsson (1941) belong to *Asterolepis,* the one probably being closely related to *A. sävesöderberghi* from Grönland. In addition also fragments of Arthrodira are recorded from the Wijde Bay Series from various localities. They all belong to the large Brachythorasi. No representatives of Phlyctænaspida have hitherto been recorded from the Wijde Bay Series. Some of the fragments may with more or less certainty be determined as *Heterostius* or *Homostius.* Especially pieces of the long, narrow front part of the AL of *Heterostius* are common. Fragments of *Homostius* are more uncertain. In Heintz' paper of1937 he regarded fragments of *Heterostius* and *Homostius* as very characteristic of the Wijde Bay Series. Correspondingly

ɔrdalen Division. Grey Hoek Series. Wijde Bay Series.

sequence of NV. Spitsbergen.

he also erroneously regarded the Gråkammen deposits as belonging to the Wijde Bay Series. As is now known *Heterostius* and *Homostius* already occur in the upper parts of the Wood Bay Series, and thus cannot be regarded as guide-fossils neither of the Wijde Bay Series nor of the Wood Bay Series. It is most probable that the species which occur in the Wood Bay and Wijde Bay Series are different. But at present we cannot determine them more definitely and thus cannot use them as guide-fossils.

A dubious *Holonema* fragment was collected in 1939 near Andredalen. From Fiskekløfta is also described a *Holonema* form (Heintz 1935). Finally we must mention a very remarkable fossil, originally collected by Vogt's expedition in 1925 south of Andredalen in the coast section. We visited the same locality, and a large number of these fossils was brought together. They display symmetrical, 4 to 7 cm long, ovoid shields (Fig. 14), cut straight off posteriorly. To this part a remarkable, almost triangular small portion is attached. The sculpture is formed of radiating lines, running from the median-posterior part, and of concentric lines, running parallel to the outside margin. The fossils were found in black shale, and practically nothing of the shield-substance is preserved. It is very difficult to determine the real nature of these forms. Most probable, however, we have here to do with some aberrant form of Pteraspidomorphi, related to real Pteraspids.

In addition to these fish-fragments, from various parts of the Wijde Bay Series, are known lammelibranchiats, ostracods and plant-fragments. None of these fossils are yet determined, except the plants which are described by Høeg (1942).

The Thickness of the Grey Hoek and the Wijde Bay Series.

To calculate the thickness of the Grey Hoek Series from the conditions in the outermost part of the peninsula between Woodfjorden and Wijdefjorden is very difficult, the deposits being very strongly folded. Our insufficient knowledge of the fossils and, at least at the moment, the absence of guide-fossils, complicate a division of the series. In the district between Skamdalen and Forkdalen, however, the conditions are probably such as to make it possible to subdivide the series on a petrographical basis and to calculate the thickness of the whole deposit. It seems most probable that the whole Grey Hoek Series is represented in this district. The lower limit can be observed in Skamdalen, and the layers of the Wijde Bay Series form the highest part of the mountains (Fig. 11). The very top of the mountain consists, however, of horizontal lava-beds of Cretaceous age forming a plateau. The geological conditions here are quite simple. From the ship we noticed that the grey-coloured layers are dominant in the lower part of the Grey Hoek Series, and the black layers in the upper part. It seems apparent that near Gråhuken itself mostly the upper black part of the series is represented.

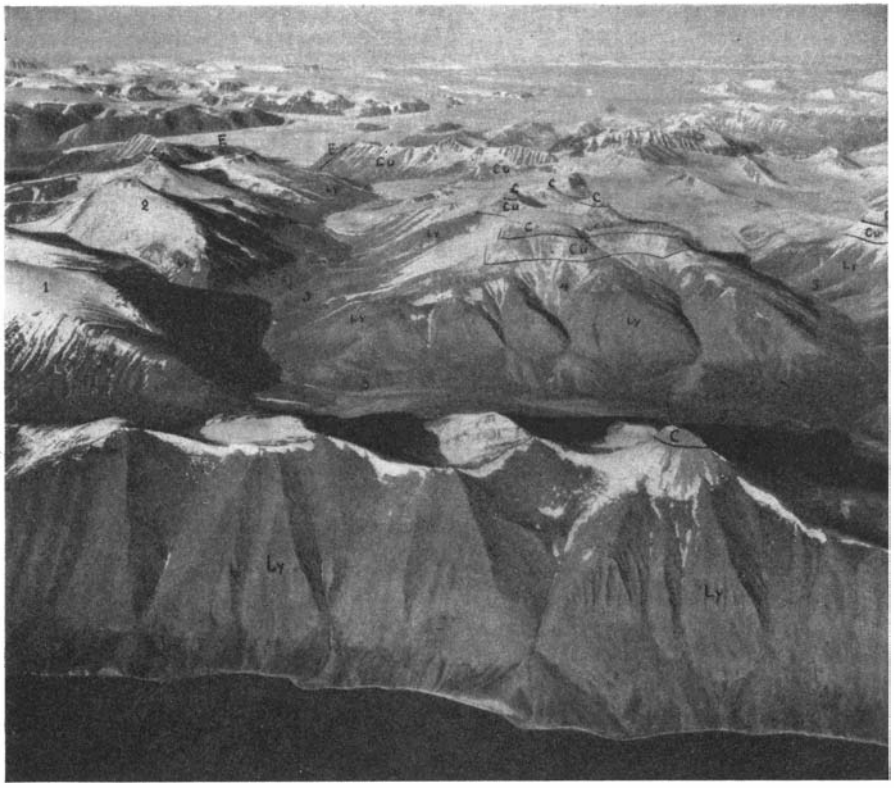


Fig. 15.

Lykta — on the East coast of Dicksonfjorden. In the background: 1 — Sophus Liefjellet. 2 — Abeltoppen. 3 — Nathorstdalen. 4 — Citadellet. 5 — Kulmdalen. C — Upper Carboniferous deposits (Cyathophyllum limestone). Cu — Culm deposits. E — Volcanic rocks. Kj — Kapp Kjeldsen deposits. Ly — Lykta deposits. . . . . The approximate limit between Kapp Kjeldsen and Lykta deposits. (NSIU. Air photograph No. 591.)

The thickness of the Grey Hoek Series is no doubt much less than that of the Wood Bay Series. As far as we can conclude it is hardly more than 1000 m.

The Wijde Bay Series is sure to be of a still lesser thickness, and we estimate it to about 500 m.

One may notice that our estimate diverges strongly from those earlier proposed. A. Hoel and O. Holtedahl calculated each of these series to be about 2000 m in thickness.

Remarks on E. Schenk's determination of the Wijde Bay Series.

During the summer of 1936 E. Schenk made some geological investigations on the outer part of the peninsula between Woodfjorden and Wijdefjorden (Andrée Land). In his paper (1937) he pointed out

that according to his opinion the Wijde Bay Series is situated between the Wood Bay Series and the Grey Hoek Series. He based the conclusion mostly on the petrographical character of the rocks. Our investigation both of fossils and geological relations (see Fig. 13; Pl. II; Pl. III) shows clearly that the opinion, advocated by Hoel, that the Wijde Bay Series is younger than the Grey Hoek Series, is the correct one. Schenk has probably determined the lower, paler portion of the Grey Hoek Series as Wijde Bay Series. As early as in 1937 Heintz pointed out that Schenk's determination is incorrect. He then, however, based his opinion mostly on fossil material, regarding the light greyish yellow sandstones on Gråkammen and other parts of Woodfjorden and Wijdefjorden as belonging to the Wijde Bay Series. As mentioned above our investigation, however, has shown that this assertion of Heintz is erronous and that the greyish yellow deposits with *Homostius* and *Heterostius* in reality form the passage-beds between the Wood Bay and the Grey Hoek Series.

Vogtdalen.

Between Vatnedalen (Lake Valley) and Gråhuken is situated a very distinct valley, which hitherto has had no name (Fig. 12; Pl. II, Fig. 3, C; Pl. III). After a conferance with the Svalbard office we proposed to name this valley "Vogtdalen" (Vogt Valley) in honour of Professor Th. Vogt, who in 1925 and 28 made very important investigations in Wijdefjorden.

Coming from Gråhuken southwards along the west side of Wijdefjorden one may easily take this valley to be Vatnedalen especially as it contains a lake which is larger than the one in Vatnedalen. The names Andredalen (Second Valley) and Sjettedalen (Sixth Valley) are thus in reality misleading as Vogtdalen has earlier not been counted. Vogtdalen, however, is almost as large as any of the other valleys and naturally must also be reckoned.

When coming northwards, however, it is impossible to mistake the valleys. Among others Tavlefjellet, situated between Skamdalen and Forkdalen, has a very characteristic outline and may easily be recognized. Moreover, with the air-photographs from Norges Svalbard- and Ishavs-undersøkelser it is not difficult to find the right names.

E. Schenk has mistaken the valleys. This is easily ascertained if one compares his map with the air-photographs, and a comparison with our geological map shows the same. His "Seetal" is not the real Vatnedalen but Vogtdalen, his "Andréetal" (misunderstood for Andredalen) is in reality Vatnedalen and his "Purpur Tal" is Forkdalen.

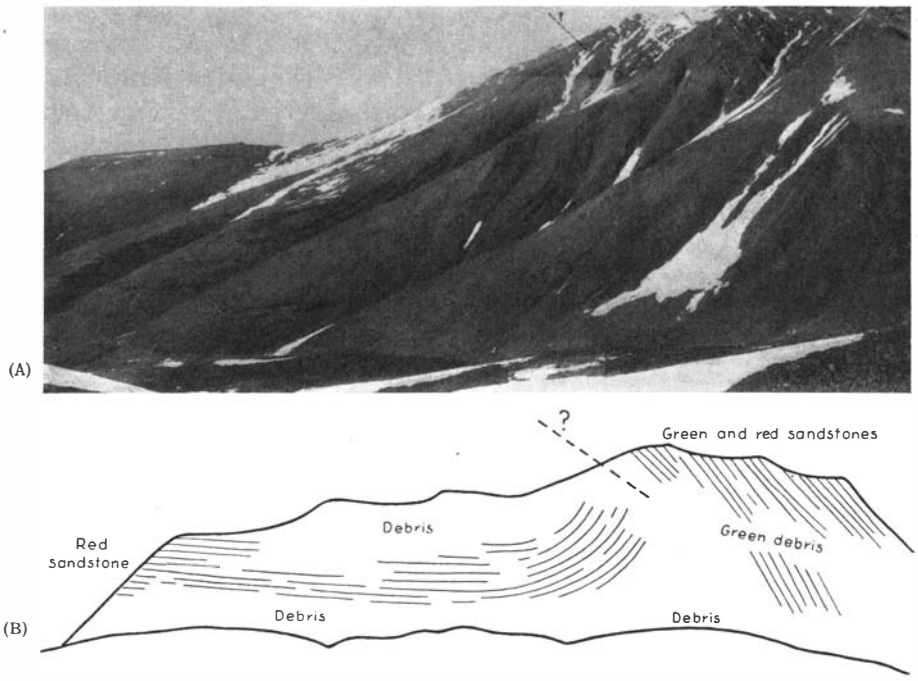


Fig. 16.

The Mountain-slope north of the valley Grønhorgdalen. (A) Photography (Føyn). (B) Sketch. - - - - - Fault-line.

Isfjorden.

(Pl. I; Pl. III).

The Devonian deposits in Isfjorden are found in the inner parts of the smaller fjords which run from Isfjorden in a more or less northerly direction: Ekmanfjorden, Dicksonfjorden, and Billefjorden (Pl. I; Pl. III). Dicksonfjorden and Billefjorden have been visited by many earlier expeditions; in Ekmanfjorden, however, only one expedition has earlier done any work (Gripp in 1924). Our investigation was mostly concentrated on Dicksonfjorden and Ekmanfjorden.

Dicksonfjorden.

The Devonian strata in Dicksonfjorden (Dickson Bay) were described by A. G. Nathorst (1910). He has also published a section showing the east-side of the inner part of the fjord. The red sandstones of Devonian age are more or less horizontal, but as a whole with a slight dip towards south. From Mt. Lykta and southwards they are unconformably covered by the white Cyathophyllum limestone of Upper Carboniferous age (Fig. 15, 17).

The E.N.S. expedition collected fossils around the inner part of the fjord between the 5th and 13th of July, that is to say before we had visited Woodfjorden and before the division of the Wood Bay Series was undertaken. Already here, at an early stage, we found out, however, that the deposits containing *Giganthaspis* and *Arctaspis* were situated below the deposits with *Arctolepis* and *Doryaspis*.

Corresponding to the conditions in Vestfjorden (Wijdefjorden) it was apparent that the continental character of the deposits is more clearly seen here than in Woodfjorden. The sandstone layers are often more massive than those in the Woodfjord, and the layers of the shale-conglomerates are very abundant. In addition the Ostracods are hitherto not recorded here. Quartz-conglomerate has been observed in Grønhorgdalen in layers belonging to the Kapp Kjeldsen Division. In three places in the mountain-sides the position of the layers seems to show current bedding on a very large scale (delta-deposits), namely: in the mountains to the west of Dicksondalen (Dickson Valley), in Stjernspetzfjellet north of Dicksondalen, and finally in Sophus Liefjellet on the north side of Nathorstdalen (Nathorst Valley). It seems, however, not excluded that these quite indistinct structures may be the results of tectonical displacements.

The greater part of the deposits on both sides of the innermost part of Dicksonfjorden contains the fossils characteristic of the Lykta Division. *Arctaspis* was, however, discovered in many places in débris in the lower part of Lykta and in mountains farther north. The transitional beds between the Lykta and Kapp Kjeldsen Divisions are thus probably to be found near the base of the mountain. In the inner part of Dicksondalen the layers belonging to the Kapp Kjeldsen Division are situated higher up (Pl. III). This is the case on both sides of the valley. On the east side *Giganthaspis* and *Arctaspis* were collected east of the glacier in Grønhorgdalen, a valley about 12 km, north of Lykta. On the west side the same forms were found in Barmfjellet. *Arctaspis* is also known from the north side of Nathorstdalen. The layers here form an anticlinal between Sophus Liefjellet and Abeltoppen (Fig. 15). At the base of the mountains in the last-mentioned locality, as also in Grønhorgdalen, the green sandstones appear in such numbers that they completely dominate the deposits, the red layers occurring only sparingly. Accordingly the moraine in front of the glacier in Grønhorgdalen is absolutely green. We mentioned above that in Vestfjorden the green sandstones occur more abundantly in the upper part of the Kapp Kjeldsen Division than in Woodfjorden. It seems that in Dicksonfjorden the increase of the green layers in relation to the red is still larger.

The mountain-sides along the east side of the fjord (Nathorst's section) show the Devonian deposits more or less completely undisturbed by foldings. In Nathorstdalen one may see, however, that

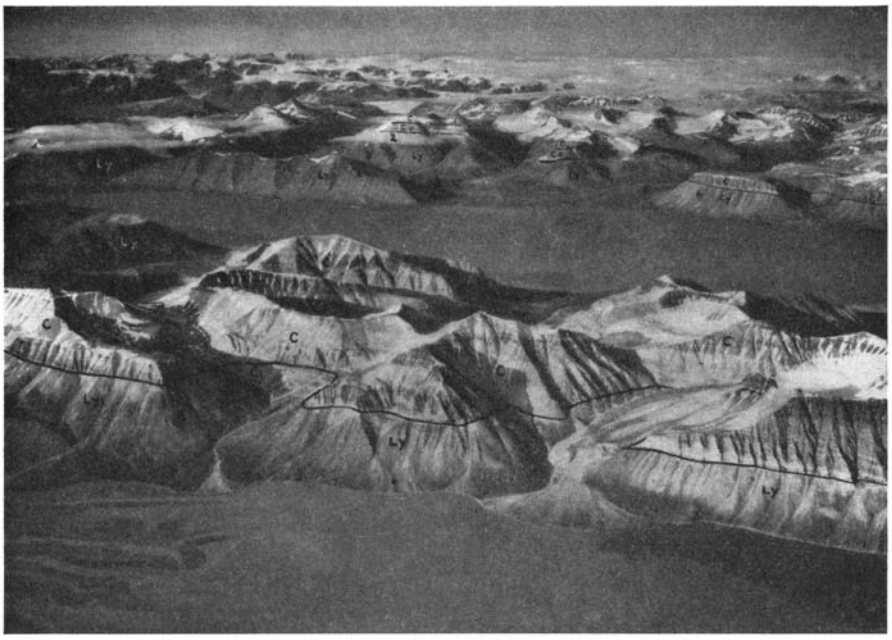


Fig. 17.

East coast of Ekmanfjorden. In the background Dicksonfjorden. 1 — Lykta mountain. 2 — Citadellet mountain. 3 — Nathorstdalen. 4 — Kulmdalen. 5 — Hugindalen. 6 — Gangerolvfjella. C — Upper Carboniferous deposits (Cyathophyllum limestone), in the foreground with intrusions of volcanic rocks. Cu — Culm deposits. Ly — Lykta deposits. (NSIU. Air photograph No. 378.)

the deposits have been exposed by a folding, which in some parts is quite strong. The folding axis runs about N ca. 20° W. The tectonical disturbance is especially distinct in a district from the place where Nathorstdalen turns south-west of Sophus Liefjellet and in a direction northwards behind Grønhorgdalen. In various parts of this district one may find a quite steep position of the layers. It seems also probable that folding-faults have been formed with the result that the layers belonging to the Kapp Kjeldsen Division near Grønhorgdalen were pushed on top of the layers of the Lykta Division (Fig. 16). Hitherto we have not, however, made sufficient investigations to be able to state this with certainty.

Ekmanfjorden.

The E.N.S. expedition visited Ekmanfjorden (Ekman Bay) on the 20th and 21st of August. Seen from the fjord the deposits in the mountain-side seemed quite undisturbed (Fig. 17). The layers dip slightly towards the south. We made collections on the east side of the head of the fjord. Here the layers, according to the fossils, belong to the Lykta Division.

Fig. 18.

Mimerdalen and West coast of Billefjorden. 1 — Estheria hill. 2 — Fiskekløfta. 3 — Lykta mountain. 4 — Hugindalen. 5 — Gangerolvfjella. 6 — Dicksonfjorden. C — Upper Carboniferous deposits (Cyathophyllum limestone). Cu — Culm deposits. Wo — Wood Bay deposits. - - - - - Fault. (NSIU. Air photograph No. 016.)

probably to its uppermost part. The occurrence of a remarkable Phlyctænaspid, *Actinolepis*, was very interesting; it has recently been described by Gross (1940) from Balticum. In Woodfjorden and Wijdefjorden it has only seldom been found. In Ekmanfjorden, however, this form seems to be common. From earlier expeditions it is known more abundantly from Reinsdyrflya only. This form is apparently characteristic of the upper part of the Lykta Division.

The mountains west and north of the fjord belong most probably to the same division. On the air-photographs one may observe, however, that further north-east towards Orsabreen (Orsa Glacier) the layers rise higher up, and in the lower parts of the mountains the layers are of a lighter colour, probably belonging to the Kapp Kjeldsen Division. Still further to the north the layers decline again.

The Devonian in this part is covered with the marine Upper Carboniferous (Fig. 17). The carboniferous layers and the basal level plain dip slightly towards the south, almost at the same angle as the Devonian layers.

Billefjorden.

The E.N.S. expedition visited Billefjorden (Klaas Billen Bay) on the 17th of August. The Devonian deposits are here exposed along the shore and in the short valleys, running more or less perpendicular to the fjord. Nathorst (1910) described this locality and depicted a section of the coast from Skansbukta (Skans Bay) to Mimerdalen (Mimer Valley). Th. Vogt's expedition in 1925 also visited these localities collecting fossils. Although being scarce, the fossils from earlier expeditions (Nathorst and Vogt) and those collected by us, show that the deposits belong to the Lykta Division [among others were found *Doryaspis* and *Arctolepis* (= *Jaekelaspis*)]. Usually the fossils are badly preserved, as the layers here are strongly folded and show stress cleavage. Only the plant-fossils seem to be well preserved. They had been collected before the E.N.S. expedition came to the Billefjord, by Høeg's Spitsbergen expedition of the same year.

Along the coast the strike of the layers was somewhat variable; in one of the valleys 7 km south of Mimerdalen the strike is NNE. No fossils were found in this valley.

Mimerdalen.

Mimerdalen (Mimer Valley) has been visisited and studied by many expeditions. Nathorst studied the geology and collected fossils here in 1882 (Nathorst 1910). Based on investigations made in 1917, Stensiö has published a geological map, sections, and a description of the quite complicated geological conditions here (Stensiö 1918, 1). Further, Th. Vogt's expeditions in 1925 and 28 went to Mimerdalen, and a large number of fossils were brought together here. The geological investigations made by Vogt are only partly published (Vogt 1938, 41). Finally, Høeg visited the locality in 1939 and collected a great many plant-fossils (Høeg 1942).

The E.N.S. expedition spent only one day in Mimerdalen ($^{18}/_{8}$), and during this short visit we did not find anything new of geological interest.

On the basis of the fossils collected here by earlier expeditions, one can see, however, that the red deposits in the outer part of the valley are sure to belong to the Wood Bay Series (Fig. 18), probably to the relatively high part of it (Stjørdalen Division?), while the deposits round the Estheria Hill apparently correspond to the Grey Hoek Series (Fig. 18, 1). Finally the Fiskekløfta layers must be regarded as equivalent to the Wijde Bay Series (Fig. 18, 2), probably, however, belonging to somewhat higher layers than those exposed in Wijdefjorden.

The Approximate Age of the Different Devonian Series in Spitsbergen.

As mentioned above the age of the 4 series, into which the Downtonian and Devonian in Spitsbergen are usually divided, has been somewhat variously determined (see p. 12). In this chapter we shall try to estimate their relative age, based on a better knowledge of the fossils and the new stratigraphical facts observed on the E.N.S. expedition 1939. At the same time we shall compare the deposits in Spitsbergen with those known from other countries.

The Red Bay Series.

The E.N.S. expedition visited Raudfjorden for only 2—3 days, and the collection made there was relatively small. This district, however, was fully investigated by Hoel's expeditions in 1910 and 11 and by Vogt's expeditions in 1925 and 28, and the material, which has already been described, as mentioned in the paper of Kiær and Heintz (1935), makes it possible to divide the whole series into a number of horizons. Taking into consideration previous descriptions of Cephalaspids and Poraspids from this series, and what is known about other Ostracoderms, the whole series, according to Kiær, may be divided into two parts: the older one, especially distinct on Frænkelryggen, being called the "Frænkelryggen Division" — and the younger one, clearly seen on Mount Ben Nevis, the "Ben Nevis Division". All the other localities, where the Red Bay Deposits have been discovered, can without great difficulty be determined as belonging to either the one or the other of these two divisions.

The Frænkelryggen Division. It is difficult to mention any special guide-fossil for this series, as hitherto none of the fossil genera is known solely from this deposit, and also none occurs in all the horizons of the division. (For the single horizons see Kiær and Heintz 1935.) The most abundant forms are the minute species of *Poraspis* (*polaris*, *brevis*, *intermedia*, *subtilis*, and *elongata*, from 25 to 40 mm long), and the narrow-striped *Anglaspis (heintzi*, *insignis). Dinaspis* is characteristic of this series, as also the minute and primitive *Pteraspis primaeva. Ctenaspis*, on the other hand, is known throughout the whole Red Bay Series. *Corvaspis* is common in the basal layer of the Frænkelryggen Division, but fragments are also known from the lower horizons of the Ben Nevis Division. The Cephalaspids are fully represented especially in the youngest part of the Frænkelryggen Division, but the

same species have also been collected in different horizons of the Ben Nevis Division. As a whole, one may say that the Frænkelryggen Division is characterized by more minute forms. The Poraspids, Pteraspids and Cephalaspids occurring here are relatively small. The most common fossils are indubitably *Poraspis*, *Anglaspis* and *Cephalaspis*, besides some new *Pteraspis*-forms. And in the oldest layers also *Corvaspis* and *Phialaspis*.

The Pteraspids from the Frænkelryggen Division are unfortunately not yet described. It is very likely that some of them may become useful as guide-fossils. In any case it is certain that *P. primaeva* is known only from this division. In 1928 and during the last summer a number of new Cephalaspids were collected on Frænkelryggen some of them were found in its oldest part. When described they may prove to be valuable as guide-fossils.

The Ben Nevis Division is very well characterized by the presence of special fossils, only known here. In the first range comes *Homaspis*, which must be regarded as an excellent guide-fossil, being found in many horizons of this division. *Benneviaspis*, *Hoelaspis* and *Kiæraspis* are also known from the Ben Nevis Division, but only from the middle part of it; and *Dictyaspis* (= *Irregularaspis*) — closely related to *Dinaspis* — appears, as far as is known, only in the lower and middle parts. A large number of Cephalaspids — among them some large and very large forms — have been found in many of the horizons. Pteraspids are also richly represented with a number of relatively large forms. One of them, *P. vogti*, is known only from the basal layers of the Ben Nevis Division. Also *Protaspis* occurs in many horizons, while *Poraspis* is very rare, the larger forms only being present (*rostrata*, *cylindrica* and *magna*, from 45 to 62 mm). Not a single *Poraspis* from Frænkelryggen Division is known here. *Ctenaspis* on the other hand is very common. One form of *Anglaspis* (*A. elongata*) is known from the lower part of the series, another (*A. platostriata*) from different horizons in the middle part.

As is seen, the division of the Red Bay Series into two underseries is not difficult. And each of the series is distinctly determined by the fauna present.

If we now should try to determine the age of these deposits, we must compare them with those in Great Britain, where their relation is best known, thanks to the recent years investigations, especially of Mr. W. W. King (1925, 34). To make a comparison between the freshwater deposits placed so far from each other, horizon to horizon, is rather hopeless. We have, therefore, not mentioned here the single horizons in the Red Bay Series, they are only of local interest. Their characteristics and distribution have earlier been discussed by Kiær and Heintz (1935).

The detailed division of the Downtonian and Dittonian in England, as proposed by W. W. King, will hardly be of any use in a comparison between the deposits in England and Spitsbergen. We must be quite content if we can state the relation between King's Downtonian (I) and Dittonian (II) and our Frænkelryggen and Ben Nevis deposits.

King has divided the Downtonian deposits in Great Britain into 10 horizons, labelled I, 1 to I, 10. The lowest part (1 to 5) is characterized by the presence of the primitive Cephalaspids — *Hemicyclaspis murchisoni* (I, 2), besides other Osteostraci as *Sclerodus*, *Thyestes* and *Didymaspis*, the latter, however, appears also in the upper part of the Downtonian (I, 6, 7). The upper part (I, 6—10) has a somewhat richer fauna. Especially common is the "Psammosteus" — *Phialaspis symondsi* and *Anglaspis macculloughi*. *Corvaspis*, *Pteraspis leathensis*, and Cephalaspid-fragments are also known.

One may notice at once that the fossils known from the lower part of the Downtonian in England are unknown from Spitsbergen. Further the fossils *Corvaspis* and *Phialaspis* which do not occur before the middle of Downtonian in England, appear in the basal part of the Frænkelryggen deposits. *Anglaspis*, which is known from somewhat younger layers in England, is abundant in the middle and upper parts of Frænkelryggen. From the upper part of the same deposits we know a number of *Cephalaspids*, which in England are restricted to the Dittonian, where they occur in great numbers.

It therefore seems most natural to compare the Frænkelryggen deposits with the upper part of the British Downtonian (from about I, 6 to I, 10). But as the fauna in Spitsbergen is much richer than in Great Britain, a more detailed correlation of the deposits is difficult.

The Dittonian in England is richer in fossils. From here 13 Cephalaspids, some of them relatively large, have already been described, further 2 *Benneviaspis*, 1 *Securiaspis*, 6 *Pteraspis* (with a number of varieties), 1 *Poraspis* (*P. sericea*), and other forms.

It is not difficult to see that this fauna corresponds very well with that from the Ben Nevis deposits. There also we have a rich occurrence of Cephalaspids, partly large forms (7 described and a number undescribed), *Benneviaspis*, *Kiæraspis*, *Hoelaspis* — the last certainly related to *Securiaspis*, a number of Pteraspids, and finally 3 *Poraspis*, which in size and form resemble *P. sericea*.

Thus the conclusion must be that the Red Bay Series in Spitsbergen probably corresponds to the upper part of the Downtonian and to the whole Dittonian in Great Britain. The Downtonian deposits or Norway, which probably belong to the Upper Ludlow or to the base of the Downtonian, have also no equivalence in Spitsbergen.

The question regarding the correlation between the Red Bay Series and the deposits known from Podolia is more difficult, as a more detailed investigation of these deposits is not yet published. They have,

however, a number of forms in common with those in Spitsbergen (*Cephalaspis*, *Poraspis*, *Dictyaspis* (= *Irregularaspis*), *Ctenaspis*, *Pteraspis, Protaspis*). It seems that the Downtonian is represented mostly or perhaps exclusively by marine beds, and the real Old Red facies in Podolia begins with the Dittonian. The Podolian Fauna is mostly reminiscent of that from the Ben Nevis group. The numerous Poraspids are of a large size. Among the ca. 60 Cephalaspids are a number of large forms. The Pteraspids are very abundant. *Ctenaspis* and *Dictyaspis* (= *Irregularaspis*) are mostly known from the Ben Nevis Division. The typical Frænkelryggen forms, as *Anglaspis* and *Phialaspis*, are absent, as is also *Hemicyclaspis,* the Lower Downtonian form. The presence of *Phlyctænaspis* shows also that the Old Red sediments in Podolia are hardly older than the Dittonian. A more precise comparison and division of these deposits can only be performed when a detailed description of the fauna and deposits in Podolia has been published.

The Wood Bay, Grey Hoek and Wijde Bay Series.

If the comparison of the Red Bay Series with the deposits in Great Britain and Podolia seems to be relatively easy, and its age may thus be determined with a fair degree of certainty, the opposite is the case with regard to the Wood Bay Series. All earlier authors have propose the Lower Devonian age for the Wood Bay Series, and recently it was especially emphasized as being of lower Lower Devonian age (Heintz, 1929, 1, 2; 37; Quenstedt 26, Stensiö 27). The fossils discovered during the summer of 1939 makes this definition more doubtful.

As mentioned above (p. 12, 14) the fauna of the Wood Bay Series consists of three different groups: first the Ostracoderms with at least two different types of Pteraspidomorphi (*Giganthaspis* and *Doryaspis*) and a great number of Cephalaspidomorphi (*Cephalaspis*, *Boreaspis*). Secondly the Arthrodira, with a great number of Phlyctænaspids (*Arctaspis*, *Arctolepis*, *Elegantaspis*, *Actinolepis*) and many larger Brachiothorasi (*Angarichthys*, *Homostius*, *Heterostius*), and finally the Crossopterygian represented by forms of the "*Porolepis*" type. As the latter forms are yet insufficiently known, we cannot here take them into consideration.

The Pteraspids are at present not known with certainty from deposits younger than the Lower Devonian. Of the two forms from the Wood Bay Series *Giganthaspis* is absolutely the most typical Pteraspid, probably related to *Pteraspis dunensis* (upper Lower Devonian, Rhineland), and *Pteraspis cornibicus* (lower Lower Devonian, Great Britain). *Doryaspis* is a more isolated type, which, as far as can be seen, has no related forms from deposits in other countries.

Cephalaspids are known from all horizons of the Wood Bay Series; but as they are also known from Lower to Upper Devonian in other

countries, they cannot be regarded as suitable guide-fossils. *Boreaspis*, on the contrary, is known from Spitsbergen only.

If we turn to the Arthrodira, we find that the Phlyctænaspids are represented in unusually great numbers in the Wood Bay Series. In no other deposit in the world we know of such a rich development of this group. Here also practically all forms are known from Spitsbergen only, except *Actinolepis*, described by Gross (1940) from the Balticum. As mentioned above this form occurs in Spitsbergen in the upper part of the Lykta Division. In Balticum it is particularly characteristic of the Pterichthys-deposits (lower Middle Devonian), but it is also known from the Heterostius-deposits (middle Middle Devonian). Brotzen (1933) recorded a number of Phlyctænaspids from Podolia, two of which are probably identical with forms from Spitsbergen (*Plataspis* = *Actinolepis* and *Arctolepis*?).

Another rich occurrence of Phlyctænaspids is known from America, from Beartooth Butte, Wyoming (Bryant, 1932—35). But no forms identical with those from Spitsbergen have been recorded.

In Germany the Phlyctænaspids are known from the whole Lower Devonian (Gross 1933, 33—37), in England and Canada also from Lower Devonian, but hitertho only one species from each country. As a whole we may notice that typical Phlyctænaspids seem to be characteristic of Lower Devonian, perhaps somewhat more abundant in the lower part and decreasing in the higher divisions. Only one form, *Actinolepis*, is recorded from Middle Devonian also.

With regard to the other Arthrodira, found in the Wood Bay Series, only a few can be determined at present. They are mostly fragments of plates belonging to large and even very large forms, the thickness of the carapace being about 1 cm. Hitherto only three forms have been determined: *Angarichthys*, *Homostius*, and *Heterostius*. The occurrence of large Arthrodira in Lower Devonian was not unexpected. From the Hunsrückschiefer, for instance, are recorded fragments of relatively large plates (Gross 1933, 33—37). The presence of *Heterostius* and *Homostius*, however, was surprising, as till now these forms are known exclusively from the Middle Devonian. They occur in many different places (Balticum, Rhineland, England, France, Greenland), mostly in the deposits of middle Middle Devonian age, and were thus regarded as good guide-fossils of the Middle Devonian, especially for its middle part.

We have thus been able to ascertain the presence of these forms and also of the typical Middle Devonian *Actinolepis* in the Wood Bay Series, and the question now arises if it is really possible to regard these deposits as belonging to Lower Devonian.

We know, however, that on the Sigurdfjell the deposits of the Kapp Kjeldsen Division lie concordant, and, as far as can be seen,

without any hiatus on the layer of the Red Bay Series. The latter are quite certainly of Upper Dittonian age, therefore it is natural in all cases to reckon the Kapp Kjeldsen deposits as representing the lower Lower Devonian. In these deposits *Homostius* and *Heterostius* are also unknown.

Angarichthys and *Homostius* make their first appearance in the upper part of the Lykta Division. From the same deposits only uncertain fragments of *Heterostius* are recorded. From the Stjørdalen Division, however, and especially from its upper part, both *Homostius* and *Heterostius* are found in abundance, while *Angarichthys* is hitherto unknown. With regard to the occurrence of *Homostius* in the Lykta Division, one must remember that, *Angarichthys* being closely related to *Homostius* (Heintz, 1934), the carapace plates of *Angarichthys*, which are very unsatisfactorily known, may be erroneously attributed to *Homostius*. Thus, it is not excluded that the fragments from the Lykta Division, determined as *Homostius*, in fact belong to *Angarichthys*. The age of the deposits where *Angarichthys* has been collected (River Bachta, Jenissei Guv. Siberia) cannot be determined with certainty, but Obručev (1927) has provisionally proposed a Lower Devonian age. If one should thus determine the age of the Wood Bay Series based on the different large Arthrodira only, it would range from the lower Lower Devonian to the lower or middle Middle Devonian. The determination, however, does not harmonize with the other fossil-finds either in the Wood Bay or in the Grey Hoek Series. As mentioned above, the Phlyctænaspids (except *Actinolepis*) and the Pteraspids are hitherto only known from the Lower Devonian, and thus, according to the occurrence of these forms, the whole Wood Bay Series, must belong to the Lower Devonian. Moreover, the fish-fauna in the Grey Hoek Series, which is really quite scarce, consists of Phlyctænaspids and *Lunaspis* — all solely known from the Lower Devonian; especially *Lunaspis* is characteristic of the middle and upper Lower Devonian in Rhineland (from Upper Siegener, Hunsrückschiefer and Koblenz). The fact that the Grey Hoek Series normally overlaps the Wood Bay Series cannot be questioned. Heintz, in his paper about *Lunaspis* (1937), regarded the Grey Hoek Series as belonging to the upper Lower Devonian, but at the same time the Wood Bay layers with *Homostius* and *Heterostius* as belonging to middle Middle Devonian. This erroneous determination was due to unsufficient knowledge of the stratigraphical position of the different layers. It was not yet known that the grey layers with *Homostius* and *Heterostius* are situated between the Wood Bay and the Grey Hoek Series. According to their fauna it was natural to regard them as lying above the Grey Hoek layers, thus belonging to the Wijde Bay Series, especially if we remember that *Heterostius* fragments were found in the typical deposits of the Wijde Bay Series.

The question regarding the age of the Wood Bay and the Grey Hoek .Series is thus a very difficult one. At present it can hardly be answered with certainty.

If we now turn to the Wijde Bay Series, it seems easier to state its age. The fossils found here consist of large Arthrodira; unfortunately they are only fragments, but *Heterostius* must be regarded as certain. Psammosteids are also found here, — a group typical of the Middle and Upper Devonian. Further two fragments of Antiarchi, — also forms only known from Middle and Upper Devonian. The "*Porolepis*"-like scales and heads, so abundant in the Wood Bay Series, known otherwise only from the Lower Devonian, are here replaced by small and large Rhizodontid scales and teeth, elsewhere known from the Middle and Upper Devonian. The fauna in Fiskekløfta in the Mimerdal seems to belong to the Wijdefjord assemblage, but represents somewhat younger layers. Probably the uppermost layers in the Wijde Bay Series, formed of ferrugineous rocks with *Psammosteus* and large Rhizodontid scales, faunistically and petrographically very similar to the Fiskekløfta deposits, are equivalent to the basal layer of the latter. As discussed by Heintz (1937) the Fiskekløfta fauna must be regarded as belonging to upper Middle Devonian (corresponding to the Asterolepis zone — Dm4 and Dm5 — in the Balticum and in the Nairn sandstone in Great Britain).

Taking into consideration that as far as can be seen, there is no break between the layers of the Grey Hoek and the Wijde Bay Series, we may state that the whole complex: Wood Bay — Grey Hoek is placed between the uppermost Dittonian (Sigurdfjellet) and upper Middle Devonian (Wijde Bay Series). How the single deposits can be correlated with deposits in other countries is difficult to say, but we must remember that single groups of fishes in some isolated districts may remain alive a long time after they have disappeared from other districts. Perhaps the Phlyctænaspids and Pteraspids in Spitsbergen have been preserved right into the Middle Devonian, whereas in other districts they disappeared already in Lower Devonian. This supposition may be supported by the fact that the fauna in Spitsbergen is relatively poor in different fish-groups. No Dipnoi are recorded, only a few Crossopterygii, no Acanthods or other sharks, only a few Brachythorasi, and Anthiarchi are also very scarcely represented. On the other hand we must remember the peculiar fossils found in the Wijde Bay Series, which are probably related to the Pteraspids (Fig. 14). This shows that such typically Lower Devonian forms have continued into the upper Middle Devonian in Spitsbergen.

The correlation of the different deposits in Spitsbergen with those in other countries is certainly a very difficult task. One must hope that a better knowledge of the fauna, when all the collected material has been described, will allow us to obtain a safer basis for a comparison with the other Devonian districts.

Literature.

Brotzen, F., 1933. Die silurischen und devonischen Fischvorkommen in Westpodolien. I. Paläobiolog. 5. Wien.

— 1936. Beiträge zur Vertebratenfauna des westpodolischen Silurs und Devons. I. Arkiv Zool. Vol. 28 A, Nr. 22, Stockholm.

Bryant, W., 1932. Lower Devonian Fishes of Beartooth Butte, Wyoming. Proc. Amer. Phil. Soc. 71, Nr. 5.

— 1933—34. The Fish Fauna of Beartooth Butte, Wyoming. Parts I, II & III. Proc. Amer. Phil. Soc. 72. Nr. 5; 73. Nr. 3.

— 1935. Cryptaspis and other Lower Devonian Fishes from Beartooth Butte, Wyoming. Proc. Amer. Phil. Soc. 75. Nr. 2.

Frebold, H., 1935. Geologie von Spitzbergen, der Bäreninsel etc., Geologie der Erde, Berlin.

Gross, W., 1933. Die unterdevonischen Fische und Giganthostracen von Overrath. Abh. Pr. Geol. Landesanst. 145.

— 1933—37. Die Wirbeltiere des rheinischen Devons. I & II. Abh. Pr. Geol. Landesanst. 154 & 176.

— 1933. Die Fische des baltischen Devons. Palaeontographica 75.

— 1940. Acanthodier und Placodermen aus den Heterostius-Schichten Estlands und Lettlands, Ann. Soc. Reb. Nat. Invest. Univ. Tartu. Const. 46.

Heintz, A., 1929, 1. Acanthaspida. Skr. Svalb. og Ishavet, Nr. 22, Oslo.

— 1929, 2. Acanthaspida, Nachtrag. Skr. Svalb. og Ishavet, Nr. 23. Oslo.

— 1934. Revision of the Estonian Arthrodira. Part I. Fam. Homostiidae Jaekel. Arch. f. d. Naturkd. Estl. I Ser. X Bd. 4 Lief, Tartu.

— 1935. Holonema-Reste aus dem Devon Spitzbergens. Norsk Geol. Tidsskr. Bd. XV, Oslo.

— 1937. Lunaspis-Arten aus dem Devon Spitzbergens. Skr. Svalb. og Ishavet, Nr. 72, Oslo.

Hoel, A., 1909. Geologiske iakttagelser på Spitsbergen-ekspeditionerne 1906 og 1907. Norsk Geol. Tidsskr. Bd. I. Kristiania (= Oslo).

— et Holtedahl 1911. Les nappes de lave, les volcans et les sources thermales dans les evirions de la baie Wood au Spitsberg. Vid. Selsk. Skr. I Mat. Nat. Kl. Nr. 8. Kristiania (= Oslo).

— et Staxrud. 1913. Résultats généraux de l'expédition norvégienne au Spitsberg (1911—12). La Géographie. Vol. 27.

— 1914, 1. Nouvelles observations sur le district volcanique du Spitsberg du Nord. Vid. Selsk. Skr. I Mat. Nat. Kl. Kristiania (= Oslo).

— 1914, 2. Géologie. Résultats des Campagnes scientifiques, accomplies sur son yacht par Albert Ier, Prince de Monaco. Fasc. 42. Monaco.

— 1929. The Norwegian Svalbard Expeditions 1906—1926. Res. Norske Statsund. Spitsbergen eksped. Bd. I, Nr. 1.

Holtedahl, O., 1913. On the Old Red Sandstone Series of Northwestern Spitsbergen. Compte Rend. Congr. Geol. Int. 12 Sess. Toronto.

— 1914. New Feature in the Geology of N. W. Spitsbergen. Amer. Journ. of Science. Ser. 4. Bd. 37.

— 1925. Some Points of structural Resemblance between Spitsbergen and Great Britain and between Europe and North America. Vid. Acad. Avh. I Mat. Nat. Kl. Nr. 4. Oslo.

— 1926, 1. Notes on the Geology of Northwestern Spitsbergen. Res. Norske Statsund. Spitsbergen eksped. Nr. 8. Oslo.

— 1926, 2. Tectonic of Arctic Regions. Pan-Amer. Geolog. Des Moines.

Høeg, O. A., 1942. The Downtonian and Devonian Flora of Spitsbergen. Norg. Svalb. og Ishav. Under. Skrift. Nr. 83. Oslo.

King, W. W., 1925. Notes on the "Old Red Sandstone" of Shropshire. Proc. Geol. Assoc. Bd. 36. London.

— 1934. The Downtonian and Dittonian Strata of Great Britain and North-Western Europe. Quart. Journ. Geol. Soc. Bd. 90. London.

Kiær, J., 1916. Spitsbergens devoniske fauna. Forh. Skand. Naturforsk. 16 Møte. Kristiania (= Oslo).

— 1927. The Structure of Mouth of the Oldest Known Vertebrates Pteraspids and Cephalaspids. Paleobiologica. Bd. 1, Wien.

— 1930. Ctenaspis, a new genus of Cyathaspidian Fishes. Skr. Svalb. og Ishavet, Nr. 33. Oslo.

— 1932 (Edited by A. Heintz) Sub-Order Cyathaspida. Skr. Svalb. og Ishavet. Nr. 52. Oslo.

— and Heintz, A., 1935. Suborder Cyathaspida. Part I. Tribe Poraspidei, Family Poraspidae Kiær. Skr. Svalb. og Ishavet, Nr. 40. Oslo.

Lankaster, R., 1884. Report on fragments of fossil fishes from the Palæozoic strata of Spitsbergen. K. Vet. Akad. Handl. Bd. 20, Nr. 9, Stockholm.

Lid, J., 1929. Mariskaret på Svalbard. N. Geogr. Tidsskr. Bd. 11, H. 7. Oslo.

Nathorst, A. G., 1910. Beitrag zur Geologie der Bäreninsel, Spitzbergen und König Karl-Landes. Bull. Geol. Inst. Upsala. Vol. 10. Upsala.

Nilsson, T., 1941. Order Antiarchi. Norg. Svalb. og Ishav. Under. Skrift 82. Oslo.

Obručev, D., 1927. Angarichthys, neue Arthrodieregattung aus dem Devon des Flusses Bachta (Sibirien). Bull. Comm. Geol. Leningrad. Bd. 45, Nr. 6. Leningrad.

Orvin, A. K., 1940. Outline of the Geological History of Spitsbergen. Skr. Svalb. og Ishavet, Nr. 78. Oslo.

Quenstedt, W., 1926. Mollusken aus den Redbay- und Greyhookschichten Spitsbergens. Res. Norske Statsund. Spitsbergenexped. Nr. 11. Oslo. Bd. 1.

Stensiö, E., 1918, 1. Zur Kenntnis des Devons und des Kulms an der Klaas Billenbay, Spitzbergen. Bull. Geol. Inst. Upsala. Vol. 16. Upsala.

— 1918, 2. Notes on a Crossopterygian fish from the Upper Devonian of Spitsbergen. Bull. Geol. Inst. Upsala. Vol. 16. Upsala.

— 1918, 3. Notes on some fish remains collected at Hornsund by the Norwegian Spitsbergen Expedition in 1917. Norsk Geol. Tidsskr. Bd. V, H. 1.

— 1926. On the sensory canals of Pteraspis and Palæaspis. Arkiv f. Zool. Vol. 18 A, Nr. 19. Stockholm.

— 1927. Family Cephalaspidæ. Skr. Svalb. og Nordishavet. Nr. 12, Oslo.

— 1932. The Cephalaspids of Great Britain. British Museum (Nat. Hist.) London.

Solle, G., 1935. Die Devonischen Ostracoden Spitzbergens. I. Leperditiidæ. Skr. Svalb. og Ishavet. Nr. 64. Oslo.

Schenk, E., 1937. Kristallin und Devon im nördlichen Spitzbergen. Geol. Rund. Bd. 28, H. 1—2. Stuttgart.

Säve-Söderbergh, G., 1934. Further Contribution to the Devonian Stratigraphy of East Greenland. Medd. om Grønl. Bd. 96. Nr. 2. København.

— 1941. Remarks on "Downtonian" and Related Vertebrate Faunas. Geol. För. Stockh. Förh., H. 3.

Traquair, R., 1890. On the Devonian fishes of Scaumanac Bay and Campbelton. Geol. Mag. (3) Vol. 7.

— 1893. Notes on the Devonian fishes of Campbelton and Scaumanac bay in Canada. Geol. Mag. (3) vol. 10.

Vogt, Th., 1926. Beretning om en ekspedition til Spitsbergen i 1925. Norsk Geogr. Tidsskr. Bd. I, H. 4. Oslo.

— 1929. Fra en Spitsbergen-ekspedition i 1928. Vid. Akad. Årbok. Oslo.

— 1938. The Stratigraphy and Tectonics of the Old Red Formations of Spitsbergen. Abstr. of the Proceed. of the Geol. Soc. of London. Nr. 1343.

— 1941. Geology of a Middle Devonian Cannel Coal from Spitsbergen. Norsk Geol. Tidsskr. Bd. 21, H. 1.

Wängsjö, G., 1937. On a new species of Benneviaspis from the Red Bay Series in Spitsbergen. Bull. Geol. Inst. Upsala, Vol. 27. Upsala.

Whiteaves, J. F., 1889. Illustrations of the fossil fishes of the Devonian rocks of Canada (Part II) Trans. Roy. Soc. Canada. Vol. 6, Sect. 4.

White, E., 1935. The Ostracoderm *Pteraspis* Knerr and the Relationships of the Agnathous Vertebrates. Phil. Trans. R. Soc. London. Ser. B. Vol. 225.

Wills, L. J., 1935. Rare and new Ostracoderm fishes from the Downtonian of Shropshire. Trans. Roy. Soc. Edinb. Vol. 58, Part II (nr. 18).

Woodward, A. S., 1900. Notes on Fossil Fish Remains collected in Spitsbergen by the Swed. Arctic Exped. 1898. Bih. Sv. Vet. Akad. Handl. Bd. 25. Stockholm.

Printed April 7, 1943.

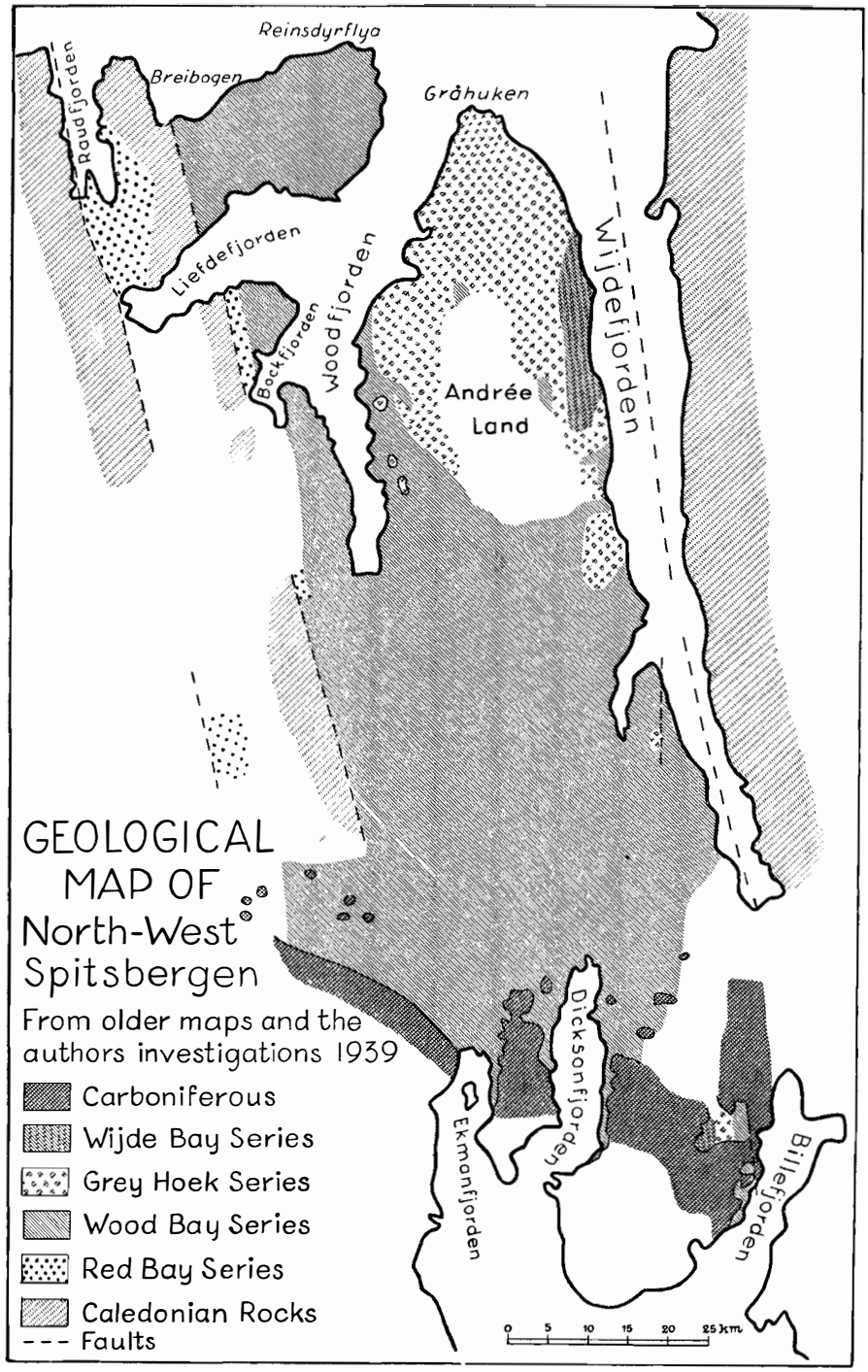

Reinsdyrflya
Breibogen
Gråhuken
Raudfjorden
Liefdefjorden
Bockfjorden
Woodfjorden
Andrée Land
Wijdefjorden
GEOLOGICAL MAP OF North-West Spitsbergen
From older maps and the authors investigations 1939
Carboniferous
Wijde Bay Series
Grey Hoek Series
Wood Bay Series
Red Bay Series
Caledonian Rocks
Faults
Dicksonfjorden
Ekmanfjorden
Billefjorden
0 5 10 15 20 25 km.

Fig. 1. Section along the East coast of the Woodfjord.

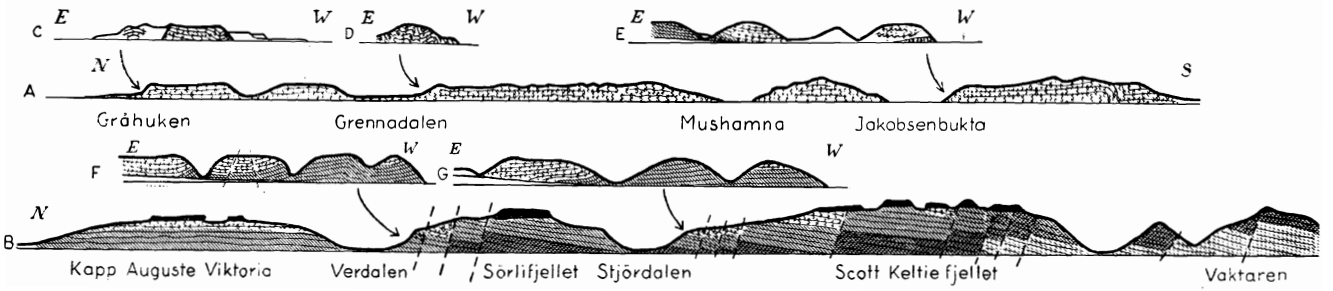
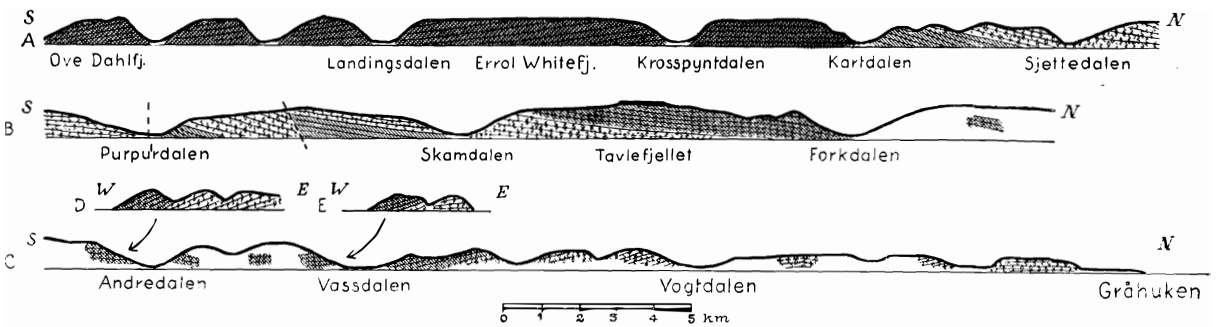
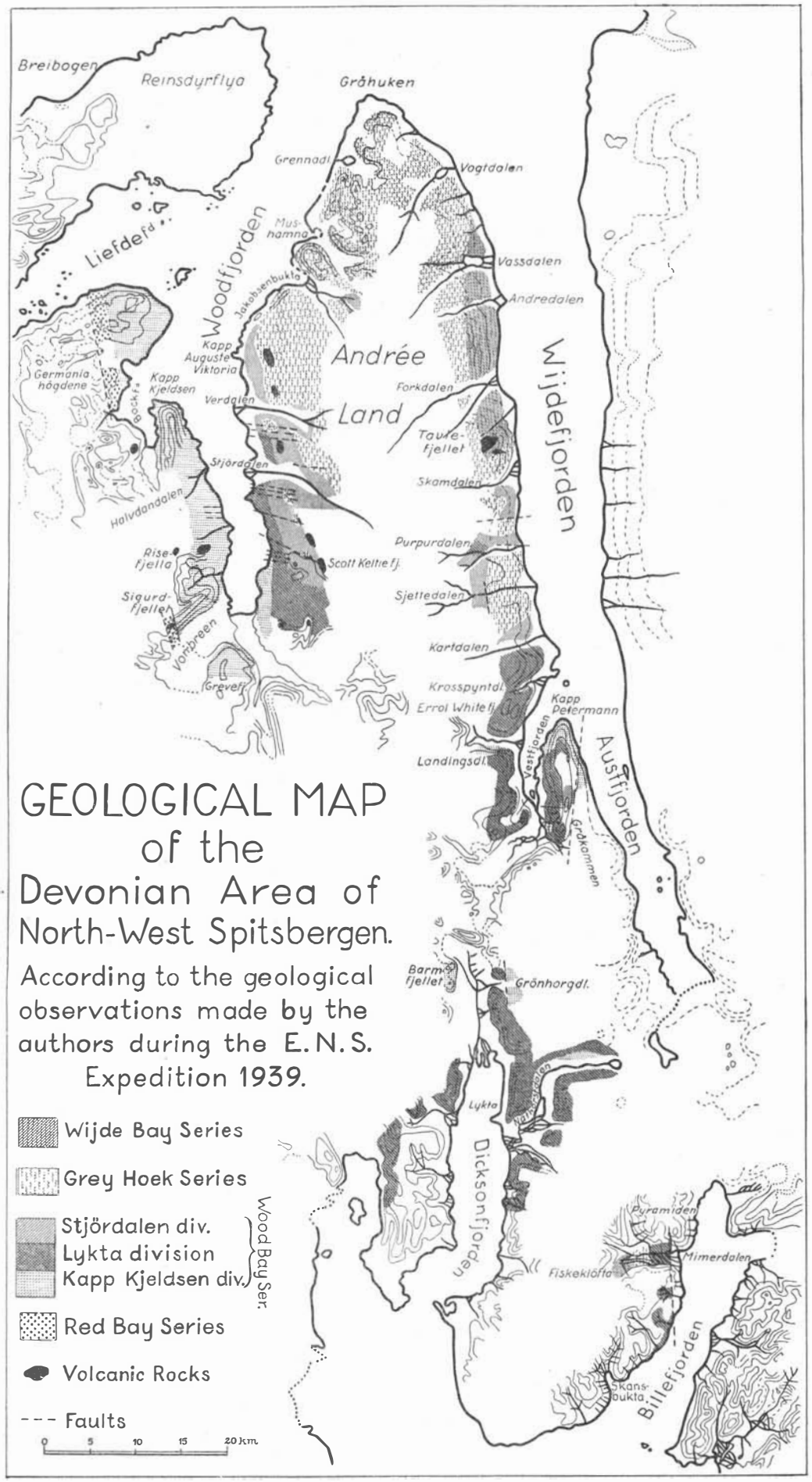


Fig. 2. Section along the West coast of the Woodfjord.

Fig. 3. Section along the West coast of the Vestfjord and the Wijdefjord



Else as on Plate III.



Contour interval 200 m.

Charts:

No. S. 1. Bear Island. 1 : 40 000. 1932. Kr. 4,00.
„ S. 2. Bear Island Waters. 1 : 350 000. 1937. Kr. 4,00.
„ S. 3. From Bellsound to Foreland Reef with the Icefjord. 1 : 200 000. 1932. Kr. 5,00.
„ S. 5. Norway—Svalbard, Northern Sheet. 1 : 750 000. 1933. Kr. 4,00.
„ S. 6. Norway—Svalbard, Southern Sheet. 1 : 750 000. 1933. Kr. 4,00.
„ S. 7. Northern Svalbard. 1 : 600 000. 1934. Kr. 4,00.
„ S. 8. Kings Bay and Cross Bay. 1 : 100 000. 1934. Kr. 4,00.
„ S. 9. From South Cape to Hamburg Bay. 1 : 350 000. 1936. Kr. 4,00.
„ S.11. East Greenland. 1 : 600 000. 1937. Kr. 4,00.

A preliminary edition of topographical maps (1 : 50 000) covering the regions around Kings Bay, Ice Fjord, and Bell Sound, together with the map of Bear Island (1 : 25 000), is published in: Svalbard Commissioner [Kristian Sindballe], Report concerning the claims to land in Svalbard. Part I A, Text; I B, Maps; II A, Text; II B, Maps. Copenhagen and Oslo 1927. Kr. 150,00.

SKRIFTER OM SVALBARD OG ISHAVET

Nr. 1. HOEL, A., *The Norwegian Svalbard Expeditions 1906—1926.* 1929. Kr. 10,00.
„ 2. RAVN, J. P. J., *On the Mollusca of the Tertiary of Spitsbergen.* 1922. Kr. 1,60.
„ 3. WERENSKIOLD, W. and I. OFTEDAL, *A burning Coal Seam at Mt. Pyramide, Spitsbergen.* 1922. Kr. 1,20.
„ 4. WOLLEBÆK, A., *The Spitsbergen Reindeer.* 1926. Kr. 10,00.
„ 5. LYNGE, B., *Lichens from Spitsbergen.* 1924. Kr. 2,50.
„ 6. HOEL, A., *The Coal Deposits and Coal Mining of Svalbard.* 1925. Kr. 10,00.
„ 7. DAHL, K., *Contributions to the Biology of the Spitsbergen Char.* 1926. Kr. 1,00.
„ 8. HOLTEDAHL, O., *Notes on the Geology of Northwestern Spitsbergen.* 1926. Kr. 5,50.
„ 9. LYNGE, B., *Lichens from Bear Island (Bjørnøya).* 1926. Kr. 5,80.
„ 10. IVERSEN, T., *Hopen (Hope Island), Svalbard.* 1926. Kr. 7,50.
„ 11. QUENSTEDT, W., *Mollusken a. d. Redbay- u. Greyhookschichten Spitzb.* 1926. Kr. 8,50.

Nos. 1—11: Vol. I. From Nr. 12 the papers are only numbered consecutively.

Nr. 12. STENSIÖ, E. A:SON, *The Downtonian and Devonian Vertebrates of Spitsbergen.* Part I. *Cephalaspidae.* A. Text, and B. Plates. 1927. Kr. 60,00.
„ 13. LIND, J., *The Micromycetes of Svalbard.* 1928. Kr. 6,00.
„ 14. KJÆR, R. and J. E. FJELDSTAD, *Tidal Observations in the Arctic.* 1934. Kr. 6,00.
„ 15. HORN, G. and A. K. ORVIN, *Geology of Bear Island.* 1928. Kr. 15,00.
„ 16. JELSTRUP, H. S., *Déterminations astronomiques.* 1928. Kr. 2,00.
„ 17. HORN, G., *Beiträge zur Kenntnis der Kohle von Svalbard.* 1928. Kr. 5,50
„ 18. HOEL, A. und A. K. ORVIN, *Das Festungsprofil auf Spitzbergen. Karbon-Kreide.* I. Vermessungsresultate. 1937. Kr. 4,00.
„ 19. FREBOLD, H., *Das Festungsprofil auf Spitzbergen. Jura und Kreide.* II. *Die Stratigraphie.* 1928. Kr. 3,00.
„ 20. FREBOLD, H., *Oberer Lias und unteres Callovien in Spitzbergen.* 1929. Kr. 2,50.
„ 21. FREBOLD, H., *Ammoniten aus dem Valanginien von Spitzbergen.* 1929. Kr. 4,00.
„ 22. HEINTZ, A., *Die Downtonischen und Devonischen Vertebraten von Spitzbergen.* II. *Acanthaspida.* 1929. Kr. 15,00.
„ 23. HEINTZ, A., *Die Downtonischen und Devonischen Vertebraten von Spitzbergen.* III. *Acanthaspida. — Nachtrag.* 1929. Kr. 3,00.
„ 24. HERITSCH, F., *Eine Caninia aus dem Karbon des De Geer-Berges.* 1929. Kr. 3,50.
„ 25. ABS, O., *Untersuchungen über die Ernährung der Bewohner von Barentsburg, Svalbard.* 1929. Kr. 5,00.
„ 26. FREBOLD, H., *Untersuchungen über die Fauna, die Stratigraphie und Paläogeographie der Trias Spitzbergens.* 1929. Kr. 6,00.
„ 27. THOR, S., *Beiträge zur Kenntnis der invertebraten Fauna von Svalbard.* 1930. Kr. 18,00.
„ 28. FREBOLD, H., *Die Altersstellung des Fischhorizontes, des Grippianiveaus und des unteren Saurierhorizontes in Spitzbergen.* 1930. kr. 4,00.
„ 29. HORN, G., *Franz Josef Land. Nat. Hist., Discovery, Expl., and Hunting.* 1930. Kr. 5,00.
„ 30. ORVIN, A. K., *Beiträge zur Kenntnis des Oberdevons Ost-Grönlands.* HEINTZ, A., *Oberdevonische Fischreste aus Ost-Grönland.* 1930. Kr. 4,00.
„ 31. FREBOLD, H., *Verbr. und Ausb. des Mesozoikums in Spitzbergen.* 1930. Kr. 17,00.
„ 32. ABS, O., *Über Epidemien von unspezifischen Katarrhen der Luftwege auf Svalbard.* 1930. Kr. 2,00.
„ 33. KIÆR, J., *Ctenaspis, a New Genus of Cyathaspidian Fishes.* 1930. Kr. 1,00.
„ 34. TOLMATCHEW, A., *Die Gattung Cerastium in der Flora von Spitzbergen.* 1930. Kr. 1,00.
„ 35. SOKOLOV, D. und W. BODYLEVSKY, *Jura- und Kreidefaunen von Spitzb.* 1931. Kr. 15,00.
„ 36. SMEDAL, G., *Acquisition of Sovereignty over Polar Areas.* 1931. Kr. 10,00.
„ 37. FREBOLD, H., *Fazielle Verh. des Mesozoikums im Eisfjordgebiet Spitzb.* 1931. Kr. 8,75
„ 38. LYNGE, B., *Lichens from Franz Josef Land.* 1931. Kr. 3,00.
„ 39. HANSSEN, O. and J. LID, *Flowering Plants of Franz Josef Land.* 1932. Kr. 3.50.
„ 40. KIÆR, J. † and HEINTZ, A., *The Downtonian and Devonian Vertebrates of Spitsbergen.* V. Suborder *Cyathaspida.* 1935. Kr. 25,00.

Nr. 41. LYNGE, B. and P. F. SCHOLANDER, *Lichens from N. E. Greenland.* 1932. Kr. 9,50.
„ 42. HEINTZ, A., *Beitr zur Kenntnis d. devonischen Fischfauna O.-Grönlands.* 1931. Kr. 4,00.
„ 43—46. BJØRLYKKE, B., *Some Vascular Plants from South East Greenland. Collected on the "Heimen" Expedition in 1931. Preliminary Report.* LID, J., *Vascular Plants.* LYNGE, B., *Lichens.* OMANG, S. O. F., *Beiträge zur Hieraciumflora.* 1932. Kr. 4,00.
„ 47. LYNGE, B., *A Revision of the Genus Rhizocarpon in Greenland.* 1932. Kr. 2,00.
„ 48. VAAGE, J., *Vascular Plants from Eirik Raude's Land.* 1932 Kr. 7,00.
„ 49. SCHAANNING, H. THO. L., 1. *A Contribution to the Bird Fauna of East-Greenland.* 2. *A Contribution to the Bird Fauna of Jan Mayen. — Zool. Res. Norw. Sc. Exp. to East-Greenland. I.* 1933. Kr. 3,00.
„ 50. JELSTRUP, H. S., *Détermination astronomique de Mygg-Bukta au Groenland Oriental,* 1932. Kr. 3,75.
„ 51. BIRKELAND, B. J. et GEORG SCHOU, *Le climat de l'Eirik-Raudes-Land.* 1932. Kr. 2,00.
„ 52. KIÆR, J. †, *The Downtonian and Devonian Vertebr. of Spitsb.* IV. Suborder *Cyathaspida.* 1932. Kr. 5,50.
„ 53. 1. MALAISE, R., *Eine neue Blattwespe.* 2. A. ROMAN, *Schlupfwespen.* 3. O. RINGDAHL, *Tachiniden und Musciden.* 4. M. GOETGHEBUER, *Chironomides du Groenland oriental, du Svalbard et de la Terre de François Joseph. — Zool. Res. Norw. Sc. Exp. to East-Greenland. II.* 1933. Kr. 4,00.
„ 54. VARTDAL, H., *Bibliographie des ouvrages norvégiens relatifs au Grœnland (Y compris les ouvrages islandais antérieurs à l'an 1814).* 1935. Kr. 12,00.
„ 55. OMANG, S. O. F., *Übersicht über die Hieraciumflora Ost-Grönlands.* 1933. Kr. 2,50.
„ 56. DEVOLD, J. and P. F. SCHOLANDER, *Flowering Plants and Ferns of Southeast Greenland.* 1933. Kr. 20,00.
„ 57. ORVIN, A. K., *Geology of The Kings Bay Region, Spitsbergen.* 1934. Kr. 20,00.
„ 58. JELSTRUP, H. S., *Détermination Astronomique à Sabine-Øya.* 1933. Kr. 2,50.
„ 59. LYNGE, B., *On Dufourea and Dactylina. Three Arctic Lichens.* 1933. Kr. 5,00.
„ 60. VOGT, TH., *Late-Quaternary Oscillations of Level in S. E. Greenland.* 1933. Kr. 5,00.
„ 61. 1. BURTON, M., M. SC., *Report on the Sponges.* 2. ZIMMER, C., *Die Cumaceen. — Zool. Res. Norw. Sc. Exp. to East-Greenland. III.* 1934. Kr. 2,50.
„ 62. SCHOLANDER, P. F., *Vascular Plants from Northern Svalbard.* 1934. Kr. 15,00.
„ 63. RICHTER, S., *A Contr. to the Archæology of North-East Greenland* 1934. Kr. 25,00.
„ 64. SOLLE, G., *Die devonischen Ostracoden Spitzbergens.* 1935. Kr. 5,50.
„ 65. 1. FRIESE, H., *Apiden.* 2. LINDBERG, H., *Hemiptera.* 3. LINNANIEMI, W. M., *Collembolen. Zool. Res. Norw. Sc. Exp. to East-Greenland. IV.* 1935. Kr. 2,50.
„ 66. 1. NORDENSTAM, Å., *The Isopoda.* 2. SCHELLENBERG, A., *Die Amphipoden.* 3. SIVERTSEN, E., *Crustacea Decapoda, Auphausidacea, and Mysidacea. Zool. Res. Norw. Sc. Exp. to East-Greenland. V.* 1935. Kr. 5,00.
„ 67. JAKHELLN, A., *Oceanographic Investigations in East Greenland Waters in the Summers of 1930—1932.* 1936. Kr. 7,00.
„ 68. FREBOLD, H. und E. STOLL, *Das Festungsprofil auf Spitzbergen.* III. *Stratigraphie und Fauna des Jura und der Unterkreide.* 1937. Kr. 5,50.
„ 69. FREBOLD, HANS, *Das Festungsprofil auf Spitzbergen.* IV. *Die Brachiopoden- und Lamellibranchiatenfauna des Oberkarbons und Unterperms.* 1937. Kr. 10,00.
„ 70. DAHL, EILIF, LYNGE, B., and SCHOLANDER, P. F., *Lichens from Southeast Greenland.* 1937. Kr. 4,50.
„ 71. 1. KNABEN, NILS, *Makrolepidopteren aus Nordostgrönland.* 2. BARCA, EMIL, *Mikrolepidopteren aus Nordostgrönland. Zool. Res. Norw. Sc. Exp. to East-Greenland. VI.* 1937. Kr. 3,50.
„ 72. HEINTZ, A., *Die Downtonischen und Devonischen Vertebraten von Spitzbergen. VI. Lunaspis-Arten aus dem Devon Spitzbergens.* 1937. Kr. 2,00.
„ 73. *Report on the Activities of Norges Svalbard- og Ishavs-undersøkelser 1927—1936* 1937. Kr. 10,00.
„ 74. HØYGAARD, ARNE, *Some Investigations into the Physiology and Nosology of Eskimos from Angmagssalik in Greenland.* 1937. Kr. 1,50.
„ 75. DAHL, EILIF, *On the Vascular Plants of Eastern Svalbard.* 1937. Kr. 3,50.
„ 76. LYNGE, B., *Lichens from Jan Mayen.* 1939. Kr. 4,50.
„ 77. FREBOLD, HANS, *Das Festungsprofil auf Spitzbergen.* V. *Stratigraphie und Invertebratenfauna der älteren Eotrias.* 1939. Kr. 5,00.
„ 78. ORVIN, ANDERS K., *Outline of the Geological History of Spitsbergen.* 1940. Kr. 7,00.
„ 79. LYNGE, B., *Et bidrag til Spitsbergens lavflora.* 1940. Kr. 1,50.
„ 80. *The Place-Names of Svalbard.* 1942. Kr. 50.00.
„ 81. LYNGE, B., *Lichens from North East Greenland.* 1940. Kr. 14,00.

From No. 82 the title of these publications has been changed from *Skrifter om Svalbard og Ishavet* to *Norges Svalbard- og Ishavs-undersøkelser. Skrifter.*

„ 82. NILSSON, TAGE, *The Downtonian and Devonian Vertebrates of Spitsbergen. VII. Order Antiarchi.* 1941. Kr. 11,50.
„ 83. HØEG, OVE ARBO, *The Downt. and Devonian Flora of Spitsbergen.* 1942. Kr. 33,00
„ 84. FREBOLD, HANS, *Über die Productiden des Brachiopodenkalkes.* 1942. Kr. 6,00.
„ 85. FØYN, SVEN, and HEINTZ, ANATOL, *The Downtonian and Devonian Vertebrates of Spitsbergen. VIII.* 1943. Kr. 5,00.

Norges Svalbard- og Ishavs-undersøkelser, Observatoriegata 1, Oslo

A. W. BRØGGERS BOKTRYKKERI A/S, OSLO