NORSK POLARINSTITUTT
MEDDELELSER NR. 87

T. S. WINSNES, A. HEINTZ
AND N. HEINTZ

ASPECTS OF THE GEOLOGY OF SVALBARD

INTERNATIONAL GEOLOGICAL CONGRESS
XXI SESSION NORDEN 1960
GUIDE TO EXCURSION NO. A 16

Reprint from:
Norges Geologiske Undersøkelse No. 212 p.

NORSK POLARINSTITUTT
OSLO 1962

DET KONGELIGE DEPARTEMENT FOR INDUSTRI OG HÅNDVERK

NORSK POLARINSTITUTT
Observatoriegt. 1, Oslo, Norway

Short account of the publications of Norsk Polarinstitutt.

The two seriespublished by Norsk Polarinstitutt, SKRIFTER and MEDDELELSER, were taken over from the former institution, Norges Svalbard- og Ishavs-undersøkelser (NSIU), which was incorporated in Norsk Polarinstitutt, when this was founded in 1948. A third series, Norsk Polarinstitutt - ÅRBOK, will be published with one volum per year. The first volume will soon appear.

SKRIFTER includes scientific papers, published in English, French or German. MEDDELELSER comprises shorter papers, often being reprints from other journals. They are generally in a more popular scale and are mostly published in Norwegian.

SKRIFTER has in the past been published under various titles:

Nos. 1—11.	Resultater av De norske statsunderstøttede Spitsbergen-ekspedisjoner.
No. 12.	Skrifter om Svalbard og Nordishavet.
Nos. 13—81.	Skrifter om Svalbard og Ishavet.
» 82—89.	Norges Svalbard- og Ishavs-undersøkelser. Skrifter.
» 90— .	Norsk Polarinstitutt. Skrifter.

Further Norsk Polarinstitutt also publishes a special series: NORWEGIAN—BRITISH—SWEDISH ANTARCTIC EXPEDITION, 1949—52. SCIENTIFIC RESULTS. This series will consist of 6 vols. By now 20 papers are published, and the series will probably be completed within 1963.

Topographical and hydrographical surveying also plays an important part of the work done by Norsk Polarinstitutt. A list of the published maps and charts is found on the back page of SKRIFTER.

A complete list of publications (including maps and charts) is enclosed in SKRIFTER No. 123.

PUBLISHED BY NORSK POLARINSTITUTT
DISTRIBUTED BY OSLO UNIVERSITY PRESS
OSLO 1962

Norges Geologiske Undersøkelse No. 212 p.

INTERNATIONAL GEOLOGICAL CONGRESS
XXI SESSION NORDEN 1960

ASPECTS OF THE GEOLOGY OF SVALBARD

Guide to excursion no. A 16

by

THORE S. WINSNES,
ANATOL HEINTZ AND NATASCHA HEINTZ
with contribution by
K. BIRKENMAJER

Editor of Norwegian guide-books:
JOHANNES A. DONS,
secretary to the
NORWEGIAN GOVERNMENT'S ORGANIZING COMMITTEE
for the
INTERNATIONAL GEOLOGICAL CONGRESS
OSLO 1960

CONTENTS

8 figures in the text.
2 plates enclosed.
Key map: see back cover.

Excursion A 16: 29th. July to 13th. Aug., 1960.

Excursion leaders:

GEOLOG THORE S. WINSNES,
Norsk Polarinstitutt, Observatoriegt. 1, Oslo, Norge.

PROFESSOR DR. ANATOL HEINTZ,

VITENSKAPELIG ASSISTENT NATASCHA HEINTZ,
Paleontologisk Museum, Sarsgt. 1, Oslo, Norge.

PREFACE

The Svalbard area was put under Norwegian sovereignity in 1925. Its international status is defined in the Svalbard treaty wherein its geographic extent is given as follows: "The Archipelago of Svalbard, comprises with Bjørnøya, all the islands situated between 10°–35° longitude East and between 74°–81° latitude North, especially Vestspitsbergen, Nordaustlandet, Barentsøya, Edgeøya, Kong Karls Land, Hopen and Prins Karl Forland, together with all islands great or small and rocks appertaining thereto".

Scientific explorations of the archipelago were begun in 1827 by the Norwegian geologist prof. B. M. Keilhau.

GEOLOGY OF SVALBARD

VESTSPITSBERGEN AND THE SURROUNDING ISLANDS

Introduction.

The main geological features of Vestspitsbergen, Nordaustlandet, Barentsøya, Edgeøya, and the smaller islands are relatively simple. Strata representing deposits from Devonian to Tertiary times lie more or less undisturbed upon one another.

The pre-Devonian strata—the Hecla Hoek sequence—were, however, in part strongly folded and metamorphosed and intruded by magmas during the Caledonian orogeny. This sequence was peneplained before the post-Downtonian sediments were deposited. The post-Downtonian sedimentary rocks are little transformed and only in a few places have basic dykes and sills been intruded. They are, however, partly folded both during the Svalbard orogeny (Upper Devonian) and especially during the Tertiary orogeny when the large syncline which imparts to the rocks on Vestspitsbergen their characteristic distribution, was formed. The axis of the syncline extends from the southern point of Vestspitsbergen to the west coast at Kongsfjord, in the direction NNW–SSE with plunge towards the SE, such that the oldest deposits are found farthest north. The outcrop of the individual formations is therefore roughly V-shaped with the apex of the V pointed towards NW. The northern, northeastern and eastern parts of Vestspitsbergen, Nordaustlandet, and the smaller islands to the east have not been appreciably effected by the folding; the rocks lie here with only a slight dip.

The pre-Downtonian Hecla-Hoek sequence includes Precambrian, Cambrian and Ordovician deposits. By and large, it is found as a belt parallel to the west coast of Vestspitsbergen, forming the western side of the syncline, and in the north where it forms large areas of the northernmost parts of Vestspitsbergen and Nordaustlandet.

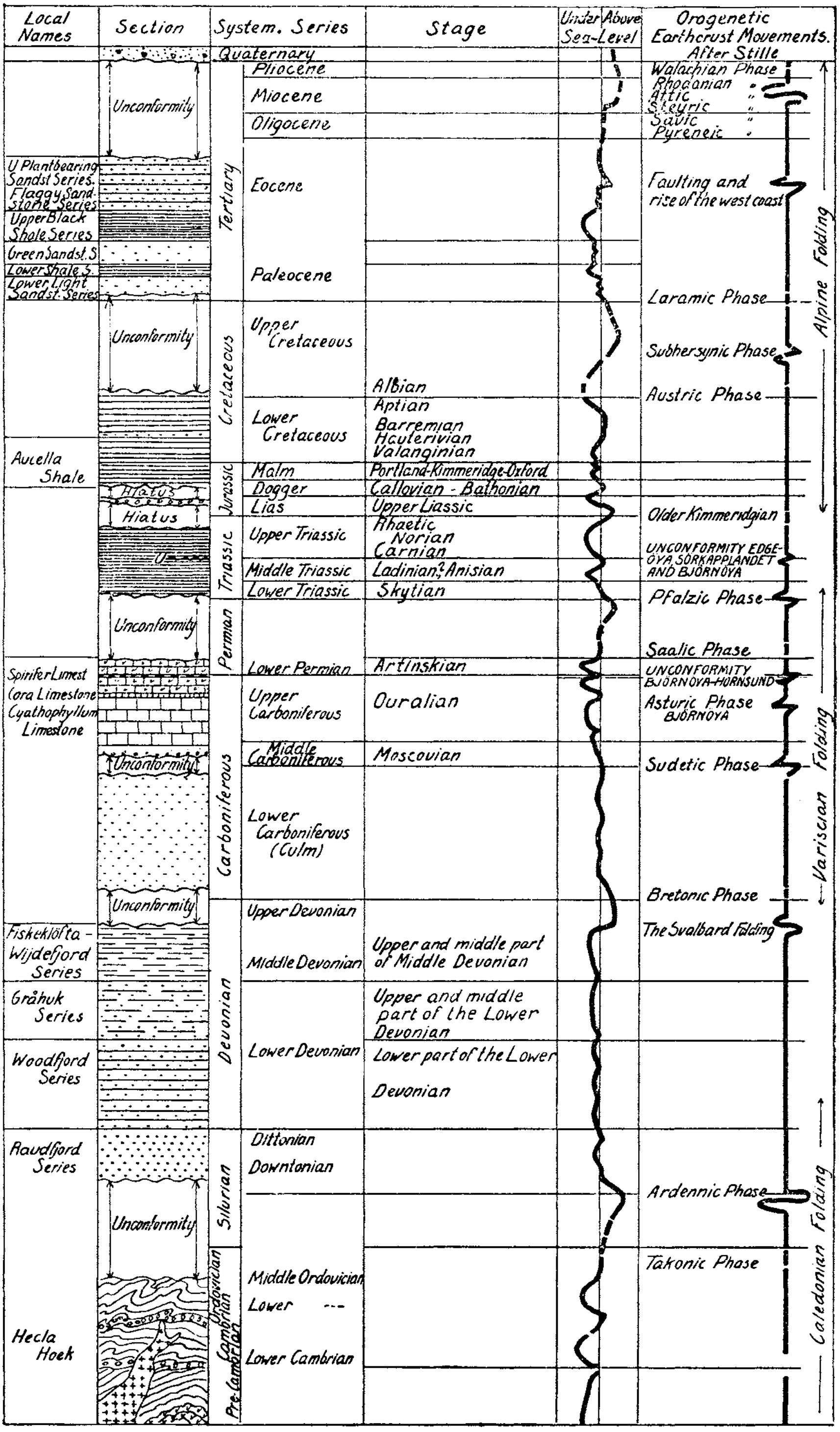
The oldest post-Downtonian sediments are of Downtonian-Devonian age. They lie unconformably on the Hecla-Hoek sequence where the contact can be observed. In the south, at Hornsund, and between Isfjorden and Kongsfjorden there occur areas with Devonian sediments, but the main area of Downtonian-Devonian rocks is north and east of the syncline where they outcrop covering a large area intersected by a series of faults. This area extends from the northern side of Isfjord to the north coast.

The younger Paleozoic deposits—Carboniferous and Permian—can be followed as a thin band along the west side of the syncline from the southern point of Vestspitsbergen to Kongsfjorden. On the east side of the syncline they are much more extensively exposed, forming a broad belt passing from Kongsfjorden towards the southeast around the inner parts of Isfjorden. From Isfjorden a broad belt of the younger Paleozoic deposits continues to Hinlopenstretet and on the south side of Nordaustlandet. The younger Paleozoic rocks rest either on Devonian strata or directly on the Hecla-Hoek sequence.

The Mesozoic sediments—Triassic, Jurassic and Cretaceous—are also found on both sides of the syncline but are of much greater extent on the east than on the west side. These formations do not occur to any appreciable extent north of Isfjorden. Along the east coast of Vestspitsbergen there are rather large areas of nearly flat-lying Triassic strata with small areas of Jurassic rocks on the tops of high mountains. Barentsøya and Edgeøya consist virtually exclusively of Triassic deposits, as does also Kong Karls Land where small areas of Jurassic and Cretaceous rocks are also known to occur.

The Cenozoic is represented only by the older Tertiary (Paleocene-Eocene(?)) deposits. They are exposed in the central part of the syncline and lie nearly horizontally. They are found mainly in the area south of Isfjord and at the extreme southeastern tip of the island.

Fig. 1. *Columnar section of the sequence found at Svalbard. Included variations of the sea-level as well as the orogenetic earth-movements. (Orvin, 1940.)*



Local Names
Section
System. Series
Stage
Under Sea-Level
Above Sea-Level
Orogenetic Earthcrust Movements. After Stille
Quaternary
Pliocene
Miocene
Oligocene
Eocene
Paleocene
Tertiary
Unconformity
U Plantbearing Sandst Series.
Flaggy Sandstone Series
Upper Black Shale Series
Green Sandst. S.
Lower Shale S.
Lower Light Sandst. Series
Walachian Phase
Rhodanian "
Attic "
Steyric "
Savic "
Pyreneic "
Faulting and rise of the west coast
Laramic Phase
Alpine Folding
Upper Cretaceous
Lower Cretaceous
Cretaceous
Albian
Aptian
Barremian
Hauterivian
Valanginian
Subhersynic Phase
Austric Phase
Aucella Shale
Jurassic
Malm
Dogger
Lias
Portland-Kimmeridge-Oxford
Callovian - Bathonian
Upper Liassic
Hiatus
Older Kimmeridgian
Triassic
Upper Triassic
Middle Triassic
Lower Triassic
Rhaetic
Norian
Carnian
Ladinian? Anisian
Skytian
UNCONFORMITY EDGEÖYA, SÖRKAPPLANDET AND BJÖRNÖYA
Pfalzic Phase
Permian
Lower Permian
Artinskian
Saalic Phase
UNCONFORMITY BJÖRNÖYA-HORNSUND
Spirifer Limest
Cora Limestone
Cyathophyllum Limestone
Carboniferous
Upper Carboniferous
Middle Carboniferous
Lower Carboniferous (Culm)
Ouralian
Moscovian
Asturic Phase BJÖRNÖYA
Sudetic Phase
Bretonic Phase
Variscian Folding
Fiskeklöfta - Wijdefjord Series
Gråhuk Series
Woodfjord Series
Devonian
Upper Devonian
Middle Devonian
Lower Devonian
Upper and middle part of Middle Devonian
Upper and middle part of the Lower Devonian
Lower part of the Lower Devonian
The Svalbard Folding
Raudfjord Series
Silurian
Dittonian
Downtonian
Ardennic Phase
Ordovician
Cambrian
Pre-Cambrian
Middle Ordovician
Lower ---
Lower Cambrian
Takonic Phase
Hecla Hoek
Caledonian Folding

Fig. 1.

Small areas of downfaulted Cenozoic rocks are also found at Forlandsundet, Kongsfjord, etc.

At the end of the Tertiary or beginning of the Quaternary Svalbard was covered by a continuous ice-mass, the weight of which depressed the whole area considerably. Only recently—geologically speaking—has the ice partly melted away and the land begun to rise, a development which can be traced and verified by study of the numerous marine terraces at various levels.

A complicated system of faults, largely directed N—S, was formed mostly during the Caledonian orogeny, Svalbard orogeny and the Tertiary orogeny. The faults divide Vestspitsbergen into a mosaic of mutually partly thrusted blocks complicating the otherwise rather simple geological picture of Svalbard. In addition, there has probably been some volcanic activity during the Quaternary, as indicated by two feeding-channels in the northern part of Vestspitsbergen. Associated with one of these (at Bockfjorden), occur hot springs.

Hecla Hoek sequence.

The Hecla Hoek sequence consists of Proterozoic and older Paleozoic sediments and has been strongly faulted and metamorphosed during the Caledonian orogeny.

Rocks of Hecla Hoek age have a fairly large geographical distribution and the sequence reaches considerable thickness. In the northeastern areas of Vestspitsbergen and Nordaustlandet the estimated thickness is about 16 000 m and in Hornsund about 11 500 m, whereas in Kongsfjorden successive layers have been measured, giving a total of 4000 m.

In the southern part of Vestspitsbergen the lower succession of the Hecla Hoek sequence is mostly made up of schists, partly garnetiferous, with intercalations of quartzites and less frequently marbles. Higher follows quartzites and dolomites, succeeded by a thick conglomerate or tillite overlain by a dolomite-limestone series, containing oolites and *Collenia*. This is again covered by a thick phyllite series which south of Bellsund is succeeded by a thick tillite. The subsequent shales yield fossils, *e.g.* trilobites and brachiopods, indicating upper Lower Cambrian age. In the thick dolomite and limestone series above, a Lower Ordovician fauna containing brachiopods, gastropods and cephalopods has been found. Thus, fossils found in the Hornsund area have shown that the Paleozoic sequence of the Hecla Hoek formation there is about 4 500 m thick. In the northeastern area of

Vestspitsbergen and Nordaustlandet similar glacial deposits as well as fossils of Cambrian and Ordovician age have been recorded, making a correlation possible.

Downtonian—Devonian.

The Downtonian-Devonian sequence is mostly built up of typical continental deposits of Old Red facies. It is divided into the following four series:

The Wijde Bay Series	Devonian
The Grey Hoek Series	Devonian
The Wood Bay Series	Devonian
The Red Bay Series . . .	Downtonian-Dittonian

The sediments are exposed in the big down-faulted area extending from the north coast of Vestspitsbergen to the north side of Isfjorden. To the east and west this area is limited by great NS running faults, the eastern one following Wijdefjorden towards Billefjorden, the two western ones passing from the west shore of Raudfjorden towards the inner part of Kongsfjorden and from Breibogen to Ekmanfjorden.

The Red Bay Series, representing the oldest part of the Downtonian-Devonian sequence, consists largely of coarse conglomerates and sandy sediments which lie unconformably on the metamorphic Hecla Hoek rocks. The block between the two western faults dips westwards, and thus the Red Bay Series deposits are found towards west and the Hecla Hoek towards east.

The Wood Bay Series seems to follow without any break on the top of the Red Bay Series. It is mainly composed of red sandstones, and covers the greatest part of the area between the fault running from Breibogen to Ekmanfjorden and Wijdefjorden. The Grey Hoek Series is built up of grey sandstones and black arenaceous shales and its scarse fishremains and fauna of pelecypods, gastropods and ostracodes indicate brackish or marine sedimentation.

The sediments of the Wijde Bay Series also consist of finegrained grey sandstones, partly with dark shales containing ferruginous concretions. They are exposed along the west coast of Wijdefjorden and in Mimersdalen, where rich finds of fish- and plant-fossils show the continental character of this series. The Mimersdalen deposits are the youngest Devonian sediments known from Vestspitsbergen.

As a whole the Downtonian-Devonian deposits of northern Vestspitsbergen yield a very interesting fauna of Agnathes and fishes. Plants have also been found in several horizons, whereas invertebrates, except in Grey Hoek Series, are scarse and mostly represented by ostracodes and pelecypods.

Devonian sediments occur also in southern Vestspitsbergen in a narrow zone from Hornsund both southwards and northwards. The sequence is here much folded and lies with an angular unconformity on the Hecla Hoek rocks. Vertebrate fossils found in the lower part indicate that these layers may be correlated with the Wood Bay Series, while shales with pelecypods higher up presumable are of Grey Hoek Series age. The presence of deposits of Wijde Bay Series is uncertain in this area. The Downtonian-Devonian deposits are about 6500 m. thick.

Carboniferous.

Sediments from the Carboniferous period found in Vestspitsbergen can according to their different lithological appearance be divided in two parts.

1. The lower Carboniferous typical Culm sequence with conglomerates and coarse sandstones indicating continental conditions.
2. Middle and Upper Carboniferous mostly marine sediments.

Culm.

Originally Culm sediments were probably deposited over most of the Svalbard area, but because of the tectonic movements and erosion before Middle and Upper Carboniferous time only scattered remnants are preserved.

Today the Culm sequence occurs in a narrow zone along the western limb of the syncline, extending from the bottom of St. Johnsfjorden passing Isfjorden and Bellsund southwards to Hornsund. Isolated areas with Culm sediments are also observed north of Sassenfjorden and in the Billefjorden area, where coal seams are subjected to mining by the Russians. The Culm Series as found today varies greatly in thickness and can locally be several hundred meters thick.

Middle and Upper Carboniferous.

The Middle and Upper Carboniferous sediments have, as mentioned (p. 4), a rather great extention at Svalbard today. But the sequence is variously developed at different places, indicating that the sedimentation has been interrupted several times. Thus, in Bellsund and Hornsund are found red sandstones and conglomerates without fossils, partly of considerable thickness, presumably deposited in Middle Carboniferous time. Similar deposits with gypsum are found at the head of Billefjorden.

Before Upper Carboniferous time a peneplain was formed, upon which the characteristic Upper Carboniferous Cyathophyllum Limestone was deposited. The limestone series rest unconformably on different formations. In the northeast area of Vestspitsbergen and Nordaustlandet it follows on top of Hecla Hoek, north of Isfjorden on Devonian, and in the Billefjorden area and along the west side of the syncline mostly on Culm (see description of Hornsund area p. 15). The Cyathophyllum Limestones contain microfossils in the lower part and a rich fauna of brachiopods and corals of Moscovian and Uralian age. Cherty layers occur at several places within this series, especially in the Isfjorden area, where also layers of anhydrite are found. The thickness of Upper Carboniferous sequence varies largely and reaches 4—500 m. in Isfjorden, in the south of Vestspitsbergen it is, however, much less.

Permian.

The Lower Permian sediments always rest conformably on the Carboniferous layers and have about the same geographical extension as these series. They are from 100—200 m. thick.

They begin with the Spirifer Limestone, that contains a rich fauna of productids, spiriferids and other Artinskian brachiopods and bryozoas. In layers above the Spirifer Limestone sponges occur. Higher up cherty layers dominate, whereas the youngest part of the Permian sequence is glauconitic. Upper Permian sediments are not found.

Triassic.

After the late Permian erosion the Svalbard area again subsides, and during the whole Triassic period there was extensive sedimentation.

In most places the Lower Triassic beds consist of fine-grained sandstones with hardly any fossils except for a few pelecypods. The following black shales with limestone lenses and marls of Middle Triassic age yield a rich fauna of different fishes, stegocephals, reptiles, ammonites and pelecypods. Fossil plants indicate a continental character of the Upper Triassic sequence.

Triassic deposits occur, as mentioned (p. 4) in a narrow zone along the west side of the syncline, in the central part of the Isfjorden area and along that part of the east coast of Vestspitsbergen which faces Barentsøya. This island, Edgeøya and Kong Karls Land consist also exclusively of flat-lying Triassic sediments.

In most places the entire Triassic sequence is found to rest conformably on Permian rocks, even along the west side of the syncline, where the layers are much folded. But in the Hornsund area the Middle and Upper Triassic follows partly directly on Culm (in west) and partly on Devonian and Hecla Hoek rocks (in south), and thus Lower and parts of Middle Triassic sediments are lacking.

The total thickness of the Triassic sediments varies very much. While being more than 1100 m at the southwestern coast of Isfjorden, it is only about 175 m in the southern part of the Hornsund area.

Jurassic and Cretaceous.

At the close of the Triassic age (Rhetian) the Svalbard area lay above sea level. During the following time negligable amounts of material was removed and the Liassic conglomerate rests without any angular unconformity on the Triassic beds. The conglomerate is succeeded by a monotonous marine sequence, 4—600 m thick, formed during the rest of the Jurassic and beginning of the Cretaceous period. It consists mainly of marly shales with calcarous concretions and thin limestones and contains a fairly rich fauna of ammonites, pelecypods and reptiles.

The continental Cretaceous sediments at places, yield large amounts of plant fossils, and coal seams are also found. They were deposited during nearly the whole remainder of Lower Cretaceous time, only interrupted by Aptian, marine layers in the uppermost part of the sequence. In Bellsund Albian sediments also occur, being the youngest member of the Cretaceous on Vestspitsbergen. Upper Cretaceous sediments have probably also been deposited, but they were removed before the beginning of the Tertiary. The continental deposits vary greatly in thickness. Along the southwest coast of Isfjorden they do not exceed 150—200 m, whereas in the eastern part of Vestspitsbergen they reach 800 m.

Volcanic activity in the Cretaceous period resulted in basic intrusions and diabase sills can be followed for several km before they cross the bedding or taper out. On the west coast and in the Isfjorden area the intrusions cut the Triassic sediments. In the eastern parts of the Svalbard area diabase dikes and sills are even more common and at Kong Karls Land they have cut even through continental Lower Cretaceous beds. The western diabases may be older than the eastern ones.

Tertiary.

Prior to the Tertiary the northern part of Svalbard had been lifted up, and this area thus provided material for the Tertiary sediments that are found in the central part of the syncline. Coarse conglomerates of Lower Tertiary age, occurring on both sides of Forlandsundet indicate that landmasses may also have existed to the west. In addition, three small areas of Tertiary beds are found one at the south side of Kongsfjorden, one in Bellsund and one at the southern tip of Vestspitsbergen.

The Tertiary sequence at Vestspitsbergen begins with continental sandstones, containing several coal horizons. The sandstones are proceeded by dark clayey shales, yielding some marine fossils. Marine fossils also occur in the overlying greenish sandstones and in the following beds of dark shales and sandstones.

In the upper part of the Tertiary sediments several coal seams and an abundance of plant fossils and petrified wood show that these layers are of continental origin. Particulary, great amounts of *Equisetum* indicate the presence of vast moors, covered with rich flora.

The average temperature (year) was about 20° C higher than it is at Svalbard today. (The mean temperature today is ÷ 5° C.)

Marine invertebrate fossils and various plants make it reasonable to assume that the Tertiary layers of Vestspitsbergen are of Lower Tertiary age (Paleocen-Eocen(?)). The total thickness of the Tertiary sediments developed in the syncline is estimated to be nearly 2000 m.

Coal seams of the upper sandstone series are and have been mined at several places. Norwegian mining companies are working in Adventfjorden and Kongsfjorden, whereas at the head of Van Mijenfjorden the mines now are given up. The Russians are at present running two mines on Tertiary coal, both on the south side of Isfjorden (Grønnfjorden and Grumantbyen).

Tertiary Folding and Faulting.

After the deposition of the youngest Tertiary sediments found at Vestspitsbergen today, a period of extensive folding took place, during which the great syncline was formed. The zone of folding can be followed from Sørkapp Land and northwards to Kongsfjorden, where it passes out into the sea. The west side of the syncline seen along the west coast of Vestspitsbergen, particulary in the big fjords exhibits intensive folding with beds dipping steeply eastwards, overfolding. The main direction of the fold axes is N-S. Fold axes trending E-W have also been observed.

The east side of the syncline has not been as much influenced by the folding and passing towards Storfjorden the layers gradually become nearly horizontal. In the area south of Hornsund Triassic and Jurassic sediments lie unfolded on the tops of the mountains west of the syncline, but the area has been subjected to extensive blockfaulting.

Nearly all the Tertiary faults are younger than the folding, their direction being parallel with the west coast of Vestspitsbergen or NE—SW. In Forlandsundet a graben was formed, limited by two great faults which bring Tertiary sediments directly in contact with Hecla Hoek rocks. Also at other places faulting has resulted in the formation of grabens, e.g. in Kongsfjorden. Some of the Tertiary faults follow old fracture lines, as e.g. the one passing along the Devonian line from Wijdefjorden to Billefjorden and Sassenfjorden.

GEOLOGY OF BJØRNØYA — (BEAR ISLAND)

The island is 68.5 sq miles (178 km^2) and lies at 74°30′ N.l. and 19° l.E.

Bjørnøya has no proper harbour, so it is difficult to go ashore there. Generally the weather conditions are unfavourable and in the summer the island is mostly enveloped in fog. We will, however, try to pass the east coast as closely as possible, and hope to be able to demonstrate the main features of the geological structure of the island.

The stratigraphy is shown in table 1.

Generally the deposits at Bjørnøya, except Hecla Hoek which was deformed during the Caledonian orogeny, lie more or less flat, without any pronounced folding, disturbed only by a series of faults (Caledonian, Upper Devonian and Tertiary). Four marked unconformities have so far been established in the whole series of deposits (tab. 1 and Fig. 2).

As the dip is about NW, the Hecla Hoek rocks are exposed in the southern and south-eastern part of the island, and in the NNW direction younger layers become visible (Devonian, Culm, Middle and Upper Carboniferous).

The Permian deposits lie essentially undisturbed, but unconformably on various units of the older series. They cap the southern moun-

Table 1.

<table>
<tr><th colspan="2">System</th><th>Series</th><th colspan="2">Division and description</th><th></th><th>Thickness in m.</th></tr>
<tr><td colspan="2">Triassic</td><td>Carmian</td><td colspan="2">Dark shales</td><td rowspan="2">Hiatus</td><td>190 m</td></tr>
<tr><td colspan="2">Permian</td><td>Lower Permian</td><td colspan="2">Spirifer limestone</td><td>120 m</td></tr>
<tr><td colspan="2" rowspan="4">Carboniferous</td><td rowspan="2">Upper Carboniferous</td><td colspan="2">Cora limestone and sandstone</td><td>Unconformity</td><td>50 m</td></tr>
<tr><td colspan="2">Fusulina limestone (dark)</td><td>Unconformity</td><td>75 m</td></tr>
<tr><td>Middle Carboniferous</td><td colspan="2">Sandstone, some shales, conglomerate mainly in the lower part of the beds</td><td></td><td>375—470 m</td></tr>
<tr><td>Lower Carboniferous (Culm)</td><td rowspan="2">Ursa sandstone</td><td>Sandstone with some conglomerate and dark shales</td><td></td><td>110—235 m</td></tr>
<tr><td colspan="2">Devonian</td><td>Upper Devonian</td><td>Sandstone with coal seams Conglomerate at base</td><td rowspan="2">Unconformity</td><td>100—360 m</td></tr>
<tr><td rowspan="4">Hecla Hoek</td><td rowspan="2">Ordovician</td><td>Middle Ordovician</td><td colspan="2">Tetradium limestone (black)</td><td>240 m</td></tr>
<tr><td>Lower Ordovician</td><td colspan="2">Younger Dolomite (grey)</td><td rowspan="2">Unconformity</td><td>400 m</td></tr>
<tr><td>Cambrian</td><td>Lowermost Cambrian?</td><td colspan="2">Slate-Quartzite (green and red)</td><td>175 m +</td></tr>
<tr><td>Precambrian</td><td>Proterozoic</td><td colspan="2">Older Dolomite (grey)</td><td></td><td>400 m</td></tr>
</table>

tains (Alfredfjellet, Hambergfjellet and Fuglefjellet) and form the plateau on Miseryfjellet. They also cover a considerable area round Laksvatnet. Triassic layers occur only on Miseryfjellet, and in spite of a large hiatus, they lie more or less conformably on the Permian Spirifer Limestone.

Coming from south along the east coast of Bjørnøya we will first see Fuglefjellet with its steep clifts. This mountain consists of the Younger Dolomite division, capped with about 60 m of Upper Carboniferous and Permian limestone (Cora and Spirifer Limestone). Futher north in Antarcticfjellet the same dolomite beds are covered by Middle Ordovician Tetradium Limestone. North of Antarcticfjellet is found an upthrusted area where the oldest members of the Hecla Hoek succession are exposed—the Slate Quartzite and the Older Dolo-

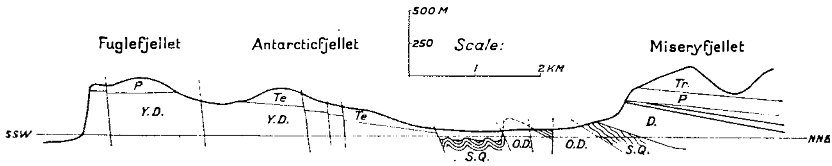


Fig. 2.

Section along the south-east part of Bjørnøya.
O.D. — Older Dolomite; S.Q. — Slate Quartzite; Y.D. — Younger Dolomite; Te — Tetradium limestone; D — Devonian; P. — Permian; Tr. Triassic.

mite division. On the southern slope of Miseryfjellet the Slate Quarzite is overlain discordantly by Devonian sediments, the upper part of which contains several coal seams. Unconformably above this, the Permian Spirifer Limestone can be seen, forming an escarpment. The top of the mountain is made up of dark Triassic shales. In the southern part of Miseryfjellet a landslide has brought the Triassic and Permian rocks down to sea level. The following part of the coast is composed of more or less flat-lying Devonian sandstones and shales with coal seams. The occurrence of coal on Bjørnøya was already known from 1609 and from 1915 to 1925 a Norwegian mining company was working on the NE coast. The Devonian coal at Bjørnøya is thus the oldest coal in the world that has been subjected to mining.

A Norwegian Meteorological station is at present situated on the north coast of the island.

AREAL DESCRIPTIONS

Bjørnøya to Hornsund.

The distance from Tromsø to Bjørnøya is about 360 naut. miles, and from Bjørnøya to Sørkapp on Vestspitsbergen about 120 naut. miles.

Approaching Sørkapplandet we will see the low strandflat, that lies in front of the higher mountains. The ice conditions are often quite difficult in the Hornsund area, and it may thus happen that we cannot go into Hornsund.

Hornsund.

by K. Birkenmajer.

In the pre-Quaternary of the Hornsund area two main units may be distinguished: 1. Hecla Hoek Succession, 2. Post-Caledonian Sequence, separated by Caledonian orogenic movements.

In the Hecla Hoek Succession six formations may be distinguished, subdivided into series. These are, from the bottom to the top: the Isbjørnhamna Formation (Proterozoic); c. 1500 m., the Eimfjellet Formation (Proterozoic); c. 1500 m., the Deilegga Formation (Proterozoic); c. 3500 m., the Sofiebogen Formation (Proterozoic-Eocambrian); c. 2500 m., the Sofiekammen Formation (Cambrian); c. 800 m., and the Sørkapp Land Formation (Ordovician); c. 1700 m.

The Isbjørnhamna Formation is composed mostly of garnetiferous mica schists intercalated, in the middle part of the formation, with marbles.

The lower part of the Eimfjellet Formation consists of quartzites, while the upper one consists either of phyllites and slates intercalated with amphibolites, limestones and varved quartz schists containing quartzite boulders (marine tillites), or of amphibolites with subordinate schist and quartzite intercalations. In an area within the amphibolite complex a very interesting zone of granitization occurs with various metasomatic rocks forming small lenses.

The Deilegga Formation begins with conglomerates followed by dolomites and, higher up, by a thick sequence of phyllites and slates intercalated in the middle part with dolomites and alum shales and in the upper part with quartzites.

The Sofiebogen Formation begins with conglomerates. Higher up occur limestones and dolomites often with oolites and *Collenia*. The upper part of the formation consists of phyllites intercalated with quartzites and, subordinately, with carbonate rocks.

The Sofiekammen Formation begins with dolomites followed by shales and, higher up, by limestones and dolomites.

The Sørkapp Land Formation begins with quartzites followed by a thick sequence of dolomites and limestones.

A number of sedimentary breaks and some strong disconformities have been found within the Hecla Hoek Succession.

All six points to be visited during the excursion are in the Hecla Hoek Succession, mainly on the northern coast of Hornsund.

The post-Caledonian sequence begins with the Wood Bay Series (Lower Devonian) overlain by the equivalents to the Grey Hoek Series and to perhaps the Wijde Bay Series. The Devonian rocks outcrop in the inner part of Hornsund. The Culm beds are present only in the NW part of Sørkapp Land, while in the inner Hornsund the Devonian is covered discordantly by the Middle Carboniferous. The last member is overlain by the Upper Carboniferous beds, and those by the Brachiopodal Cherty Limestone (Lower and partly Middle Permian). A sequence of Triassic beds follows overlain by the Jurassic, Cretaceous and the Palaeocene.

There are numerous sedimentary breaks within the post-Caledonian sequence of beds caused mainly by regressions and subaerial erosion, partly by tectonic movements.

In the inner Hornsund some instructive coast profiles may be seen from distance showing tectonic deformations (folds, faults, overthrusts) of Alpine age.

The only non-metamorphosed magmatic rocks in the Hornsund area are dolerites which intruded both the Hecla Hoek Succession and the post-Caledonian sequence of beds.

Hornsund to Bellsund.

From Hornsund to Bellsund the ship will follow the ragged coast, which is built up of strongly folded, partly overthrusted and faulted, metamorphic Hecla Hoek rocks. Several big glaciers reach the coast here, e. g. Torellbreen.

Bellsund.

If the weather permits we will make a short stop at Bellsund, where at Midterhuken can be seen the folded sediments of Carboniferous, Permian and Triassic age. Midterhuken is the peninsula between the two eastgoing fjords, the southern one is Van Keulenfjorden, the northern one Van Mijenfjorden, the entrance of which is nearly completely blocked by the long, narrow Akseløya.

Bellsund to Isfjorden.

On the journey from Bellsund to Isfjorden the ship will pass along the low strandflat that lies in front of the higher mountains, some of which rise to nearly 900 m.

Isfjorden.

During the rest of our visit to Vestspitsbergen, we will spend the time in Isfjorden, making excursions on shore at several places.

The Festningen section.

Our first stop will be when turning into Isfjorden, near Kapp Linné, where a landing will be made. Between Grønnfjorden and Kapp Linné, the western limb of the central syncline crosses Isfjorden and a natural section through the steeply inclined sediments, ranging from Culm up to Tertiary, can be investigated by following the shore some km. This section, called "Festningsprofilet" (the Festning section), has been measured in detail and the fossil content has to a great extend been described.

We will start our excursion near Nimrododden in the Culm strata, that westwards lie unconformably on the Hecla Hoek rocks. Moving eastwards we will pass the Culm sandstones, which contain plant fossils. The culm layers are followed by Upper Carboniferous marine deposits, and the boundary between these two sequences is not far from Kapp Starostin. Here are found cherty layers in some of which an abundance of fossils occur. Very common is *Productus sp.,* but numerous specimens of *Spiriferella, Marginifera* and *Spirifer* are also seen. This fauna is contemporaneous with the Upper Carboniferous "Cora Limestone" at Bjørnøya.

Kapp Starostin is the westernmost point of a small peninsula, in the western part of which the strata are mostly covered by scree and gravel. Only a few limestone beds penetrate the debris, these beds also being of Upper Carboniferous age. The Upper Carboniferous beds are about 290 m thick. From the central to the western part of the peninsula the deposits yield fossils of Lower Permian (Artinskian) age. The Lower Permian sequence all together is about 100 m thick.

In the little bay between the peninsula and Vestre Tvillingodden are found soft, sandy shales of Lower Triassic age. They succeed conformably on top of the Lower Permian sediments, and some poorly preserved pelycopods and ammonites are found in the lower part of the strata. The fossils are: *Clareia sp., Myalina degeeri* and *Anodontophora breviformis.*

The middle Triassic layers start at Vestre Tvillingodden. They correspond to the Lower Sauriehorizon, typical of the inner part of Isfjorden. *Gymnotoceras* and other ammonites occur in these layers.

The pelycopod *Daonella* and worm-tracks indicate the beginning of the Upper Triassic sequence at Østre Tvillingodden. *Daonella* appear in great numbers in the equivalent layers in the inner part of Isfjorden, just below the Upper Sauriehorizon, whereas the worm-tracks also are known from Triassic beds in the southern part of Vestspitsbergen.

The rest of the Upper Triassic sequence consists of more sandy layers, only with a few fossils. The total thickness of the Triassic sediments at the Festningen section, is 1150 m, being apparently the maximal value of Triassic at Svalbard.

About 350 m east of Østre Tvillingodden a thin zone of conglomerate indicates the beginning of Jurassic. This conglomerate is perhaps equivalent to the Liassic conglomerate found in the southern and eastern part of Vestspitsbergen. Then follows a sequence with shales with ammonites and pelycopods, *Quenstedticeras* and *Macrodon* being the most common ones and dating the layers to Upper Callovian. The presence of Upper Oxfordian sediments is indicated by *Cardioceras alternoides,* whereas in Lower Kimmeridgian beds an abundance of *Aucella bronni* occur. Also Portlandian layers are likely to be present, but the fossils in this part of the Jurassic sequence do not allow this to be determined with any certainty. The whole thickness of the Jurassic beds is 320 m.

The boundary between the Jurassic and Cretaceous sediments is found about 450 m west of Festningsodden. The lowest Cretaceous shales are of Valangian age, but, infortunately, yield no good guide fossils. At Festningsodden the continental Festning sandstone is exposed, and this and the following sandstones contain plant fossils, i. e. *Ginko* and *Elatides,* the age thus being Upper Valangian-Barremian. The succeeding layers contain a marine fauna, the guide fossils *Crioceras* and *Ditrupa* are characteristic for the Aptian division. The thickness of the Cretaceous layers is 735 m.

The Tertiary beds begin with a conglomerate, then follows a sandstone sequence that is nicely exposed along the west side of Grønnfjorden, starting about 1 km from Festningsodden. At this place we will be taken on board again.

Festningen to Longyearbyen.

The ship will then continue to Longyearbyen in Adventfjorden, going along the south coast of Isfjorden. Except for a few, small isolated areas, all the sedimentary rocks along this part of Isfjorden are of Lower Tertiary age. The coast is at many places very steep, and southwards several peaks can be seen, *e. g.* the beautiful Vesuvfjellet.

On this part of the journey, we will pass three of the four Russian settlements found on Vest-Spitsbergen today. In Grønnfjorden Barentsburg is situated, which is the administrative centre where the Russian consul resides. In Coles Bay, further east, there are no mines, but it serves as harbour for the Grumant mines, lying even further east; communication between the two places is by railway.

Longyearbyen in Adventfjorden.

Adventfjorden is a short branch running south from Isfjorden. Here the largest Norwegian coal mines on Svalbard are situated.

The mountains on either side of the fjord consist in their lower parts of Cretaceous sediments, overlain by Lower Tertiary strata. As previously mentioned (p. 4) the more or less flatlying coalseams on the south side of Isfjorden occur in the Tertiary rocks and thus the mine entrances lie high up on the mountain sides.

The presence of coal in these strata has been known for many years and in 1910 an American by name John Longyear (giving the name to the settlement) started to exploit the coal. In 1916 the Norwegian Company "Store Norske Spitsbergen Kulkompani" took over the mines, and they have worked them ever since, with only a pause of some years during and just after the war. The old mines, which are now nearly exhausted, are situated on both sides of the short Longyeardalen, while the new mines lie in a small valley which runs parallel to it. The annual production is in the region of some 300 000 tons of coal, the quality of which is very good, but it is rather too easily pulverized.

The settlement of Longyearbyen is situated on both sides of Longyeardalen. Besides the people working for the coal company, the Norwegian governor, the state mining engineer and the staff of Svalbard Radio are resident here. In all about 1000 people live in Longyearbyen; the town having its own school, church, hospital, local radio station, shop and post office. Because of the ice conditions, no ship can usually call here between November and the last days of May, thus the shipping season for the coal is fairly short.

During one of our stops in Longyearbyen, we hope that there will be an opportunity to arrange an excursion to the coal mines. In any case a visit will be paid to the moraine in front of Longyearbreen at the bottom of Longyeardalen. Here numerous Lower Tertiary plant fossils can be collected, some of which are wonderfully preserved.

Adventfjorden to Dicksonfjorden.

From Adventfjorden the party will travel northwards, passing Nordfjorden to Dicksonfjorden. On the western shore of Nordfjorden it is possible to see how the Permian sediments have been thrust eastwards during the Tertiary orogeny. Several large glaciers enter the sea on the western side of Nordfjorden.

Dicksonfjorden.

Dicksonfjorden is a northern branch of Isfjorden. The inner part of the fjord is very shallow and we can thus with our ship only come to Mt. Lykta, where we will go ashore.

The visit to Dicksonfjorden will allow the opportunity to get acquainted with the typical Devonian deposits that are found mainly in a down-faulted area in the northern part of Vestspitsbergen (see p. 7). Investigations made in this part of Vestspitsbergen during the last century mostly by Swedish and Norwegian geologists, have resulted in the division of the Downtonian-Devonian deposits into the following four main series as indicated in table 2.

Table 2.

Name of Series	Division	Approx. thickness	Types of layers	Main occurrence in Vestspitsbergen	Age
Wijde Bay Series	Mimersdalen	500 m.	Grey sandstone, shales with iron concretions	Wijdefjorden Mimersdalen Hornsund?	Middle Devonian
Grey Hoek Series		1000 m.	Grey sandstones, black shales	Wijdefjorden Woodfjorden Billefjorden Mimersdalen Hornsund	Lower-Middle? Devonian
Wood Bay Series	Stjørdalen Division	500 m.	Red sandstones with yellow limy sandstone-layers	Wijdefjorden Woodfjorden Billefjorden? Dicksonfjorden? Hornsund?	Lower Devonian
	Lykta Division	600 — 900 m.	Red sandstone	Wijdefjorden Woodfjorden Billefjorden Dicksonfjorden Ekmanfjorden Hornsund?	
	Kapp Kjeldsen Division	1000 — 1500 m.	Red and green sandstone with shaly sandstone	Wijdefjorden Woodfjorden Liefdefjorden Dicksonfjorden Ekmanfjorden	
Red Bay Series	Ben Nevis Division	1000 m.	Limestone, grey sanstone	Raudfjorden Bockfjorden Liefdefjorden	Dittonian
	Fraenkelryggen Div.	500 m.	Shaly sandstone, red and grey sandstone	Raudfjorden	Downtonian

As mentioned earlier (see p. 7) the greatest part of the Downtonian-Devonian sediments on Vestspitsbergen are typical continental deposits. They yield a very interesting fauna of lower vertebrates, and

Table 3.

	Layers	Heterostraci	Osteostraci	Arthrodira	Anthiarchi	Crossopterygii	Plants	Invertebrata
	Wijde Bay Series	Psammolepis		Heterosteus Holonema	Astero-lepis	Rhizodontia, Coelacanthus	Svalbardia, Enigmo-phyton, Hyenopsis	Pelycopods
	Grey Hoek Series			Huginasips, Arctolepis, Lunaspis		Rhizodontia	Psiloden-drion, Hostimella	Pelecypods, Gastropods, Ostracods, Estheria
Wood Bay Series	Stjør-dalen Div.	Minute Pteraspids	Cephalaspis, Nectaspis	Monaspis, Homosteus, Heterosteus		Porolepis		Ostracods
Wood Bay Series	Lykta Div.	Doryaspis, minute Pteraspids	Cephalaspis, Boreaspis, Nectaspis	Actinolepis, Arctolepis, large — Brachyo-thorasi		Porolepis	Psilophyton, Hostimella	Ostracods
Wood Bay Series	Kapp Kjeldsen Div.	Gigantapis, Pteraspis	Cephalaspis, Benneviaspis, Boreaspis, Axinaspis, Arcotomaspis, Nectaspis	Arctaspis, Brachyo-thorasi fragments		Porolepis		
Red Bay Series	Ben Nevis Div.	Pteraspis, Homaspis, Irregulaspis, Ctenaspis, Poraspis, Anglaspis	Cephalaspis, Securiaspis, Tegaspis, Benneviaspis, Hoelaspis, Kiaeraspis	fragments?				Pelycopods Ostracods
Red Bay Series	Fraenkel-ryggen Div.	Ctenaspis, Corvaspis, Traquairaspis, Pteraspis, Poraspis, Anglaspis	Cephalaspis, Ectinaspis				Taeniocrada	Pelycopods

studies of these forms have contributed greatly to our knowledge of *e. g.* Cephalaspids, Poraspids and different Arthrodirs. Invertebrates and plants have also been found in several layers. Table 3 gives the occurrence of the most typical fossils in the different series.

Concerning the relative age of the Downtonian-Devonian deposits at Vestspitsbergen, it is fairly certain that the Red Bay Series is mostly of Dittonian age. The Wood Bay Series is supposed to be of lower Lower Devonian, whereas the Grey Hoek Series is assumed to belong somewhere between this and middle or upper Middle Devonian, which is probably also the age of Wijde Bay Series. The correlation of the different Devonian deposits at Vestspitsbergen with those in other countries is still very difficult, and one may expect that a more detailed knowledge of the Devonian faunas will in part lead to other results.

Inner part.

In the inner part of Dicksonfjord we can study three formations overlying each other: 1) The Devonian Sandstone, 2) Culm deposits and 3) Upper Carboniferous Cyathophyllum Limestone.

On our excursion we will only have the opportunity to get acquainted with the Devonian deposits, as both the Culm and Upper Carboniferous layers are difficult of access within the time we have at our disposal.

The Devonian deposits in the mountain sides along the east coast of Dicksonfjord (fig. 3) are generally more or less horizontal, with only a slight dip towards S. They mainly belong to the Lykta Division (tab. 2) and are composed mostly of relatively fine-grained red sandstones, partly with interformational conglomerate-like layers. Cross-bedding and many other traces certainly formed in quickly running water, can often be seen.

Fossils (tab. 3) are not common, but in some places they occur very abundantly, however the fossiliferous horizons are as a rule not of great extent. The most common forms are: *Doryaspis, Cephalaspis, Arctolepis* and *Porolepis*.

Excursion to Nathorstdalen.

From the beach near Kapp Nathorst, where a large post-glacial terrace rich in pelycopods *(Mytilus edulis, Cyprina islandica, Chlamys islandica* etc.) is developed, the excursion will follow the western slope of the mountain Lykta to Nathorstdalen. On the way we can study

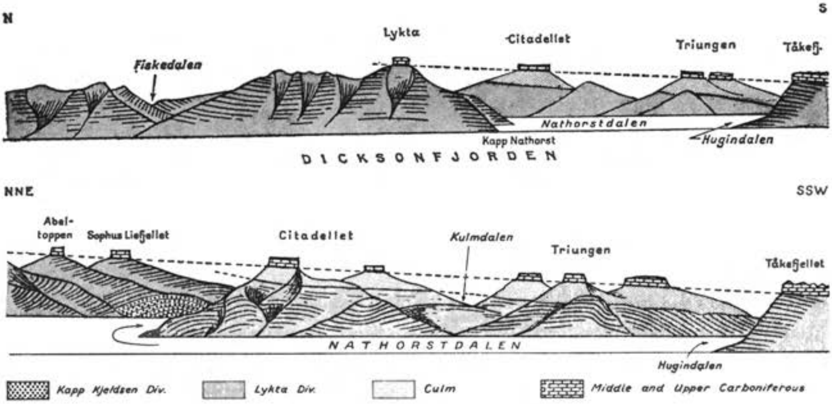


Fig. 3.

View along the east side of Dicksonfjorden (upper picture) and east side of Nathhorst-dalen (lower picture).

the slopes of Mt. Lykta strewn with different kinds of Devonian rocks, partly with fossil fragments. In a rather steep slope ca. 200 m above sea level, we hope to be able to demonstrate a richly fossiliferous horizon. Here we can also study the lithology of Devonian rocks.

The W side of the Nathorstdalen is limited by two mountain complexes, *Triungen and Citadellet,* separated by a deep valley–*Kulmdalen.* (Fig. 3,4.)

In both mountains the Cyathophyllum limestone is found in the uppermost part, resting on a Culm succession of varying thickness, composed of yellow, reddish, grey and partly black sandstones and shales. Some very thin coal seams and fossil plant fragments have been found here.

A marked fault runs NNW–SSE mainly along the middle part of Nathorstdalen, cutting through the western ridge of Triungen. The Devonian layers are here mostly strongly faulted and farther southeast, along the northeast side of Hugindalen they have a pronounced dip to SSW. On Abeltoppen and Sophus Liefjellet (inner part of Nathorstdalen) and on Tåkefjellet (S of Mt. Lykta) the Cyathophyllum limestone rests directly on the Devonian sandstones, thus indicating the extent of the down-faulted area with Culm deposits. (Fig. 3,4.)

In Hugindalen, as mentioned, the Devonian layers dip towards SSW, thus the younger deposits become visible in the inner part of the valley. The red Lykta deposits are here conformably covered by grey shaly layers of presumably the Grey Hoek Series. Hugindalen runs in the direction of Mimersdalen, where the youngest Devonian deposits

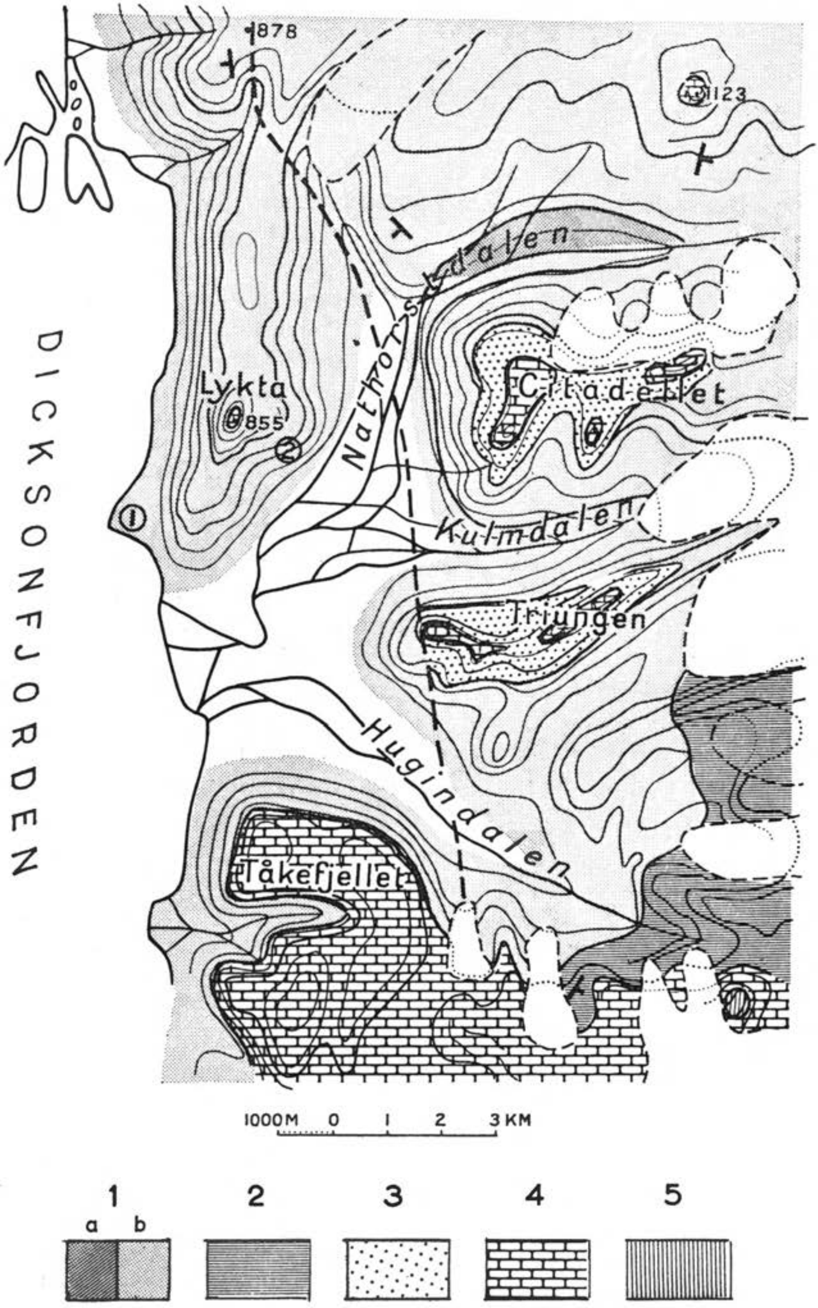


Fig. 4.

Geological map of the inner part of Dicksonfjorden.
1a — Kapp Kjeldsen Division; 1b — Lykta Division; 2 — Grey Hoek Series; 3 — Culm; 4 — Middle and Upper Carbinoferous; 5 — Permian; 6 — Triassic; 7 — Jurassic; 8 — Cretaceous; 9 — Tertiary; 10 — Diabase.

known from Spitsbergen are found. (Mimersdal-series—Upper (?) Middle Devonian, tab. 2).

Along the north side of the inner part of Nathorstdalen the Devonian layers generally dip to W. Thus the oldest parts of deposits become visible in the inner part of the valley, where the red and green sandstones of Kapp Kjeldsen division are exposed.

The very narrow valley, extending northwards along the E slope of Lykta most probably follows the before mentioned fault-line. The expressed disturbance in the Devonian layers which has partly, though only fairly locally, caused a very steep—nearly vertical—dip, makes it possible to follow the fault-line further north behind Mt. Lykta (e. g. Fiskedalen).

Kongressfjellet, Kapp Wijk.

The sedimentary beds in Dicksonfjorden lie as mentioned earlier (p. 23) nearly horizontally, only with a slight dip towards south. Going from the head of the fjord in the direction of Isfjorden, younger and younger deposits are found, reaching from Devonian to Triassic.

A visit will be made to Kongressfjellet, which is mostly built up of Triassic sediments, with some Permian layers in the northern part. We will go ashore just south of Kapp Wijk and hope, if weather conditions are good, to get an opportunity to study more or less the whole of the following section. (Fig. 5.)

Table 4.

Series	Division	Lithology	Thickness in meters
Upper Triassic	Upper Sauriehorizon	Shales and sandstone	150 m
Middle Triassic		Black shales	50 m
	"Daonella"-shales	Soft, marly shales	75 m
	Lower Sauriehorizon	Dark shales with big concretions	40 m
Lower Triassic	"Fiske-horisont"	Marly shale with small concretions	20 m
		Light fine sandstone and clay	90 m
Permian		Cherty layers	

Fig. 5.

Kongressfjellet viewed from Kapp Wijk.
1 — Permocarboniferous; 2 — Sandstone without fossils; 3 — "Fiske-horisont" — shales with fossil fishes; 4 — Lower Sauriehorizon; 5 — Middle part of Triassic; 6 — «Daonella»-shales; 7 — Upper Triassic; 8 — Upper part of Upper Triassic without marine fossils; D — Diabase. (Frebold, 1931.)

The Permian sequence consists mostly of cherty layers, seen about 150 m above sea level in the northern part of Kongressfjellet, whereas in the south they disappear below sea level.

The Lower Triassic sequence begins with fine sandstone-shales with ripple marks. No fossils are, however, found in these deposits. The overlying shales contain limestone concretions that can be easily split, and thin limestone horizons with ammonites, pelecypods and vertebrates. The most common fossils are: Invertebrate: *Arctoceras, Posidonimya mimer.* Vertebrate: *Acrodus, Polyacrodus, Wimania, Axellia, Birgeria, Saurichthys* and *Boreosomus.*

The lower parts of Triassic sediments are composed of harder shales, causing the slope of the mountain to be steeper. Within this series several hard dolomite concretions occur and on top of it lies the Lower Sauriehorizon yielding vertebrate fossils. The following soft shales with some coprolitezones weather to form a much easier slope, but about

240 m a.s.l. harder shales again dominate and the mountainside thus becomes steeper.

The upper part of this division is called "Daonella"-shales, because the pelecypod *Daonella* is very abundant in this layer. The Upper Sauriehorizon contain many vertebrate fossils, e. g. isolated bones of Ichthyosauridae, and in the limestone concretions the ammonite *Ptychites* is found.

Higher up the strata become more sandy and the content of clay-ironstone concretions gives the rocks a more red colour, when weathered. This strata indicates the beginning of Upper Triassic. Kongressfjellet is capped by a diabas sill that is about 10 m thick.

Dicksonfjorden to Billefjorden.

We will board the ship again a little south of Kapp Wijk, and then proceed to Billefjorden, which is another northern branch of Isfjorden. Passing along the southern part of Kongressfjellet and Tshermakfjellet the diabase sills, occurring at several horizons are easily observed. Further east at Kapp Thordsen and near Rotundafjellet the diabase sills are also found at sea level.

Billefjorden.

Skansbukta.

A stop will be made in Skansbukta, where we will go ashore to see the Lower Permian Spirifer Limestone (south side of the bay) and the Upper Carboniferous gypsum-anhydrite layers (north side). (Fig. 6.)

In Mt. Skansen the Carboniferous gypsum series can be seen at sea level. Then follows the Cyathophyllum limestone, here mostly covered by talus. Lower Permian cherty strata form the escarpment of Mt. Skansen, beginning with the Spirifer limestone, that can be seen as a lighter zone in the cliff. Lower members of the sequence are encountered as one goes northwards.

The Carboniferous sequence can here be separated into the following divisions:

Upper Limestone Division	125 m thick
Gypsum Division	100 m thick
Lower Limestone Division	175 m thick

In the Gypsum Division about 20 beds, varying in thickness from 50 cm up to 6 m are found. These consist mostly of anhydrite, only about 20 % of it being gypsum.

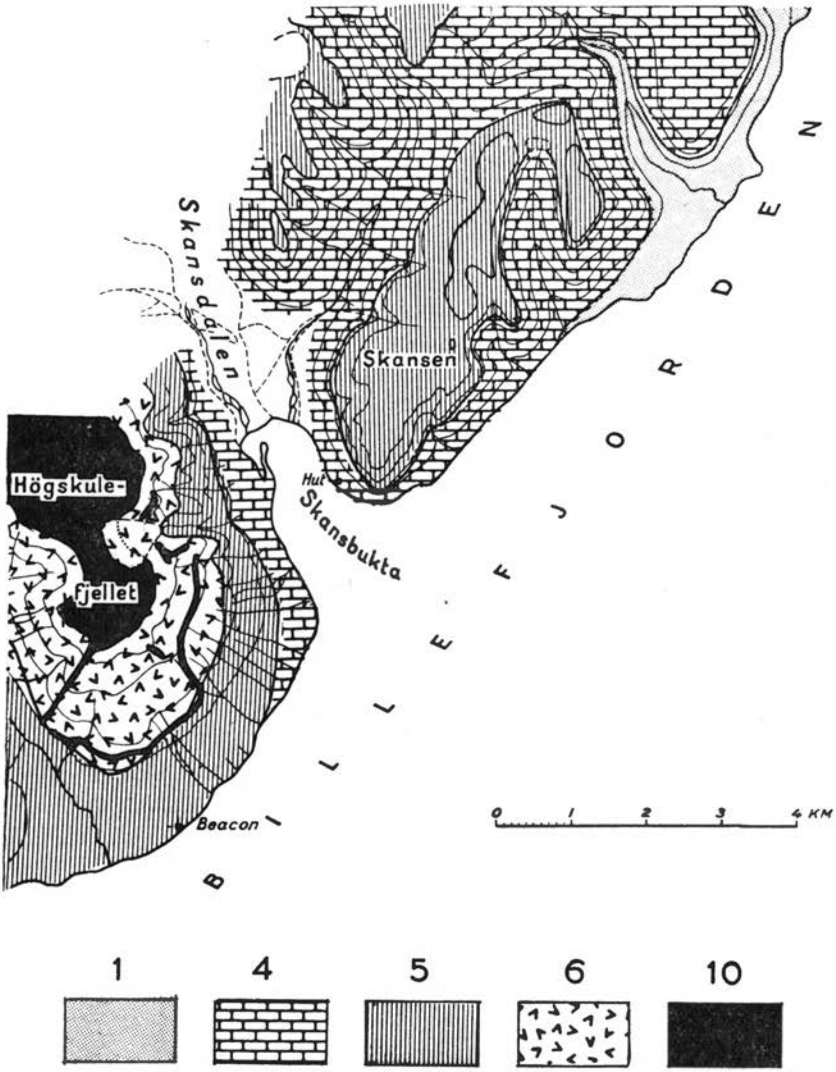


Fig. 6.

Geological map of the west coast of Billefjorden. Explanation see fig. 4.

In the middle of 1930 a Norwegian company started mining the gypsum deposits at the foot of Mt. Skansen, but owing to the very high percentage of anhydrite, the work soon was abandoned.

In Høgskuleberget south of Skansbukta the Spirifer Limestone forms the escarpment, and where the streams have cut deeply into the mountain side, the limestone beds are well exposed, making fossil collecting very easy. The most common fossils are:

Productus timanicus, P. impressus, P. inflatus, Chonetes variolata, Streptorhynchus kempei, Spiriferella polaris, Spirifer dieneri, S.marcoui and bryozoas of the genera *Fenestella* and *Batostomella.*

The higher part of Høgskuleberget is built up of Lower Triassic strata, where also diabase sills and dykes occur. The top of the mountain is capped by a thick diabase exhibiting the typical columnar structure.

Detour into Billefjorden.

As mentioned before, the Permo-Carboniferous strata on the NW side of Billefjorden, dip southwards. Not far from Skansbukta the Cyathophyllum limestone rests upon folded Devonian sediments, presumably belonging to the Lykta Division of the Wood Bay Series. A large N-S striking fault, together with several minor ones, limits the extent of the Devonian towards the east. On the other side of the fault, Upper Carboniferous limestone rests upon Culm Sandstones. In the mountain Pyramiden, near the bottom of Billefjorden, thick Culm deposits, containing several coal-seams, (now being mined by the Russians), are overlain by the Cyathophyllum Limestone. (Fig. 6.)

In the bottom and on SE side of Billefjorden, the Culm deposits, partly resting on rocks of the Hecla Hoek formation, are also succeeded by Middle and Upper Carboniferous and Permian strata. In the lower part of this Permo-Carboniferous succession, gypsum-bearing horizons occur. Further to the SW—near the mouth of Billefjorden, the continuation of the fault from the NW side of Billefjorden can be seen. A small area of Culm deposits situated near the shore, lies west of the fault-line. Here the Upper Carboniferous and Permian beds have been subjected to Tertiary faulting. The faults have followed the preexisting Post-Culm trend.

Billefjorden to Tempelfjorden.

Leaving Billefjorden we pass the small islands called Gåsøyane consisting of diabase sills. Then we will proceed into Sassenfjorden sailing below the famous and beautiful mountain Templet, built up of nearly horizontal Permo-Carboniferous strata. The mountain rises sharply up to 783 m. above sea level.

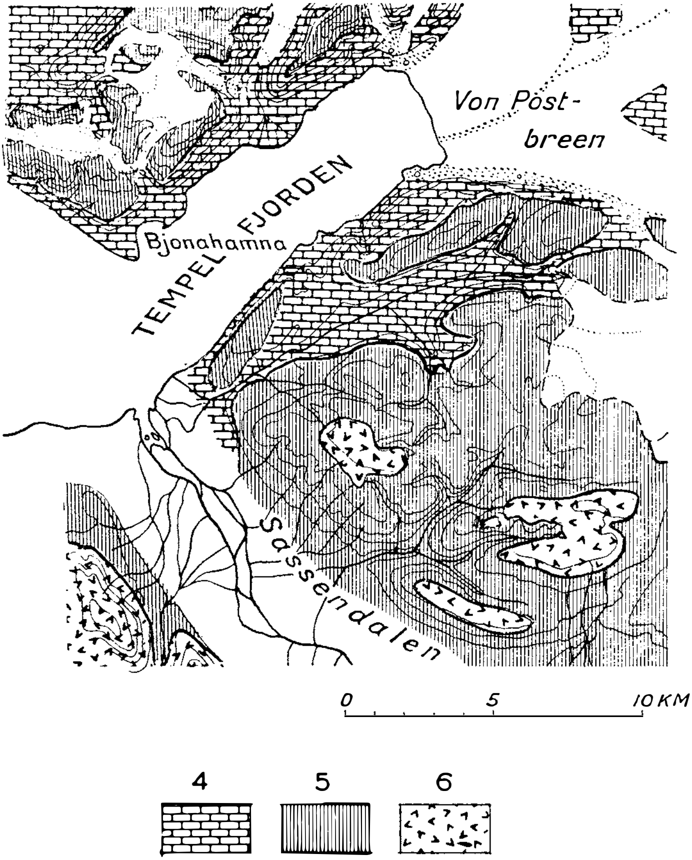


Fig. 7.

Geological map of Tempelfjorden and Sassendalen. Explanation see fig. 4.

Tempelfjorden.

Tempelfjorden is a northerly branch of Sassenfjorden, and as we enter the fjord, we will see to the left an area with raised beaches, surrounding a small bay—Bjonahamna. (Fig. 7.)

The mountains on both sides of Tempelfjorden are mostly built up of Carboniferous sediments. On the south shore gypsum beds are found, and attempts have been made to exploit them. But as the unweathered beds mostly proved to be anhydrite, the mining was stopped.

Further into the fjord the lower part of the Cyathophyllum limestone contains a zone, several metres thick, with dark sapropelitic limestone, containing a vast number of foraminifers, the most abundant being: *Triticites, (?Schwagerina),* and also *Tetrataxis, Climacammina* and *Bradyina.* Higher up in the same series corals are found, which mostly belong to the following genera: *Caninia, Lithostrotion, Roemeripora* and *Syringopora.*

Sassenfjorden.

The next stop will be at the end of Sassenfjorden—where a landing will be made, to visit Sassendalen. This is a broad, open valley, extending eastwards, with the large Sassen river flowing through it. Sassendalen is also known as being one of the most colourful valleys in Vestspitsbergen, for many different kinds of wild flowers grow there, and the Spitsbergen reindeer is common here. (Fig. 7.)

Near the shore, raised marine terraces can be studied. The lower part of the valley is built up of Permo-Carboniferous sediments and it will be possible to collect Lower Permian brachiopods from the Spirifer Limestone.

The mountains surrounding Sassendalen consist of almost flat lying sediments of Permian, Triassic, Jurassic and Cretaceous age.

The following table (tab. 5) shows the development of the Carboniferous-Triassic sediments in the inner part of Isfjorden (Billefjorden, Sassenfjorden and Tempelfjorden).

Table 5.

System	Series	Division	Northwest (Billefj.)	Southeast (Tempelfj.)
Triassic	Upper Middle and Lower		150+ m. 250 m.	150+ m. more sandy 300 m. richer fauna
Permian	Lower		210 m.	380 m.
		Spirifer limestone	10 m.	40 m.
Carboniferous	Upper	Upper Cyathophyllum Limestone	125 m.	220 m.
		Gypsum division	100 m.	80 m. tapers out in east
		Lower Cyathophyllum Limestone	175 m.	200 m.
	Middle?	Strata below Fusulina Limestone	50 m.	150 m.

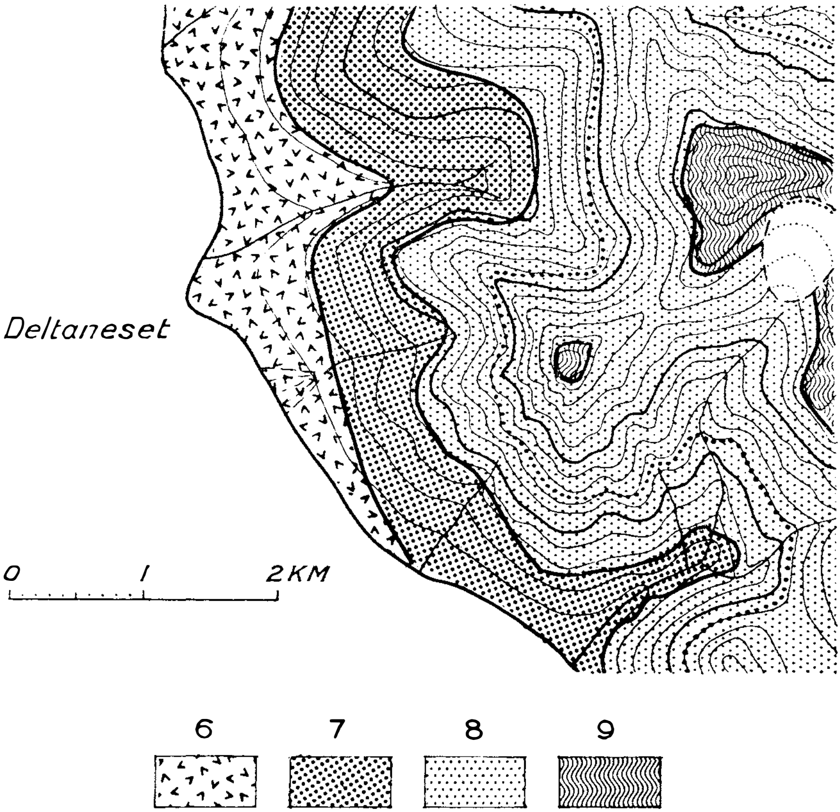


Fig. 8.

Geological map of the area around Deltaneset. Explanation see fig. 4.

Deltaneset in Isfjorden.

From Sassendalen we will proceed to Deltaneset, which is situated on the south coast of Isfjorden not far from Adventfjorden. Coming ashore we will first examine the continental Upper Triassic layers, succeeded about 100 m a.s.l. by the Liassic conglomerate, which marks the base of the Jurassic sediments. In the lower part of this sequence belemnites are found. Beds situated about 250 m a.s.l. yield vertebrate fossils, i.e. fragments of bones of *Plesiosaurus* and *Ishtyosaurus*. The contact between the Jurassic and Cretaceous sediments lies ca. 300 m a.s.l. and is clearly visible because the Cretaceous limestones become reddish brown when weathered. A thin limestone bed here contains an anbundance of ammonites and pelecypods. The Cretaceous Festning sandstone is found 475 m a.s.l.

Passing Forkastningsfjellet, on our way back to Longyearbyen, we can see several landslides on the slope of the mountain. Continental Cretaceous deposits have slid down on marine shales, causing the illusion of repeated sandstone horizons.

After a stay in Longyearbyen the ship will leave for Norway, with planned arrival in Bodø at 13th of August.

Literature:

Horn, G. and *A. K. Orvin.* Geology of Bear Island. Skr. Svalbard- og Ishavs-unders. Nr. 15. Oslo 1928.

Orvin, A. K. Outline of the geological history of Spitsbergen. Skr. Svalbard- og Ishavs-unders. Nr. 78. Oslo 1940.

——————

Birkenmajer. K. Preliminary report on the stratigraphy of the Hecla Hoek Formation in Wedel-Jarlsberg Land, Vestspitsbergen. Bull. Acad. Polon. Sér. Sci. Chim., Geol., Geogr., Vol 6, No. 2. Warszawa 1958.

Frebold, H. Untersuchungen über die Fauna, die Stratigraphie und Paläogeographie der Trias Spitzbergens. Skr. Svalbard- og Ishavs-unders. Nr. 26. Oslo 1929.

— Geologi von Spitzbergen, der Bäreninsel, der König Karl- und Franz-Joseph-Landes. Geologie der Erde. Berlin 1935

Føyn S. and *A. Heintz.* The Downtonian and Devonian Vertebrates of Spitsbergen. VIII. Skr. Svalbard- og Ishavsunders. Nr. 85. Oslo 1943.

Gee, E. R., W. B. Harland and *J. R. H. McWhae.* Geology of central Vestspitsbergen. Part II. Carboniferous to Lower Permian of Billefjorden. Trans. Royal Soc. of Edinburg. Vol. 62. No. 9. Edinburg 1952.

Harland, W. B. The Caledonian sequence in Ny Friesland, Spitsbergen. Quart. Journ. Vol 64. London 1959.

Hoel, A. und *A. K. Orvin.* Das Festungsprofil auf Spitzbergen. Skr. om Svalbard- og Ishavet. Nr. 18. Oslo 1937.

Kulling, O. The "Hecla Hoek Formation" round Hinlopenstredet. Scientific results of the Swedish—Norwegian arctic expedition in the summer of 1931. Vol. 2, part 11. Stockholm 1936.

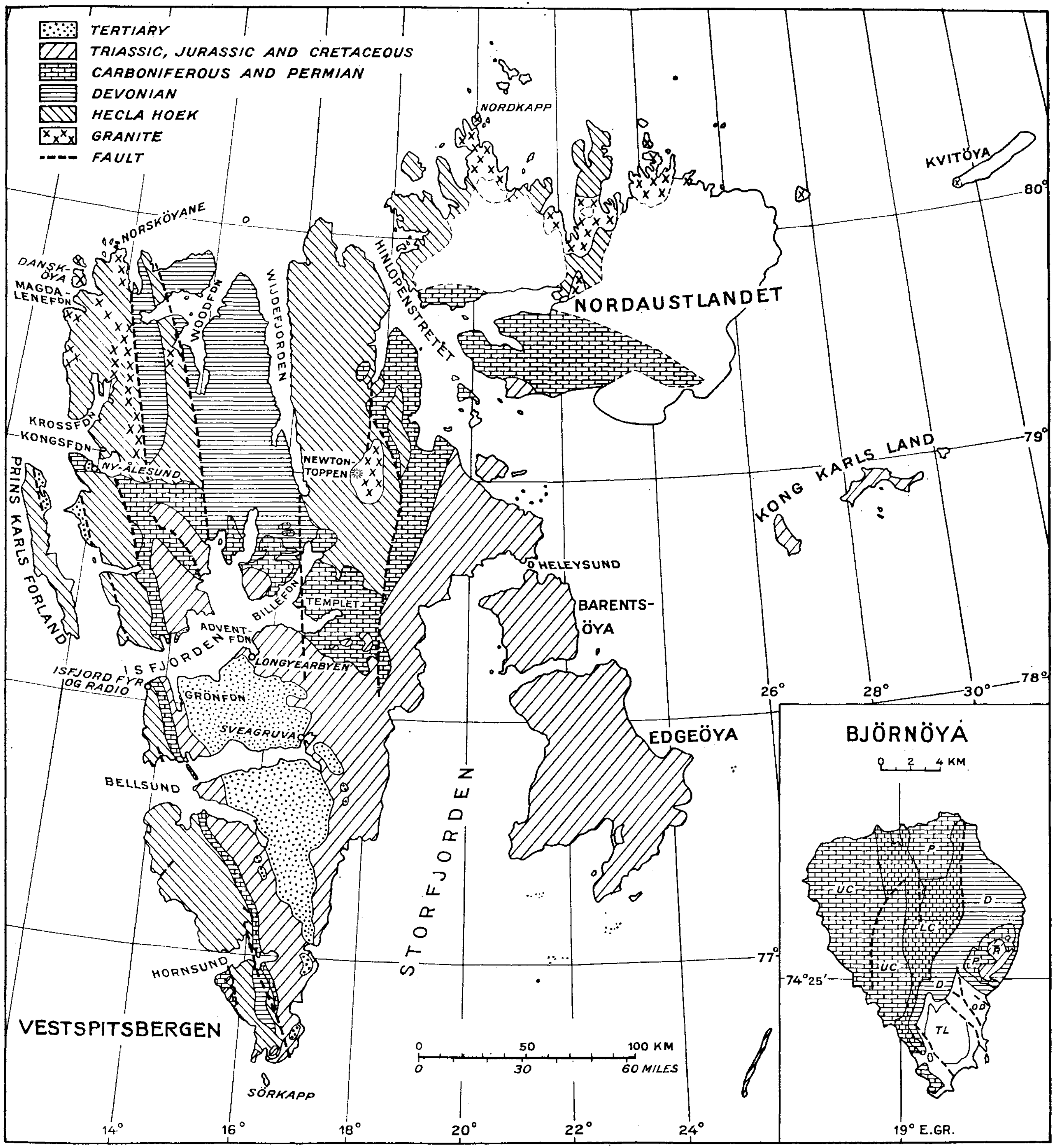
Major, H. and *T. S. Winsnes.* Cambrian and Ordovician fossils from Sørkapp Land, Spitsbergen. Skr. Norsk Polarinstitutt. Nr. 106. Oslo 1955.

Sokolov, D. and *W. Bodylevsky.* Jura und Kreidefaunen von Spitzbergen. Skr. Svalbard- og Ishavsunders. Nr. 35. Oslo 1931.

References to other papers dealing with the geology and paleontology of Svalbard published by Norsk Polarinstitutt (former Norges Svalbard- og Ishavs-undersøkelser) are found in:

Orvin, A.K. Bibliography of literature about the geology, physical geography, useful minerals, and mining of Svalbard. Skr. Norges Svalb.- og Ishavs-unders. No. 89, 1947.

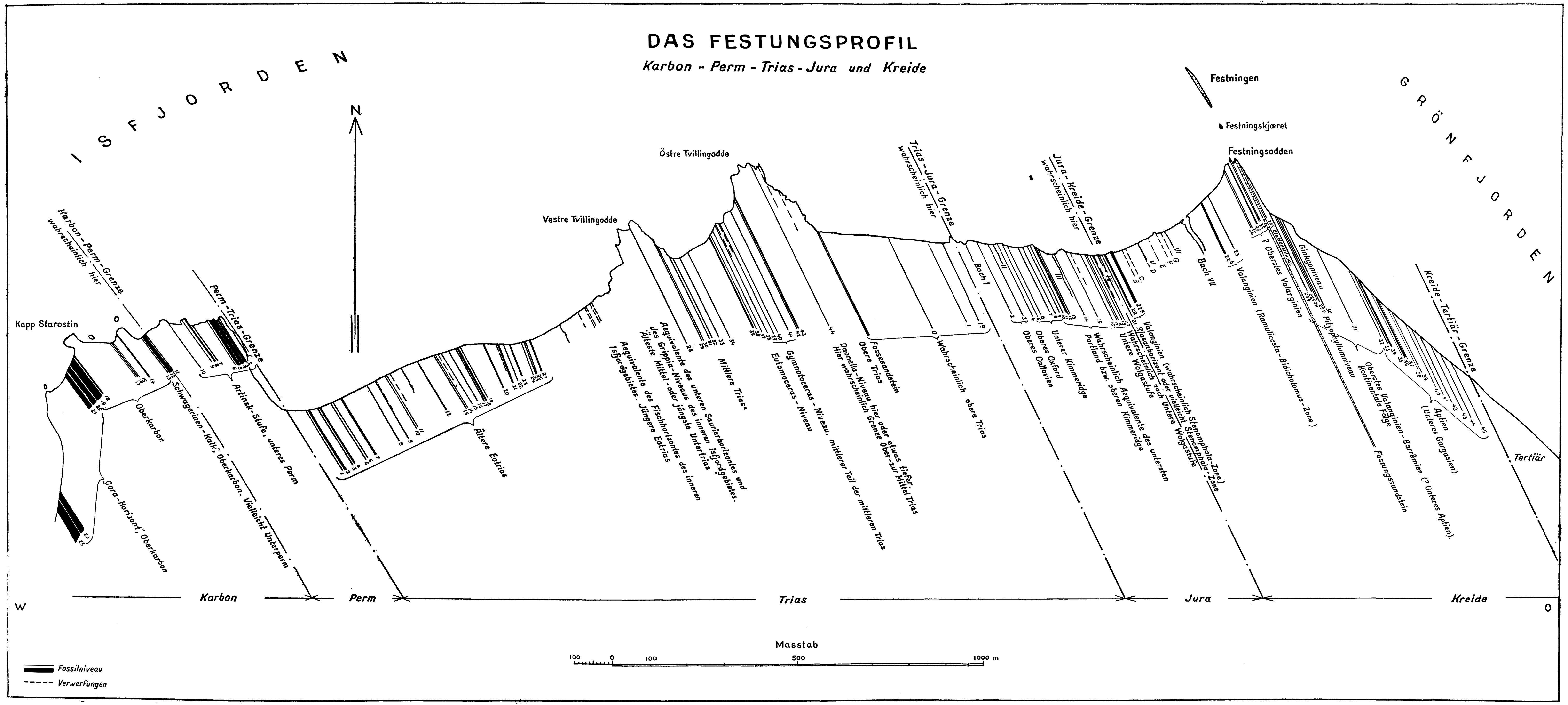
Notes.



GEOLOGICAL MAP OF SVALBARD

Explanation to the symbols on the map of Bjørnøya:

Tr — Triassic.		
P — Permian.		
UC — Upper Carboniferous.		
LC — Lower Carbonferous.		
D — Devonian.		
TL — Tetradium Limestone	}	Hecla Hoek.
Q — Slate Quartzite		
OD — Older Dolomite		



MAP OF
THE FESTNINGEN SECTION
The numbers indicate different horizons.
For further explanation see Hoel and Orvin, 1937.

MEDDELELSER

Meddelelser 1—50, see numbers of Meddelelser previous to Nr. 81.

Nr.

51. OSTERMANN, HOTHER: *Bidrag til Grønlands beskrivelse, forfattet av nordmenn før 1814.* 1942. Kr. 7,60.
52. OSTERMANN, HOTHER: *Avhandlinger om Grønland 1799—1801.* 1942. Kr. 6,40.
53. ORVIN, ANDERS K: *Hvordan opstår jordbunnsis?* 1941. Kr. 1,00.
54. STRAND, ANDREAS: *Die Käferfauna von Svalbard.* 1942. Kr. 1,00.
55. ORVIN, ANDERS K: *Om dannelse av strukturmark.* 1942. Kr. 1,00.
56. TORNØE, J. KR.: *Lysstreif over Noregsveldets historie.* I. 1944. Kr. 9,00.
57. ORVIN, ANDERS K: *Litt om kilder på Svalbard.* 1944. Kr. 1,60.
58. OSTERMANN, HOTHER: *Dagbøker av nordmenn på Grønland før 1814.* 2. 1944. Kr. 5,80.
59. OSTERMANN, HOTHER: *Dagbøker av nordmenn på Grønland før 1814.* 3. 1944. Kr. 1,60.
60. AAGAARD, BJARNE: *Antarktis 1502—1944.* 1944. Kr. 12,00.
61. AAGAARD, BJARNE: *Den gamle hvalfangst.* 1944. Kr. 1,60.
62. AAGAARD, BJARNE: *Oppdagelser i Sydishavet fra middelalderen til Sydpolens erobring.* 1946. Kr. 5,00.
63. DAHL, EILIF og EMIL HADAČ: *Et bidrag til Spitsbergens flora.* 1946. Kr. 1,00.
64. OSTERMANN, HOTHER: *Skrivelser angaaende Mathis Iochimsens Grønlands-Ekspedition.* 1946. Kr. 1,50.
65. AASGAARD, GUNNAR: *Svalbard under og etter verdenskrigen.* 1946. Kr. 1,00
66. RICHTER, SØREN: *Jan Mayen i krigsårene.* 1946. Kr. 1,50.
67. LYNGAAS, REIDAR: *Oppføringen av Isfjord radio, automatiske radiofyr og fyrbelysning på Svalbard 1946.* Kr. 1,00.
68. LUNCKE, BERNHARD: *Norges Svalbard- og Ishavs-undersøkelsers kartarbeider og anvendelsen av skrå-fotogrammer tatt fra fly.* 1949. Kr. 1,00.
69. HOEL, ADOLF: *Norsk ishavsfangst. En fortegnelse over litteratur.* 1952. Kr. 2,50.
70. HAGEN, ASBJØRN: *Plants collected in Vestspitsbergen in the Summer of 1933.* 1952. Kr. 2,00.
71. FEYLING-HANSSEN, ROLF W: *Conglomerates formed in Situ on the Gipshuk coastal plain, Vestspitsbergen.* 1952. Kr. 2,50.
72. OMDAL, KIRSTEN: *Drivisen ved Svalbard 1924—1939.* 1952. Kr. 2,50.
73. HEINTZ, ANATOL: *Noen iakttagelser over isbreenes tilbakegang i Hornsund, V. Spitsbergen.* 1953. Kr. 3,50.
74. ROOTS, ERNEST. F.: *Preliminary Note on the Geology of Western Dronning Maud Land.* 1953. Kr. 2,00.
75. SVERDRUP, HARALD U.: *The currents off the coast of Queen Maud Land.* 1953. Kr. 1,00.
76. HOEL, ADOLF: *Flateinnholdet av breer og snøfonner i Norge.* 1953. Kr. 1,50.
77. FEYLING-HANSSEN, ROLF W.: *De gamle trankokerier på Vestspitsbergens nordvesthjørne og den formodede senkning av landet i ny tid.* 1954. Kr. 2,00.
78. ROER, NILS: *Landmålerliv i Dronning Maud Land*: 1953. Kr. 2,00.
79. MANUM, SVEIN: *Pollen og sporer i tertiære kull fra Vestspitsbergen.* 1953 Kr. 2.00.
80. THORSHAUG, KNUT, AND ANTON FR. ROSTED: *Researches into the prevalence of Trichinosis in animals in Arctic and Antarctic waters* 1956 Kr. 1.50
81. LIESTØL, OLAV: *Glacier dammed lakes in Norway.* 1956. Kr. 2,00.
82. FJELDSTAD, JONAS E.: *Harald Ulrik Sverdrup og* S. RICHTER: *H. U. Sverdrups forfatterskap.* 1958 Kr. 2,50.
83. LØNØ, ODD: *Reinen på Svalbard.* 1959. Kr. 2,00.
84. LØNØ, ODD: *I. Transplantation of the muskox in Europe and North-America. II. Transplantation of hares to Svalbard.* 1960. Kr. 4,00.
85. MANUM, SVEIN: *Some Dinoflagellates and Hystrichosphaerids from the Lower Tertiary of Spitsbergen.* 1960. Kr. 2,00.
86. FEYLING-HANSSEN, ROLF W. AND INGRID, OLSSON: *Five radiocarbon datings of Post Glacial shorelines in Central Spitsbergen.* 1959—60. Kr. 2,00.
87. WINSNES, T. S., HEINTS, A., AND HEINTZ, N.: *Aspects of the Geology of Svalbard.* 1962. Kr. 2,00.

A. W. BRØGGERS BOKTRYKKERI A/S