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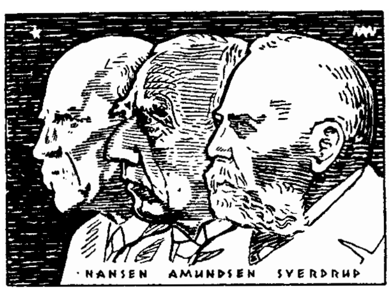

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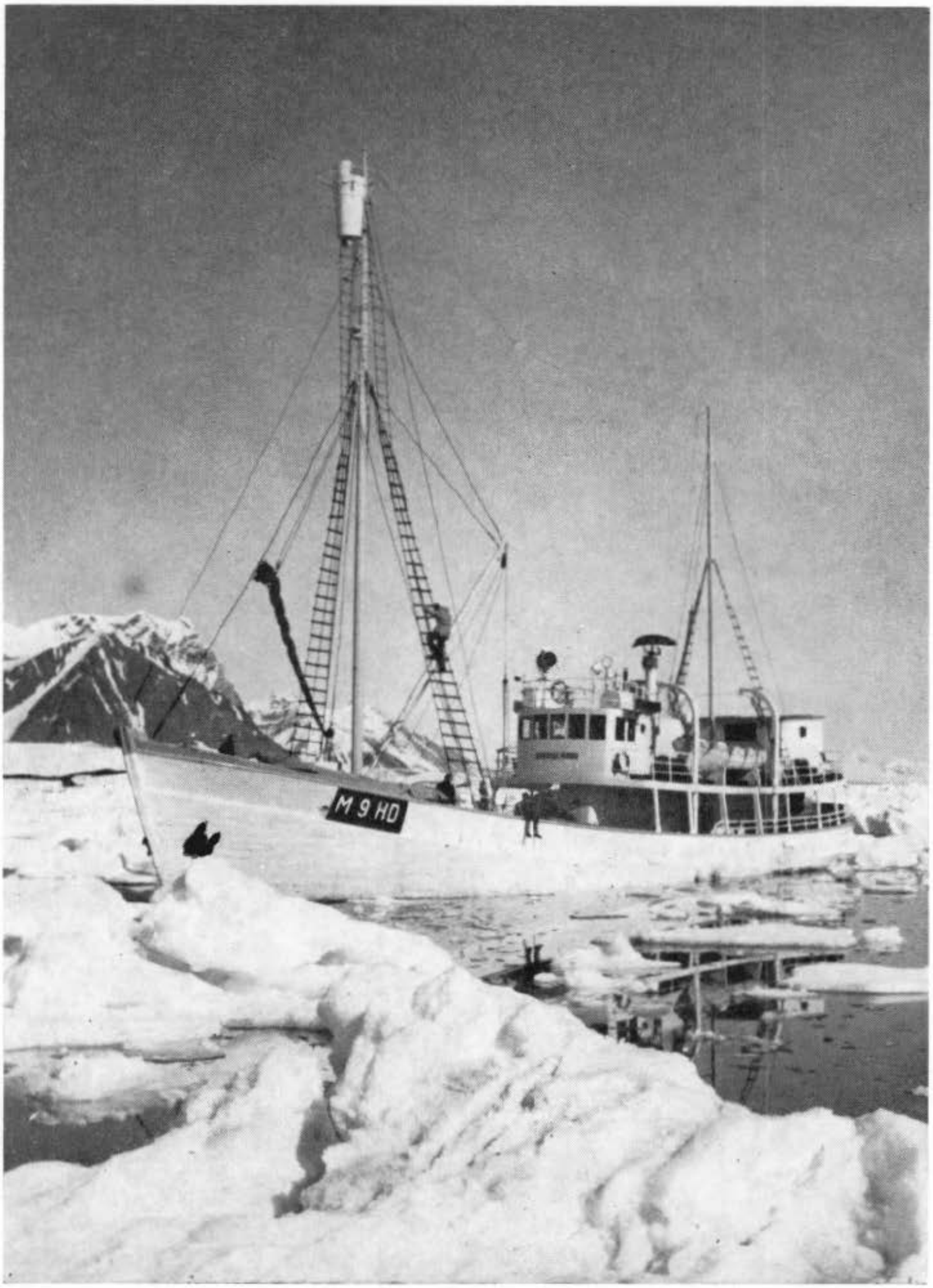


Isen kan ofte skape store vanskeligheter når feltpartiene skal på land. Her siger Norsk Polarinstitutts ekspedisjonsfartøy M/S «Signalhorn» mellom isflakene i Van Keulenfjorden. Foto: S. Manum.

Innholdsfortegnelse

Observations on the Carboniferous and Permian rocks of Vestspitsbergen

BY

THORE S. WINSNES

Contents

Abstract

Sixteen sections through the dominantly marine Carboniferous and Permian sedimentary rocks of southern and central Vestspitsbergen are presented. Earlier published sections from within the same and adjacent areas are mentioned and the sedimentary history is discussed. It is proposed that the boundary between the Carboniferous and the Permian should be placed below the "Fusulina Limestone".

Introduction

In Vestspitsbergen the Carboniferous and Permian rocks outcrop along the western, northern and northeastern rim of a great open south–southwest plunging syncline, formed during the Tertiary. The distribution of the outcrops is shown in Fig. 1. In the west they are found in a narrow zone extending from near Sørkapp to Kongsfjorden, strongly folded up against the older Hecla Hoek rocks. The bedding generally dips steeply to the east and is in places overturned. In the westernmost area faulting has occurred and the Carboniferous–Permian rocks are exposed in some narrow grabens.

The northeastern side of the syncline dips gently towards the south–south-

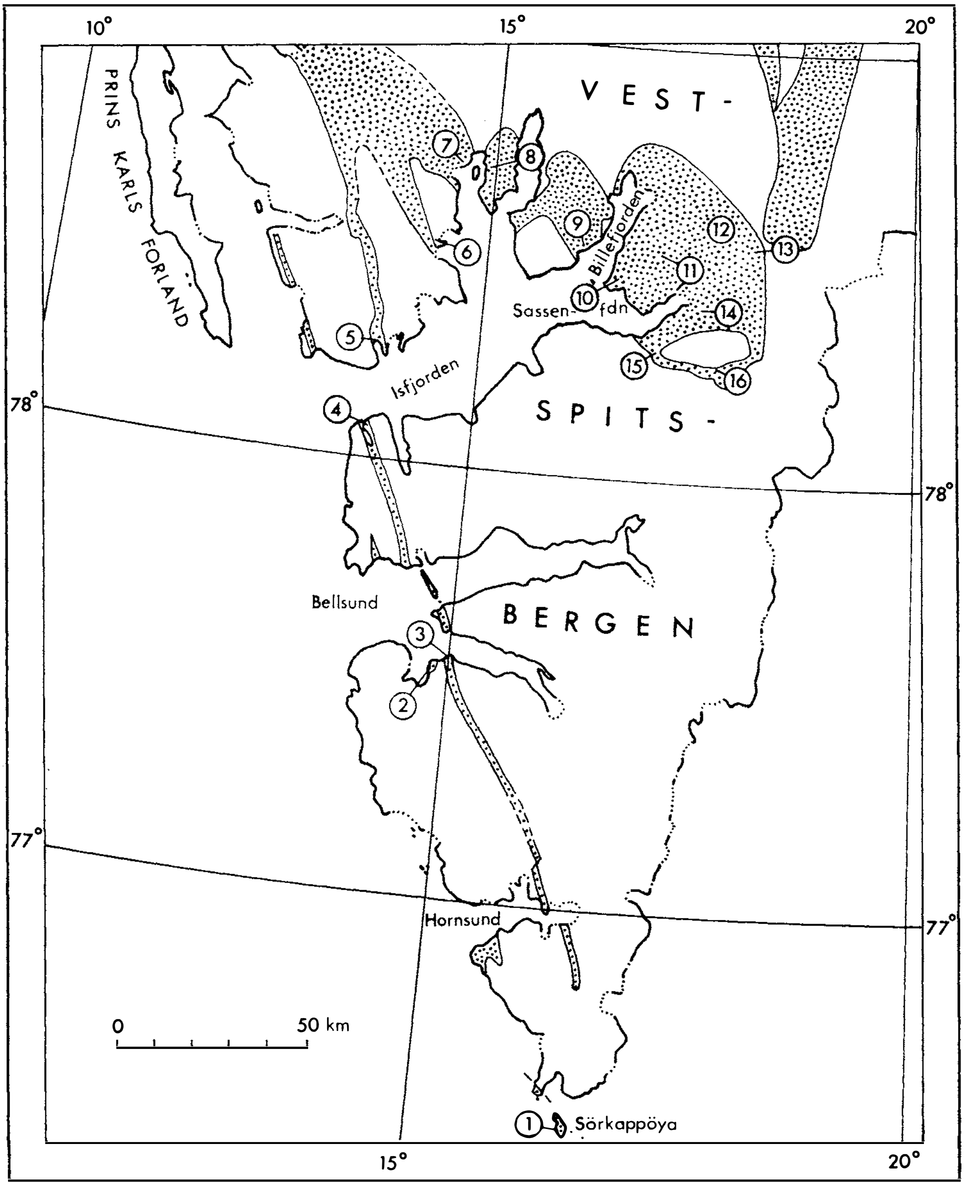


Fig. 1. *Areas of Carboniferous and Permian rocks in southern part of Vestpistbergen. Numbers in circles show locations of sections described and tabulated in fig. 3.*
1 Sørkappøya, 2 Reinodden, 3 Ahlstrandodden, 4 Kapp Linné, 5 Trygghamna, 6 Mediumfjellet, 7 Kolosseum, 8 Kapitol, 9 Skansen, 10 Gipshuken, 11 Finlayfjellet–Högbomfjellet, 12 Tunabreen, 13 Malte Brunfjellet, 14 Przybyllokfjellet, 15 Gjelhallet, 16 Stensiöfjellet.

west and the Carboniferous–Permian outcrops are located in a broad arc passing from Kongsfjorden to the area around the head of Isfjorden. Further east, a north–south striking fault with a downthrow to the east displaces the outcrop rim northwards and the Carboniferous–Permian rocks are found on both sides of Hinlopenstretet. The observations presented here are restricted to the area west of this fault.

During the early stages of exploration of Spitsbergen much geological interest was concentrated on the highly fossiliferous Carboniferous and Permian strata. Since the middle of the last century many fossil descriptions have appeared. The stratigraphy and regional distribution have also been dealt with extensively in several papers (HOLTEDAHL 1913; ORVIN 1934; FREBOLD 1937). However, detailed stratigraphic descriptions are few and the following are of note; a section south of the mouth of Isfjorden (HOEL and ORVIN 1934), eighteen sections in the inner part of Isfjorden (GEE, HARLAND and McWHAE 1952), six sections in Hornsund (BIRKENMAJER 1964), and one section in the same area (SIEDLECKI 1960).

During several years of geological mapping in Vestspitsbergen the present author has measured a number of sections through the Carboniferous and Permian. As these observations have been made over a wide area it is hoped they can contribute to our knowledge of the history of sedimentation and the development of the fauna of the Middle and Upper Carboniferous and Permian in Spitsbergen.

Most of the stratigraphical sections were measured using an aneroid barometer combined with a tape, or, where the strata were dipping steeply, only with tape. The measurements have been corrected for the dip of the strata to give true thicknesses. The aneroid measurements were corrected for daily variations in atmospheric pressure if they were taken over a period of several hours; true readings were obtained by utilizing the correction curve of the instrument. In many instances it was not possible to measure a complete section in one place, but by correlating several sections within a restricted area it has been possible in most cases, to get a fairly complete picture of the whole sequence.

An explanation of the terminology used for the lithological descriptions is given on p. 27.

Description of the sections

The sections are presented from three general areas, Sørkapp Land, Bellsund and Isfjorden. They have been numbered 1 to 16 and their locations are given in Fig. 1.

Sørkapp Land

In Sørkapp Land, south of Hornsund, Carboniferous and Permian rocks are found in three main localities. Crossing the head of Hornsund, the strata belonging to the western rim of the syncline stretch southwards nearly to Sørkapp. In the south they consist of Culm sandstones and conglomerates, up to 400 m thick and containing plant remains. Overlying these there occur about 200 m of reddish conglomerates and sandstones wich are thought to be of Middle Carboniferous age (ORVIN 1940). A discontinuity separates these from the overlying metres of cherty sandstones containing Permian brachiopods.

At the head of Hornsund the strata have been more closely investigated (BIRKENMAJER 1964; BIRKENMAJER and TURNAU 1962). The lowermost 300 m of shales and sandstones (Adriabukta Series) contain plant remains of Viséan age. Unconformably overlying these are the Hyrnefjellet Beds made up of at least 270 m of conglomerates and sandstones which are often red in colour and are generally similar to those described from further south. Disconformably above, follow the Treskelodden Beds; these are largely clastic and contain five limestone intercalations bearing brachiopods, corals and foraminifers. Their age has been given as Upper Carboniferous (BIRKENMAJER and CZARNIECKI 1960) and Lower Permian (LISZKA 1964). Unconformably above, and deposited on a fissured and eroded surface, follows a cherty limestone, about 6 m thick, containing abundant brachiopods and bryozoans of Permian age.

South of the moth of Hornsund a thick series of Culm sandstones, shales, and conglomerates has been measured (SIEDLECKI 1960). Lowermost, are the Hornsundnesset Beds; 750 m of sandstones with intercalated shales and conglomerates. Above these follow the Sergievfjellet Beds made up of 170 m of shales and including a coal horizon. The whole sequence has been referred to the Lower Carboniferous.

On Sørkapp just north of Sørkappøya, Permian rocks are found in a small syncline faulted against Tertiary sandstones to the east. On Sørkappøya another syncline with Permian rocks occurs, with the strata outcropping in the western and northern parts of the island. In the west they are nearly vertical and strike towards the north–northwest. In the northern part they dip south–southeast at twenty degrees. On the northern tip of the island quartz sandstones with some plant remains are thought to be of Lower Carboniferous age. Similar sandstones are to be found in the skerries to the east of the island. On the small islands between Sørkappøya and the mainland, Permian rocks occur. Several small faults cut the area, and a major fault runs south–southwest just northwest of Sørkappøya.

Section 1 – Sørkappøya

During a short visit to the island a rough section through the Permian strata was measured (Fig. 4). In the western limb of the syncline below Triassic sandstones there occur. (All sections are tabulated from the top downwards.)

160	m	mostly covered, shaly, fine sandstone are included. About 50 m from the top there occurs a massive, hard, greenish sandy dolostone (2–3 m).
10	m	quartz sandstone; with brachiopods.
1	m	quartz sandstone, light grey.
5	m	limy quartz sandstone; with brachiopods.
5	m	sand-limestone, soft.
15	m	limy quartz sandstone; with brachiopods.
1.7	m	quartz sandstone, light.
4.5	m	lime-sandstone, soft.
1	m	quartz sandstone, light.

8	m	limy sandstone, soft, light; with brachiopods.
35	m	covered.
2	m	sandstone; with brachiopods.
10	m	covered.
12	m	quartz sandstone; with brachiopods.
75	m	covered, scree of fissile limy sandstones.
2	m	quartz sandstone, light.
22	m	covered.
22	m	clayey sand-limestones, black, fine grained and fissile.
20	m	clayey sand-limestones, dark, fissile and with chert.
15	m	limy shales, grey-black.
24	m	cherty clay-limestone, dark.
22	m	clayey limestone, dark; with a few brachiopods and bryozoans.

The underlying stata are covered by the sea.

A detailed section through the same rocks in Tokrossøya, between Sørkappøya and the mainland, has been published (SIEDLECKI 1964). This section has been inversely tabulated. More detailed investigations of this area by SIEDLECKI are in progress.

Bellsund

The following two sections are located along the south shore of Bellsund. The western one, at Reinodden, is from a downfaulted block surrounded by Hecla Hoek rocks. The strata are steeply inclined and offer a good opportunity for the measurements of Carboniferous, Permian and younger systems Further east, at Ahlstrandodden, occur steeply inclined Carboniferous and Permian strata along the western margin of the main syncline. The present distance between the two profiles is much less than that existing at the time of deposition; this is also reflected in the marked difference in lithofacies.

Section 2 – Reinodden

Below fine laminated Triassic sandstones there occur:

10	m	sandstone and chert-sandstone, the former is dark. A breccia is included.
10	m	sandstone, dark, flaggy, and in part laminated, with a breccia at the base; partly covered.
18	m	sandstones, dark, flaggy, alternating light and dark beds, partly containing chert and glauconite.
32	m	chert-sandstones and sandy chertstones; brachiopods in the middle part.
9	m	cherty lime-sandstone, glauconitic; rich in brachiopods and bryozoans.
13	m	sandstones, medium grained, bedded, and of different colours; containing a few brachiopods in the upper part.

2.7 m lime-sandstone and limy sandstone; with some horny shelled brachiopods. The upper beds have a greenish weathered surface.
10 m quartz sandstones, thin bedded and partly glauconitic.
9.5 m lime-sandstones and sand-limestones, partly covered.
26 m sandstone, glauconitic, in beds of variable thickness and containing chert zones; a few brachiopods and bryozoans are present in the lower part.
30 m chert-sandstones and sandy chertstones, partly with glauconite.
8 m limestones, thin-bedded, partly sandy; containing brachiopods and bryozoans.
55 m lime-sandstones, thick beds seperated by fissile clays (10 cm); some brachiopods in the sandstones.
9.5 m claystone, fissile and dark, partly covered. Limy in the lower part; a few fossils in the latter.
10 m chertstone, dark and thick bedded.
2 m limy claystone, fissile; with sponges.
20 m chertstones, dark, and in uneven beds divided by dark, cherty, fissile claystones.
5 m dolo-limestone, massive; rich in silicified brachiopods.
8 m dolostone, yellow weathering.
53 m covered.
20 m dolostone, yellow weathering.
24 m covered, some dolostone present.
10 m sandstone, red, and some conglomerate. Partly covered.
45 m clayey sandstones, fine, red and green, thin bedded and partly fissile. In the lower part are some red fissile claystones.
1.8 m quartz conglomerate, containing nut sized pebbles.
25 m quartz sandstones and claystones, the latter are fissile; containg three zones of pure limestones (0.3–0.5 m) with corals.
9 m conglomerate, coarse, and containing more or less angular pebbles of different composition in a red, sandy matrix.

Underlying this section are over 580 m of Culm sandstones and dark fissile claystones. The former dominate the upper part and the latter the lower. Plant remains are found throughout the whole of this series.

Section 3 – Ahlstrandodden

At Ahlstrandodden, 5 km to the east, the upper part of the section was measured on the strandflat, and the lower part on the escarpment to the south, and gave the following section below Triassic sandstones;

38 m covered.
31 m quartz sandstone, massive thick beds.
10 m sandy chertstones, containing a yellow-brown shaly sandstone; in the middle; with brachiopods and bryozoans.
4 m sandy limestone, yellow weathering.

25 m	chertstone, dark.
23.5 m	covered.
12 m	limy sandstones, thin bedded; some brachiopods.
25 m	chertstone and cherty sandstone, the former are dark.
11 m	quartz sandstone, light and massive.
5 m	lime-chertstone, light; with some brachiopods.
19 m	covered.
11 m	chert-sandstone and sandstones; latter contain sponges.
11 m	sandy lime-dolostone; containing brachiopods and bryozoans.
25 m	chertstones.
7 m	lime-dolostone; rich in brachiopods and bryozoans.
25 m	lime-sandstones, sandstones and dolostones, thick beds containing some chert.
18 m	sandstones, with layers of chert in the upper part.
11 m	dolostone, grey, thick-bedded, partly sandy; rich in brachiopods; the Spirifer Limestone.
6.5 m	sandstones, thin-bedded, dark and shaly in the middle part.
12 m	sandy dolostone, grey.
20 m	sandstones, containing some yellow-red weathering dolostones.
52 m	sandy dolostone, with an interformational conglomerate 10 m from the base.
37 m	dolo-sandstones, grey and thick-bedded.
3.5 m	conglomerate, consisting of small quartzite pebbles.
13 m	dolomitic sandstone, grey, with a few beds of conglomerates.
38 m	quartz sandstones, massive, fine, and coarse partly conglomeratic beds.
3 m	clayey sandstone, dark and fissile.
1 m	dolostone, grey; with corals.
29 m	sandstones, with current bedding and conglomeratic beds.
2.5 m	quartz conglomerate, made up of nut sized pebbles.
15 m	quartz sandstones, yellow.
6.5 m	conglomerate, with nut sized, well rounded quartz pebbles.
13 m	limy quartz sandstone, light grey.
9 m	sandy dolostone, light grey.
15 m	dolerite.
5 m	dolostone, massive yellow weathering; containing a few solitary corals.

A few metres of scree covers the unconformity between the dolostone and the underlying Hecla Hoek phyllites. In this section ORVIN (1940) and ROZICKY (1959) mentioned 200 m of Culm at the base. This is taken to be a misinterpretation of the lower sandy parts, tabulated above.

Isfjorden

The distribution of the Carboniferous and Permian rocks in the Isfjorden area is indicated on Fig. 1. The western margin of the syncline crosses Isfjorden near its mouth. West of this, between Isfjorden and St. Jonsfjorden, a downfaulted narrow strip of Carboniferous–Permian rocks is exposed. Northeast of the mouth of Isfjorden another isolated Carboniferous–Permian outcrop occurs, in Mediumfjellet (Section 6) and to the north, where the rocks are overthrusted towards the east.

Gently dipping Carboniferous–Permian rocks make up many of the mountains in the inner part of Isfjorden. In the area of Billefjorden, northeast of Gipshuken (Section 10) GEE HARLAND and MCWHAE, (1952) have published eighteen sections, giving a detailed account of the Carboniferous–Permian of the area. They gave the following stratigraphic scheme:

320 m	Brachiopod Cherts; cherts and sandstone, with a limestone at the base.
216–284 m	Upper Gypsiferous Series; limestones and gypsum.
228–294 m	Wordiekammen Limestone, limestones.
0–270 m	Passage Beds; limestones, breccias and sandstones, of presumed Middle Carboniferous age.
0–285 m	Lower Gypsiferous Series; gypsum and limestone also of Middle Carboniferous age.
0–235 m	Culm sandstones.

This scheme, together with the one used previously, (i. a. ORVIN 1940) is tabulated in Fig. 4.

A very detailed section through the Permian exposed on the south side of the mouth of Isfjorden has been published by HOEL and ORVIN (1937). Their section from the Spirifer Limestone to the Triassic is incorporated in Section 4 (given below in a simplified form).

North of the mouth of Isfjorden DINELEY (1958) recorded the following:

240 m	Brachiopod Cherts.
220 m	Cyathophyllum Limestone.
440 m	Charlesbreen Group; massive quartzites and conglomerates in the upper part, underlain by red shales. All were referred to the Middle Carboniferous.
125 m	Vegard Sandstone Formation; quartzose sandstones and thin shales.
200 m	Trygghamna Formation; pale and cream massive quartzites, conglomerates and rare black shales with plant remains.

Detailed sections through the marine sequences in the Isfjorden area are given below, starting in the west.

Section 4 – Kapp Linné

The upper 383.5 m are simplified after HOEL and ORVIN (1937). Below Triassic follows:

4.5 m	cherty limestone, dark, and partly shaly.
30.5 m	chertstone, dark, partly limy and partly shaly.
3 m	cherty limestone, with a chert bed in the middle.
61.5 m	chertstone, grey, and partly limy.

7	m	limestone, light grey; rich in brachiopods.
94	m	chertstone, dark.
37	m	lime-chertstone.
14.5	m	chertstone.
5	m	sandy limestone, hard.
99.5	m	chertstone, dark grey, partly limy. Two bands of limestone at the top.
22	m	limestone, upper part is dark and the lower is light; rich in brachiopods; the Spirifer Limestone.
3	m	limestone.
1	m	dolerite.
4	m	limestone and fissile claystone.
45	m	covered.
45	m	sandy dolostone and limestone, thin-bedded, partly soft and brownish.
48	m	covered. The scree is mostly made up of sandy limestones.
4	m	sandy dolostone, grey.
ca. 140	m	covered.
10	m	dolostone, brown, hard, massive, thick beds.
60	m	covered. Scree of soft, brown limestones.
18	m	dolostone, light grey.
15	m	dolerite sill.
22	m	dolostone, light grey and massive.
13	m	clayey limestone, dark, thin-bedded, and smelling of hydrogen sulphide; containing fusulinids.
16	m	sand-limestone, containing in the middle 2.5 m of current bedded lime-sandstone; with fusulinids. Just below is a rich coral horizon.
23	m	clayey limestone, soft and dark.
60	m	covered. On the shore are dark sandy limestones and clay-limestones smelling of hydrogen sulphide. The basal 8 m are covered.
7	m	clayey limestone, dark.

Below this section there follow about 50 m of quartz sandstones and conglomerates. Red sandstones were recorded in the scree. South of Linnévatnet, below the "7 m clayey limestone", there occurs a 1 m conglomerate underlain by 0.3 m of limestone with a few rugose corals. Further west, several hundred metres of quartz sandstones of Lower Carboniferous age outcrop in the mountain ridge along the coast from Isfjorden to Bellsund, (ORVIN 1940).

Section 5 – Trygghamna

On the north side of Isfjorden, Carboniferous and Permian rocks are beautifully exposed on the east side of Trygghamna. In the eastern part the strata are vertical and even overturned; in the north, they strike towards the northeast, disappear below Esmarkbreen, reappear east of the glacier and outcrop further north in the nunataks.

The upper part of the section at Trygghamna was measured near the mouth of the bay, and the lower part 3 km further north.

Below Triassic shales, there follow:

16 m	sandy shaly chertstone.
20 m	covered.
9.5 m	chertstone, light and massive.
56 m	chertstone, dark.
8 m	lime-chertsone; upper part is very rich in bryozoans.
32 m	chertstone, dark.
1.5 m	chertstone, light; containing brachiopods.
67 m	chertstone, dark.
42 m	lime-chertstone, partly sandy; containing brachiopods.
19 m	chertstone, the upper 2 m are light coloured.
11 m	shaley limy chertstone; fossiliferous.
112 m	chertstone, dark.
7 m	clay-chertstone, dark and thin-bedded.
4.5 m	chertstone, dark and thin-bedded.
10 m	limestone, light; rich in silicified brachiopods.
8 m	limestone, grey; rich in brachiopods; the Spirifer Limestone.
10 m	dolomitic limestone, light and thin-bedded.
5 m	dolerite.
65 m	limestones, soft, dark, and mostly covered by scree.
16 m	dolomitic limestone, dark brown and harder.
110 m	clayey limestone, soft, dark, and mostly screecovered.
10 m	dolomitic limestone, dark brown, brecciated, hard and thick-bedded.
82 m	limestone, dark, in uneven, thick beds.
55 m	dolostones, light grey and thin-bedded.
19 m	sandy dolostone, dark and light; containing fusulinids.
14 m	cherty dolomitic limestone, dark.
7 m	sandy dolomitic limestone, light.
12 m	limestone, dark.

These are underlain by current bedded sandstone, a light quartz conglomerate, and sandstones. Extensive Culm sandstones with plant remains are found further west and northwest.

Section 6 – Mediumfjellet

30 km northeast of Trygghamna, Permian rocks reappear in an upthrusted area, overlying dark Triassic shales. The strata are isoclinally folded. A few km from the sea, on the eastern side of Mediumfjellet, it was possible to measure the upper part of the sequence.

Below Triassic shales, there follow:

35 m chertstone, light.
18 m limy and sandy chertstone, yellow weathering; containing somc brachiopods.
5 m chertstone, black and thick-bedded.
0.5 m lime-sandstone, yellow weathering.
17 m chertstone, dark and thin-bedded.
6 m chertstone, dark and light beds with layers of dark fissile chert-claystone.
12 m chertstone, light, and partly sandy.
10 m chertstone, dark and massive.
12 m shaly chert-limestone, in part covered.
1.5 m chert-limestone, light yellow weathering; with bryozoans and brachiopods.
2 m lime-claystone, dark.
4 m chertstone, light.
12 m clayey chertstone, dark.
4 m limestone, light grey; rich in brachiopods; the Spirifer Limestone.
4 m limestone, dark grey and soft.
0.5 m anhydrite.
100 m +limestones, soft, grey, with several thin beds of anhydrite in the upper part. The lower part may be a repetition of the upper with the underlying beds screecovered.

Section 7 – Kolosseum

22 km north of Mediumfjellet, east of the head of Ekmanfjorden, marine Carboniferous and Permian strata dipping gently to the south–southwest rest unconformably on folded Devonian red clay-sandstones. In Kolosseum the uppermost beds are missing. The rest of the section from above is:

28 m chertstone, dark, in uneven thin layers.
30 m sandy and limy chertstones, light yellow weathering; some brachiopods are present.
7 m claystone, black, and fissile; containing brachiopods, bryozoans and a few sponges.
4 m limy sandstone and chertstone, the former is yellow.
32 m chertstone, dark, thin-bedded and uneven.
3 m lime-dolostone, grey; the Spirifer Limestone.
150 m limestones, dark grey, partly covered by scree.
60 m anhydrite, gypsum and clayey limestone, the beds are of variable thickness and anhydrite makes up about fifty percent of the thickness.
68 m dolomitic limestones, hard and, in part, a little sandy.
22 m sandy limestone, thick-bedded.
10 m limestone, thin-bedded.
5 m limestone, dark, sapropelic; rich in fusulinids.
5 m limestone, dark.

12 m	dolomitic limestone, softer and partly covered in the lower part.
7 m	limestone, grey, thin-bedded, with interlayers of soft clayey limestone.
7 m	dolomitic limestone, grey, with small chert nodules.
15 m	sandy and clayey limestones.
10 m	calcarenite, grey, in 1 m thick beds, the uppermost containing chert nodules.
15 m	limestone, grey, partly calcarenitic, partly sandy, with some chert nodules in the upper part.
13 m	limestone, hard and thin-bedded, with softer thin interlayers of clayey, fissile limestone. The uppermost contains large chert nodules. The lower part is a coarse calcarenite, in part covered.
7 m	limestone, massive, with large nodules of chert.
22 m	calcarenite, coarse, and thick-bedded with clayey limestone. A few chert nodules are present.
18 m	sand-limestones and lime-sandstones, thick-bedded.
2 m	sandstone.
2 m	sandstone and conglomerate.

Section 8 – Kapitol

To the east of Ekmanfjorden, on Kapitol, it was possible to measure a detailed section from the underlying Devonian up into chertstones above the Spirifer Limestone. A 20 m dolerite sill caps the mountain. Below this there occur:

8 m	clayey chertstone, partly contact metamorphosed to a light brown colour; containing some bryozoans.
1.5 m	limestone, partly sandy and green; some brachiopods are present.
52 m	chertsone, dark in the lower part, and lighter higher up.
3.5 m	limestone, grey: rich in brachiopods; the Spirifer Limestone.
11 m	limestones, grey and yellow, soft.
30 m	limestone and sandy dolostone, the former is dark, som gypsum in the upper part.
7 m	clayey limestone and gypsiferous dolostone.
21 m	dolostone, light, hard and alternating with dark softer limestones.
23 m	limestone and dolostone, hard, thick beds containing a thin bed of gypsum in the lower part.
20 m	dolostone and limestone, dark.
104 m	gypsum and anhydrite, with intercalated soft clayey lime-dolostone.
62 m	dolostone, soft and thin-bedded.
2 m	limestone, soft.
58 m	sandy limestone and sand-limestone, interbedded; fusulinids occur in a zone 16 m above the base.
4 m	limestone, sapropelic; rich in fusulinids.
60 m	dolostone and limestone, thick beds separated by layers of clayey, laminated dolostone. Ubiquitous chert nodules occur.

48 m dolostone and limestone, thick beds, in part sandy. The limestone are frequently calcarenites. Nodules of chert common, and are developed as jasper in the lower part. Corals and a few brachiopods are also found in the lower part.

6 m sandstones, soft and grey-green in the upper part, and red and green in the lower part.

Below these follow folded red Devonian clay-sandstones.

Section 9 – Skansen

About 30 km southwest of the above section at Skansbukta, near the entrance of Billefjorden, no complete section was found. However, by correlating several incomplete sections, it proved possible to get some knowledge of the Carboniferous and Permian stratigraphy in the area. The composite section, below Triassic sandstones is:

80 m chertstone, dark and grey, more or less sandy. In the upper part some chert-sandstone occur. The sandstones contain glauconite, giving the beds a greenish colour, weathering yellow-brown.

50 m chertstone, blue-grey, with a few layers of yellow weathering sandstones.

2 m clay-chertstone, dark and laminated; contains bryozoans and sponges.

1.5 m lime-sandstone; containing brachiopods and bryozoans.

70 m clayey chertstone, dark, with some light chert in the upper parts.

12 m limestone, with chert bands; rich in brachiopods. On top are 2 m of massive chert; the Spirifer Limestone.

10 m lime-sandstone, hard, light grey and flaggy.

120 m limestones, soft, dark and partly sandy, smelling of hydrogen sulphide. In the upper part are a few thin (0.1–0.5) m bands of gypsum.

110 m anhydrite and clay-limestone, laminated and in thick beds. The total thickness of the anhydrite is about 42 m.

35 m limestone, dark, partly sandy and thick-bedded.

66 m dolostone, thick, massive beds, seperated by thinner layers of thin-bedded dolostone.

46 m dolostones and limestones, thick beds with the latter often calcarenitic. At the top is a sapropelic limestone; rich in fusulinids. Nodules and irregular masses of chert are present.

6 m limy sandstones and conglomerates. The conglomerates contain boulders of Devonian fine sandstones and fissile claystones.

The section is underlain by folded Devonian clay-sandstones.

Section 10 – Gipshuken

Several sections through Carboniferous and Permian strata outcropping on the south side of Billefjorden have been combined to give a complete section. The uppermost part is missing, but the lithology of the top layers indicate proximity to the Permian–Triassic border. The section is:

7 m	sandstone, glauconitic.
5 m	chert-sandstone, glaconitic.
27 m	chertstone, grey-blue.
11 m	clayey chertstone, dark, massive, beds.
8 m	cherty sandstone, glauconitic.
80 m	chertstone, grey-blue and dark, with a yellow weathering glauconitic sandstone near the top.
3 m	cherty sandstone.
16 m	chertstone, dark.
3 m	sandy and clayey limestone; with brachiopods and bryozoans.
85 m	chertstones, mostly dark, but including some lighter bands. Some layers are clayey and well laminated.
37 m	sandy limestone and chertstone, thick beds; rich in brachiopods, and containing bryozoans at the base; the Spirifer Limestone.
3 m	lime-sandstones.
63 m	limestones, soft, with some thin layers of gypsum near the top.
24 m	limestone, dark, and smelling of hydrogen sulphide.
88 m	limestones, soft, grey-brown, and thin-bedded.
105 m	gypsum, with subordinate dolostone and limestone.
75 m	limestone and dolostone, grey, in thick massive units.
8 m	sandy and clayey limestone, dark.
60 m	dolostone, grey, massive and partly sandy.
50 m	dolostone, massive thick beds alternating with thinner layers of clayey dolostone; the latter contain fusulinids. The beds are partly covered by scree.
12 m	sandy limestone, contain a few pebbles of quartzite and red Devonian shales at the base.

Just west of a north striking fault across Gipsdalen, the marine rocks rest with angular unconformity on Culm sandstones and shales, containing plant remains. The Culm is exposed north of Gipshuken along the shore of Billefjorden.

Section 11 – Finlayfjellet–Högbomfjellet

This section is a combination of two profiles located about 20 km east and northeast of Gipshuken. The upper beds are best exposed on Högbomfjellet at the head of Tempelfjorden, and the lower beds on Finlayfjellet in Gipsdalen.

As the strata dip gently south–southwest, the top of the Permian does not outcrop. The measurements gave the following section:

40 m	chertstone
3 m	sandstone, glauconitic.
26 m	covered, much dark chertstone in the scree.

20 m sandstones and sandy chertstones, the chert is partly very light; small brachiopods are present.
11 m covered.
80 m chertstone, the upper part containing light, and the lower part very dark bands.
35 m sandy and cherty limestone, with horizons of pure chert; rich in brachiopods; the Spirifer Limestone.
85 m limestone, dark. Partly covered. In the middle is a layer of clayey limestone smelling of hydrogen sulphide.
20 m dolostone and limestone, hard, yellow-green and brown, with some chert nodules and sand-limestone in the upper part.
110 m dolostone and limestone, hard and grey. These are in part covered.
11 m sand-limestone and lime-sandstone partly shaly; containing some brachiopods.
50 m covered, some massive dolostone is exposed.
35 m dolostone, hard.
40 m dolostone, hard, massive, thick-bedded, with thinner interlayers of softer clayey dolostone.
2 m clayey limestone, dark; with fusulinids.
40 m limestones, light and dark, with dark, partly clayey layers.
70 m limestone, massive, thick-bedded, and containing chert nodules in the lower part; fusulinids in the uppermost part.
40 m covered.
66 m limestone, massive thick beds, seperated by clayey limestones. The limestones are calcarenitic and often contain nodules.
5 m sand-limestone.

Scree covers the lower part of the slope. One band of sandstone is exposed 30 m below the "5 m sand-limestone", and 200 m below this sandstone, Culm sandstones with plant remains and coal outcrops.

A few km north of Finlayfjellet the covered part of the section is seen to consist of:

30 m sandy limestone and sandstones, the latter is yellow and red, conglomerate occur at the top.
13 m sand-limestone, grey.
20 m gypsum, partly coloured pink by the overlying red sandstones.
18 m lime-sandstone, yellow weathering, with a porous sandstone at the base.

The contact with the Culm sandstones, a short distance below is covered by scree.

Section 12 – Tunabreen

About 20 km north of the head of Tempelfjorden, a section was measured through the lower part of the Carboniferous and Permian rocks outcropping along Tunabreen.

87 m	sandy limestone, grey.
3 m	sandstone, grey, and partly current bedded.
25 m	sandy clayey limestone, dark, thick-bedded; fusulinids are present near the base.
18 m	limestone thick beds, some containing large chert nodules.
15 m	sandy limestone, soft.
110 m	dolostone, massive, thick beds with subordinate thinner layers of fissle claystone. Nodules of chert occur in the lower part.
24 m	sandy limestone and dolostone, thick-bedded.
7 m	sandstone, lightgrey and limy in the upper part.
3–8 m	conglomerate, coarse and red, consisting of gebbles of angular red and green quartzites.

Unconformably below the conglomerate, Hecla Hoek red and yellow quartzites and sandstones are present.

Section 13 – Malte Brunfjellet

A similar section to Section 12 was measured 10 km to the east of Tunabreen, on the eastern side of Malte Brunfjellet, where Carboniferous–Permian rocks rest unconformably on steeply inclined Hecla Hoek phyllites, quartzites and tillites.

9 m	lime-sandstone and sand-limestone, hard and thin-bedded.
1 m	limy sandstone, current bedded.
32 m	covered, sandy limestone in the scree.
2 m	limestone, dark; rich in fusulinids.
18 m	sandy limestone, grey.
1.5 m	limestone, grey; containing fusulinids.
22 m	sandy limestone, grey and thin-bedded.
3 m	sandy dolostone, massive and grey, (top of cliff).
118 m	limestone and dolostone, massive and thick-bedded. The upper part contains some softer clay-sandstones; the lower part some horizons with chert nodules.
18 m	sandstone, grey, with a sand-limestone band in the middle of the unit.
14 m	conglomerate, fine, with quartz pebbles, and subordinate coarse sandstone.
60 m	sandstones, gray in the upper parts and red in the lower.

No conglomerate was recorded separating these sandstones from the underlying Hecla Hoek.

Section 14 – Przybyllokfjellet

The mountains south and southeast of Tempelfjorden are made up of Carboniferous and Permian rocks. The strata are slightly inclined to the southwest, and in the south the mountains are capped by Triassic shales. The following section was measured at Przybyllokfjellet, starting within the Productus Chertstone.

46 m chertstone.
2 m sandstone, yellow weathering; containing brachiopods and bryozoans.
45 m clayey chertstone, black, with fissle chert-claystone.
18 m chertstone and sandstone, light, and in the lower part glauconitic; small brachiopods in the lower part.
58 m chertstone, dark, clayey in the lower part.
21 m cherty limestone and chertstone, light; rich in brachiopods; the Spirifer Limestone.
50 m sandy limestone, light, and containing some darker horizons in the lower part.
18 m clayey limestone, containing some fine sandy layers.
2.5 m limy sandstone.
70 m sandy and limy claystone, dark grey.
23 m claystone, hard and grey-brown, containing an intraformational conglomerate in the lower part.
37 m sandy limestone, grey-brown and hard.
43 m limy claystone, light grey and soft.
10 m lime-sandstone.
20 m lime-claystone, soft and containing some gypsum.
12 m sandy dolostone, the lower part is thin-bedded.
10 m clay-dolostone, thin-bedded.
25 m sandy dolostone, grey-brown.

Scree covers the rest of the section. Nearer to the fjord to the north of the section, a fusulinid bearing zone occurs close below the base of the section. This is presumed to be the "Fusulina Limestone".

Section 15 – Gjelhallet

Permian chertstones outcrop along the north and east side of Sassendalen and dip gently south into the head of the valley. At Gjelhallet 4 km from the sea, the stratigraphy below the Triassic is as follows:

30 m sandstone, green and glauconitic.
24 m chertstone, blue-grey and dark, with some sandy layers.
4 m sandstone, glauconitic.
16 m covered.
26 m sandstone, grey; the lower part contains many worm tracks and borings.
38 m sandy chertstone, light.
10 m covered.
48 m chertstone, in part covered.
3 m limy sandstone, yellow weathering; containing brachiopods and bryozoans.
60 m covered.
1 m cherty limestone; some brachiopods present.
10 m chertstone, light.

80 m	chertstone, dark, with bands of light chert 20 and 60 m above the base.
34 m	cherty limestone; rich in brachiopods; the Spirifer Limestone.

Lower down, the slope is screecovered.

Section 16 – Stensiöfjellet

At the head of Sassendalen, on the south side of Stensiöfjellet, it was possible to get a section through the upper part of the Permian. This is the southernmost locality in the Isfjorden area, where a section is measured. Below the Triassic there occur:

23 m	sandstone, green and glauconitic.
15 m	chertstone, grey-blue.
15 m	covered.
21 m	sandstones, containing some chert in the lower part and calcareous in the upper part. Wormtracks are present in the former.
105 m	chertstones, grey-blue and yellowish.
2 m	sandstone, yellow-brown weathering, with chert bands; latter contain brachiopods and bryozoans.
13 m	claystone, fissile and dark; with bryozoans and sponges.
7 m	covered.
0.5 m	sandstone, glauconitic.
2 m	sandy chertstone.
10 m	chertstone, light.

The underlying strata are covered by scree. Some 100 m below the "10 m chertstone" a brachiopod bearing sandy limestone occurs, the Spirifer Limestone?

Dating of the Carboniferous–Permian succession

The fossil content of the Carboniferous and Permian of Spitsbergen has been studied by several geologists and palaeontologists. A few of the most important publications are mention below. Brachiopods were originally described by Toula (1873, and 1875), and subsequently by Wiman (1914), Frebold (1937), and Gobbet (1963); their affinities to the Russian faunal province have been demonstrated. Corals have been extensively described by Heritsch (1939).

In 1911, Holtedahl described a fauna of Middle Carboniferous (Moscovian) age from the base of the Cyathophyllum Limestone, south of Kongsfjorden (Holtedahl 1911). Most authors have placed the rest of the Cyathophyllum Limestone in the Upper Carboniferous.

In recent years, foraminifers have proved valuable in dating the Cyathophyllum Limestone. The fusulinids of the "Fusulina Limestone" were first described by Schellwien (1908) and Staff and Wedekind (1910). Later works by Forbes, Harland and Hughes (1958), Forbes (1960), and Ross (1965), described Permian fusulinids in the lower part of the Cyathophyllum Limestone. This made it necessary to draw the Carboniferous–Permian boundary at a lower horizon than was previously accepted.

Fig. 2 illustrates the distribution of foraminifers within the lower 140 m of Section 7 (Kolosseum). With the "Fusulina Limestone" at the top, the levels 1–13 are distributed evenly downwards. The present author proposes the base of the "Fusulina Limestone" for the Carboniferous–Permian boundary, this limestone, recognized over wide areas, marking the first appearance of *Schwagerina* sp.

The range of *Fusulinella* sp., *Pseudostaffella* sp. and *Ozawainella* sp. from the basal part of the Cyathophyllum Limestone to a few metres below the "Fusulina Limestone" indicates that the Middle Carboniferous is much thicker than was previously estimated. The Upper Carboniferous *Fusulina* Zone and *Triticites* Zone are much more restricted in the Kolosseum Section (between levels 8 and 13), being some fifty to sixty metres thick.

Near the Kolosseum Section, and generally in the inner parts of Isfjorden, a fossil zone is located at a level of 30 to 50 m above the "Fusulina Limestone" containing *Parafusulina* sp. This indicates proximity to the Middle Permian.

The rocks below the Cyathophyllum Limestone are mostly continental facies, yielding plant remains of Lower Carboniferous age. In the Isfjorden area, a few marine fossils have been found in the upper part, indicative of a Middle Carboniferous age (Gobbet 1963).

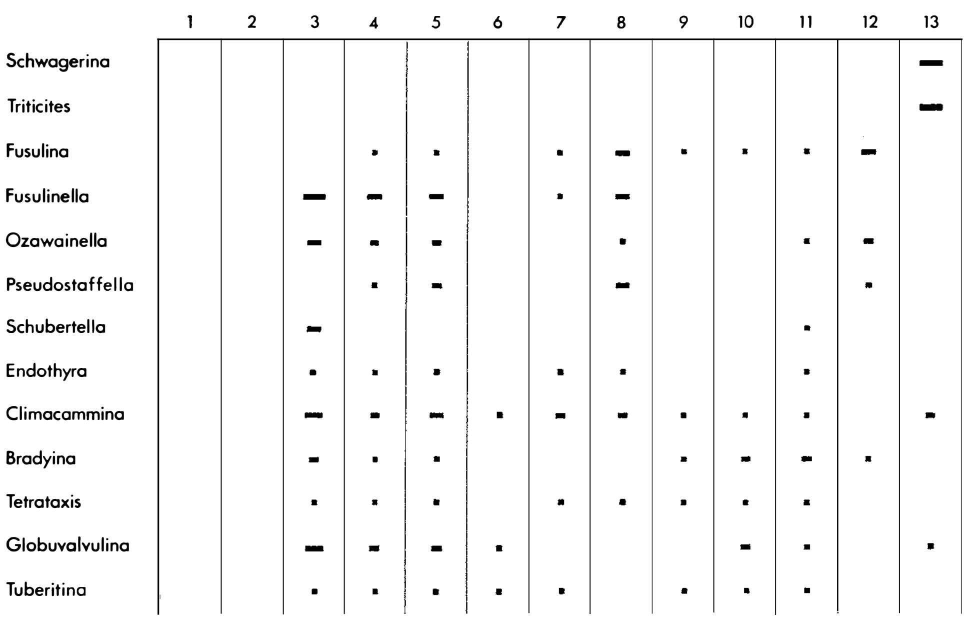


Fig. 2. *Foraminifers of the lower part of section 7, Kolosseum, Ekmanfjorden. The length of heavy lines indicate quantity of specimens.*

History of the sedimentation

Comparison of the different sections described above allows a more complete assessment of the history of Carboniferous and Permian sedimentation in Spitsbergen, than hitherto. The work broadly confirms ORVIN's conclusions (1940).

During the early Carboniferous, continental conditions prevailed in Spitsbergen and thick plant bearing sediments were deposited. Today these rocks are found in Sørkapp Land, along the western coast, and in the inner part of Isfjorden.

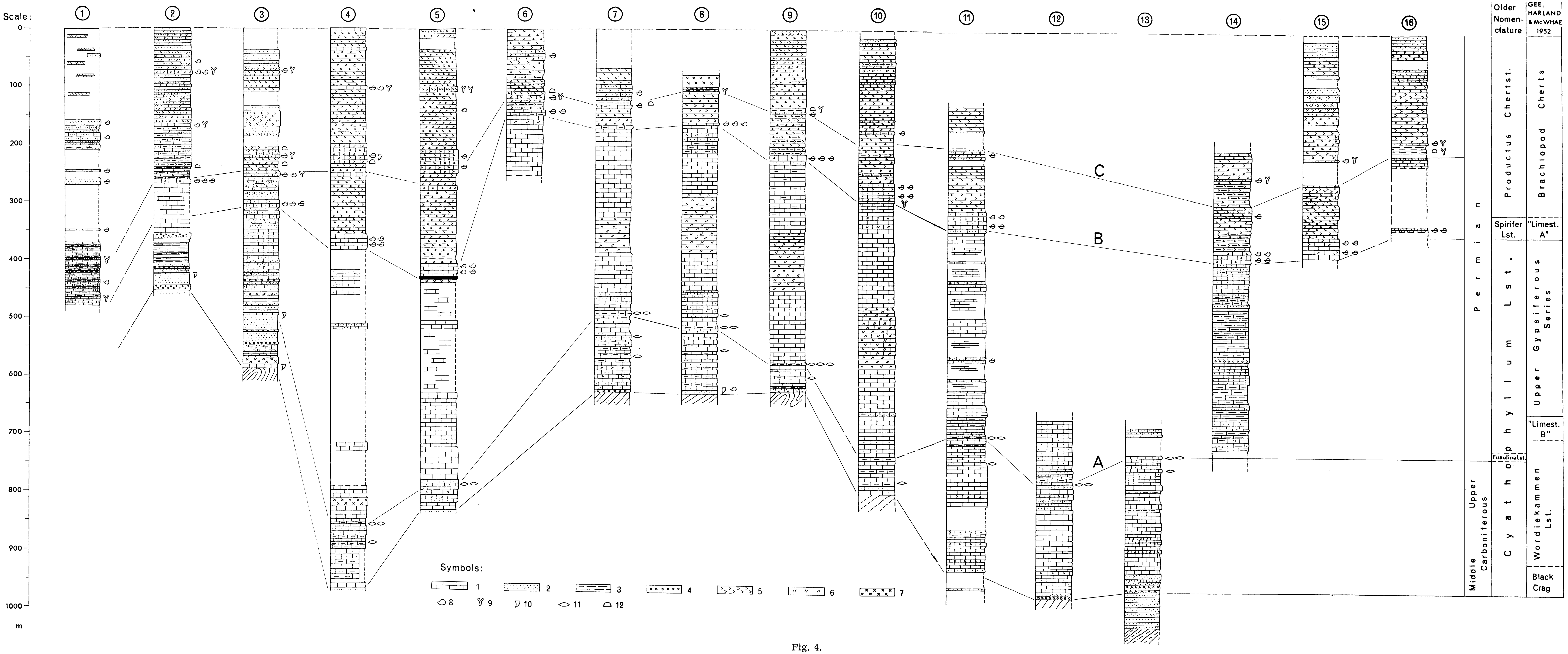
In the early part of the Middle Carboniferous uplift occurred in central Vestspitsbergen and the Culm was eroded in this area. East of Kapitol (Section 8) on the east side of Dicksonfjorden a pocket of Culm is present lying unconformably below marine Middle Carboniferous. Extensive Middle Carboniferous sedimentation took place in restricted and rapidly subsiding basins in the inner part of Isfjorden, north of the mouth of the fjord and also in Sørkapp Land. Thick conglomerates and other clastic rocks, often of red colour, indicate a rapid accumulation of sediments.

During the upper Middle and Upper Carboniferous, the facies indicate proximity to land to the south–southwest, with alternating sedimentation and denudation. Cyclic sedimentation occurred in Hornsund and Reinodden (Section 2). In the Isfjorden area marine conditions prevailed and the Cyathophyllum Limestone was deposited. In the lower part thick layers of dark (sapropelic ?) limestone are exposed at the mouth and inner part of Isfjorden, indicative of stagnant water conditions in restricted basins. Considerabled variation in the thickness of strata below the "Fusulina Limestone" (in Fig. 4 compare the 30 m of Upper Carboniferous in central Isfjorden, with the 230 m recorded for Kongsfjorden by HOLTEDAHL, 1911) are indicative of unstable conditions during this period of deposition.

More stable conditions existed during the Permian. The "Fusulina Limestone" i a fairly constant horizon over much of the area, and is best developed in the inner part of Isfjorden, where it attains a thickness of 6 m. The base of this limestone, separating the Carboniferous from the Permian, is joined by the line "A" in Fig. 4. Anhydrite and gypsum in the eastern part of Isfjorden require the existence of a closed basin in this area. The evaporites thin eastwards, giving

Fig. 4. *Sections from localities 1–16. 1 Sørkappøya, 2 Reinodden, 3 Ahlstrandodden, 4 Kapp Linne, 5 Trygghamna, 6 Mediumfjellet, 7 Kolosseum, 8 Kapitol, 9 Skansen, 10 Gipshuken, 11 Finlayfjellet–Högbomfjellet, 12 Tunabreen, 13 Malte Brunfjellet, 14 Przybyllokfjellet, 15 Gjelhallet, 16 Stensiöfjellet. For locations see fig. 1. Symbols used: 1 Limestone, dolostone, 2 Sandstone, 3 Claystone, 4 Conglomerate, 5 Chertstone, 6 Gypsum, anhydrite, 7 Dolerite, 8 Brachiopod zone, 9 Bryozoa zone, 10 Coral zone, 11 Fusulinid zone, 12 Sponge zone.*

Four lines are drawn through the sections. The lowermost is at the base of the Cyathophyllum Limestone, line marked A through the base of the "Fusulina Limestone", marking the base of Permian, line marked B through the base of the Spirifer Limestone and line marked C through the base of the "Sponge Zone".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Symbols:
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Older Nomen-clature
GEE, HARLAND & McWHAE 1952
Permian
Middle Upper Carboniferous
Cyathophyllum Lst.
Productus Chertst.
Brachiopod Cherts
Spirifer Lst.
"Limest. A"
Upper Gypsiferous Series
"Limest. B"
Fusulina Lst.
Wordiekammen Lst.
Black Crag

Fig. 4.

way laterally to a carbonate facies. Whilst this marine deposition occurred in the east and northeast, near shore facies were being deposited in the southern part of Vestspitsbergen.

Overlying the Cyathophyllum Limestone, the Spirifer Limestone has been recognized over wide areas (see Fig. 4, line "B"). It appears at Ahlstrandodden (Section 3) in the south, and occurs at the base of the Section at Kapp Linné, measured by HOEL and ORVIN (1937); (they indicate a higher position). Towards the north it outcrops at Trygghamna (Section 5), and is poorly developed in Mediumfjellet (Section 6) and in Kolosseum (Section 7). North of here it is absent, whilst towards the east it thickens to a maximum of 40 m.

The overlying Productus Chertstone was deposited over the whole area, though in the Hornsund area it locally thins to a few metres. Within it, a dark, clayey chertstone and black fissile claystone form a marked horizon, recognized over almost the whole area and very prominent in the east (south of Section 13 and 14). The zone is characterised by the abundance of silicious sponges, bryozoans and small brachiopods. It is marked by the line "C" in Fig. 4.

The top layer of the Productus Chertstone at Sørkapp is very sandy, indicating continued proximity to land in the southwest. Part of the Permian has been eroded in this area, the result of pre-Middle Triassic uplift. A landmass also appears to have been present in the east, late in the Permian, with glauconitic sandstones being deposited in the inner part of Isfjorden and further east, at the top of the Productus Chertstone.

Lithological nomenclature

Most of the lithologies described here are limestones, dolostones (dolomite), chertstones, sandstones and claystones. For the purposes of this paper the following scheme of nomenclature has been adopted, based largely on hand specimen assessment of the constituents.

1. For combination of limestone, sandstones and claystones, the triangular diagram (Fig. 3) indicates the constituent percentages of the rock types.

Where two constituents predominate the terms are hyphenated, with the latter just in excess of the former (e. g. clay-limestone). Where the second constituent is clearly subordinate an adjectival prefix is employed (e. g. clayey limestone).

Where three (or more) important constituents are present, the least is given first, as an adjectival prefix (e. g. clayey sand-limestone, clayey sandy limestone).

2. Where chertstone, or dolomite have been important constituents, schemes based on similar triangular diagrams to the one above, with the main constituents at the corners, have been adopted.

3. The term shale has been used to refer to fissile claystones and siltstones where they have not been differentiated.

4. The term dolo-limestone and lime-dolostone have been used when the amounts of calcium carbonate and dolomite are uncertain but one constituent is thought to predominate.

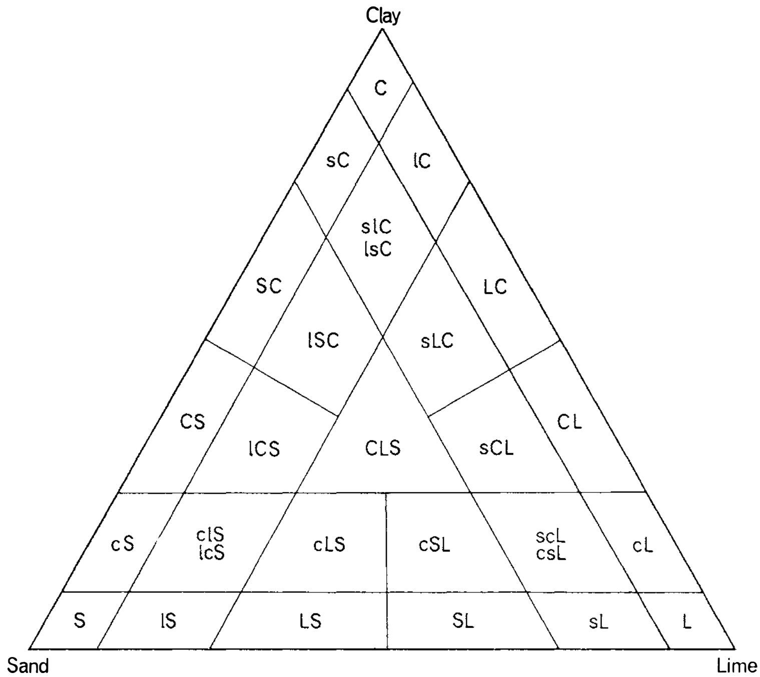

Fig. 3. *Table of lithologic nomenclature used in the description of the rocks.*
Abbrevations: C claystone, sC sandy claystone, lC limy claystone, slC sandy limy claystone, lsC limey sandy claystone, SC sand-claystone, lSC limey sand-claystone, LC lime-claystone, CS clay-sandstone, lCS limey clay-sandstone, CLS clay-lime-sandstone, sCL sandy clay-limestone, CL clay-limestone, cS clayey sandstone. clS clayey limey sandstone, lcS limey clayey sandstone, cLS clayey lime-sandstone, cSL clayey sand-limestone, scL sandy clayey limestone, csL clayey sandy limestone, cL clayey limestone, S sandstone, lS limey sandstone, LS lime-sandstone, SL sand-limestone, sL sandy limestone, L limestone.

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Literature

BIRKENMAJER, K., 1964: Devonian, Carboniferous and Permian Formations of Hornsund, Vestspitsbergen. *Studia Geol. Polon.* **11**. Warszawa.

— and S. CZRNIECKI, 1960: Stratigraphy of marine Carboniferous and Permian deposits in Hornsund (Vestspitsbergen), based on brachiopods. *Bull. Acad. Polon. Sci.* Sér. sci. géol. et géogr. **VIII**, (3). Warszawa.

— and E. TURNAU, 1962: Lower Carboniferous age of the so-called Wijde Bay Series in Hornsund, Vestspitsbergen. *Norsk Polarinst. Årbok 1961.* Oslo.

DINELEY, D. L., 1958: A review of the Carboniferous and Permian rocks of the west coast of Vestspitsbergen. *Norsk Geol. Tidsskr.* **38**, (2). Bergen.

FORBES, C. L., 1960: Carboniferous and Permian Fusulinidae from Spitsbergen. *Paleontology.* **2**, (2). London.

— W. B. HARLAND, and N. F. HUGHES, 1958: Paleontological Evidence for the Age of the Carboniferous and Permian Rocks of Central Vestspitsbergen. *Geol. Mag.* **95**, (6). London.

FREBOLD, H., 1937: Das Festungsprofil auf Spitzbergen. IV. Die Brachopoden und Lamellibranchatenfauna und die Stratigraphie des Oberkarbons und Unterperms. *Skr. Svalb. og Ishavet.* Nr.69. Oslo.

GEE, E. R., W. B. HARLAND, and J. H. R. MCWHAE, 1952: Geology of Central Vestspitsbergen. Part II. Lower Permian of Billefjorden. *Trans. R. Soc. Edinburgh.* **62**, 2, (9). Edinburgh.

GOBBETT, D. J., 1963: Carboniferous and Permian Brachiopods of Svalbard. *Norsk Polarinst. Skr.* Nr. 127. Oslo.

HERITSCH, F., 1939: Die Korallen des Jungpaläozoikums von Spitzbergen. *Ark. Zool.* **31A**, (16). Stockholm.

HOEL, A. und A. K. ORVIN, 1937: Das Festungsprofil auf Spitzbergen. Karbon-Kreide. I. Vermessungsresultate. *Skr. Svalb. og Ishavet.* Nr. 18. Oslo.

HOLTEDAHL, O., 1911: Zur Kenntnis der Karbonablagerungen des westlichen Spitzbergens. I. Eine Fauna der Moskauer Stufe. *Skr. Vidensk. Selsk. Krist.* I. Mat.-Nat. Kl. 1911. Nr. 10. Oslo.

— 1913: Zur Kenntnis der Karbonablagerungen des westlichen Spitzbergens. II. Allgemeine stratigraphische und tektonische Beobachtungen. *Skr. Vidensk. Selsk. Krist.* I. Mat.-Nat. Kl. 1912. No. 23. Oslo.

LISZKA, S., 1964: Occurrence of Lower Permian Foraminifera in the Treskelodden Beds of Hornsund, Vestspitsbergen. *Studia Geol. Polon.* **XI**. Warszawa.

ORVIN, A. K., 1934: Geology of the Kings Bay Region, Spitsbergen. *Skr. Svalb. og Ishavet.* Nr. 57. Oslo.

— 1940: Outline of the geological history of Spitsbergen. *Skr. Svalb. og Ishavet.* Nr. 78. Oslo.

ROSS, CH. A., 1965: Fusulinids from the Cyathophyllum Limestone, Central Vestspitsbergen. *Contr. Cushman Found. Foraminiferal Research.* **XVI**, (2). Bridgewater, Mass.

SCHELLWIEN, E., 1908: Monographie der Fusulinen. *Paleontographica.* **55**, (3–4). Stuttgart.

SIEDLECKI, S., 1960: Culm Beds of the SW coast of Hornsund, Vestspitsbergen. *Studia Geol. Polon.* **IV**. Warszawa.

— 1964: Permian succession on Tokrossøya, Sørkapplandet, Vestpsitsbergen. *Studia Geol. Polon.* **XI**. Warszawa.

STAFF, H. VON und R. WEDEKIND, 1910: Der oberkarbone Foraminiferensapropelit Spitzbergens. *Bull. geol. Inst. Univ. Upsala.* **10**. Uppsala.

TOULA, F., 1873: Kohlenkalk-Fossilien von der Südspitze von Spitzbergen. *S. B. Akad. Wiss. Wien.* **68**, (1). Wien.

— 1875: Permo-Carbon-Fossilien von der Westkuste von Spitzbergen. *N. Jb. Min. Geol. Palaont. Jahrg.* 1875. Stuttgart.

WIMAN, C., 1914: Über die Karbonbrachiopoden Spitzbergens und Beeren Eilands. *Nova Acta Soc. Sci. Upsal..* Ser. 4. **3**, (8). Uppsala.

On the crystalline rock of northwest Spitsbergen

BY

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Abstract

An outline of the structure, stratigraphy, metamorphism and intrusion of northwest Spitsbergen is presented along with a map and sections through the area. Regional metamorphism (possibly late Pre-Cambrian) of a marble, pelite and amphibolite succession correlated with the Lower Hecla Hoek, was followed by extensive migmatisation and subsequent posttectonic intrusion.

Introduction

During the summer of 1964, three geological parties of the Norsk Polarinstitutt carried out a reconnaissance of the metasediments, migmatites, and intrusive rocks of Albert I Land and west Haakon VII Land, northwest Spitsbergen. This paper is based on the field reports of the three geologists TONY VAN AUTENBOER, DAVID G. GEE and AUDUN HJELLE, and notes from previous seasons' work by TORE GJELSVIK. It outlines the main features of the structure, stratigraphy, metamorphism and intrusion of the area.

The project in northwest Spitsbergen was part of a combined geological and topographical survey under the leadership of THOR SIGGERUD. It was supported by helicopter transport, which greatly facilitated the work in the more remote parts of the area.

Previous investigations

The occurrence of crystalline rocks, particularly marbles, north of Kongsfjorden was recorded by SCORESBY (1820). DUROCHER (GAIMARD 1855) in an account of "L'expédition de la Recherche" in northwest Spitsbergen (1839) was the first to present a general account of the northern part of the area. He reported a "terrain primitif" made up of schists, amphibolites and granites. He recognised two types of granite; an earlier one, foliated and lying in the gneissosity, and a later coarse-grained unfoliated type. He noted that the schists were transitional to the gneisses.

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The southern part of Albert I Land was described by BLOMSTRAND (1864), who observed that the gneisses extended down the west coast as far as the southernmost of the Sju Isfjella. The granites he recorded to be of two types, grey and red, the former being foliated and earlier, the latter unfoliated and later. He was the first to record the limestone skarn associations in the granites, noting assemblages including augite, idocrase, wollastonite, garnet and scapolite.

Some years later VON DRASCHE (1874) made similar observations in the area and differentiated between acid igneous rocks of the following types: tonalite, quartz syenite, red granite and granites with mica schist inclusions. These were added to by BRYANT (1905) with the record of coarse amphibole granite in Amsterdamøya. Subsequently SCHETELIG (1912) on the basis of field work by HORNEMAN (1906) presented more detailed petrographic descriptions of the granites and gneisses making up "les formations primitives".

Correlation of the metamorphic rocks of the inner part of Kongsfjorden with the Hecla Hoek formations described from other parts of Spitsbergen was made by NORDENSKIÖLD (1866). This correlation was accepted by HOEL, HOLTEDAHL and ORVIN (1934, 1940) and has recently been amplified by HARLAND (1960). However, prior to the Isachsen Expeditions of 1909 and 1910 and the Hoel-Staxrud Expedition of 1911, there is general agreement in the literature that the metasediments in the southern part of the area correlated with the Hecla Hoek were part of a later formation overlying a northern "Archaean" complex. Not until HOEL and HOLTEDAHL (1914) traversed the more inaccessable interior of west Albert I Land, was it apparent that the metamorphic grade of the Hecla Hoek metasediments increased northwards, and that the granites were transitional to these sediments and later than them. This increase in degree of metamorphism and intrusion towards the north was related by HOLTEDAHL (1926) to greater depth during Caledonian orogenesis. SCHENCK (1937), regarding the grey granites as being produced by anatexis, considered the granitization to occur under hydrostatic pressure after the Caledonian folding. This interpretation of the migmatite zone as a "non-directed, hydrostatic, upwelling" has been compared by HARLAND (1961) with apparently similar phenomena in East Greenland.

Thus, prior to the most recent Norsk Polarinstitutt investigations much information of a reconnaissance nature existed, particularly from the coastal areas. In 1964 investigations were extended into the areas not previously visited by geologists, the prime object being to locate minerals of economic importance. However, in the course of this work it was possible to compile a geological map of the area, a simplified presentation being given in Fig. 1, establish a stratigraphical sequence in some parts, and elucidate the broad outlines of the metamorphic and igneous events in the area.

Geological setting

A map of the area is given in Fig. 1. The crystalline rocks occur in two north–south trending belts, separated by the conglomerates and sandstones making up the Red Bay Series and the Siktefjellet Group. The eastern belt has been investi-

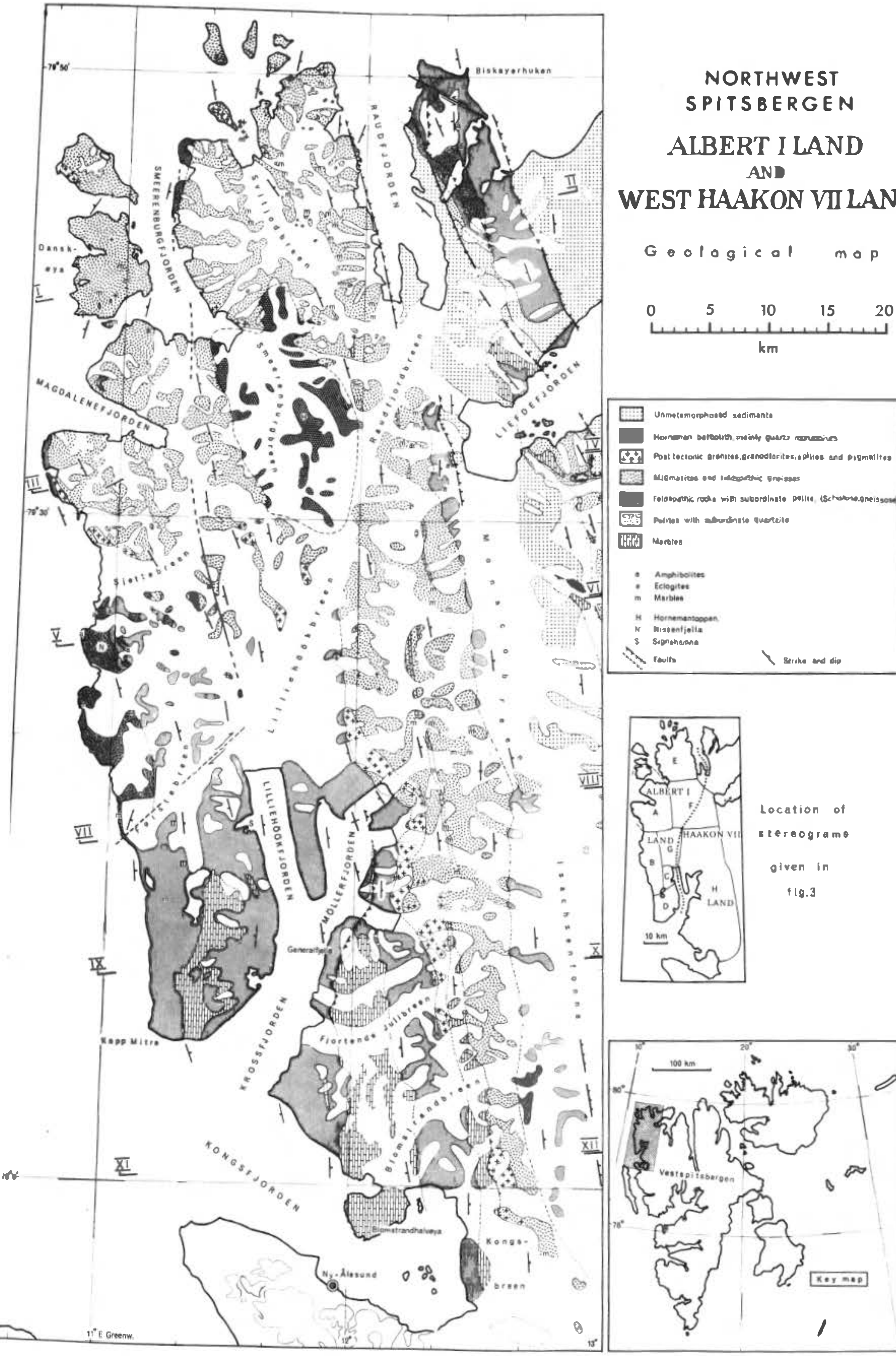


Fig. 1. *A geological map of northwest Spitsbergen. Area east of Raudfjorden from* GEE and MOODY-STUART (1965) *and* GEE (1965); *area east of Monacobreen from* GJELSVIK (unpublished map).

gated in detail by one of us (D. G. G., as a member of the Cambridge Spitsbergen Expeditions 1961–3) in the north, and in the south by T. GJELSVIK. The relationships shown in Fig. 1 are based on this work.

To the west of the trough of Red Bay Series (Gedinnian) sediments there occur an east dipping strip of metasediments extending from Raudfjorden to Kongsbreen, and transitional westwards into migmatites. The latter outcrop extensively in the northern and central part of the area, and give way southwestwards to metasediments.

The structure of the western belt has a strong westerly asymmetry, with south plunging folds overturned to the west and cut by east dipping reverse faults. The youngest and least metamorphosed rocks occur in the southwest, marbles with minor quartzites and pelites passing down through a thick pelitic sequence with subordinate quartzites, into pelites with subordinate interbanded amphibolites and various felspathic rocks.

Unfoliated granite, granodiorite, aplite and pegmatite dykes occur commonly in the metasediments marginal to the migmatite area. Within the migmatites, grey granodiorites occur transitionally and discordantly to the migmatites. Red "granite" appears as an important intrusion centred on Hornemantoppen. This intrusion, being largely made up of quartz monzonite, has been referred to previously as the Smeerenburgbreen batholith (HARLAND 1961). The name Horneman batholith is preferred here to avoid possible confusion with the place Smeerenburg on Amsterdamøya, where other granitic rocks occur.

Lithologies and stratigraphy

An belt of metasediments occurs in the west and southwest in the Krossfjorden area and extends north to Nissenfjella. South plunging folds expose successively lower horizons northwards. No evidence of a major stratigraphical break has been detected in the sequence, and though local inversion may occur in the overturned limb of a fold, the regional relationships suggest lack of important lithological repetition by folding or faulting. In the Mitrahalvøya area observations of small scale ripple bedding and transitions from pelite to quartzite indicate lack of inversion.

The stratigraphy is summarised in Fig. 2. Comprehensive descriptions of the lithologies await a more detailed study, and a preliminary account of the main formations follows.

Generalfjella Formation

This formation is made up predominantly of marbles with subordinate pelites and quartzites. The most complete succession is located in Generalfjella, south of Tinayrebukta, where blue and buff-white marbles occur interbanded with pelites and quartzites and pass up through some 200 m of pelites and psammites into a thick marble unit (4–500 m) – the Blomstrandhalvøya marbles. These have been described briefly by previous authors (BLOMSTRAND 1864, SIGGERUD 1962).

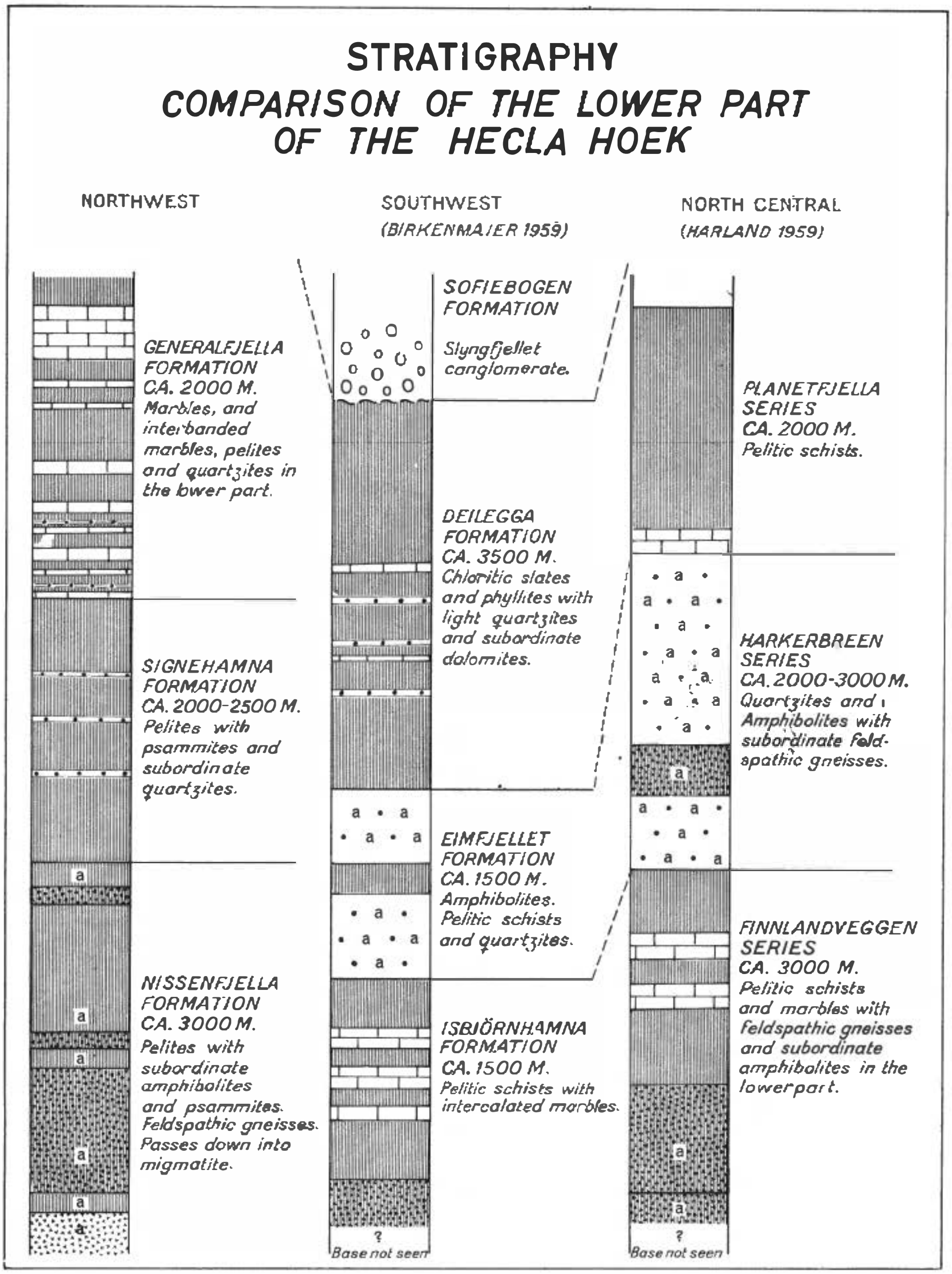


Fig. 2. *Stratigraphy. Comparison of the lower part of the Hecla Hoek.*

In Mitrahalvøya the marbles are interbanded with pelites and quartzites and the sequence from the highest to the lowest carbonate horizon does not exceed 200 m (Scoresbyfjellet). These marbles are considered to represent either a thinning of the carbonate facies westwards or to be equivalent to the lower part of the Generalfjella Formation of the type area.

Signehamna Formation

The Generalfjella Formation is underlain by a thick sequence of pelites, subordinate psammites, and conspicuous buff-brown quartzite bands. The thickness of this formation is estimated at 2000–2500 m and is most fully developed in the area south of Førstebreen, between Signehamna and the west coast. The pelites contain about fifty percent micas with variable proportions of muscovite and biotite, and subordinate garnet. Quartz is present in excess of plagioclase, and accessories include tourmaline and zircon. Interbanding of pelites and psammites, and transitional relationships between them are usual. The buff-brown quartzite bands have not been recorded to exceed 15 m in thickness, but greater thicknesses occur due to fold repetition.

Nissenfjella Formation

In the Nissenfjella area the pelites contain concordant amphibolite bands up to ca. 2 m thick. Fine interbanding of pelite and amphibolite has been recorded. Various feldspathic lithologies also occur, some having the composition and texture of granite but containing a well developed foliation or lineation. Others carry soda feldspar augen, are gneissose, and are transitional to pelite. The Nissenfjella formation passes northwards into migmatites. The estimated minimum thickness is ca. 3000 m and the base is not seen.

Migmatites

In the eastern part of the area the migmatites occur on the north side of Kongsbreen. There, they are associated with grey granodiorites, and are thrust (SIGGERUD, 1962) over the marbles of the Generalfjella Formation in the eastern limb of the Feiringfjellet antiform. Signehamna pelites occur in the core of this antiform, and these pass northwards into migmatites, the latter being cut by unfoliated granodiorites. Thus to the north of Fjortende Julibreen the migmatites occur on both sides of the marbles located in the eastern limb of the Feiringfjellet antiform. North of this location marbles either occur as bands or lenticles (marked "m" in Fig. 1) in the migmatites, in downstrike continuity into the northwest corner. Whereas in the south amphibolites are almost unknown in the marble associations (two thin garnet amphibolite bands have been recorded just below the marbles in Mitrahalvøya) they are common in the migmatites in association with the marbles of Vasahalvøya and north Albert I Land.

The migmatites usually occur with transitional contact to the metasediments. In the latter, feldspar porphyroblasts occur, and granodiorite veins meander through the schistosity. There is much variation in the composition of the metatect of the migmatites particularly adjacent to the metaster, (for migmatite terminology see the "English List" in "Symposium on Migmatite Nomenclature" edited by H. SØRENSEN, 1961). The latter include marbles, quartzites, amphibolites and pelites, the last of these being the most common. Evidence of greater mobility increases away from the metasediment contact zone. The relict metasedimentary compo-

Fig. 3. *Looking westwards towards Magdalenefjorden. Hornemantoppen in the centre*
Photo: B. LUNCKE.

sitional banding becomes more diffuse with the increased infiltration of fluid material of granite-granodiorite composition. Relicts of the lithological and structural phenomena in the metaster allow reconstruction of some of the relationships existing prior to mobilisation. However, with increasing distance from the metasediment transition zone the metatect becomes more homogenous and the metaster, with increasing assimilation, looses orientation related to earlier structure. This agmatitic migmatite passes into more homogenous gneisses of generally quartz dioritic composition. (Table 1).

Intrusive rocks

Unfoliated grey granodiorites with white plagioclase feldspar megacrysts occur in the migmatites, and show concordant and discordant relationships to the gneissosity. Granodiorites (Table 1) are intruded into the contact zone between the migmatites and the metasediments. In the latter, marginal to the transition zone into migmatite, sheets of soda granite, aplite and pegmatite cut the schistosity in the pelites, and the folds crenulating this schistosity.

Centred on Hornemantoppen there occurs a quartz monzonite batholith, first mapped by HORNEMAN in 1906, later described by SCHETELIG (1912). This massive red "granite" pluton contrasts markedly with the adjacent migmatites into which it is discordantly intruded. The roof zone is well exposed in the northern part of the outcrop, with roof pendants of horizontally foliated migmatite in part assimilated by the quartz monzonite.

Much variety exists in the texture of the Horneman intrusion. The typical rock is coarse to medium grained with about equal proportions of potash and plagioclase feldspars. The plagioclases often show zoning from basic inner cores (And 40–50) to more acid margins (An 15–25) and are in part decomposed to epidote, muscovite and calcite. Variation in the quantities of the main minerals is given in Table 1.

As noted by HARLAND (1961) xenoliths are uncommon in this intrusion and are largely restricted to the margins. SHENK (1937) recorded an envelope of grey granite mantling the red granite. Although a grey granodiorite was located down the eastern side of the Horneman batholith, no similar rocks were recorded in the south and south-west.

In association with the Horneman intrusion quartz felspar porphyries and lamprophyres have been recorded.

Structure

The main structural relationships are illustrated in Figs. 1 and 4. Structures affecting only the crystalline rocks include folds asymmetrical to the west and in some areas overturned, and reverse faults dipping to the east. North trending fracture zones of uncertain age occur, and a major dextral strike slip fault has been inferred to account for the incompatibility of lithology and structure on each side of Førstebreen.

The micaceous rocks in the area exhibit a schistosity parallel to the compositional banding of the metasediments. In the Krossfjorden area this schistosity has been recorded paralleling the axial surfaces of small isoclinal cylindrical folds, (referred to as F1). This schistosity is folded and crenulated by ubiquitous small tight similar folds (with limb separation of ca. 20–60°) (F2), occurring with the formation of a conspicuous crenulation lineation. It is followed by boudinage. The axial surfaces of the latter minor folds are themselves folded by major antiforms and synforms (F3). These folds are cut by reverse faults dipping to the east at moderate to low angles.

Measurements of the schistosity and the gneissosity are presented diagramatically in Fig. 5. In the western belt of crystalline rocks, folds plunge to the south in all areas except to the west of Monacobreen (Fig. 5F). In general the different folds (F1, F2, F3) are approximately homoaxial (S.S.E.). However, within the non-

Table 1. *Mineral compositions of quartz monzonites, granodiorites and quartz diorite gneisses from Albert I Land.*

Mineral	Horneman quartz monzonite 7 specimens		Mainly granodiorites 21 specimens		Mainly quartz diorite gneisses 23 specimens	
	variation	mean	variation	mean	variation	mean
Quartz	26–37	*32*	27–39	*32*	20–46	*31*
Potash feldspar	15–41	*27*	6–40	*25*	1–35	*11*
Plagioclase	19–32	*26*	20–49	*31*	13–54	*33*
An content of plagioclase	12–35*	*28*	6–33	*27*	11–69	*28*
Muscovite	2– 8	*4*	0–10	*3*	1–13	*3*
Biotite	1– 8	*5*	1–12	*6*	2–38	*17*
Chlorite	0– 3	*1*	0– 2	*0*	0– 5	*0*
Epidote/clinozoisite	0– 6	*2*	0– 2	*0*	0	*0*
Amphibole	0	*0*	0	*0*	0–10	*0*

All numbers except the An content of the plagioclases are volume percentages obtained by counting thin sections (each ca. 1000 points). The relatively coarse grained quartz monzonites were also point counted in hand specimen (ca. 1000 points over an area of ca. 200 cm^2).

* Most of the plagioclases in the quartz monzonites are zoned. The figure quoted is an estimate of the average An content.

agmatitic migmatitic gneisses of the north some systematic non-homoaxial refolding of early isoclinal folds has been recorded (Fig. 5A).

Structures recorded in the metaster of the migmatites include folds reminiscent of the F2 in the metasediments, and boudinage phenomena. If this fold identification is correct the migmatisation occurred at least in part after F2 folding. Whereas in the metasediments the F2 folds were followed by refolding into more open structures (F3) and cut by brittle structures, in the migmatite areas more mobile conditions existed with the migmatites immersing the older structures (including F2) and themselves being refolded and thrust westwards over the metasediments. Thus relative movement throughout the area, with the possible exception of Danskøya, appears to be towards the west.

An account of the deformation affecting the non-metamorphosed sediments has been presented in Gee and Moody-Stuart (1965). In this connection it is of interest to note the record of Gjelsvik (personal communication) that, east of Monacobreen, a wedge of metamorphic rocks occurs thrust into the Red Bay Series. Taken in relation to the pre-Red Bay Series derformation of the Siktefjellet group, it is clear that the instability at the end of the main Caledonian orogeny continued into the Gedinnian prior to the more stable conditions during the Siegenian, Eifelian and Givetian (Friend 1961), and the pre-Culm Svalbardian folding (Vogt 1936).

Metamorphism

The highest grade of metamorphism of the metasediments occurred with the formation of the dominant schistosity. At this time garnet crystallised throughout most of the area in the pelites and amphibolites, and only in the highest part

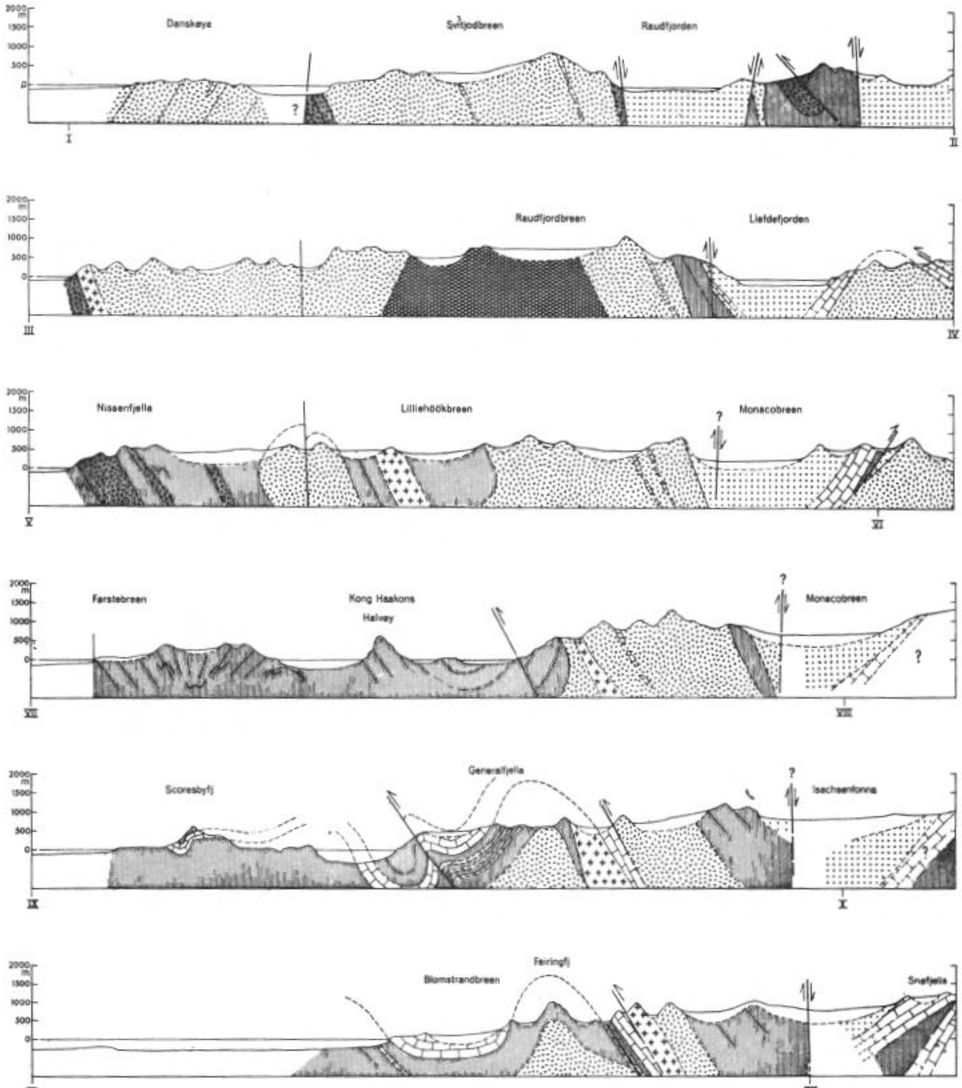


Fig. 4. *Diagrammatic east-west sections through northwest Spitsbergen. The area of Snøfjella from* PRESTON (1959). *See Fig. 1 for ornamentation.*

of the succession in Mitrahalvøya do the pelites contain biotite and muscovite alone. This decrease in metamorphic grade occurs along with a decrease in grainsize.

Folding (F2) of the schistosity is accompanied by retrogression of garnet to biotite and chlorite in the Krossfjorden area, and recrystallisation of the micas mimetically in the crenulations. Insufficient petrological work has been completed to establish the relationship between this crystallisation and the migmatisation, but on the basis of the structural data the two appear to be related in time; post-F2 mimetic crystallisation of the micas occuring with the migmatisation of the deeper structural levels, and assimilation of F2 folds into the metaster of the migmatites. In the migmatic gneisses sillimanite has been recorded from Danskøya and from east of Magdalenafjorden.

Time of metamorphism

Prior to HOLTEDAHL the migmatitic terraines of northwest Spitsbergen were ascribed to an Archaean basement on which the Hecla Hoek sediments were deposited. HOLTEDAHL reinterpreted the area as a belt of Caledonian mobilisation and intrusion and tentatively correlated the Blomstandhalvøya marbles and the Liefdefjorden marbles with the Ordovician Tetradium Limestone of Bear Island. HARLAND (1961) noted the close comparability between the Lower Hecla Hoek of Ny Friesland and the metasediments of northwest Spitsbergen, and on the basis of this considered them to be Pre-Cambrian.

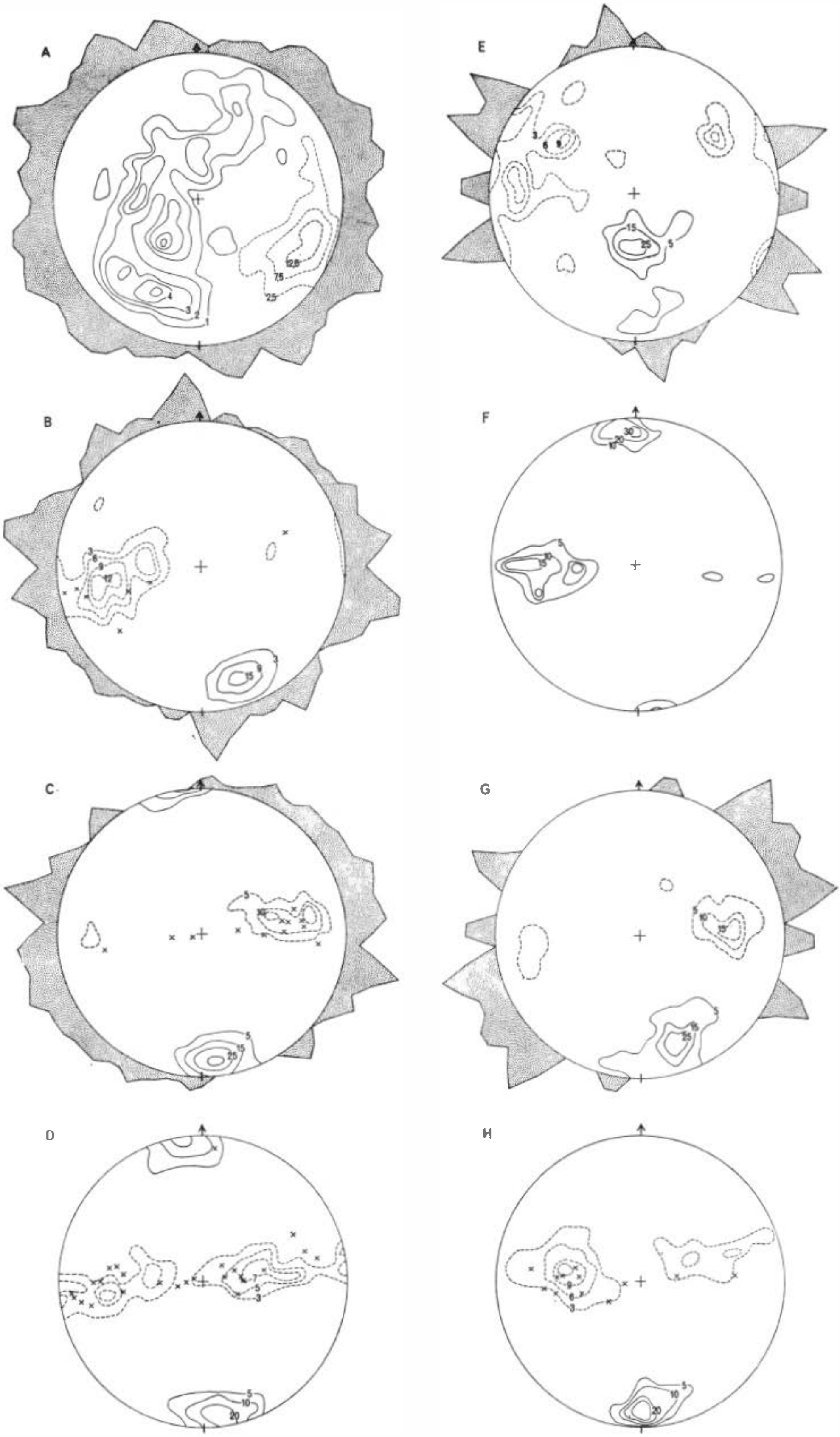
Successions established in Ny Friesland (HARLAND and WILSON 1956), Hornsund (BIRKENMAJER 1959) and northeast Greenland (HALLER 1961, HALLER and KULP 1962) favour the existence of a geosynclinal sequence in this part of the Arctic containing a thick succession of late Pre-Cambrian sediments. Comparison (Fig. 2) of the lower parts of this succession in Spitsbergen gives support to the Pre-Cambrian correlation. Although it is possible that lithologies correlated with the Lower Hecla Hoek may be stratigraphically equivalent to the Lower Palaeozoic part of the Upper Hecla Hoek, differing in tectonic, metamorphic and sedimentary facies, this is considered unlikely by the present authors.

Age determinations from the area have been summarised in GAYER *et al.* (in press) and suggest that migmatisation occurred in the Caledonian. F2 folds in the Krossfjorden area are closely comparable in style, and structural and fabric relationships with the F2 folds associated with mica crystallisation in the Biskayerhuken area at ca. 430 m. y. The earlier schistosity in that area was considered by one of us (D. G. G. in GAYER *et al.*) to be possibly related to a group of age determinations at ca. 600 m. y.; an interpretation permissible only if the metasediments in the northwest corner are part of a Pre-Cambrian succession.

In relation to the possibility of this late Pre-Cambrian metamorphism (formation of the isoclinal folds (F1) and crystallisation of the dominant schistosity, during the highest grade of regional metamorphism) it is of interest to note the following data: –

1. HARLAND (1960) on the basis of unpublished work by the late C. B. WILSON, reported that in the area of Oscar II Land (south of Kongsfjorden) a hiatus exists between the rocks correlated with the Lower Hecla Hoek and those correlated with the Middle Hecla Hoek.

2. WILSON (unpublished report to the Norsk Polarinstitutt, 1959), mapped a schist formation (the Comfortlessbreen Schists – Polarisbreen Group of the Upper Hecla Hoek, HARLAND 1960) to rest on different horizons of the underlying metasediments. The contact may be tectonic, the area being notable for its extensive Alpine as well as Caledonian deformation, but the possibility exists that it may mark an important stratigraphic break between the Upper and Middle Hecla Hoek.


A
B
C
D
E
F
G
H

3. HOLTEDAHL (1913) recorded rocks of tillitic type in south St. Jonsfjorden. Subsequent mapping of the area has suggested a probable unconformity between these rocks and the underlying metasediments (SIGGERUD, personal communication).

Thus from northwest Spitsbergen the scanty stratigraphical data available permits a late Pre-Cambrian age for the "early Caledonian" orogenic deformation. This question has been discussed further in relation to other age determinations of ca. 600 m. y. from Hornsund and Nordaustlandet in GAYER *et al.*

Comparison with other areas

The lower Hecla Hoek stratigraphy of south Albert I Land compares with the stratigraphical relationships existing in the area of north Haakon VII Land. The former is tabulated in Fig. 2 along with the Lower Hecla Hoek sequences in Hornsund and Ny Friesland. HARLAND and BIRKENMAJER have both and independently correlated the Finnlandveggen Group with the Isbjørnhamna Formation and the Harkerbreen Group with the Eimfjellet Formation, the amphibolite bearing lithologies overlying the dominantly calcareous and pelitic sequence. This is the inverse relationship to that found in the northwest of Spitsbergen, and the lack of evidence of inversion in that area may bear on the stratigraphic relationships suggested for the other areas. In this connection W. SMULIKOWSKI (personal communication, through K. BIRKENMAJER) has suggested that in south Spitsbergen the Eimfjellet Formation underlies the Isbjørnhamna Formation.

ATKINSON (1960), in an account of the tectonics of Prins Karls Forland, described thrust units of the Hecla Hoek with relative transport towards the southwest. This is in the opposite sense to the Alpine thrusting of Oscar II Land, immediately to the east across Forlandsundet. North of Kongsfjorden the effects of this Alpine deformation are very minor, and the structures related to Caledonian age determinations, west of the Biskayerhuken area, are directed towards the west. Thus it would appear that within the Hecla Hoek rocks of western Spitsbergen, north of Isfjorden, the Caledonian deformation was accompanied by relative movement towards the west.

Fig. 5. *Stereographic projection of foliation and fold measurements; lower hemisphere equal area plot. For location of Diagrams* A *to* H *see* Fig. 1. *Lines – fold axes and associated linear structures. Broken lines – poles to schistosity and gneissosity. Crosses – axial surfaces of minor folds. Arrows indicate magnetic north. Shaded areas – directions of approximately vertical joints. The rosettes were obtained by counting out of data about every fifth degree using ten degrees as a counter cell. Numbers on the lines – percentage of the contour interval.*

	Poles to foliation (Gneissosity schistosity)	Fold axes and associated lineations	Joints
A	173	298	367
B	54	52	105
C	61	67	73
D	77	84	–
E	29	10	19
F	23	16	–
G	50	18	21
H	98	35	–

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References

ATKINSON, D. J., 1960: Caledonian tectonics of Prins Karls Forland. *Int. Geol. Congr.* Rep. XXI Session. Part XIX, 17–27. Copenhagen.

BIRKENMAJER, K., 1959: Report on the geological investigations of the Hornsund area, Vestspitsbergen, in 1958. Part I. The Hecla Hoek Formation. *Bull. Acad. Polon. Sci.* Ser. des Sci. Chim. Géol. et Géogr. **7**, (2), 129–136. Krakow.

BLOMSTRAND, C. W., 1864: Geognostiska iakttagelser under en resa till Spetsbergen år 1861. *K. Sv. Vet. Akad. Handl.* **4**, (6). Stockholm.

BRYANT, D. L., 1905: *Beitrage zur Petrographie Spitzbergens.* 40 pp. Erlangen.

DRASCHE, R. VON, 1874: Petrographisch-geologische Beobachtungen an der Westkuste Spitzbergens. *Tscherm. Min. Mitt.* (3), 181–198, 261–8. Wien.

FRIEND, P. F., 1961: The Devonian Stratigraphy of North and Central Vestspitsbergen. *Proc. Yorks. Geol. Soc.* (33), 77–118. Hull.

GAIMARD, P., 1855: *Voyages en Scandinavie, en Lapponie, au Spitzberg et aux Feröe, pendant les années 1838, 1839, et 1840 sur la corvette La Recherche.* Observations géologiques sur la Scandinavie et le Spitzberg, par M. J. DUROCHER. Livraison 29c., 469–478. Paris.

GAYER, R. A., GEE, D. G., HARLAND, W. B., MILLER, J. A., SPALL, H. R., WALLIS, R. H., WINSNES, T. S., 1966: Radiometric age determinations on rocks from Spitsbergen. *Norsk Polarinst. Skr.* Nr. 137. Oslo.

GEE, D. G., 1965: A note on the occurrence of ecologite in Spitsbergen. *Norsk Polarinst. Årbok 1964.* Oslo.

— and M. MOODY-STUART, 1965: The base of the Old Red Sandstone in central north Haakon VII Land, Spitsbergen. *Norsk Polarinst. Årbok 1964.* Oslo.

Geological Society Phanerozoic Time-Scale, 1964. A symposium edited by HARLAND, W. B., A. GILBERT SMITH, and B. WILCOCK. *Quart. J. Geol. Soc. London.* 458 pp. London.

HALLER, J., 1961: Account of Caledonian orogeny in Greenland. *Geol. of Arctic.* **1**, 170–187. Univ. of Toronto Press. Toronto.

— and J. L. KULP, 1962: Absolute Age Determinations in East Greenland. *Medd. Grønland* Nr. 171, (1), 1–77. Copenhagen.

HARLAND, W. B., 1959: The Caledonian sequence in Ny Friesland, Spitsbergen. *Quart. J. Geol. Soc. Lond.* **114** (for 1958), (3), 307–42.

— 1960: The Development of Hecla Hoek rocks in Spitsbergen. *Int. Geol. Congr.* Rep. XXI Session. Part XIX, 7–16. Copenhagen.

— 1961: An Outline Structural History of Spitsbergen. *Geol. of Arctic.* **1**, 68–132. Univ. of Toronto Press. Toronto.

HARLAND, W. B. and C. B. WILSON, 1965: The Hecla Hoek succession in Ny Friesland, Spitsbergen. *Geol. Mag.* **93**, 265–86, Hertford.

HOLTEDAHL, O., 1926: Notes on the Geology of Northwestern Spitsbergen. *Result. av Statsunderst. Spitsbergeneksp.* **1**, (8), 1–28. Oslo.

HOEL, A., 1914: Exploration du Nord-ouest du Spitsberg (Mission Isachsen) .*Res. des campagnes scient. du Prince de Monaco.* **XLII**, (III). Géologie. Monaco.

NORDENSKIÖLD, A. E., 1866: Utkast till Spetsbergens geologi. *K. Sv. Vet. Akad. Handl.* **6**, (7), 35. Stockholm.

ORVIN, A. K., 1934: Geology of the Kings Bay region, Spitsbergen; with special reference to the coal deposits. *Skr. Svalb. og Ishavet.* Nr. 57, 1–195. Oslo.

— 1940: Outline of the geological history of Spitsbergen. *Skr. Svalb. og Ishavet.* Nr. 78, 1–57. Oslo.

PRESTON, J., 1959: The geology of the Snøfjella and Dovrefjella in Vestspitsbergen. *Geol. Mag.* **96**, 45–57. Hertford.

SCHENK, E., 1937: Kristallin und Devon im nordlichen Spitzbergen. *Geol. Rdsch.* **28**, 112–24. Stuttgart.

SCHETELIG, J., 1912: Exploration du Nord-Ouest du Spitsberg (Mission Isachsen). *Res. des campagnes scient. du Prince de Monaco.* **XLIII**, (IV), Les Formations Primitives. Monaco.

SCORESBY, W., 1820: *An account of the arctic regions.* Vol. I: Chronological list of voyages. Vol. II: Account of whale fishing. Edinburgh.

SIGGERUD, T., 1963: On the marble-beds at Blomstrandhalvøya in Kongsfjorden. *Norsk Polarinst. Årbok 1962.* 44–49. Oslo.

SØRENSEN, H., ed. 1961: Symposium on Migmatite Nomenclature. *Int. Geol. Congr.* Rep. XXI Session. Part XXVI, Suppl. vol. Copenhagen.

VOGT, T., 1936: Orogenesis in the region of Palaeozoic folding of Scandinavia and Spitsbergen. *Int. Geol. Congr.* Rep. XVI Session. Part 2, 953–5.

Folding, faulting and dolerite intrusions in the Mesozoic rocks of the fault zone of central Spitsbergen

BY

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Abstract

The sedimentary succession and the tectonic structure of the southern continuation of the Wijdefjorden–Billefjorden fault line, south of Sassenfjorden, Vestspitsbergen, are described. Three periods of post Palaeozoic movement are recognised along the fault line in this area: Middle Triassic; late Jurassic–early Cretaceous; and post Eocene. Stratigraphical evidence for the age of the Isfjorden dolerites as post Upper Jurassic and pre-Cretaceous is given and this is discussed briefly in relation to the new radiometric age determinations and to the occurrence of the dolerites elsewhere in the Barents Shelf.

Introduction

The area to be discussed in this paper is a linear belt of country some 10 kilometres in width and trending slightly east of south from Flowerdalen, on the south side of Sassenfjorden, to Kjellströmdalen (Fig. 1). The structures developed in the Mesozoic and Tertiary rocks of this area are related to the southern continuation of the Wijdefjorden–Billefjorden fault line (ORVIN 1940, MCWHAE 1953), this fault line being a prominent structural feature of Spitsbergen and having had an important pre-Mesozoic history.

The fault in Flowerdalen has been recorded by several authors and HAGERMAN (1925) has given details of the structures seen in Kjellströmdalen. However, it was not until the publication of ORVIN's account of the geology of Spitsbergen (1940) that a comprehensive description, together with cross-sections, of the fault line south of Sassenfjorden was given. Reference must also be made to Norsk Polarinstitutt 1:100,000 geological map of Adventdalen and its forthcoming accompanying memoir. I am indebted to Mr. H. MAJOR of Norsk Polarinstitutt for a copy of the stratigraphical legend to this map which was kindly sent in advance of the map's publication.

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Work by the Cambridge Spitsbergen Expeditions in the area began in 1962 in Flowerdalen and during the summers of 1963 and 1964 was extended south to Kjellströmdalen. These investigations have resulted in new stratigraphical evidence as to the age of the Spitsbergen dolerites and were thought to be of sufficient interest to be published in advance of the more detailed stratigraphical and structural study now in progress. A general account of the stratigraphy of the area is given and the dolerites are discussed in relation to the post Palaeozoic structural history of the fault line; for recent radiometric age determinations on these dolerites, reference should be made to GAYER *et al.* (1966).

I should like to express my thanks to the following: Shell International Petroleum Company Ltd. for the award of a Research Studentship; M. L. SAUGY of Compagnie d'Exploration Pétrolière for logistic support during the 1964 season; members of the Cambridge Spitsbergen Expeditions for assistance and discussion both in the field and at Cambridge; Mr. W. B. HARLAND for his organisation of the Cambridge Spitsbergen Expeditions and for his help and advice during the course of this study.

Sedimentary succession

Permian. Palaeozoic rocks are only seen in the north of the area, outcropping as a narrow strip along the coast of Sassenfjorden eastwards from the Flowerdalen fault. Some 300 m of cherts with subsidiary sandstones and shales are exposed and, together with the *Spirifer* limestone at the base, these form the Tempelfjorden group of the Adventdalen geological map. The Tempelfjorden group is equivalent to the Brachiopod Cherts of preious authors and is of Middle Permian age (GOBBETT 1964).

Triassic. The Triassic stratigraphy of Svalbard has recently been reviewed by BUCHAN *et al.* (1965). The new lithostratigraphical divisions of the Triassic as proposed in that paper are given below, together with brief lithological descriptions and approximate thicknesses for the Sassenfjorden area.

Kapp Toscana formation
- De Geerdalen member
- Tschermakfjellet member

Sassendalen group
- Botneheia formation
- Sticky Keep formation
- Vardebukta formation

Vardebukta formation: flaggy sandstones with interbedded shales and siltstones; Lower Scythian in age and equivalent to the "Alteren Eotrias" of FREBOLD (1939). Thickness 115 m.

Sticky Keep formation: dark grey shales and siltstones with hard yellow weathering siltstone bands; Upper Scythian in age and equivalent to the *Posidonomya* layers of NATHORST (1910). Thickness 120 m.

Botneheia formation: cliff forming bituminous shales with large yellow weathering calcareous nodules; Anisian and possibly Ladinian in age and in part equivalent to the *Daonella* layers of WIMAN (1910). Thickness 130–160 m.

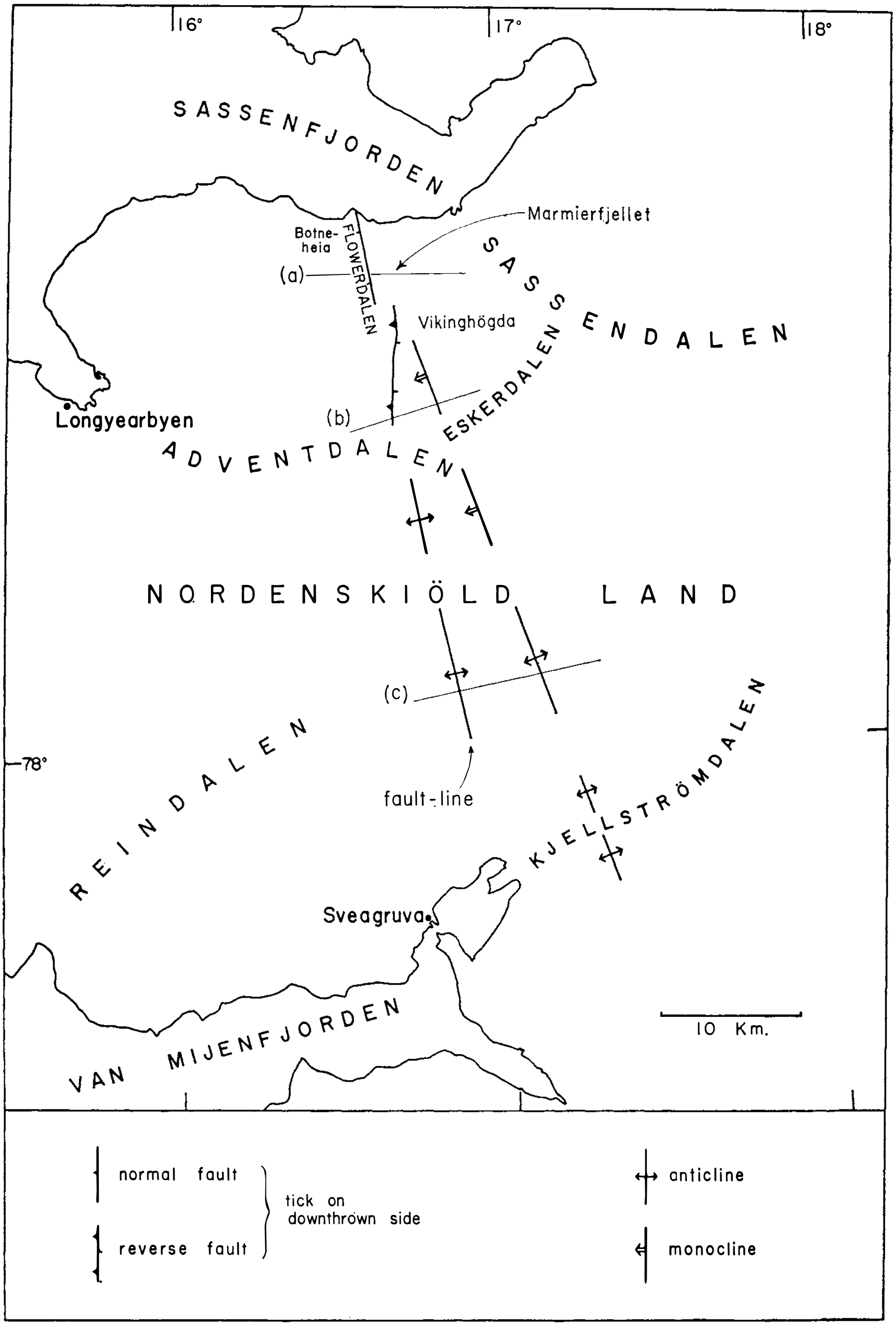

Fig. 1. *Map showing location of structures and of the cross sections.* (Fig. 2).

Kapp Toscana formation, Tschermakfjellet member: shales with small red weathering clay ironstone nodules, occuring above the main *Daonella* shale escarpment; Ladinian and possibly Carnian in age. Thickness 65–90 m.

Kapp Toscana formation, De Geerdalen member: non-marine flaggy crossbedded plant-bearing sandstones with interbedded sandy shales; age uncertain, probably Carnian to Liassic. Thickness 250 m.

The Kongressfjellet formation, as shown on the Adventdalen geological map, is equivalent to the Sticky Keep formation, the Botneheia formation and the lower part of the Tschermakfjellet member of the Kapp Toscana formation (see discussion in Buchan *et al.* 1965).

Jurassic–Cretaceous. The following lithostratigraphical scheme for the Jurassic–Cretaceous strata is based on the three formations given on the Adventdalen geological map (Janusfjellet formation, Helvetiafjellet formation and Carolinefjellet formation) together with the divisions established by Hagerman (1925: Festningen sandstone, Shore sandstone, Lower Lamina sandstone, Cretaceous shale and Upper Lamina sandstone).

Carolinefjellet formation	Upper Lamina sandstone Cretaceous shale Lower Lamina sandstone
Helvetiafjellet formation	Shore sandstone Festningen sandstone
Janusfjellet formation	Upper Janusfjellet formation Lower Janusfjellet formation with 'Lias' conglomerate at base

The upper part of the Kapp Toscana formation (see above) may be of Liassic age but in the absence of any definite evidence is left within the Triassic.

The Janusfjellet formation is a predominently argillaceous succession and was formerly termed the '*Aucella* Shale' (Nathorst 1910) after the abundant occurrence in it of the bivalve *Aucella* (now called *Buchia*). It is divided into an upper and lower part on lithological characteristics as follows:

Lower Janusfjellet formation with 'Lias' conglomerate at base. A thin conglomerate (1–3 m) is found throughout Spitsbergen at the base of the Janusfjellet formation. Although marking the Bathonian-Callovian transgression the conglomerate is, in places, a condensed and remanie deposit, phosphatic nodules in it containing fossils of Middle and Upper Toarcian age. Above the conglomerate is a series of dark grey shales with interbedded brown and yellow weathering siltstones, uppermost Bathonian – lowermost Callovian to Lower Volgian in age. The top is marked by a band of red weathering siltstone containing abundant crushed *Dorsoplanites* spp. The thickness of these shales in the upper Adventdalen area is 200 m.

Upper Janusfjellet formation. Above the Upper Volgian non-sequence is a series of grey shales and siltstones with red-brown weathering calcareous siltstone nodules, of Valanginian age. The thickness is 200 m, the top 50 m being a more arenaceous development with sandstones, siltstones and sandy shales.

The Helvetiafjellet formation consists of non-marine sandstones and carbonaceous shales of Hauterivian-Barremian age. The lower part is the massive coarse-grained quartzitic Festningen sandstone, which is some 20–25 m thick in the area under discussion. This is overlain by the Shore Sandstone, a complex of plant-bearing sandstones, shales, ironstones and coals, 70–85 m thick.

The Carolinefjellet formation marks a return to marine conditions but is poorly fossiliferous. The divisions are as follows:

Lower Lamina sandstone: flaggy fine grained grey-brown sandstones with interbedded shales. Thickness in the Kjellströmdalen area is 120 m.

Cretaceous shale: dark grey shales with orange weathering siltstone bands and nodules and occasional sandy developments. Fossils from near the base of this unit indicate an Upper Aptian age. Thickness 420 m.

Upper Lamina sandstone: very similar lithologically to the Lower Lamina sandstone. Some 200 m are exposed and the unit is overlain unconformably by the Tertiary. Fossils from the base of the unit indicate a Lower Albian age.

Tertiary. Tertiary rocks are only seen in the south of the area where the Firkanten formation (Lower Light sandstone of NATHORST 1910) of probable Palaeocene age overlies the Cretaceous with slight angular unconformity.

Dolerite intrusions

Although found throughout much of Spitsbergen, dolerite sills occur principally in the three following areas:

Hinlopenstretet
Storfjorden
Isfjorden

Around Hinlopenstretet the sills intrude Carboniferous, Permian and Triassic rocks, while in the Storfjorden and Isfjorden regions they are confined mainly to rocks of Triassic age. The distribution of dolerites in these areas has been related by BACKLUND (1921) and SANDFORD (1926) to a system of deep seated fractures.

The literature referring to the Spitsbergen dolerites has been summarised by TYRRELL and SANDFORD (1933), ORVIN (1940) and HARLAND (1961). On the evidence available TYRRELL and SANDFORD postulated a late Jurassic-early Cretaceous age for the dolerites whereas both ORVIN and HARLAND argued for a late Cretaceous or Laramide age.

The dolerites are known to intrude sediments of Upper Jurassic age (lower part of the Janusfjellet formation) at Agardhbukta, Storfjorden (GRIPP 1929) and in Torell Land (ROZYCKI 1959), but there are no records of dolerites intruding Cretaceous or younger rocks. Evidence will be given below for a pre-Cretaceous age for the dolerites of the Isfjorden area and although no effusive equivalents are known from Isfjorden, this age is consistent with DE GEER's report (1923) of basaltic lavas overlain by unbaked Lower Cretaceous sediments on Wilhelmøya, Hinlopenstretet.

Further east the dolerites and basalts may be of younger age. There is evidence from Kong Karls Land of at least two eruptions (NATHORST 1910). Although the main basalt flows there overlie strata of Valanginian age and are interbedded with continental deposits similar to the Helvetiafjellet formation of Spitsbergen, the presence of dolerite fragments in the sediments below the lavas would suggest a previous, possibly late Jurassic–early Cretaceous, phase of eruption or sill emplacement. In Franz Josef Land, dolerite sills are intruded into the Lower Volgian (PIROZHNIKOV 1958) but the lavas are again interbedded with continental deposits (POMPECKJ 1900).

Structure

The major structures in the Mesozoic and Tertiary rocks overlying the southern continuation of the Billefjorden fault line in Nordenskiöld Land are of Tertiary age and form two distinct lines, one over the fault line and the other to the east of the fault line and diverging from it southwards (Fig. 1). In the north of the area eastwards directed thrusts are developed over the fault line and westward facing monoclines along the line to the east. Both pass into anticlines further south and a syncline separates the two lines of structures. The structures over the fault line die out south of Reindalen but the structures to the east are seen in Kjellströmdalen and may continue to Kvalvågen. The structures appear to have been superimposed on the westward regional dip (east side of the Tertiary basin) without any net displacement of either downthrow to the east or to the west along the fault line.

A noticeable feature of the cross sections of the northern part of the area (Figs. 2a and 2b) is the thinning and disappearance of the lower part of the Janusfjellet formation and of the Kapp Toscana formation across the eastern line of structures. If the effect of the Tertiary movements is removed from these cross sections, this variation is seen to be due to the presence of a pre-Cretaceous anticlinal flexure along the eastern line of structures. This is shown in Figs. 3a and 3b which are the cross sections of Figs. 2a and 2b replotted with the base of the Festningen sandstone as a horizontal datum and thus represent the attitude of the strata at the end of the Valanginian. This anticlinal structure dies out southwards along the plunge and cannot be traced south of Adventdalen. It involves strata up to and including the Upper Jurassic part of the Janusfjellet formation but had been eroded before the deposition of the Cretaceous part of the Janusfjellet formation which overlies progressively older rocks when traced north from Adventdalen, resting on the Triassic Botneheia formation on Marmierfjellet. The anticline apparently persisted in places as a partially levelled submarine feature where the more resistant Upper Triassic sandstones had not been breached (see Fig. 3b). The period of movement and erosion thus corresponds to the Upper Volgian non-sequence found over the rest of Spitsbergen. In the northern part of the area, where the western limb of the structure coincided with the fault line, some movement with downthrow to the west occurred on the fault (see Fig. 3a).

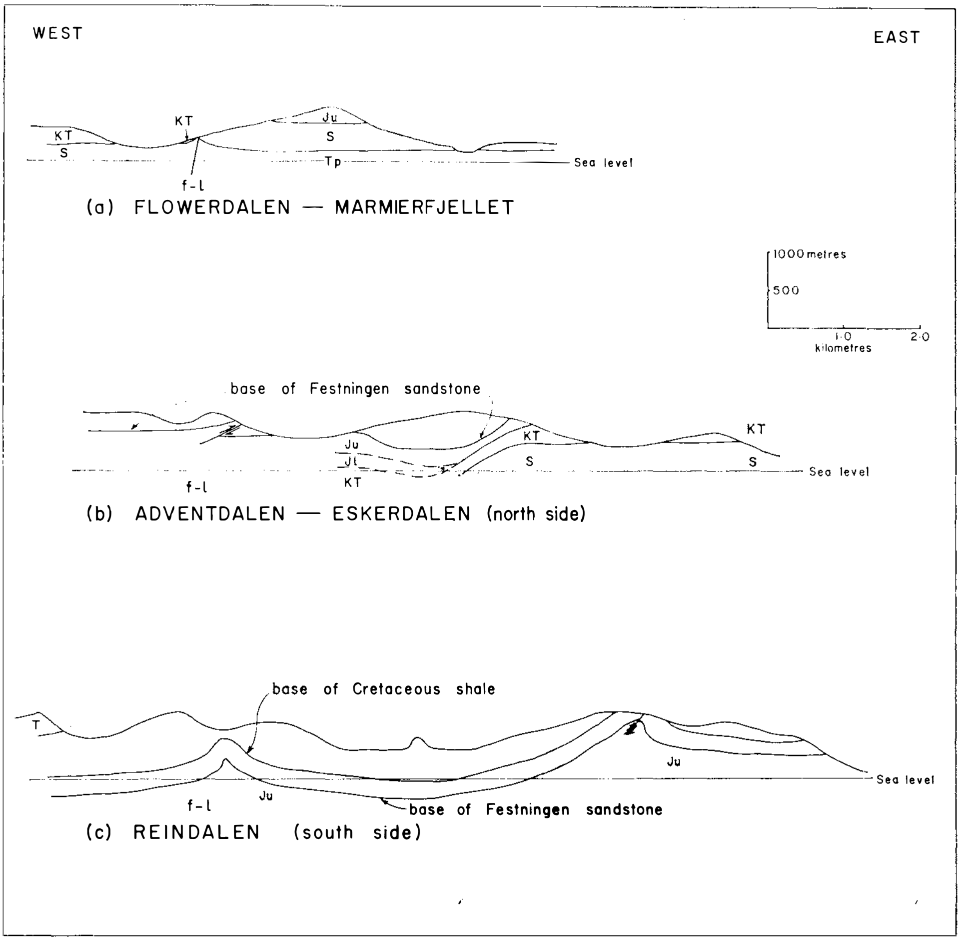

Fig. 2. *Cross sections of the area.*

Abbreviations:		*KT*	– *Kapp Toscana Formation*
T	– *Tertiary*	*S*	– *Sassendalen group*
Ju	– *Upper part of the Janusfjellet formation*	*Tp*	– *Tempelfjorden group*
Jl	– *Lower part of the Janusfjellet formation*	*f-l*	– *fault line*

Further south, where the structure had diverged from the fault line and was dying out, there was apparently no movement on the fault (see Fig. 3b).

Tectonic history

In the Wijdefjorden–Billefjorden area to the north, the fault line is known to have been active throughout much of Palaeozoic time (McWhae 1953, Harland 1961) and the three periods of post-Palaeozoic movement which have been recognised in the area under discussion appear to continue this activity.

Middle Triassic. Movement along the fault line with downthrow to the east is suggested at this time by an increase in thickness of some 55 m in the Botneheia formation and the Tschermakfjellet member of the Kapp Toscana formation eastwards

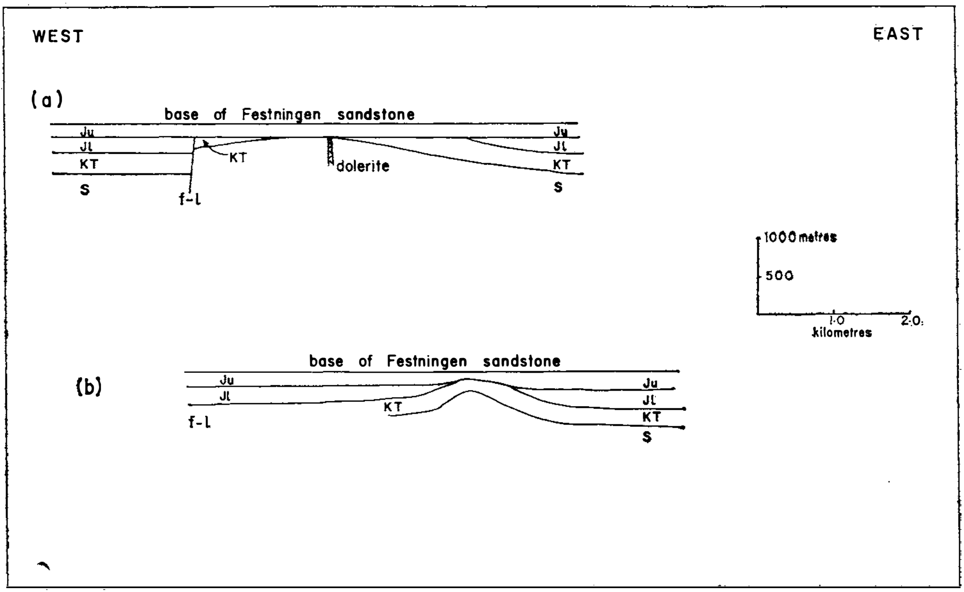

Fig. 3. *Pre-Tertiary structure of the area. For explanation see text. Abbreviations as for* Fig. 2. *The dolerite in section 3a is shown diagrammatically only.*

across the fault line from Botneheia to Vikinghøgda (see Fig. 1). This movement was most probably the result of flexuring in the underlying Palaeozoic rocks.

Uppermost Jurassic–lowermost Cretaceous. The presence of a post Upper Jurassic–pre-Cretaceous structure has already been noted above and this period of movement is related to the intrusion of the dolerites. On Marmierfjellet, the Triassic Botneheia formation, which forms the centre of the eroded pre-Cretaceous structure, is overlain unconformably by the Valanginian shales of the upper part of the Janusfjellet formation. Dyke-like bodies of dolerite, intrusive into the Triassic shales, terminate against the line of the unconformity and are nowhere seen to cross the unconformity to intrude the Cretaceous. Immediately beneath the unconformity the dolerite is very weathered and the Cretaceous shales appear to overlie these truncated dolerites. The evidence thus suggests a pre-Valanginian age for the dolerites of the Isfjorden area. The radiometric age determinations on the dolerites, as given in Gayer *et al.* (1966), are consistent with a stratigraphical age for the dolerites of post Lower Volgian (see above) and pre-Valanginian.

Tertiary. The Tertiary structures, described above, are of post Eocene age (Orvin 1940) and their formation is probably directly related to an east–west compression originating in the west coast Tertiary deformation belt, and assisted by limited décollement in the shales of the Janusfjellet formation. The particular localization of the Tertiary deformation in the area would be accounted for by the continued activity along the Palaeozoic fault line, by sedimentary irregularities in the strata below the upper Janusfjellet formation resulting from this activity and from the presence of the eroded pre-Cretaceous anticline, and possibly also by the regional thinning of the whole Janusfjellet formation eastwards out of the central basin (see de Sitter 1956, p. 240, 319).

References

BACKLUND, H., 1921: Tektonik och Isostasi på Spetsbergen. *Geol. För. Stockh. Forh.* **43**, 397–402. Stockholm.

BUCHAN, S. H., A. CHALLINOR, W. B. HARLAND and J. R. PARKER, 1965: The Triassic stratigraphy of Svalbard. *Norsk Polarinst. Skr.* Nr. 135. Oslo.

FREBOLD, H., 1939: Das Festungsprofil auf Spitzbergen: V, Stratigraphie und Invertebraten fauna der älteren Eotrias, nebst Beschreibung anderer Vorkommen in Spitzbergen. *Svalb. og Ishavet Skr.* Nr. 77, 1–58. Oslo.

GAYER, R. A., D. G. GEE, W. B. HARLAND, J. A. MILLER, H. R. SPALL, R. H. WALLIS and T. S. WINSNES, 1966: Radiometric age determinations on rocks from Spitsbergen. *Norsk Polarinst. Skr.* Nr. 137. Oslo.

GEER DE, G., 1923: *Mission scientifique pour la mésure d'un arc de méridien au Spitsberg.* Mission suédoise; **II** (9), Topographie et géologie. Stockholm.

GOBBETT, D. J., 1964: Carboniferous and Permian Brachiopods of Svalbard. *Norsk Polarinst. Skr.* Nr. 127. 1–201. Oslo.

GRIPP, K., 1929: Glaziologische und geologische Ergebnisse der Hamburgischen Spitzbergen Expedition 1927. *Abh. Naturw. Hamburg.* **22**, 145–249. Hamburg.

HAGERMAN, T. H., 1925: Results of the Swedish expedition to Spitzbergen 1924: II, Stratigraphical and structural investigations within southwestern Spitzbergen. *Geogr. Annlr.* **7**, 195–221. Stockholm.

HARLAND, W. B., 1961: An outline structural history of Spitsbergen. In RAASCH, G. O. (Edit.): *Geology of the Arctic.* **1**, 68–132. Toronto.

MCWHAE, J. R. H., 1953: The major fault zone of central Vestspitsbergen. *Quart. J. geol. Soc. Lond.* **108**, 209–232. London.

NATHORST, A. G., 1910: Beiträge zur Geologie der Bären Insel, Spitzbergen und des König-Karls-Landes. *Bull. geol. Instn. Univ. Uppsala.* (10) 261–415. Uppsala.

ORVIN, A. K., 1940: Outline of the geological history of Spitsbergen. *Svalb.- og Ishavsunders. Skr.* Nr. 78, 1–57. Oslo.

PIROZHNIKOV, L. P., 1958: The Upper Jurassic rocks of the Franz Josef Archipelago. *Doklady Akad. Sci. U.S.S.R.* **122**, 462–4. Moscow.

POMPECKJ, J. F., 1900: The Jurassic fauna of Cape Flora, Franz Josef Land. *Norw. North Polar Exped. 1892–96.* Sci. Res. No. 1. Kristiania.

ROZYCKI, S. Z., 1959: Geology of the north-western part of Torell Land, Vestspitsbergen. *Studia geol. polon.* **2**, 1–98. Warsaw.

SANDFORD, K. S., 1926: The geology of North-East Land (Spitsbergen). *Quart. J. geol. Soc. Lond.* **82**, 615–68. London.

SITTER DE, L. U., 1956: *Structural Geology.* McGraw-Hill. 1–552. New York.

TYRELL, G. W. and K. S. SANDFORD, 1933: Geology and petrology of the dolerites of Spitsbergen. *Proc. R. Soc. Edin.* **53**, (3), 284–312. Edinburgh.

WIMAN, C., 1910: Ein paar Labyrinthodontenreste aus der Trias Spitzbergens. *Bull. geol. Instn. Univ. Uppsala.* **9**, 34–40. Uppsala.

The base of the Old Red Sandstone in central north Haakon VII Land, Vestspitsbergen

BY

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Abstract

A sequence of green sandstones and mixed boulder conglomerates outcropping on Siktefjellet is described, overlying the metamorphic rocks in the North Liefdefjorden area. The name Siktefjellet Group is proposed for these rocks. They are overlain unconformably by a conglomerate (containing predominantly marble boulders) which passes up into the sandstones of the Red Bay Series. These are known to contain Downtonian (Gedinnian) vertebrates.

South of Liefdefjorden further outcrops of the Siktefjellet Group are described in the western fault belt of the main Devonian graben. They also occur farther west, thrust over the schists and marbles of the Bockfjorden antiform.

The age of the Siktefjellet Group is discussed.

Introduction

Comprehensive summaries of previous work on the Red Bay Series are given in FØYN and HEINTZ (1943) and FRIEND (1961). Only those papers immediately relevant to this study are referred to here.

In 1892 NORDENSKIÖLD recorded the presence of coarse conglomerates on both sides of Raudfjorden (Konglomeratodden and Rivieratoppen). HOLTEDAHL (1914, 1926), after more extensive reconniassance of the area, defined the Red Bay Series, and in recording its position unconformably overlying the metamorphic rocks established an upper limit to the time of metamorphism. Subsequently, the fossiliferous part of the Red Bay Series has been ascribed to the Gedinnian (HEINTZ 1937, VOGT 1938, WHITE 1956).

The conglomeratic facies at the base of the Red Bay Series was described in some detail by HOLTEDAHL (1926). He recorded two distinct types of conglomerate; the one with a red matrix, "the fragments mainly consisting of dolomites and limestones", and the other a mixed-boulder conglomerate, "to a large extent made up of granitic rocks, among others the garnet bearing varieties occurring in

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the same area". He regarded these as local facies variations at the base of the Series (HOLTEDAHL 1926, p. 23). FRIEND (1961) used the name Red Bay Conglomerate for this part of the succession. The provenance of the basal part of the Red Bay Series has been discussed by HOLTEDAHL (1926), HARLAND (1960, 1961) and FRIEND (1961), and is considered further below.

Between 1959 and 1964 the area shown in Fig. 1 was visited by members of the Cambridge Spitsbergen Expeditions under the direction of W. B. HARLAND. In the neighbourhood of Siktefjellet on the northern side of Liefdefjorden it was found that two conglomerates similar to those described by HOLTEDAHL were separated by an unconformity. The upper marble conglomerate unconformably oversteps green sandstones which pass down into a coarse mixed-boulder conglomerate resting unconformably on the metamorphic rocks of the area.

We propose that the name Red Bay Conglomerate be restricted to the marble conglomerate, and to the more variable quartz and quartzite pebble conglomerate overlying it. We propose the name Siktefjellet Group for the sandstones and conglomerates unconformably overlain by this Red Bay Conglomerate.

In Siktefjellet the Siktefjellet Group is approximately 1500 m thick; for the most part green sandstones, but with about 100 m of conglomerate at the base. Farther to the north, the sandstone thins and in Lilljeborgfjellet, where the maximum thickness of conglomerate (ca. 400 m) occurs, the sandstone is absent. The conglomerates are referred to as the "Lilljeborgfjellet Conglomerate" and the sandstones as the "Siktefjellet Sandstone". The outcrop of these facies in relation to the Red Bay Series, the metamorphic rocks, and the Wood Bay Series is illustrated in Fig. 1.

The metamorphic rocks underlying the Siktefjellet Group have been compared to the Lower Hecla Hoek (HARLAND 1960). Uncertainty in correlation of all these metamorphic rocks with the Lower Hecla Hoek of Ny Friesland, and the possible existence of pre-Hecla Hoek rocks in the area which one of us (D. G. G.) will argue elsewhere, favour the use of the term "metamorphic basement". Uncertainty of the precise age of the Siktefjellet Group means that the grouping 'pre-Downtonian rocks' may include post-Hecla Hoek as well as Hecla Hoek rocks, which was not its intention in earlier use.

The Red Bay Conglomerate

The red weathering marble conglomerate described by previous authors (in particular HOLTEDAHL 1926, p. 10 and HARLAND 1961, p. 90) extends from Konglomeratodden and Rivieratoppen in the north to the islands of Liefdefjorden. Similar conglomerates are known to exist further south, on the western side of the Bockfjorden antiform, and in the area of Snøfjella and Dovrefjella (PRESTON 1959). HARLAND (1960, 1961) described the lithologies of boulders in localities in Liefdefjorden and Raudfjorden. He commented on the frequent boulders of marble in the conglomerate overlying the Hecla Hoek marbles in the south, while pelitic schists were common in the north. He noted that "almost no pebbles were found that could not be matched closely with Lower Hecla Hoek types".

Our observations coincide with this in that the base of the Red Bay Conglomerate is a conglomerate consisting mainly of marble boulders, which passes up into a conglomerate containing more varied clasts (the vein quartz, quartz mica schist, and pink and green quartzites of HARLAND 1960). This is the case whether the Red Bay Conglomerate rests on the Hecla Hoek, as in North Raudfjorden and Liefdefjorden, or on the Siktefjellet Group as in between. The persistance of this marble boulder conglomerate is in marked contrast to its variation in thickness, as the following account of the outcrops from north to south shows.

In Konglomeratodden, on the western side of Raudfjorden, the marble boulder conglomerate (20 m) appears as a distinct unit overlying about 30 m of coarse red sandstones with conglomerate filled channels. These pass down into a migmatite bearing conglomerate with a green sandy matrix. The two together are about 100 m thick, the base being faulted. The migmatite bearing conglomerate may be a separate unit related to the Siktefjellet Group. HARLAND (1961) had noted the absence of migmatites and granites from the Red Bay Series. However, no angular discordance was noted between the sandstone and the marble boulder conglomerate.

In the northernmost exposures on the eastern side of Raudfjorden (Rivieratoppen) about 100 m of marble boulder conglomerate rest directly on Hecla Hoek pelites (HOLTEDAHL 1926). Further south on the western flank of Lilljeborgfjellet, faulted against the Lilljeborgfjellet conglomerate, two marble conglomerates occur. Each is about 15 m thick, and they are separated by about 30 m of green sandstone and red siltstones with a thin buff-white limestone band. The upper marble boulder conglomerate is overlain by nearly 200 m of coarse green and yellow sandstones and subordinate red siltstones which pass up into the vein quartz and quartzite pebble conglomerate with a red matrix, typical of the upper part of the Red Bay Conglomerate.

To the south of here, on the southeast side of Andréebreen the best exposure of the Red Bay Conglomerate resting on the Siktefjellet Group occurs. This is shown in Fig. 2. Grey and green ripplebedded Siktefjellet sandstones and shales dip at about 40° to the west. The overlying conglomerates dip at a higher angle westwards and the contact between the two is very irregular. Boulders of the Siktefjellet Group occur in the lowermost part of the dominantly marble boulder conglomerate.

In Wulffberget and southwest to the islands of Liefdefjorden, the Red Bay Conglomerates rest on the Hecla Hoek marbles comparable with those on the conglomerates (HARLAND 1961). A similar relationship exists south of the fjord.

Measurement of foreset beds in the upper part of the Red Bay Conglomerate and the overlying sandstones in the centre of Raudfjorden (Buchananhalvøya) suggested derivation from the south (10 readings, Vector mean 26°, Standard Dev. 25°, Probability level 10^{-2}). There were less definite indications that in Rabotdalen the derivation of the sandstones was more from the east, while to the west of Buchananhalvøya currents seemed to come more from the west. However, taking this in conjunction with the evidence of extensive marble boulder conglomerates at the base of the Red Bay Series resting on non-carbonate meta-

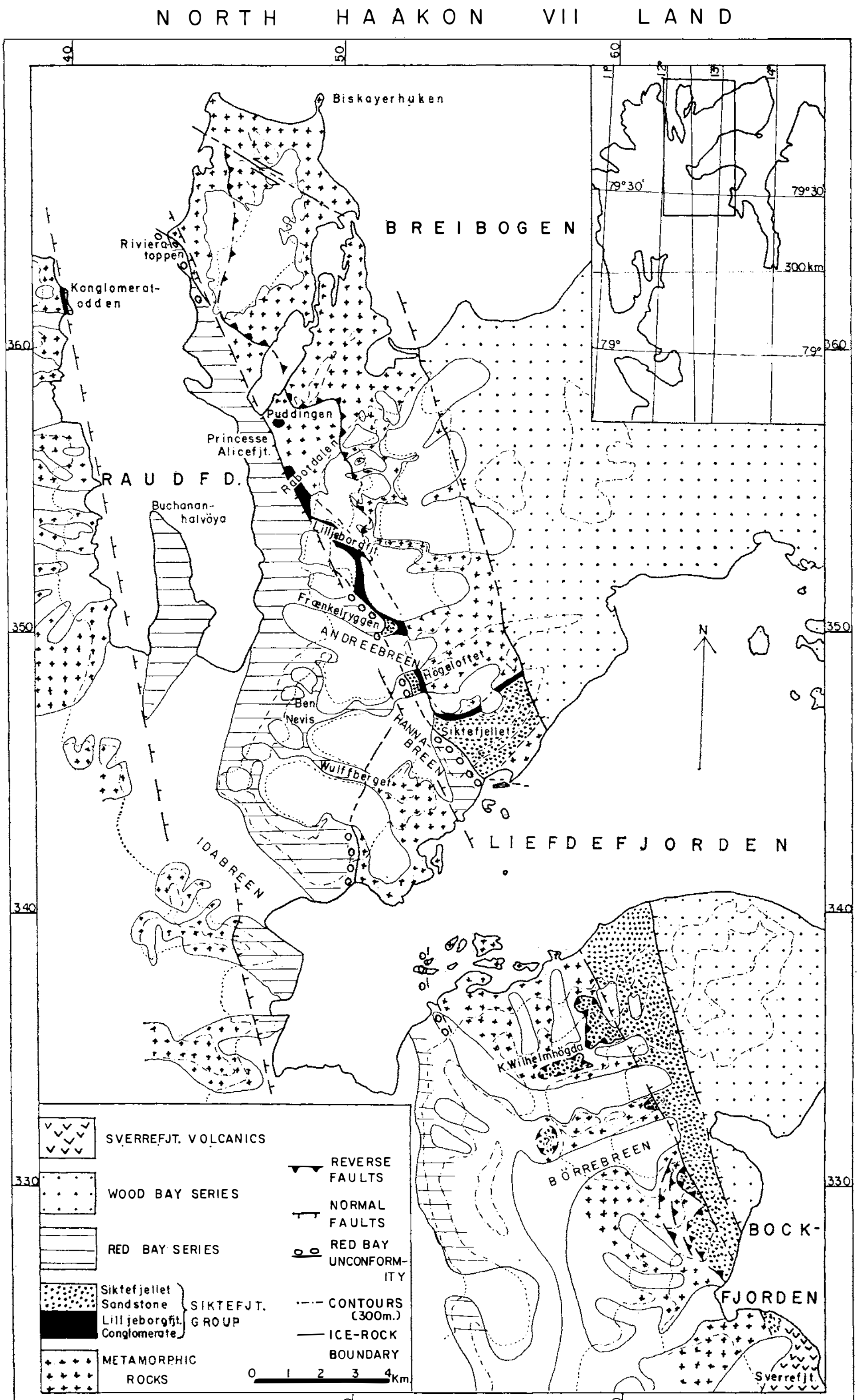

Fig. 1. *Geological map of North Haakon VII Land. Topography based on unpublished Norsk Polarinstitutt maps revised in Cambridge.*

morphic basement and the Siktefjellet Group, it is considered probable that the basal part of the Series in Raudfjorden was derived from the south where large outcrops of marble are common. The extent of the marble boulder conglomerate and the restricted quantity of truly local material in this basal facies favours low relief of the local metamorphic basement during deposition and allows extension of the depositional area east and west of the present Raudfjorden structural basin.

It is possible that a sedimentary basin or trough centred on Raudfjorden developed after the deposition of the conglomerates and during the deposition of the sandstones. Further mapping and measurement of thicknesses are required to prove this. The evidence now available consists of the current directions mentioned above, and the fact that dips in the conglomeratic facies at the base of the Red Bay Series at the eastern flank of the structural basin are steeper (ca. 70°) than those in the sandstones is east Ben Nevis.

It was HOLTEDAHL's opinion that the present distribution of the Old Red Sandstone was principally determined by very prominent faulting (HOLTEDAHL 1926, p. 27), and that deposition occurred in long narrow depressions, separated by ridges.

High angle faults occur down the western (the Raudfjorden fault) and the eastern (the Rabotdalen fault) margins of the structural basin. The latter fault is of particular interest. In the north between Puddingen and Prinsesse Alicefjellet the downthrow is to the west, a minimum of 200 m. The fault can be traced south to Fraenkelryggen where it may cross the ridge in a poorly exposed gully, but shows negligible displacement. A direct continuation southwards of the line of this fracture coincides with the northern extension of the Hannabreen fault, showing an easterly downthrow. The problem cannot be simply resolved in terms of strike and/or dip slip and is regarded here as a pivotal fault with the fulcrum in western Andréebreen.

The Siktefjellet Group

By contrast with the overlying Red Bay Series none of the rocks of the Siktefjellet Group are red in fresh or weathered outcrops. This factor more than any other accounts for our initial assumption that Siktefjellet was composed entirely of metamorphic rocks.

In Siktefjellet 1400 m of green and grey medium grained sandstone, with intercalations of quartz chip conglomerate, pass down into 100 m of coarse conglomerate in a sandy green matrix. The quartz chips in the sandstone are up to two centimetres in diameter while the boulders in the conglomerate are up to thirty centimetres across. The boulders are rounded, and are composed largely of schistose pelites and psammites comparable with the underlying metamorphic rocks. The contact of the conglomerate with the metamorphic rocks in Siktefjellet is often inaccessible. The conglomerates have been observed, undeformed, separated by two metres of scree from the underlying metamorphic rocks. To the north, in Fraenkelryggen and Rabotdalen the actual contact is well exposed.

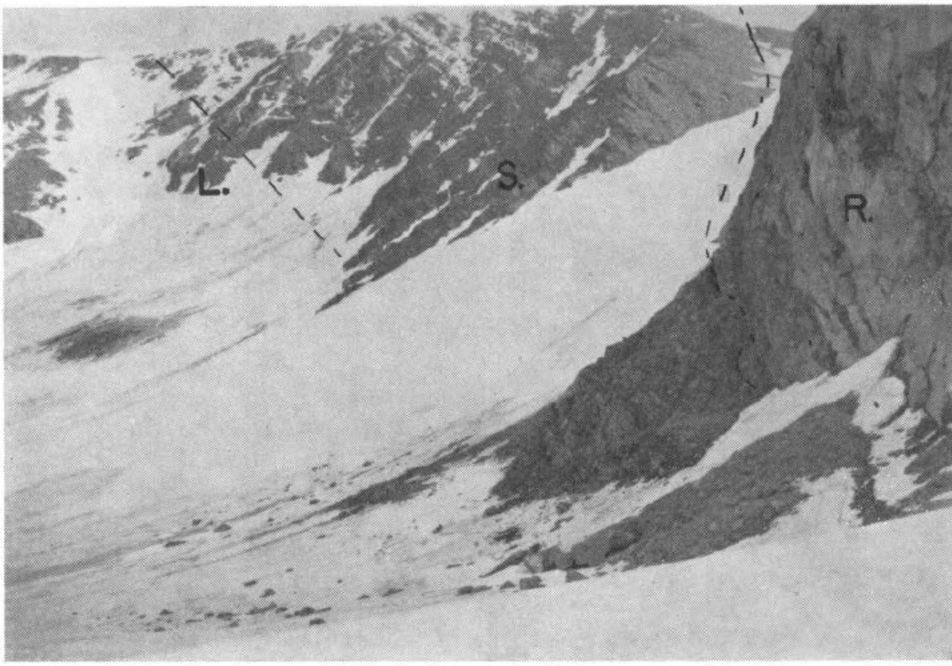

Fig. 2. *On Andréebreen, showing Red Bay Conglomerate* (R) *resting unconformably on the Siktefjellet Group* (S=*Siktefjellet Sandstone,* L=*Lilljeborgfjellet Conglomerate*).

North of Siktefjellet the thickness of both conglomerate and sandstone is considerably reduced, and on Fraenkelryggen the two together are about 100 m thick. However, the same green sandstones and conglomerates continue into North Fraenkeltoppen. Still further north about 400 m of "quartzite and mica schist conglomerates" (HOLTEDAHL 1926) are present, the basal part containing amphibolite and other metamorphic rocks represented locally in the underlying basement. The relationships are illustrated in the diagrammatic section A of Fig. 3.

In Rabotdalen, north of Lilljeborgfjellet, HOLTEDAHL (1926) recorded the presence of a coarse conglomerate lying to the northeast of the marble conglomerate. He noted that it passed down into a "zone made up of huge, often angular, pieces of the . . . basement complex." He included a photograph of these, the best exposure of the Lilljeborgfjellet Conglomerate resting on the metamorphic rocks (HOLTEDAHL 1926, pl. 2).

The contrasted composition of the marble conglomerate in Prinsesse Alicefjellet and the mixed boulder conglomerate in Puddingen was mentioned by HOLTEDAHL. Puddingen is isolated from the other unmetamorphosed rocks, and the conglomerate is accepted as a northerly extension of the Siktefjellet Group, on the basis of its location down strike of the latter and the similar heterogeneity of its clasts.

The facies variation within the Siktefjellet Group is illustrated in NNW–SSE section in Fig. 4.

In Siktefjellet the sandstones and conglomerates are folded into an anticline on

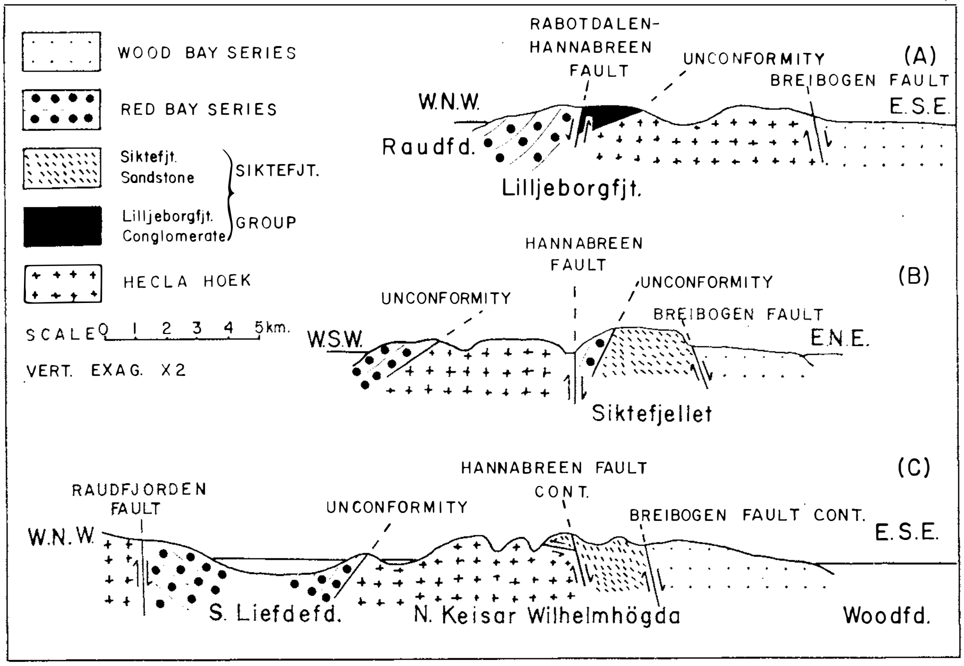

Fig. 3. *Diagrammatic sections to illustrate the relations of the Siktefjellet Group.*

an axis plunging to the southwest at ca. 20°. This fold is truncated by the Red Bay Conglomerate, and from the westerly dip of these conglomerates it is clear that the folding affecting the Siktefjellet Group, prior to the deposition of the Red Bay Series, occurred about approximately horizontal axes trending NE–SW. North of this Siktefjellet anticline, folding of the Siktefjellet Group prior to the Red Bay Series has not been demonstrated with certainty. HOLTEDAHL has drawn attention to the faulting of the Lilljeborgfjellet Conglomerate in Rabotdalen, and though it has not been possible to assess the sense of movement on the fractures, they are high angle faults and earlier than the Rabotdalen fault. The very coarse basal breccias of this area dip more steeply to the west than the corresponding lithologies to the north in Puddingen and to the south in Lilljeborgfjellet.

In the underlying metamorphic rocks reverse faults heading to the east, disrupt the metamorphic fabric. These major fractures do not appear to penetrate the conglomerates. One such reverse fault is shown on the map (Fig. 1.)

On the north side of Liefdefjorden the outcrop of the Siktefjellet Group is confined to the area between two converging faults, the Hannabreen fault and the Breibogen fault. Both downthrow to the east, the Breibogen fault bringing the Wood Bay Series against the Hecla Hoek and the Siktefjellet Group (Fig. 2, Section B).

South of Liefdefjorden the Wood Bay Series is separated from the metamorphic rocks by "grey-green sandstones and rare black shales" (FRIEND 1961). FØYN and HEINTZ (1943) tentatively ascribed these to the Red Bay Series on the basis

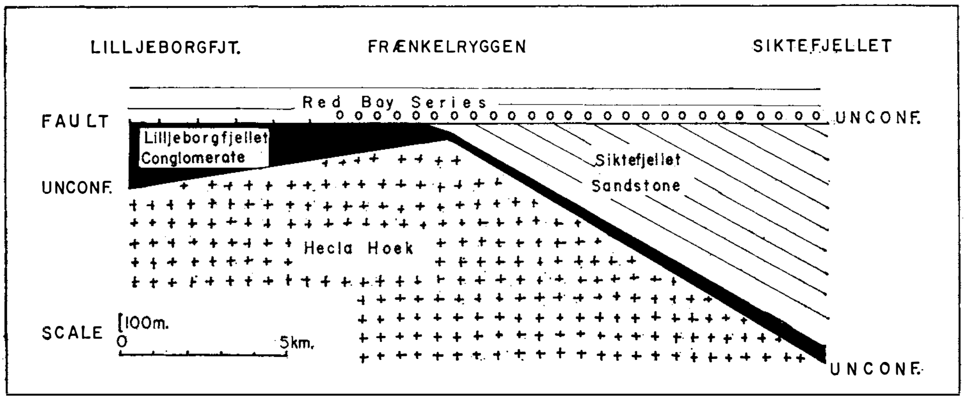

Fig. 4. *Diagrammatic N–S section to show the thickness variation in the Siktefjellet Group north of Liefdefjorden.*

of "scanty fossils". There is a strong lithological similarity between these sandstones, containing quartz chip conglomerates, and the Siktefjellet Sandstones. In the upper part of the sandstones to the south of Liefdefjorden the occurrence of rare black shales and red siltstones has not been matched with similar lithologies in Siktefjellet.

The sandstones south of the fjord are separated from the metamorphic rocks by a fault downthrowing east. This fault is convergent with the fault separating the same sandstone from the Wood Bay Series, and the outcrop of the green sandstones narrows southwards. Fig. 1 illustrates the close similarity of the converging fault pairs north and south of Liefdefjorden, and the similarity of lithological type between them. It will be noticed that there is a two kilometre sinistral displacement of these fault pairs and the Raudfjorden fault, across Liefdefjorden and Idabreen.

Minor symmetrical folds about horizontal NE–SW trending axes occur in the green sandstones between the fault pair south of Liefdefjorden. This is the same trend as in Siktefjellet. Similar structures are not found in the adjacent Wood Bay Series, and the folds are cut by the major N–S faulting.

West of the main outcrop of the green sandstones between the convergent fault pair, outcrops of similar sandstones occur as outliers on the Hecla Hoek (See Fig. 3, Section C). Their contacts with the metamorphic rocks are mylonitized and dip at a low angle to the east. Similar dislocations are found in the underlying marbles. The fractures increase in dip eastwards towards the fault pair and are truncated by the westerly of these (Fig. 5). The outliers of green sandstone contain minor folds on NE–SW trending axes.

These green sandstones are considered to be part of the Siktefjellet Group on the following grounds:

1) Similarity of lithology.
2) Similarity of location between the major N–S faults.
3) Similarity of deformation within the group.

The pair of faults converge south of Bockfjorden in the vicinity of the volcanic vent of Sverrefjellet. At this point highly deformed green sandstones, black shales, and red siltstones of the Siktefjellet Group are seen faulted against the Hecla Hoek marbles. The Siktefjellet Group is not known from south of this point. On the north side of Vonbreen at the head of Woodfjorden the basal Wood Bay Series rests conformably on fossiliferous green sandstones of Red Bay age (FØYN and HEINTZ 1943). Between this and the metamorphic rocks lies a faulted block of typical Red Bay Conglomerate. Between Woodfjorden and Bockfjorden, FRIEND (1961) described a faulted outcrop of green sandstones and conglomerates. The conglomerates contain pebbles of green sandstone as well as of marble. This outcrop is taken to be of Red Bay age. Similar fragments of green sandstone are found along with marble fragments as clasts in a conglomerate in Bockfjorden. This conglomerate (cf. FØYN and HEINTZ 1943 Fig. 7 locality (2)), is conformably overlain by rocks of known basal Wood Bay Series age.

In the exposure of Red Bay Series between Bockfjorden and Woodfjorden observations on the troughs of megaripples suggest a derivation from the south. (12 readings, Vector mean 347, Standard Dev. 10°, Probability level 10^{-3}). This agrees with current bedding readings taken on the Red Bay Series of Buchananhalvøya (Raudfjorden). It is, however, in marked contrast to the results obtained from the Siktefjellet Group south of Liefdefjorden which suggest derivation from the west-north-west. (10 readings, Vector mean 118°, Standard Dev. 18°, Probability level 10^{-2}). Local results from the Wood Bay Series along the fault suggest similar derivation from the west. (64 readings, Vector mean 59°, Standard Dev. 23°, Probability level 10^{-15}).

The age of the Siktefjellet Group

Estimates of the age of the Siktefjellet Group must be based on what is known about the deposits above and below, and on the fossil content of the Siktefjellet Group itself. This can be summarised as follows.

(1) The overlying Red Bay Series contains Downtonian (Gedinnian) vertebrates some 200 m above its base (HEINTZ 1937, VOGT 1938, WHITE 1956, FRIEND 1961). The Siktefjellet Group must therefore be Lower Gedinnian or earlier. The fact that earth movements and erosion took place after the deposition of the Siktefjellet Group and before the deposition of the Red Bay Series suggests an earlier age.

(2) No recognisable macrofossils have been found in the Siktefjellet Group. Plant spores have been extracted in the Department of Geology, Cambridge, from the beds south of Liefdefjorden. Fragments of vegetable matter have been found in Siktefjellet itself, where the grain size of the samples taken was considerably coarser. Although the spores found are well preserved, the stratigraphical control on the species found is not as yet sufficient to distinguish between a Lower Devonian or Upper Silurian age for the Siktefjellet Group, or to correlate within the Group.

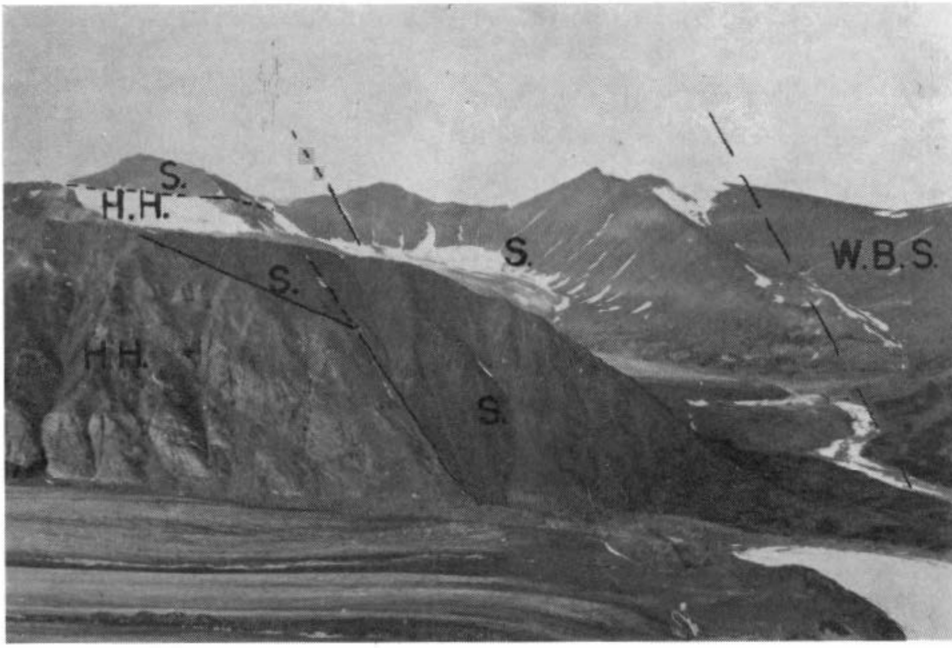

Fig. 5. *Looking north from Børrebreen. The figure shows the Siktefjellet Group* (S) *faulted against the Wood Bay Series* (W. B. S.) *and the Hecla Hoek* (H.H.), *and also as thrust outliers.*

(3) The Siktefjellet Group rests on metamorphic rocks (Hecla Hoek). HAMILTON *et al.* (1962) dated several specimens of these rocks, by rubidium-strontium and potassium-argon methods. They indicate an age of 383 ± 10 million years. On the basis of (1) above, they tentatively suggested this (383 ± 10 million years) as the oldest date for the base of the Downtonian (Gedinnian). The presence of the Siktefjellet Group between the metamorphic rocks and known Devonian will modify this conclusion, as will the presence of faults cutting the metamorphic rocks prior to the deposition of the Siktefjellet Group. For further discussion see GAYER *et al.* (1966).

Sequence of events in Haakon VII Land

1) The folding and recrystallisation sequence in the metamorphic rocks was followed by a series of dislocations dipping at low angles to the east. These are associated with folding strongly assymetrical to the west. These major reverse faults have not displaced the Siktefjellet Group.

2) Deposition of the Siktefjellet Group occurred in an area of strong relief with local derivation dominant. The upper sandstones were derived from the west. The area of deposition may have continued to the east into at least part of the area now occupied by the main Devonian graben.

3) Further compression of the area led to local folding of the Siktefjellet Group about NE–SW axes, and to thrusting of the sandstones over the metamorphic rocks.

4) The Red Bay Series was then deposited. Present outcrops occur both west and east of the present Biskayerhuken–Bockfjorden ridge of metamorphic rocks. This ridge may not have existed during the deposition of the basal boulder conglomerate. The marble and sandstone clasts found in these rocks are thought to be related to uplift of a thick marble formation in South Haakon VII Land. This uplift occurred during and/or after the folding and faulting of the Siktefjellet Group. Granites cutting the metamorphic rocks are found in this region as in many others in Spitsbergen (HARLAND 1961). The uplift may be related to the intrusion of these.

5) The Ben Nevis structural basin was formed after, and possibly partly during, the deposition of the Red Bay Series. Absence of basins of similar size in the Wood Bay Series may point to the formation of this basin prior to the deposition of the Wood Bay Series. However, in the main Devonian graben to the east the Red Bay Series passes conformably up into the Wood Bay Series (FØYN and HEINTZ 1943).

Neither the Raudfjorden–Monacobreen fault, nor the Rabotdalen–Hannabreen fault (and its southern continuation) cut the Wood Bay Series. PRESTON (1959) inferred a pre-Wood Bay age for a north–south fault south of Woodfjorden. HOLTEDAHL (1926) suggested the same for the Raudfjorden fault. These conclusions may also apply to the Rabotdalen–Hannabreen fault.

6) The deposition of the Wood Bay Series occured next, with derivation from the west in this part of North Haakon VII Land. Fragments of sandstone and marble occur in the Wood Bay Series near the Breibogen–Bockfjorden fault and suggest the existence of a Biskayerhuken–Bockfjorden ridge at this time. The continuity of this ridge southwards into James I Land, where the Wood Bay Series rests directly on metamorphic rocks (HOLTEDAHL 1926) has not been demonstrated.

7) Finally, the post-Wood Bay Series faulting took place along the Breibogen–Bockfjorden line.

Acknowledgements

This work is one of the results of the Cambridge Spitsbergen Expedition's field work from 1959–1964 under the direction of W. B. HARLAND. Funds for this were made available to him by the Department of Scientific and Industrial Research. We acknowledge the help of many other expedition members in the field and in Cambridge, in particular of P. F. FRIEND for advice on Devonian studies. N. F. HUGHES and J. C. MOODY-STUART examined samples palynologically.

We acknowledge the use of unpublished Norsk Polarinstitutt coastline maps and oblique aerial photographs. The work was carried out in the Sedgwick Museum and we are grateful to Professor O. M. B. BULMAN and the staff for facilities there. M. MOODY-STUART acknowledges a Studentship from the Shell International Petroleum Company.

Bibliography

FØYN, S. and A. HEINTZ, 1943: The Downtonian and Devonian Vertebrates of Spitsbergen. The English-Norwegian-Swedish Expedition 1939. VIII. Geological results. *Skr. Svalb. og Ishavet.* Nr. 85, 1-51. Oslo.

FRIEND, P. F., 1961: The Devonian Stratigraphy of North and Central Vestspitsbergen. *Proc. Yorks. Geol. Soc.* **33**, (1), No. 5, 77–118.

GAYER R. A., GEE D. G., HARLAND W. B., MILLER J. A., SPALL H. R., WALLIS R. H., WINSNES T. S., 1966. Radiometric age determinations on rocks from Spitsbergen. *Norsk Polarinst. Skr.* Nr. 137. Oslo.

HAMILTON E., W. B. HARLAND and J. MILLER, 1962: Isotopic ages from some Spitsbergen Rocks. *Nature,* **195**, (4847), 1191–1192. London.

HARLAND, W. B., 1960: The Development of Hecla Hoek Rocks in Spitsbergen. *Report of the XXI Int. Geol. Congr.,* Copenhagen. Part XIX, 7–16. København.

— 1961: An outline of the structural history of Spitsbergen. *Geology of the Arctic.* Univ. Toronto Press. Toronto.

HEINTZ, A., 1937: Die Downtonischen und Devonischen Vertebraten von Spitzbergen. VI. Lunaspis-arten dem Devon Spitsbergens. *Skr. Svalb. og Ishavet.* Nr. 72, 1–23. Oslo.

HOLTEDAHL, O., 1914: On the Old Red Sanstones Serie of Northwestern Spitsbergen. *C. R. XIIth Session, Int. Geol. Congr.,* Canada 1913, 707–712. Ottawa.

— 1926: Notes on the Geology of Northwestern Spitsbergen. *Skr. Svalb. og Ishavet,* Nr. 8, 1–25. Oslo.

NORDENSKIÖLD, G., 1892: Redögörelse för den svenska expeditionen till Spetsbergen, 1890. *Bihang Kung. Sv. Vet. Akad. Hdl.* **17**, (3), p. 52. Stockholm.

PRESTON, J., 1959: The Geology of the Snøfjella and Dovrefjella in Vestspitsbergen. *Geol. Mag.* **96,** 45–57. London.

VOGT, T., 1938: The Stratigraphy and Tectonics of the Old Red Formations of Spitsbergen. *Abstr. Geol. Soc. Lond.* No. 1343, p. 88. London.

WHITE, E. I., 1956: Preliminary Note on the Range of the Pteraspids in Western Europe. *Bull. Inst. Sci. Nat. Belg.* **32,** (10), 1–10. Bryssel.

Preliminary report on the geology of Eastern Torell Land, Vestspitsbergen

BY

JENÖ NAGY

Contents

Abstract

A brief account of the stratigraphy and structure of eastern Torell Land is given and a geological map is presented. The rocks exposed in the area is of Lower Cretaceous and Tertiary age, mainly shales, sandstones and siltstones. The succession is subdivided into five series.

Introduction

The area described in this report is situated on the eastern coast of southern Vestspitsbergen. It includes the mountains along the coast of Storfjorden from Kovalskifjella in the south to Veteryggen in the north, and the inland area between Skjoldfonna and Fallberget. Large parts of the area is covered by glaciers and snow fields.

The adjacent regions, the central part of Torell Land and northeastern part of Sørkapp Land, were investigated by K. BIRKENMAJER in 1962 (BIRKENMAJER & NAREBSKI, 1963). In the area between Veteryggen and Kvalvågen field work was carried out by the present author in 1962.

The rocks exposed in the area dealt with herein, are of Lower Cretaceous and Tertiary age, as shown on the geological map of Svalbard by A. K. ORVIN (1940). The strata lie either horizontally or with a slight dip, which gives the mountains and nunataks a tabular structure.

The geological map presented here is based on observations in the field, and on aerial photographs. The following areas were mapped by means of aerial photographs and were not visited in the field: The mountains between Stabbfonna, Ryggbreen and Skjoldfonna, the nunatak area between Skjermen and Fallberget, and the western extension of Veteryggen and Bellingen. The remaining parts of the mapped area are covered by field observations carried out in August 1962 and 1963 on the expeditions organized by Norsk Polarinstitutt.

For the mapping, the author used a topographic map at a scale of 1:50,000. Thicknesses of less than 10 m were measured by tape, while greater thicknesses were determined by aneroid barometer.

Thanks are due to Mr. M. GALÅEN for the final drafting of the geological map and sections, and to Mr. R. G. BENNETT who kindly corrected the English of the manuscript.

Stratigraphy

The Lower Cretaceous and Tertiary deposits exposed in eastern Torell Land are in the following subdivided into five series: The Lower Cretaceous is represented by the Ditrupa Shale Series (Ditrupa Shale Series is here applied in accordance with ROZYCKI, 1959). The Tertiary is represented by four series, the Lower Light Sandstone, the Lower Dark Shale, the Green Sandstone, and the Upper Black Shale. (This subdivision of the Tertiary is adapted from NATHORST, 1910). The distribution of the series is shown in the geological map Fig. 2.

LOWER CRETACEOUS

Ditrupa Shale Series

The Ditrupa Shale Series includes the oldest deposits exposed in eastern Torell Land. Exposure of the base of the series has not been observed. The upper part of the series is widely exposed in the eastern part of the mapped area along the coast of Storfjorden. In the western part of the area, the upper part of the series crops out only on Stolovajafjellet.

The most extensive sections of the Ditrupa Shale Series were measured on the eastern slope of Belcherfjellet, on Skrenthøgda, and on the western part of Kovalskifjella. The exposed thickness at these localities amount to 300–330 m measured from the lowest exposed bed to the top of the series. The lowermost parts of the sections in the three localities mentioned are made up of dark-grey shales with lenses and spherical concretions of clay-ironstone. These deposits probably correspond to the upper part of the "Cretaceous Shale" of HAGERMAN (1925).

The above mentioned shales are overlain by a sequence of alternating beds of green-grey sandstones and dark-grey shales, containing lenses of clay-ironstone. The sandstones are distinctly laminated and split into plates along the bedding planes. This part of the Ditrupa Shale Series occurs widely exposed in the eastern half of the mapped area. It is probably equivalent to the "Upper Lamina Sandstone" of HAGERMAN. Pelecypods are frequent in this part of the series. They

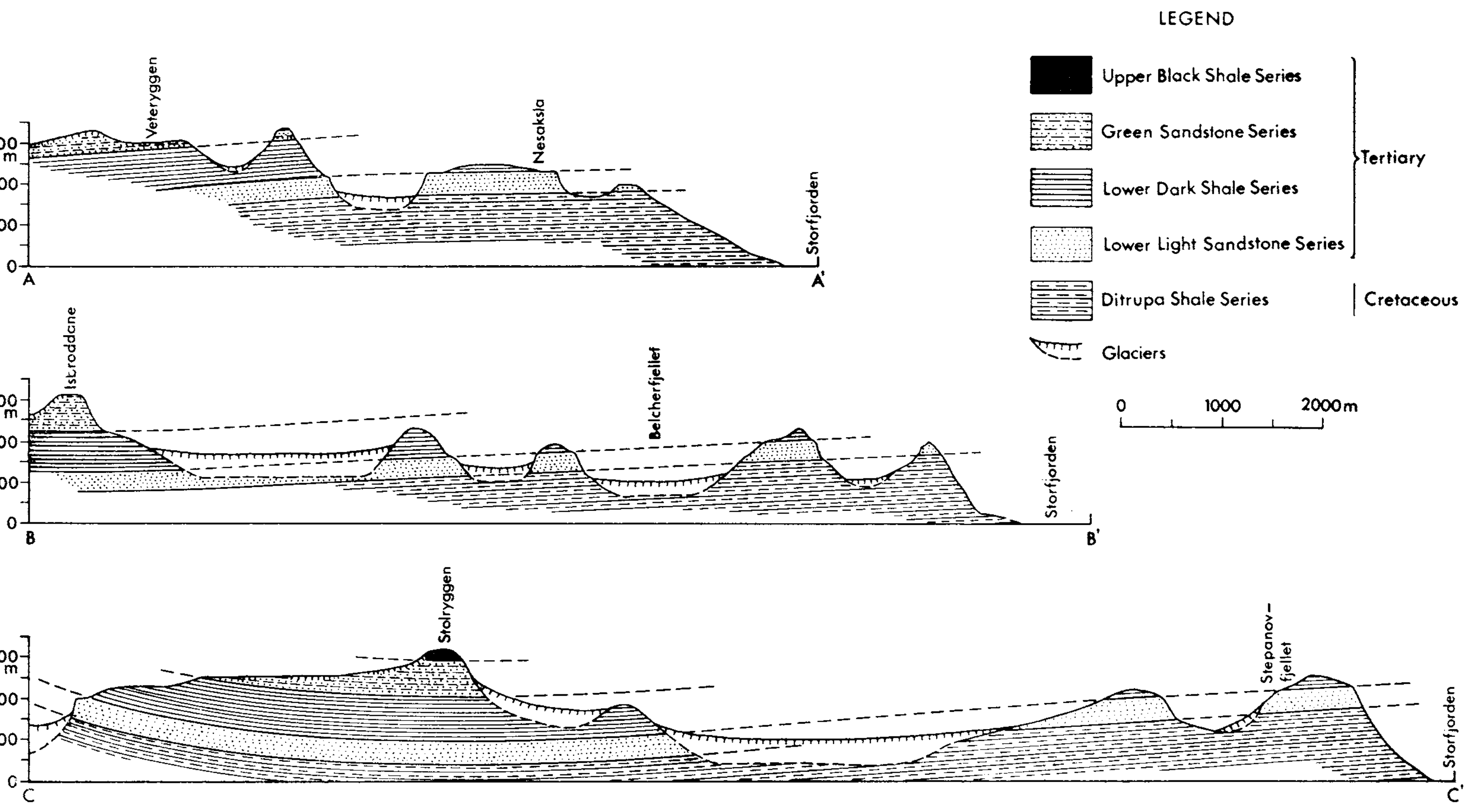

Fig. 1. *Cross-sections of eastern Torell Land. (Section lines, see Fig. 2.)*

Fig. 2. *Geological map of eastern Torell Land.*

occur usually as shell-concentrations, often in the clay-ironstone lenses. More rarely occur gastropods, ammonites, and stem fragments of crinoids. Worm tracks are abundant on the bedding planes of the sandstones and shales.

TERTIARY

Lower Light Sandstone Series

The series is extensively exposed in the eastern part of the mapped area. In the western part of the area it crops out only on the mountains between Skjoldfonna and Stabbfonna.

The Lower Light Sandstone Series rests upon weathered Lower Cretaceous rocks. At the base of the series a conglomerate is locally developed. Its maximal observed thickness is 50 cm measured on the northern slope of Bellingen. The conglomerate was also observed on Belcherfjellet, Stellingfjellet and Kovalskifjella.

The lowermost part of the series is a 5–15 m thick sequence composed largely of soft shales, siltstones and sandstones, containing carbonised plant detritus, and in several localities coal seams and beds of coal-shale. On Kovalskifjella these deposits are overlain by a bed of massive quartzitic sandstone with a thickness of 3–7 m. It contains sand-filled burrowings, about 1 cm in diameter, which are similar in shape to those of *Ophiomorpha* LUNDGREN.

The middle part of the series is a 40–50 m thick sequence composed of arenaceous shales alternating with sandstones.

The uppermost part of the series is a 50–60 m thick sequence made up by massive thick-bedded sandstones. This part of the series forms steep slopes and bluffs, and gives rise to plateaus and shelves.

The total thickness of the Lower Light Sandstone Series increases slightly from the north to the south in the mapped area. The series is about 95 m thick on Veteryggen, 110 m on Stepanovfjellet and 130 m on Kovalskifjella.

Lower Dark Shale Series

In the eastern part of the mapped area the Lower Dark Shale Series forms the higher parts of the mountain ridges and summits and covers the plateaus. In the western part of the area extensive exposures occur on the slopes of the mountains between Stabbfonna and Skjoldfonna. Scattered smaller exposures occur in the nunatak area between Fallberget and Ryggbreen.

The Lower Dark Shale is about 200–220 m thick in the mapped area. The uppermost 40–60 m of the series have not been studied in the field, and the total thickness given above is obtained from arerial photographs.

The lower 160 m of the series, which was studied in the field, consists of dark-grey clay-shale. This splits into angular pieces and contains scattered, rounded pebbles of quartzite and grey flint. On Kovalskifjella three layers of plastic clay-like material, yellow and reddish in color, were observed 18 m, 88 m, and 140 m respectively above the base of the series. The thickness of the layers is 25 cm, 20 cm, and 7 cm respectively. Thin layers of similar material are reported from the Lower Dark Shale Series on the western side of Colesbukta by GRIPP (1927), who stated that the material is weathered tuff.

Green Sandstone Series

Extensive exposures of this series occur in the western part of the mapped area; on the mountains and nunataks between Skjoldfonna and Fallberget, and furthermore on the western extensions of Bellingen and Veteryggen. The series has not been investigated in the field, its distribution shown in the geological map (Fig. 2) is based mainly on aerial photographs.

The series is marked by steep slopes and bluffs, and gives rise to platform summits which are most pronounced in the area between Skjoldfonna and Skjermen. The total thickness of the series measures 150–170 m, as obtained from aerial photographs.

Upper Black Shale Series

Only the lowermost part of the series is present in the mapped area. It is exposed on Stolryggen and Isbroddane, where the dark shale is easily distinguished even at a distance, and also on the aerial photographs. The shale covers the platforms and shelves formed by the Green Sandstone Series.

Structure

The mapped area is composed of horizontal and gently dipping strata, and shows a tabular structure (Fig. 1). The regional dip in the eastern half of the mapped area is west–southwest at an estimated angle of 2°. In the western half of the area between Stolryggen and Fallberget the strata lie horizontally, while between Skjoldfonna and Stabbfonna the dip is to the east–northeast at about 5°. One fault has been observed, on the western part of Kovalskifjella. It trends northwest–southeast, having a throw of about 80 m with the downthrow side to the northeast.

References

BIRKENMAJER, K., & W. NAREBSKI, 1963: Dolerite drift blocks in marine Tertiary of Sørkapp Land and some remarks on the geology of the eastern part of this area. *Norsk Polarinstitutt Årbok 1962*. Oslo.

GRIPP, K., 1927: Beiträge zur Geologie von Spitzbergen. *Abh. Naturw. Ver. Hamburg*. **21**, (3–4). Hamburg.

HAGERMAN, T. H., 1925: Stratigraphic and Structural Investigations within Southwestern Spitzbergen. Results of the Swedish Expedition to Spitzbergen in 1924. *Geogr. Annaler* 1925, (3–4). Stockholm.

NATHORST, A. G., 1910: Beiträge zur Geologie der Bären Insel, Spitzbergens und des König-Karl-Landes. *Bull. Geol. Inst. of Uppsala*. **10**. Uppsala.

ORVIN, A. K., 1940: Outline of the Geological History of Spitsbergen. *Skr. Svalbard og Ish.* Nr. 78. Oslo.

ROZYCKI, S. Z., 1959: Geology of the north-western part of Torell Land, Vestspitsbergen. *Studia Geol. Polon.* **2**. Warszawa.

Lower Cretaceous tidal deposits of central Vestspitsbergen

BY

KRZYSZTOF BIRKENMAJER[1]

Abstract

The present author made some sedimentological observations in the marine Aptian (Ditrupa Beds) of Sverdruphamaren, Longyearbyen, and of the Festningen Section, Grønfjorden (Isfjorden area, central Vestspitsbergen), during an excursion to Svalbard in 1960. Most characteristic sedimentary structures are described and illustrated and reconstructions of sedimentary environment and of palaeogeography of the Aptian sea are attempted.

Introduction

Taking the opportunity of the excursion to Svalbard in connection with the XXI International Geological Congress in Norden (N. HEINTZ 1962) the present author made in August 1960 some sedimentological observations on the Lower Cretaceous marine deposits at two localities south of Isfjorden, central Vestspitsbergen. The first locality examined was the Festningen Section in Grønfjorden, the other – the cliff section of Sverdruphamaren at Longyearbyen, Adventfjorden.

The short time of the visit did not allow the present author to make any more extensive study. Therefore, only more significant sedimentary structures will be discussed against the palaeogeographical position of the beds examined.

The present author is deeply indebted to Prof. Dr. IVAR HESSLAND (The University of Stockholm), member of the excursion to Svalbard, for valuable discussions in the field.

Geological situation

The localities examined are situated in the northern part of the area in Vestspitsbergen covered by the Lower Cretaceous deposits (A. K. ORVIN 1940, map): Festningen Section in the western –, and Sverdruphamaren in the eastern limbs of the central depression of Vestspitsbergen (Fig. 1).

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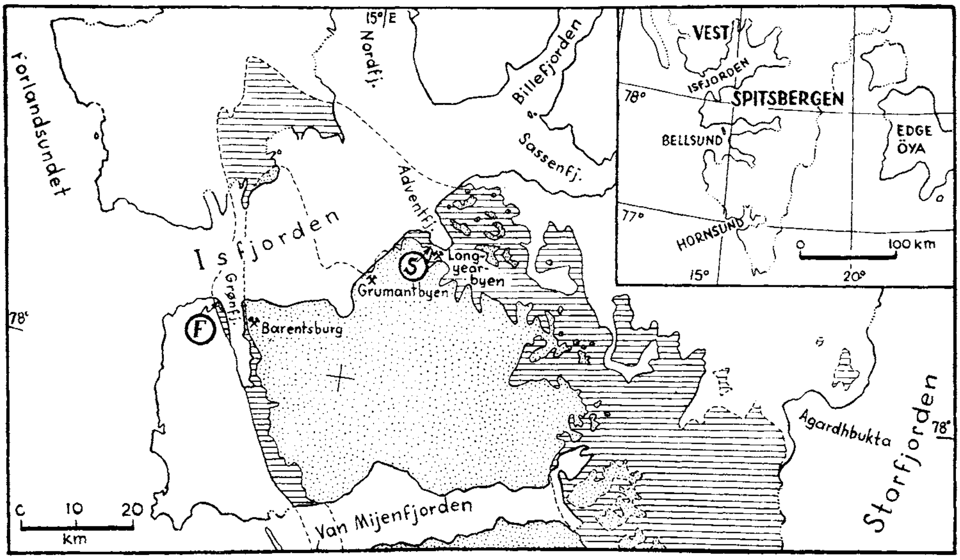


Fig. 1.

Key maps to show the positions of localities examined. Geological features after A. K. ORVIN (1940). *F – Festningen Section; S – Sverdruphamaren; Tertiary – dotted; Cretaceous – hatched; Pre-Cretaceous formations – blank.*

The rocks studied belong to the marine Ditrupa Beds (previously Dentalium Beds), the youngest member of the Cretaceous in Svalbard, regarded as representing the Aptian (Lower Gargasian) and in some area also Albian (cf. FREBOLD 1951).

Observations at Sverdruphamaren

General remarks

The cliff section examined extends at a distance of about 2.5 km between Longyearbyen harbour and the outlet of the stream flowing from Blomsterdalen. The section exposes beds belonging most probably to the Lower Lamina Sandstone *sensu* T. H. HAGERMAN (1925), i.e. to the lower part of the Ditrupa Beds. The member consists here of sandstones alternating with shales. The ratio of sandstones to shales is changing: 2:1, 1:1, 1:2. The sandstones are fine grained and laminated, grey, greyish green, and yellowish green if weathered, sometimes micaceous. They form layers usually 5–80 cm thick, often wedging out or reducing to single laminae 2–3 cm thick. The sandstones are sharply delimited from the shales both at the sole and at the top. The shales are grey, greenish grey, in bands 5–300 cm thick. They contain lenticular intercalations of clay ironstones 0.1–1.0 m thick, 1–20 m long, grey, and yellow or rusty yellow if weathered. The clay ironstones often show cone-in-cone structures. Pyrite concretions 1–3 cm in diameter have also been found.

The fossils are rather uncommon. At the sole of some sandstone layers have been found small pelecypod shells in stable positions. Trace fossils are repre-

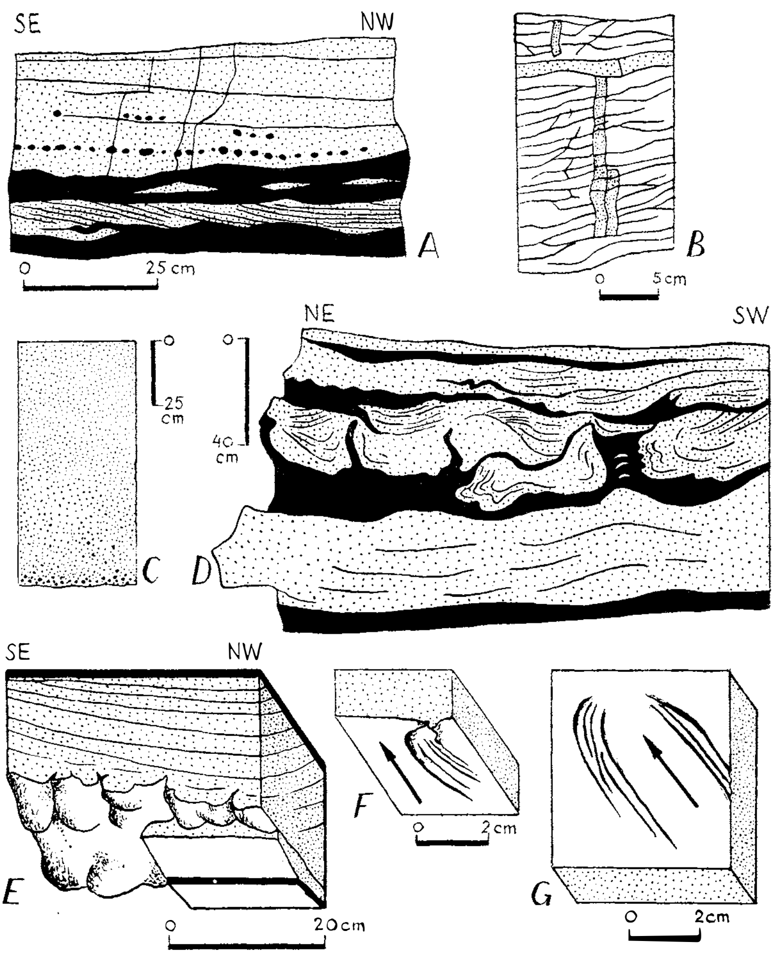


Fig. 2.

Sedimentary features of the Ditrupa Beds at Sverdruphamaren. A – Foreset lamination of the sandstones and isolated sand ripples (shales in black, quartz pebbles marked in the upper sandstone layer). B – Organogenic sand pipes in shales with thin intercalations of sandstones. C – An example of normal incomplete graded bedding. D – Load-casted megaripples (shales in black). E – Multidirectional flowage casts at the sole of cross-bedded sandstone which fills the channel (shales in black). F – Prod cast. G – Twisted groove (drag) casts.

sented by sand pipes 0.5–1 cm in diameter vertically crossing the shales (Fig. 2B), and by worm trails found at the soles of many sandstone layers.

The sandstones are generally fine grained and homogeneous (monofractional). Coarser material consisting of quartz pebbles 3–10 mm in diameter was found occasionally, mostly in the lower parts of the sandstone layers (Fig. 2A) or as fine gravel lags covering channel floor. Angular or rounded shale clasts 0.5–2 cm in diameter have been observed lying parallel to foreset laminae, but without preferred orientation of longer axes.

Graded bedding is quite exceptional. Fig. 2C shows an example of normal in-

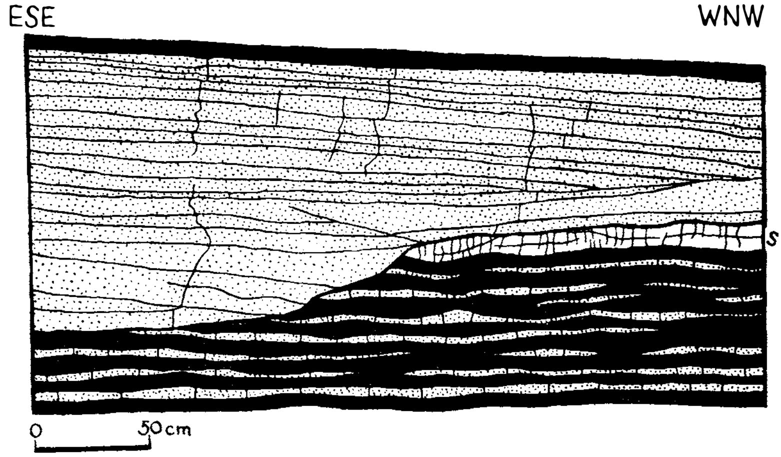


Fig. 3.
Sedimentary features of the Ditrupa Beds at Sverdruphamaren. Transversal section of a channel filled with cross bedded sandstone. The floor of the channel consists of alternating rippled sandstones and shales (black). S– Clay ironstone.

complete graded bedding (Gc–n type of BIRKENMAJER 1959). The coarsest quartz grains 2–10 mm in diameter occur here in a very thin band just at the bottom of the layer, and grain grades quickly diminish upwards down to 0.1 mm in diameter.

The most common types of bedding are current lamination and ripple bedding. Among the ripples have been recognized both symmetric ripple marks related to wave action, and asymmetric ripple marks related to current action. Lower part of Fig. 2A shows a sandstone layer with well visible foreset lamination. The bottomsets are present, the topsets are lacking; small ridges at the upper surface of the layer correspond to individual ripples. The ripples are flattened and load-casted, as shown by convexities at the sole of the sandstone. Base of the ripple in the left part of the figure produced a tongue-like intrusion of quick sand into underlying mud. In the middle part of the same figure we see isolated, symmetric, sligthly deformed ripples which had formed on muddy bottom from redeposited very thin layer of sand. The ripple index amounts here to 9–8.5.

Thin sandstone layers with symmetric ripple marks are characteristic of many parts of the member discussed. Usually (Fig. 3, lower part) they are 1–6 cm thick, lenticular, rhythmically interbedded with shales. Casts of symmetric ripples observed at the sole of some sandstones had well marked sharp ridges 0.5–1 cm high, 8–15 cm apart; the ripple index amounted to 15–16.

Channels

Current bedding is confined mostly to sandstones filling erosional channels. Fig. 3 shows transverse section of a channel cut down to minimum 40 cm in a sequence of thin, ripple-marked sandstones, rhythmically alternating with shales, capped by clay ironstone. This example indicates, moreover, lithification of the clay ironstone as being very quick, penecontemporaneous with the channeling of the sea bottom by currents. The sandstones filling the channels form layers much thicker than usual, often reaching 1 m or so. Other examples of channel-fill deposits are shown in Fig. 2E and Fig. 4.

Load casting and slumping

Some examples of incipient deformation of ripples under their own load have been discussed above. The degree of deformation is related both to the volume (weight) of the sand load, and to the type of ripple bedding. Isolated small ripples (symmetric and asymmetric) show only slight deformations, their bottoms being either nearly flat or only slightly convex downwards. The same is true of thin current-bedded sandstone layers showing surficial ripples (Fig. 2A).

In the case of thicker current-bedded sandstone layers filling erosional channels (Fig. 2E) we may often observe irregular bottom markings caused by flowage of hydroplastic sediment (multidirectional flowage casts of BIRKENMAJER 1958).

Still stronger deformations prior to diagenesis are shown in Fig. 2D. In the middle part of the figure we see boudin-like sandstone bodies with internal disturbation of cross (current) lamination. Most of the "boudins" are still connected with each other. The underlying clay intruded between the "boudins". One "boudin" is totally separated from the others.

It is supposed that particular "boudins" correspond to individual megaripples (*sensu* HÜLSEMANN 1955), their original wave length being 30–50 cm, deformed syndepositionally under their own load. The factors involved in the formation of the discussed structures were:

1. Suitable mobility of bottom clay subjected to diapiric movements (located principally under megaripple troughs) due to unequal load of superimposed megaripples.
2. Suitable mobility of water-filled fine grained sand forming the megaripples.
3. Suitable duration of wave or current action. The megaripples are usually produced by high-velocity tidal currents (cf. KLEIN 1964); this may well have been the case of our structures.

It is possible that with suitable bottom topography differential movements in hydroplastic sediment have led to the formation of plastic glides as shown in Fig. 4. Here we see transversal section of an erosional channel about 2 m deep, filled with several slumped beds of sandstone, one of them (near the floor of the channel) plastically folded and boudinaged, with traces of current bedding and with small but well preserved sole markings. The wedging out sandstone beds in the upper part of the channel (above the "boudinaged" layer) are evenly laminated and apparently formed *in situ* after slumping.[1]

[1] The reader will find more information on subaqueous slumping in the following papers (with references to extensive literature): PH. H. KUENEN (1948), M. KSIAZKIEWICZ (1958), S. DZULYNSKI (1963) and others.

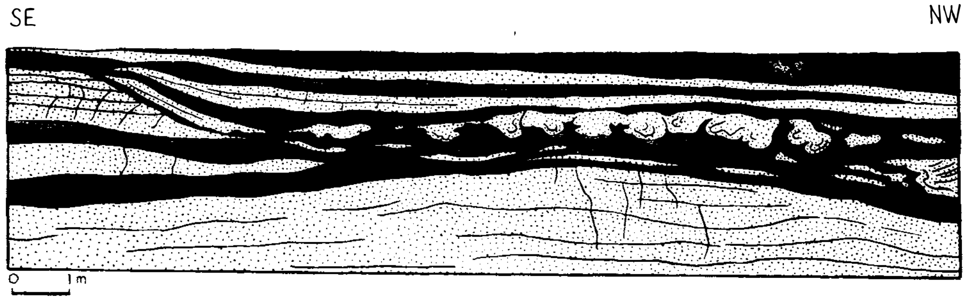


Fig. 4.
Sedimentary features of the Ditrupa Beds at Sverdruphamaren. Transversal section of a channel filled with several slumped and plastically folded layers of sandstone.

Current markings

Current markings are represented by uncommon small-scale flute markings (casts), prod markings (casts), and by much more common groove casts, connected almost exclusively with layers of cross-bedded sandstones filling channels.[1] Some examples of prod casts and of twisted endings of short groove casts (Fig. 2F, G) are illustrated from fallen blocks. The directions of grooves of the same sole may differ by 10–30°.

Interpretation of directional structures

The measurements of direction of flute-, prod- and groove casts are plotted in Fig. 5A, B. They show two opposite directions of currents (Fig. 5B: S_1 and S_2) concordant with the direction of submarine channels. As these sole markings are confined to cross-bedded sandstones filling the channels, the most probable explanation is that they were left by bi-directional currents generated by tides in the channels (tidal currents).

Most of the measurements of foreset lamination presented in Fig. 5A were made on current ripple bedded sandstones outside the channels. The mean directions are located in the first and third quadrants (Fig. 6B), nearly at right angle to the current directions in the channels.

The formation of current ripple bedded sandstones was most probably related to tides acting on flat bottom outside channels.[2] The mean directions F_1 and F_2 (Fig. 5B), normal to the ripple crests, indicate the direction of water during high tide (flood) and low tide (ebb) respectively. It seems on regional evidence (see below) that the F_1 direction corresponds to flood, i. e. points the direction of the coast.

[1] For information on terminology, directional significance and experimental production of current markings the reader is referred to papers by S. DZULYNSKI (1963) and S. DZULYNSKI and E. K. WALTON (1963).

[2] In Fig. 5A directions of foreset lamination (normal to the ripple crests) of rippled sandstones outside channels are not separated from those of cross-bedded sandstones in the channels. However, the latter are represented only by 2–3 measurements which does not change the general pattern.

Observations at Festningen Section

General remarks

The Festningen Section ("Festungsprofil") denotes cliff exposures along the southern coast of Isfjorden, between Kapp Starostin and the entrance of Grønfjorden (cf. A. HOEL and A. K. ORVIN 1937). The marine Ditrupa Beds are exposed east of Festningsodden. They pass downwards into Continental Wealden and are unconformably overlain by Lower Tertiary strata.

The fauna determined by D. N. SOKOLOV, D. N. SOKOLOV and W. BODYLEVSKY, H. FREBOLD, and H. FREBOLD and E. STOLL listed by HOEL and ORVIN (*o. c.*, faunal horizons Nos. 45–32) indicates an Aptian (Lower Gargasian) age; the Albian fossils have not been recognized.

As follows from detailed measurements by HOEL and ORVIN the thickness of the member discussed does not exceed 180 m.[1] The column may be subdivided into three members, comparable with those of HAGERMAN (1925). And so, to the Upper Lamina Sandstone 5.65 m thick only (four topmost beds distinguished by HOEL and ORVIN) are included sandstones alternating with shales devoid of determinable fossils.

To the "Cretaceous Shale" 109.10 m thick (faunal horizons Nos. 45–40 and three beds distinguished by HOEL and ORVIN above the faunal horizon No. 45) are included shales and arenaceous shales with thin intercalations and concretions of impure (sideritic) limestone. Only one sandstone intercalation (0.15 m thick) was described by HOEL and ORVIN from the upper part of the member.

To the Lower Lamina Sandstone 63.65 m thick (faunal horizons Nos. 39–32 including full thickness of sandstones of horizon No. 32 i.e. 11 m) correspond sandstones alternating with shales (subordinate), with clay ironstone concretions.

The contacting Lower Tertiary strata consist of grey conglomerates (3.8 m thick according to HOEL and ORVIN *o. c.*) with well rounded or rounded pebbles of white or grey quartz embedded in soft grey quartzose matrix. Coal fragments and carbonized plants are present in the matrix. The conglomerates are overlain by grey or dirty grey shales and by yellow weathering sandstones with black coal seams (0.5–1 m thick). The contact of the conglomerates with the Ditrupa Beds is tectonically disturbed (Fig. 5E).

Sedimentary features

As a whole the Ditrupa Beds of the Festningen Section are less interesting from sedimentological point of view than their equivalents from Sverdruphamaren. In the upper part of the sequence (equivalent to the Upper Lamina Sandstone) the sandstones are laminated, fine grained, showing symmetric ripple marks (Wellenfurchenhorizont No. 1 of FREBOLD 1931) of the following characteristics: $h = 0.5$–1 cm, $\lambda = 8$–12 cm, ripple index = 16–12. About 1 m below the contact with the Tertiary, worm trails on rippled top surface of sandstone

[1] The scale given to Tafel V by HOEL and ORVIN (1937) is incorrect. It should be 1:1000 instead of 1:10,000.

illustrated already by FREBOLD (1931, Taf. IV, Fig. 2) are still to be seen. The sandstones show sometimes slight diagonal (current) lamination. Pelecypod shell detritus was observed at soles of some sandstones.

The middle part of the column (equivalent to the "Cretaceous Shale") has shown no sedimentological features of interest.

Finally, in the lower part of the sequence (equivalent to the Lower Lamina Sandstone) the sandstones become again rich in symmetric (oscillation) ripple marks with sharply defined ridges, preserved mostly as positives at the top surface of the sandstones, described in detail by FREBOLD (1931: Wellenfurchenhorizonte Nos. 2–7). Some soles of these sandstones have shown infrequent faint groove casts (Fig. 5D). The ripple marks are especially frequent near the bottom of the Ditrupa Beds (fossil horizon No. 33 – see HOEL and ORVIN 1937). The sandstones often contain clay pellets, carbonized plant detritus and shell debris. Scarce quartz pebbles have also been found. Trace fossils (worm trails) at rippled top surfaces of sandstone layers become again more common.

More detailed field characteristics of ripples has not been attempted due to short time of the visit. FREBOLD (1931) listed ripple wave lengths $\lambda = 11–16$ cm (Wellenfurchenhorizonte Nos. 2–7), but not the amplitudes (h). Hence the ripple index $\frac{\lambda}{h}$ can be calculated on his observations only for "Wellenfurchenhorizont No. 10" (Continental Wealden): $\lambda = 8$ cm, $h = 0.8$ cm, $\frac{\lambda}{h} = 10$. This value is lower than those already calculated for oscillation ripple marks of the marine Aptian (see above): 12–16 at Festningen Section (Wellenfurchenhorizont No. 1), and 15–16 at Sverdruphamaren.

It should be added that near the faunal horizon No. 32 with *Tropaeum arcticum* (STOLLEY) (cf. HOEL and ORVIN 1937) has been found by A. G. NATHORST (1910, p. 366) a conglomeratic bed considered by FREBOLD (1930, pp. 45, 46; 1931, p. 46, Fig. 10) as the basal conglomerate of marine Aptian. The presence of this conglomerate has not been confirmed either by HOEL and ORVIN or by the present author. Possibly it was only a thin intercalation or lense in the limestone, as follows from NATHORST's (*l. c.*) description: "es findet sich hier in einem Kalkgestein eine dünne konglomeratische Lage mit erbsengrossen Quarzgeröllen". On the other hand a basal conglomerate was recognized by HAGERMAN (1925) at the bottom of the Lower Lamina Sandstone at Innkjegla east of Braganzavågen.

Interpretation of directional structures

Fig. 5C is a diagrammatic representation of directions of oscillation ripple marks measured in the Lower Cretaceous of the Festningen Section by FREBOLD (1931, p. 47 *sequ.*, Fig. 10). Most of his measurements (7 out of 13) refer to the Lower Lamina Sandstone (Wellenfurchenhorizonte Nos. 2–7), one measurement (Wellenfurchenhorizont No. 1) to the Upper Lamina Sandstone, four measurements to the upper part of the Continental Wealden (Wellenfurchenhorizonte Nos. 8–10), and one measurement to the top surface of the Festningen Sandstone. Des-

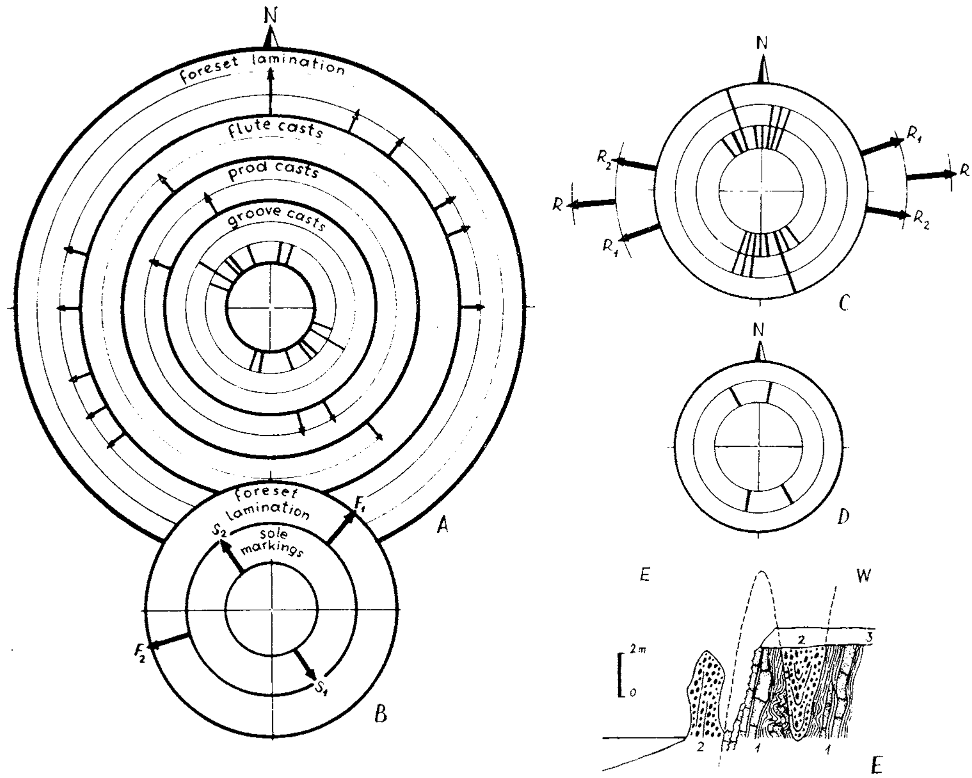


Fig. 5.

Orientation diagrams of directional sedimentary features of the Ditrupa Beds. A – Sverdruphamaren. The smallest distance between the circles corresponds to one measurement (altogether 26 measurements). B – Mean directions calculated for Sverdruphamaren. F_1 (azimuth 41°) and F_2 (azimuth 253°) indicate prevailing directions of foreset lamination, principally outside channels. S_1 (azimuth 148°) and S_2 (azimuth 323°), nearly opposite to each other indicate directions of water movement in the channels. C – Festningen Section. The diagram shows the directions of symmetric ripples (mostly Ditrupa Beds, partly uppermost Continental Wealden) after data published by H. FREBOLD (1931, Fig. 10). *The smallest distance between the circles corresponds to one measurements (altogether 13 measurements). R_1 (azimuth 71° resp. 251°) and R_2 (azimuth 101° resp. 281°) indicate mean directions normal to two maxima of ripple crest directions. R (azimuth 86° resp. 266°) indicates mean direction normal to the whole series of measurements. D – Festningen Section, groove cast directions (2 measurements). E – Contact of the Tertiary and the Cretaceous at the Festningen Section in Grønfjorden. 1 – Ripple marked sanstones and shales of the Ditrupa Beds (possibly Upper Lamina Sandstone); 2 – Lower Palaeogene conglomerates; 3 – Raised terrace deposits (Holocene).*

pite differences in age they show a remarkable consistency in ripple directions as pointed out already by FREBOLD.

R_1 and R_2 (Fig. 5C) are normal to two maxima of ripple crest directions. R is the mean normal of the whole series of FREBOLD's measurements. The pattern obtained is very similar to that established for Sverdruphamaren (Fig. 5A, B). This allows to conclude that oscillatory movements of the sea water which produced the symmetric ripples were related to tidal floods and ebbs directed WSW–ENE rather, than to the single action of landward or seaward winds. The latter agent has possibly played a subordinate role, rotating the horizontal axis of oscillatory movements of the water, subparallel to the coastline.

Groove cast directions measured at Festningen Section are too few (cf. Fig. 5D) to allow any conclusions. However, they indicate directions of current as being similar to those established for the Sverdruphamaren channels.

Conclusions

Sedimentary environment

The above incomplete observations allow but tentative conclusions as refers to sedimentary conditions during the higher Aptian (Lower Gargasian) in the area of Isfjorden. A shallow marine environment strongly influenced by tides is expressed best by the deposits at Sverdruphamaren, which could be regarded as tidal deposits. It is believed that they had formed just below, or very near to, the low tide mark on slowly subsiding bottom channelled by tidal currents parallel or subparallel to the coast. The deposition of cross bedded sand in active channels occurred both during flood tide and ebb tide, while in the abandoned channels lateral slumping and occasional (very seldom) turbidity currents interrupted quiet sedimentation of high-tide clay and low-tide rippled sand. The latter deposits had formed principally on submarine terrace, possibly tilted to the W and SW. The true intertidal zone (tidal flat) deposits have not been recognized so far. They could be expected to the east or north-east of Longyearbyen.

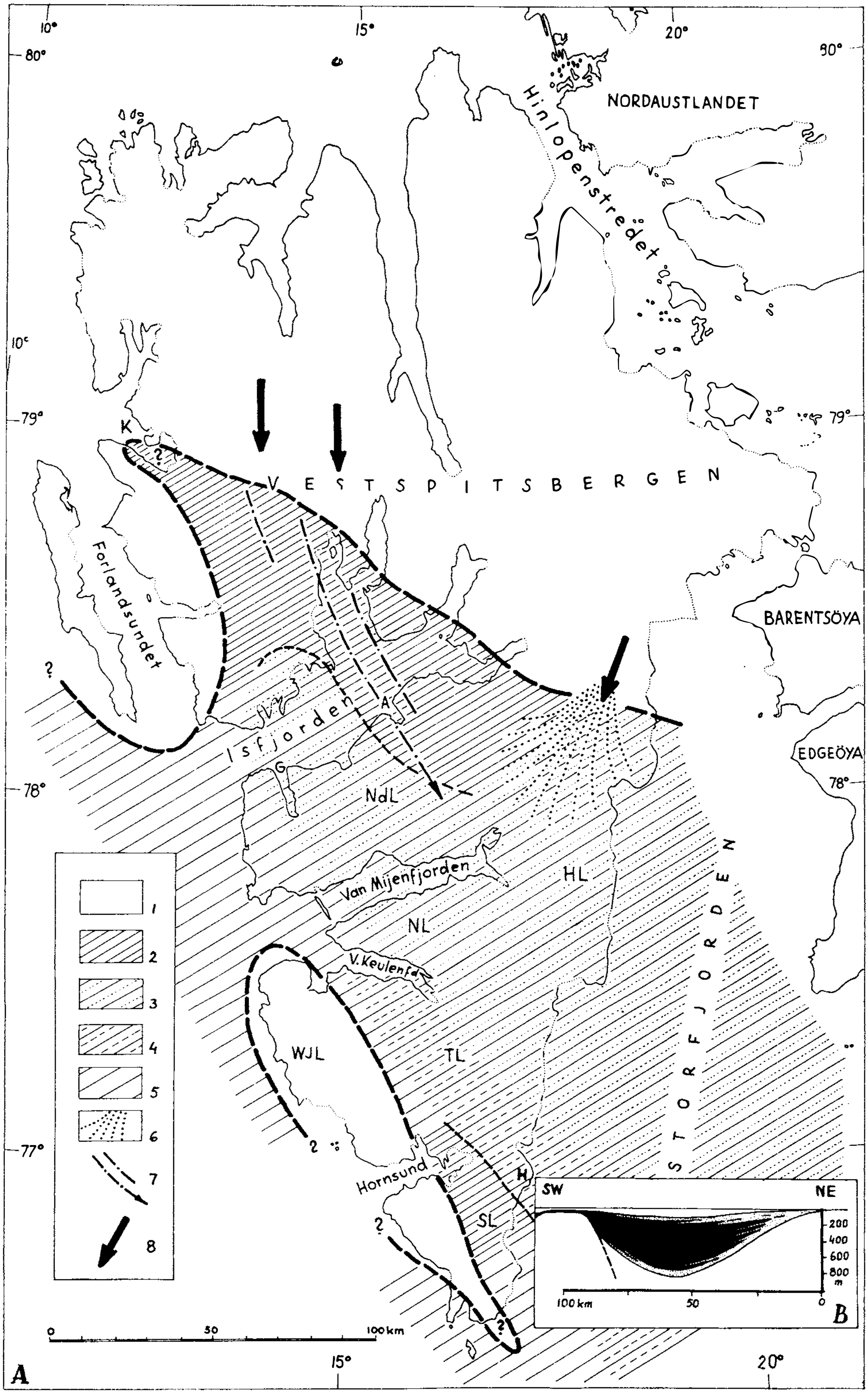
It is hoped that with more detailed investigations more features in common with the Recent tidal deposits known best from the Dutch Wadden Sea (cf. VAN STRAATEN 1953, 1963) and Bay of Fundy, Nova Scotia (cf. KLEIN 1963, 1964; KLEIN and SANDERS 1964) will have been found.

The deposits of the Ditrupa Beds examined at the Festningen Section seem to be deposited in slightly deeper waters than those of Sverdruphamaren, but still within the shallow neritic zone. They were situated farther from the eastern source of clastic material.

Fig. 6.

A – *Tentative reconstruction of palaeogeography of the Aptain sea in Svalbard during the deposition of the Lower Lamina Sandstone. 1 – Supposed lands; 2 – Zones of shale-sandstone sedimentation controlled by tides; 3 – Slightly deeper zone with sandstone sedimentation prevailing (main area of deposition of the Lower Lamina Sandstone); 4 – Predominantly shaly facies (sandstone intercalations infrequent); 5 – Supposed shallow zones surrounding western lands; 6 – Possible extension of the Shore Sandstone underlying the Lower Lamina Sandstone (area of Kjellströmdalen); 7 – Probable course of submarine channels; 8 – Supposed directions of clastic sediment supply; A – Adventfjorden; G – Grønfjorden; H – Hedgehogfjellet (Tromsøbreen is situated to the south of this mountain); HL – Heer Land; K – Kongsfjorden; NL – Nathorst Land; NdL – Nordenskiöld Land; SL – Sørkapp Land; TL – Torell Land; WJL – Wedel-Jarlsberg Land.*

B – *Schematic section of the Aptian marine basin in Svalbard to show supposed interrelations between the Lower and Upper Lamina Sandstones (dotted) and the "Cretaceous Shale" (in black).*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Forlandsundet
Isfjorden
BARENTSÖYA
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V. Keulenfd
WJL
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78°
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Palaeogeographic remarks

Fig. 6A presents an attempt to reconstruct the palaeogeography of the Aptian in Svalbard during the deposition of the Lower Lamina Sandstone. The sources of clastics are located to the NE and E of the elongated marine basin. The zone affected by tides, with bottom crossed by tidal channels extends along the eastern coast of the basin. The presence of the "Shore Sandstone" 60 m thick (corresponding to the Upper Continental Wealden ?) recognized by HAGERMAN in the area of Kjellströmdalen at the base of the Lower Lamina Sandstone may be the evidence of proximity of land. The basin was deepening lenghtwise towards the SE, where in central Torell Land the lower part of the Ditrupa Beds, equivalent to the Lower Lamina Sandstone (examined by the writer in 1962) consists mostly of dark shales with very thin and infrequent evenly laminated sandstone intercalations devoid of ripple marks, with intercalations of clay ironstone etc. A northward lateral passage of the Lower Lamina Sandstone into shale was also recognized by HAGERMAN in the vicinity of Kjellströmdalen.

The western boundary of the basin is uncertain. FREBOLD (1931) argued that it coincided with the Caledonian belt of the western coast of Vestspitsbergen. If so, this land had to be nearly flat as it furnished practically no clastic material to the basin. It could be added that near Tromsøbreen, NE Sørkapp Land, the present writer recognized in 1962 a very shallow facies of the Lower Lamina Sandstone with many features typical even of intertidal zone. These littoral deposits could have been deposited along the western margin of the basin.

Palaeogeographical reconstructions of the Lower Cretaceous sea in Svalbard have been attempted by FREBOLD. According to him (1930, Taf. XXIII) during the Aptian there existed two separate lands (islands) in Nordaustlandet and Franz-Joseph Land, and an extensive land (prolongation of Fennoscandia) in the southern part of the Barents Sea shelf south of Bjørnøya. In the Albian he assumed the existence of the land over most of the Barents Sea shelf, only the western and middle parts of Vestspitsbergen being covered by the sea.

In the next paper FREBOLD (1931) paid more attention to the existence during the Aptian–Albian of a land west of Vestspitsbergen, eventually covering part of its western coast.

ORVIN (1940, pp. 33–35) assumed the existence of land during the late Lower Cretaceous to the E or SE of Vestspitsbergen.

As follows from the preliminary sedimentological observations presented above the only land which could have been active source of clastics during the deposition of the Ditrupa Beds would cover NE and E parts of the Svalbard archipelago. The western land evidenced by many features during the Devonian (O. HOLTEDAHL 1928; ORVIN 1940), Carboniferous–Permian (ORVIN 1940; BIRKENMAJER 1964), Triassic–Cretaceous (FREBOLD 1931) and Tertiary times (HOLTEDAHL *o. c.*; FREBOLD *o. c.*) was most probably inactive (levelled) at the time of deposition of the Ditrupa Beds, as it supplied practically no clastics to the Aptian–Albian sea.

References

BIRKENMAJER, K., 1958: Orientated flowage casts and marks in the Carpathian Flysch and their relation to flute and groove casts. – *Acta Geol. Polon.* **VIII**, 117–148. Warszawa.

— 1959: Classification of bedding in flysch and similar graded deposits. – *Studia Geol. Polon.* **III**, 1–133. Warszawa.

— 1964: Devonian, Carboniferous and Permian formations in Hornsund, Vestspitsbergen. – *Ibidem.* **XI**, 47–123.

DZULYNSKI, S., 1963: Directional structures in flysch. – *Ibidem.* **XII**, 136 pp.

— and E. K. WALTON, 1963: Experimental production of sole markings. – *Trans. Edinb. Geol. Soc.* **19** (3), 279–305. Edinburgh.

FREBOLD, H., 1930: Verbreitung und Ausbildung des Mesozoikums in Spitzbergen (Nebst einer Revision der Stratigraphie des Jura und der Unterkreide in Nowaja Semlja und einem Entwurf der mesozoischen Fntwiklungsgeschichte des Barentsseeschelfes). – *Skr. Svalb. og Ishavet.* Nr. 31, 126 pp. Oslo.

— 1931: Fazielle Verhältnisse des Mesozoikums im Eisfjordgebiet Spitzbergens (Ein Beitrag zur Entwicklungsgeschichte des Skandiks). – *Ibidem.* Nr. 37, 94 pp.

— 1951: Geologie des Barentsschelfes. – *Abh. Deutsch. Akad. Wiss. zu Berlin,* Kl. Math.-allg. Naturw. Jg. 1950, Nr. 5 (Abh. Geotekt. Nr. 4), 156 pp. Berlin.

HAGERMAN, T. H., 1925: Stratigraphic and structural investigations within south-western Spitsbergen. – *Geogr. Ann.* **7**, 195–221. Stockholm.

HEINTZ, N., 1962: Geological excursion to Svalbard in connection with the XXI International Geological Congress in Norden 1960. – *Norsk Polarinstitutt Årbok 1960.* 98–106. Oslo.

HOEL, A., and A. K. ORVIN, 1937: Das Festungsprofil auf Spitzbergen, Karbon-Kreide. I: Vermessungsresultate. – *Skr. Svalb. og Ishavet.* Nr. 18, 59 pp. Oslo.

HOLTEDAHL, O., 1928: Tectonics of Arctic regions. – *Congr. Geol. Int., C.-R. XIV Sess. en Espagne,* 1926. **4**, 1735–1748. Madrid.

HÜLSEMANN, J., 1955: Grossrippeln und Schrägschichtungs-Gefüge im Nordsee-Watt und in der Molasse. – *Senckbg. Leth.* **36**, 359–388. Frankfurt a.M.

KLEIN, G. DE V., 1963: Bay of Fundy intertidal zone sediments. – *J. Sed. Petrol.* **33** (4), 844–854. Menasha.

— 1964: Sedimentary facies in Bay of Fundy intertidal zone, Nova Scotia, Canada. – *Developm. in Sedim.* I: Deltaic and shallow marine deposits (L. M. J. U. VAN STRAATEN Ed.), 193–199. Amsterdam.

— and J. E. SANDERS, 1964: Comparison of sediments from Bay of Fundy and Dutch Wadden Sea tidal flats. – *J. Sed. Petrol.* **34** (1), 18–24. Menasha.

KSIAZKIEWICZ, M., 1958: Submarine slumping in the Carpathian flysch. – *Ann. Soc. Geol. Pol.* **XXVIII**, 123–150. Kraków.

KUENEN, PH. H., 1948: Slumping in the Carboniferous rocks of Pembrokeshire. – *Q. Jour. Geol. Soc. Lond.* **CIV**, 365–385. London.

NATHORST, A. G., 1910: Beiträge zur Geologie der Bären-Insel, Spitzbergens und des König-Karl-Landes. – *Bull. Geol. Inst. of Upsala.* **X**, 261–416. Uppsala.

ORVIN, A. K., 1940: Outline of the geological history of Spitsbergen. – *Skr. Svalb. og Ishavet.* Nr. 78. 57 pp. Oslo.

STRAATEN, L. M. J. U. VAN, 1953: Megaripples in the Dutch Wadden Sea and in the basin of Arcachon (France). – *Geol. en Mijnbouw.* **15**, 1–11. The Hague.

— 1963: Aspects of the Holocene sedimentation in the Netherlands. – *Ver. K.N.G.M.G.* **21** (1), 149–172. Amsterdam.

Seismic measurements on the glacier Hardangerjøkulen, Western Norway

BY

MARKVARD A. SELLEVOLL[1] and KJELL KLOSTER[2]

Abstract

Reflections and refraction measurements were carried out in the glacier Hardangerjøkulen, Western Norway, with a refraction apparatus. The maximum ice-thickness along a 1400 m long profile is 360 m (Fig. 3).

Introduction

In April 1963 a number of reflection and refraction measurements were carried out on the glacier Hardangerjøkulen in Western Norway along a 1400 m line running between A and B in Fig. 1. The object was to determine the velocity variation in the snow and ice as well as the surface topography beneath the glacier.

A base line was measured to be 3200 m long (Fig. 1). Flags were set up at distances of 200 m.

Instruments

The seismic instrument used was a complete 25 channel refraction apparatus with

a. 25 channel A. G. Fischer Oscillograph,
b. 20 channel refraction amplifier,
c. 20 Hall-Sears vertical geophones.

a. *The oscillograph*

20 galvanometers were connected to their respective seismometers via the amplifier unit. Two galvanometers were connected in series for recording the short instance by sending a break of a 1000 cps tone caused by the shot via walkie-talkie to the oscillograph. The galvanometers are coil galvanometers, electromagnetic damped to 0.7 of critical damping. Their natural frequency is 180 csp, the internal resistance is 20 ohm, and they have a DC sensitivity of 33 mm/mA. The camera paper speed was 50 cm/sec with timing lines every 10 millisec.

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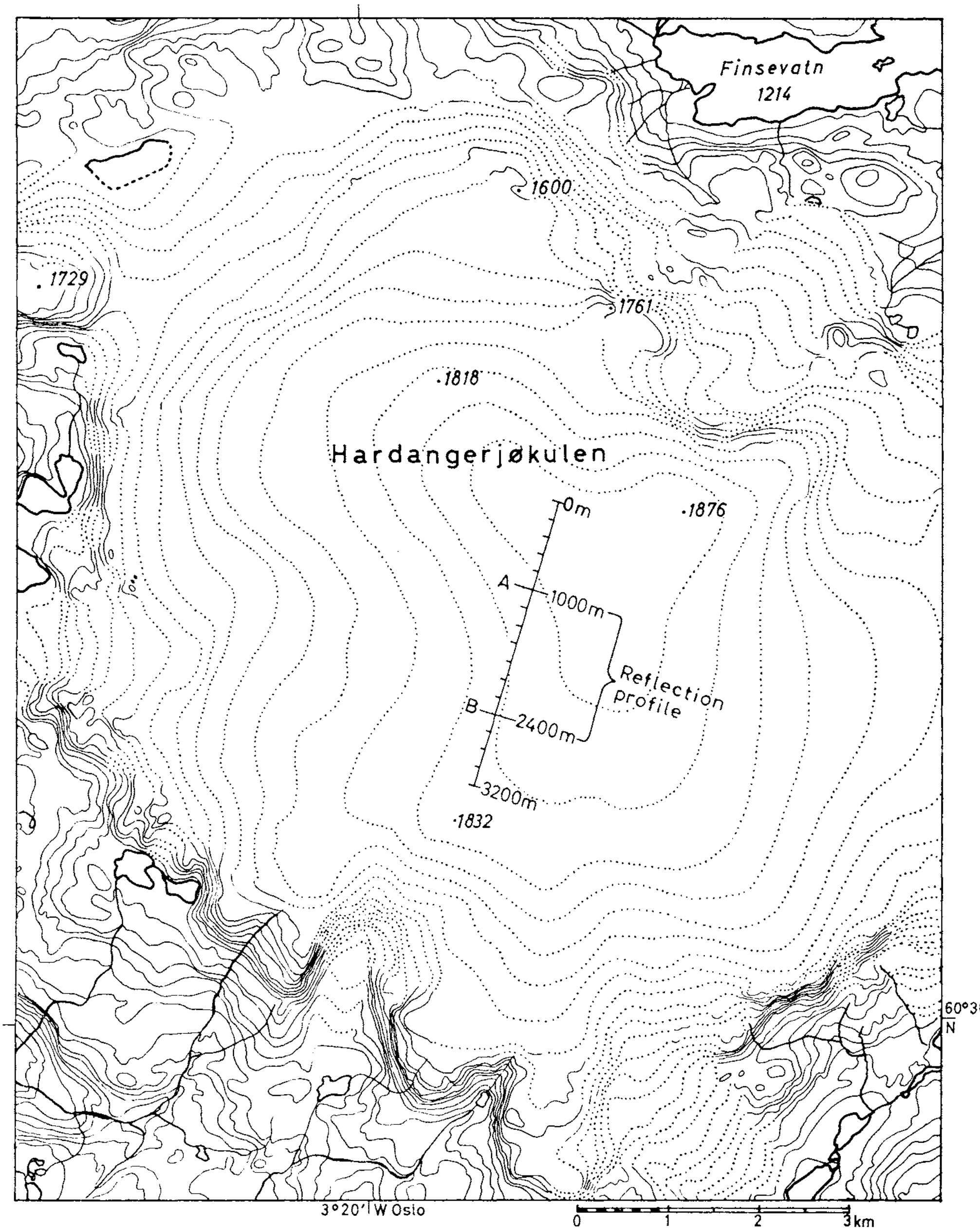

Fig. 1. *Location of seismic profile.*

b. *The refraction amplifier*

The amplifier unit contains 20 six-stage refraction-amplifiers without filters. Two amplifier-channels joined in one plug-in-unit and the response-curve of the transistor amplifier is flat between 10 and 1000 cps.

The amplifiers are constructed by Mr. C. ANDERSEN and modified by Mr. A. AURDAL and Mr. F. VEIM, Seismological Observatory, University of Bergen.

c. *The seismometers*

The seismometers used are the Hall-Sears HS-1. The frequency is 14 cps, the internal resistance is 215 ohm and the sensitivity is 1.3 V/cm sec^{-1} with 540 ohm load resistance.

Refraction measurements

Refraction measurements were made in three stages:

1. with a 2 m detector interval (20 detectors) and shots 2 m from both ends of the profile.
2. with a 5 m detector interval (20 detectors) and shots 5 m from both ends of the profile.
3. with a 20 m detector interval and shots from one end of the profile.

Velocity depth curves

Travel-time plots for 2 and 5 m detector intervals have been combined and averaged to one curve for the P-wave. The corresponding velocity-depth curve is computed under the following assumption: The velocity does not decrease with depth anywhere between the surface and the depth to maximum ice-velosity.

The computation of the velocity-depth curve is done after the method of simple horizontal multilayer. The approximation made is supposed to be within the limits of error for the reading of the reflected pulse. The P-wave velocity increases from 1050 m/sec at 2 m below the surface to 3570 m/sec about 45 m below the surface of the glacier.

An unsuccessful attempt was made to determine the depth of the glacier between 0 and 1500 m (Fig. 1) by refraction shooting. A number of charges ranged in sizes from 10 to 25 kg high explosive dynamite were fired at 0 m (Fig. 1), and recorded between 1200–1500 m in the profile (Fig. 1). The onsets were very weak and the quality of the refracted waves from the surface rock under the glacier were poor.

Reflection measurements

A successful attempt with reflection measurements was then made in order to determine the ice-thickness along the profile line. Shots for vertical reflections were made at 200 m intervals between 1000 and 2400 m. The interval between the geophones was 5 m and the shots were between the geophone points 10 and 11. Good records were obtained in almost every instance between 1000 and 2400 with one kg charge of high explosive dynamite (Fig. 2).

The charges were fired in 5 m deep bore-holes and the geophones placed directly on hard-trampled snow and this arrangement strongly "attenuated" the direct waves from the shot to the geophones so that the onsets of the reflected

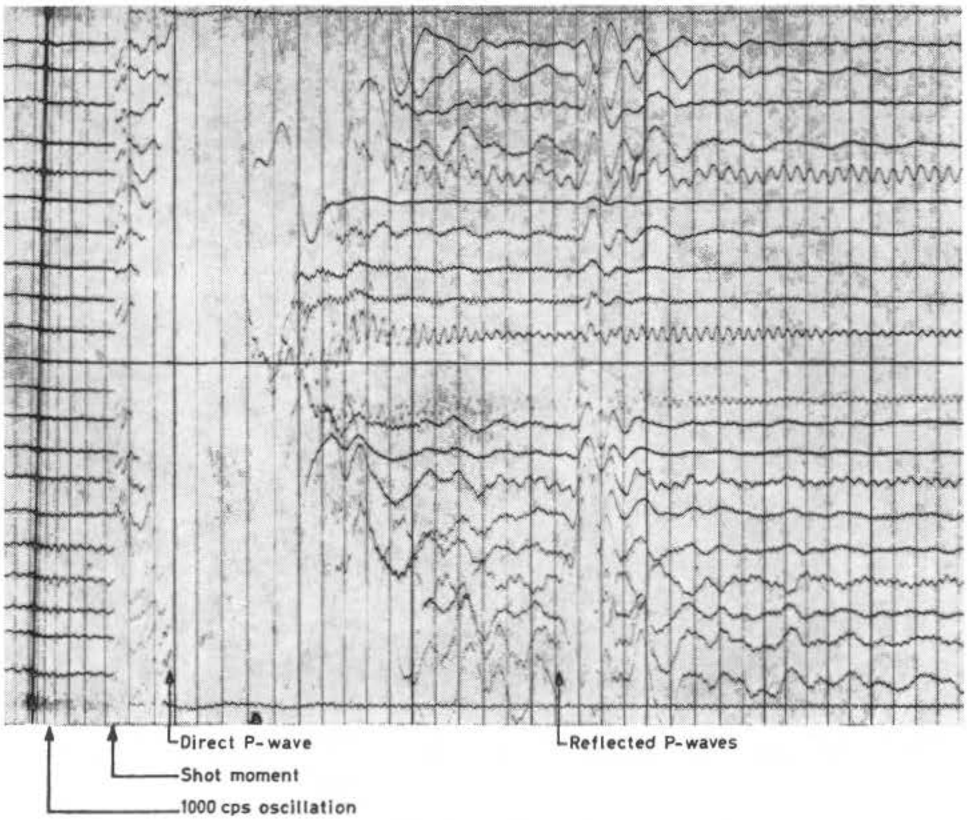

Fig. 2. *Typical seismogram from the reflection measurements.*

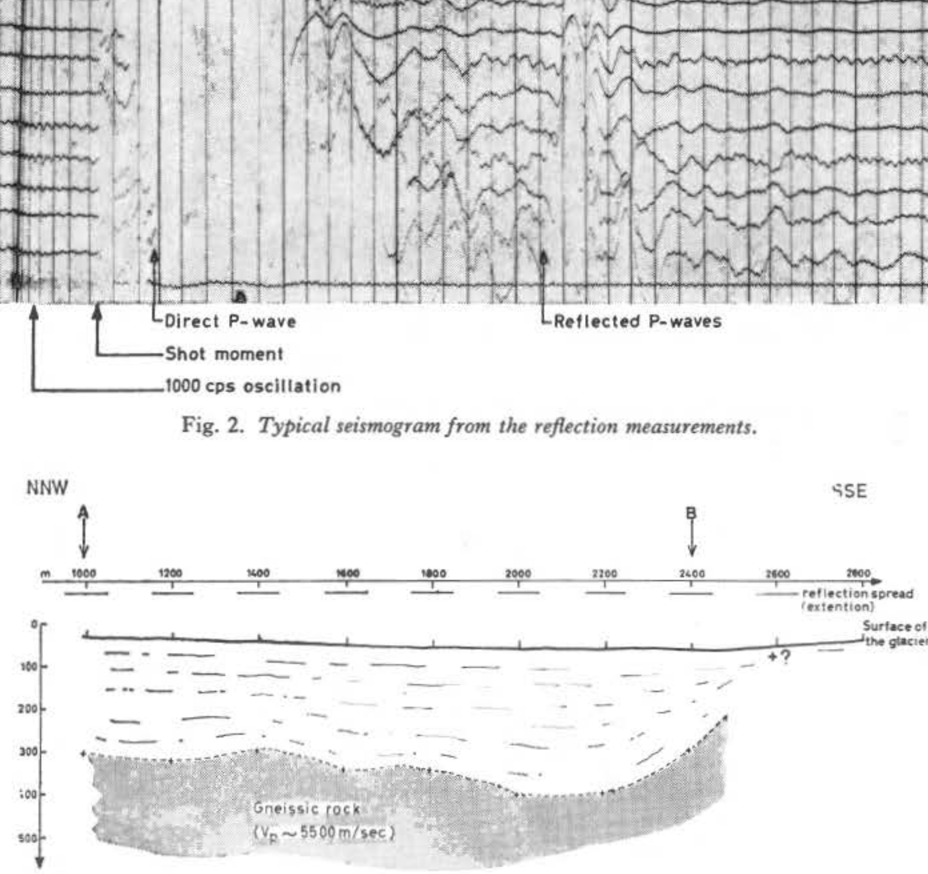

Fig. 3. *Depth profile of the central part of the glacier Hardangerjøkulen.*

waves were not much disturbed by the direct shot-pulse in the seismograms (Fig. 2). The frequencies for the direct P-waves were 90–100 cps. The frequencies for the reflected waves were usually higher: 100–120 cps.

The quality of the records at 2600 and 2800 m were not as good as the others.

Not far from the 2800 m flag in the profile direction, we found solid rock and the other morphological feature indicated a rather rapid change in the elevation of the surface beneath the glacier between the 2400 m and 2800 m flags. These circumstances must be the reason for the bad reflections at the flag positions 2600 and 2800 m.

Results

Refraction measurements carried out on the glacier Hardangerjøkulen show that the P-wave velocity increases from 1050 m/sec at 2 m below the surface to a constant maximum velocity of 3570 m/sec about 45 m below the surface of the glacier.

Reflection measurements along a 1400 m long profile (A–B, Fig. 1) show varaition in the ice-thickness between 240–360 m (Fig. 3).

Acknowledgements

The authors would like to express their gratitude to Norsk Polarinstitutt, especially to Mr. OLAV LIESTØL, for cooperation and assistance.

Russian opinion about the discovery of Spitsbergen[1]

BY

ANATOL HEINTZ[2]

Abstract

In Western Europe it is commonly accepted that W. BARENTS discovered Spitsbergen in 1596, even though it is mentioned in old Norse sagas, that Svalbard (= Spitsbergen ?) was found in 1194.

Russian scientists believe, however, that Spitsbergen was discovered by the Pomors probably as early as in the 10th century, and that they trapped there from the 12th and 13th centuries or perhaps even earlier.

Five Russian papers are referred and according to the present author the Russian evidence is unsatisfactory and often of questionable character. He supposes that it is more probable that the Pomors, apart from possible accidental visits to Spitsbergen before BARENTS, did not trap on the island regularly before the second half of the 17th century. At that time all sailing to the eastern parts of the Polar Sea was prohibited by the Russian Government. The Russian trapping in Spitsbergen stopped about 1850. The question of when the Russians first came to Svalbard may perhaps only be solved by careful archaeological investigations.

Взгляд русских на вопрос об открытии Шпицбергена

Автор разбирает в настоящей статье пять работ русских авторов (Иванова, 1935, Ставницина, 1935, Бадигина, 1953, Белова, 1956, и Обручева, 1964), касающихса вопроса об открытии Шпицбергена. Все они категорически утверждают, что Шпицберген несомненно был открыт русскими поморами и его богатства утилизированы ими задолго до открытия этого острова Баренцом в 1596 году — быть-может уже в XI или XII веке — и во всяком случае не позже XV столетия.

По мнению автора настоящей работы все те доводы, которые приводят русские авторы, не достаточно убедительны и не могут служить неоспоримыми доказательствами того, что русские поморы действительно промышляли на Шпицбергене до Баренца. Автор критечески разбирает все приведенные данные и со своей стороны приводит ряд доводов, которые указывают на то, что если поморы может-быть действительно и

[1] A somewhat extended translation of a paper published in "Norsk Geografisk Tidsskrift", Vol. XIX, (3–4), 175–203. Oslo 1964.

[2] Paleontologisk Museum, Oslo, Norway.

посещали изредко Шпицберген до Баренца, то они во всяком случае не промышляли и не перезимовывали там регулярно. По мнению автора поморы начали систематически посещать Шпицберген лишь с конца XVII века, после того как указом царя Михаила Феодоровича в 1619 году было категорически запрещено плавание как иностранных так и русских судов на восток и северо-восток вдоль северного побережья России.

Вопрос о том, кто и когда открыл Шпицберген, может по всей вероятности быть решен лишь при помощи интенсивных археологических исследований на Шпицбергене.

In the West it is commonly acknowledged that Spitsbergen was discovered in 1596 by a Dutch expedition led by W. Barents. However, in the "Annals from Iceland", it is recorded that Svalbard, (generally accepted to be the old Norse name for Spitsbergen), was discovered in 1194. This is repeated in eight different manuscripts. "Svalbard" is mentioned in some sagas, where navigating instructions are to be found for sailing to these islands, (Ingstad 1948, p. 21). Svalbard is situated "North, in bottom of the sea" (Mathiesen 1957, pp. 7, 8).

The Russians, on the other hand, present a quite different interpretation regarding the discovery of Svalbard. They emphasize in their papers that Spitsbergen was found and its riches exploited by Russian Pomors long before any one else.

I will try here to give a general view of the Russian claims based on information given in five Russian books.

Badigin, K., 1953: Way to Grumant. Pictures of the Pomors real life. Russian Polar Sea sailers – a historical account.

Belov, M., 1956: Arctic navigation from the oldest times to the middle of the 19th century. Vol. I of "The history of the discovery and utilization of the Northern Sea Route".

Ivanov, I. M., 1935: Spitsbergen.

Obruchev, S. V., 1964: Russian Pomors on Spitsbergen in the 15th century and what a Nürenberg physician wrote about them in 1493.

Stavnizer, M., 1948: The Russians on Spitsbergen.

Ivanov's book I have only had the opportunity to look through during a visit to Russia in 1959. The four others are in my possession.

The selection of the books is quite casual, but I do not believe that other sources would have given more comprehensive data, as all five books, more or less, repeat the same facts and refer to the same sources. In Belov's and Obruchev's books one also finds a comprehensive list of literature, whilst the three others have much shorter references. On the whole Belov's and Obruchev's books seem to be the most objective and reliable. By contrast Badigin's book is of a more doubtful quality. Badigin narrates in the latter part of his book (Historical review) that some copies of old maps and manuscripts from the 15th century, in his possession, show that the Pomors long ago knew the way to Grumant

(=Spitsbergen), that they were excellent sailors, and that they had partly colonized the coasts of the Polar Sea from Murmansk in the west to Alaska(!) in the east. BELOV in his book criticizes BADIGIN's «documents». He writes that "The mentioned documents have been examined by experts at the Institute for Literature in the Academy of Science in SSSR. The experts stated that the copies found by K. S. BADIGIN «represent a resently produced complete falsification». Based on this information BADIGIN's conclusions must be regarded as rather questionable, representing, in reality, only the results of a literary fantasy". (BELOV, p. 34, footnote).

To us this condemnation of BADIGIN's book, of which 90 000 copies were printed, is more comprehensible if we look at the year of its publication. It was published in 1953, which means that is was written *before* STALIN's death. BELOV's book, however, is published in 1956, 3 years after STALIN's death.

The Russian opinion on the question of the discovery of Spitsbergen can best be illustrated by a few short quotations from the above mentioned books. In BELOV's book (p. 66) one reads: "The commonly acknowledged fact that the Russians were the first to reach Spitsbergen and the first to use its natural riches is only disputed by some few American and Norwegian geographers". STAVNIZER also agrees: "In all books and scientific magazines referring to Spitsbergen one finds that the history about the conquest of this far off and cold country, began with the Russian hunters – «grumljanos», who were the first to winter there. Even the most prejudiced foreign writers must accept the Russian Pomors outstanding bravery. With great persistency, they took possession of these severe archipelagos" (p. 3). BADIGIN also emphasizes the same point. "Without doubt it is unjust to give the Dutchman BARENTS the honour of having discovered Grumant. In reality the archipelagos represent an old Russian country, which was discovered and used by the Pomors about 400 years earlier than when BARENTS came there for the first time. The Russian priority with regard to the discovery of Grumant is undisputable" (p. 268). Also OBRUCHEV mentioned on p. 138: "We can no longer doubt that already by the end of the 15th century, Russians had hunted on this archipelago (= Spitsbergen) and wintered there".

Thus, all the authors point out that the Pomors discovered Spitsbergen. But who were these «Pomors», where did they live, and where did they come from? BADIGIN goes into great detail about this, and even if one must be a little sceptical with regard to his assertions, his narrative about the Pomors is probably in general correct.

As early as in the 9th and 10th centuries, and increasingly later on, farmers and poor people living in restricted circumstances sought to get away from the central part of feudal Russia.

They fled from the pursuit, suppression and injustice of the princes and sheriffs, the monasteries and merchants. They set out into the unknown; southwards to the Russian plains, eastwards to the forests in the Ural mountains, and northwards to the desolate coasts of the White Sea. Those who went south and east became the bold cossacs who for several centuries formed a martial community. They fought against the Tartars, Poles and other «non-christian» people, de-

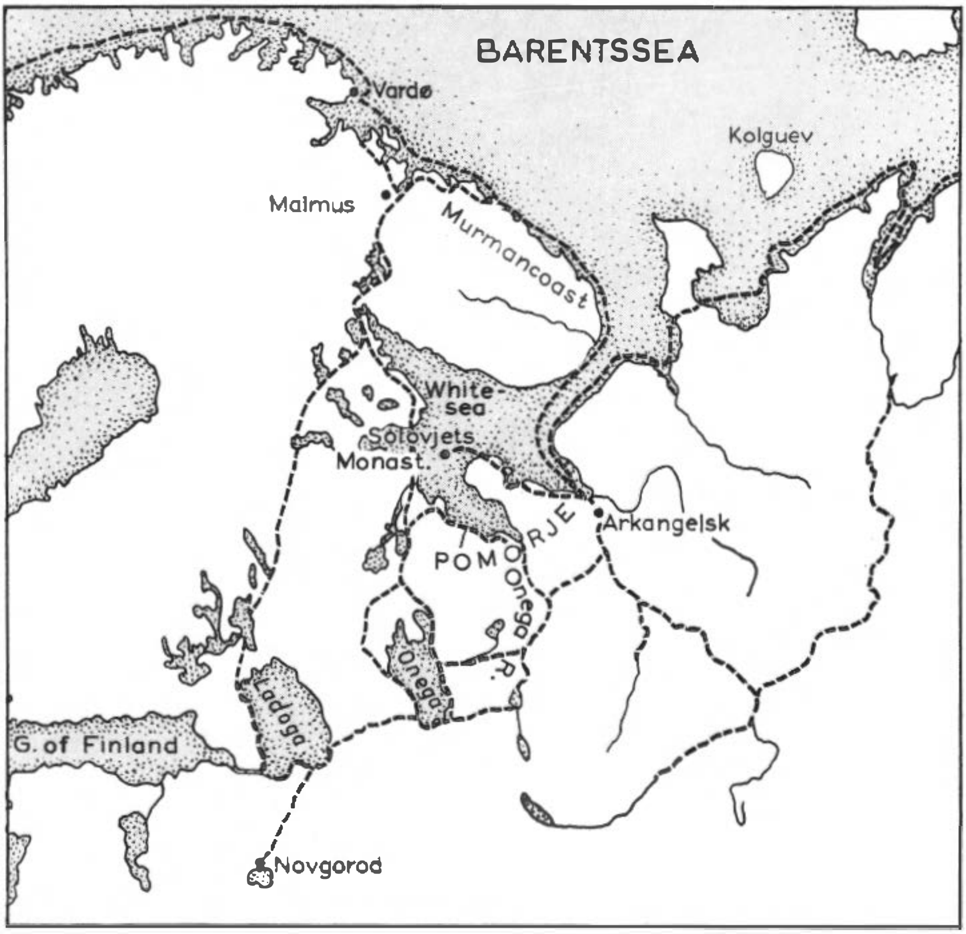

Fig. 1. *The Pomors' journey in the Arctic Oceans during the 12th to 14th century.* (*Broken line – the routes of the Pomors*). (After Belov).

fending in reality the frontiers of Russia, the country they did not themselves acknowledge.

Those farmers who fled northwards, probably reached the coasts of the White Sea near Onega and settled there (Fig. 1) by the 10th and 11th centuries. This part of the country was called «Pomorje», meaning the country by the sea (po means – by, and more – the sea) and the people who settled there were called «Pomory». The greater part of the Pomors were farmers from the central Russian plains, from where, according to an old Russian proverb, "one has to ride for seven years before meeting the sea". The sea and the life along the coast were quite alien to them, even if previously they had been used to travelling in simple boats on rivers and lakes. There, in the far north, and far away from the princes and bailiffs, they were able to lead a free life, but at the same time they had to alter their way of living. The soil was poor, the climate severe; they could not subsist by the usual farming but had to seek other means of living, dependent on the sea. At that time, enormous herds of walrus lived on the sand-banks in the bays

Fig. 2. *A Pomor settlement at the Murman-coast.* (*Redrawn after a picture from 1881*). (After BELOV).

of the White Sea, and large numbers of seal and whale were to be found everywhere. Catching of walrus, seal and whale in the sea and furred animals in the forests and on the plains became their most important occupation. The teeth and blubber of the walrus, and skin and furs, they sold or exchanged for corn with the merchants in Novgorod. From ancient times Novgorod was an important commercial centre, a refuge, independent of the rest of Russia, and not subjected to the Tartars. The merchants from Novgorod carried on their trade from Scandinavia and Balticum in the west to the White and Polar Seas and Siberia in the east; «Pomorje» was the furthest outpost towards the north and northeast (Fig. 1). Gradually, as the walruses were reduced in the White Sea, and the Pomors learned to navigate among the ice-floes, they built strong sea-going boats and sailed further out of the White Sea following the walrus and seal, which steadily retreated towards the north and northeast. They discovered and partly colonized the coastal regions as far as Vaigach, and hunted on Novaja Zemlja and along the coasts of Siberia. Russian investigators are of the opinion that the Pomors went westwards at a very early stage, founded colonies on the coast of Murman (Fig. 2), and chased walrus along the icefront. Whilst following the edge of the ice in the summer and autumn, they apparently discovered the Island Medved (Bjørnøya) and Grumant (Spitsbergen) and began to hunt and winter in these parts. This happened, according to the Russians, perhaps as early as in the 10th, but certainly in the 11th–12th centuries.

BELOV writes the following on p. 66: "The Pomors often visited Spitsbergen, Grumant or Grunt. The Russians' first visit to Spitsbergen was in prehistoric times. Geographical literature acknowledges almost unanimously that Russian seafarers were the first to discover Spitsbergen. The Norwegian scientist B. M. KEILHAU writes that one can establish that Russian sea-farers came to Spitsbergen in the 13th century. In a monograph about Spitsbergen published in Paris in 1943 ROMANOVSKY presents the opinion that the Russians had discovered Spitsbergen

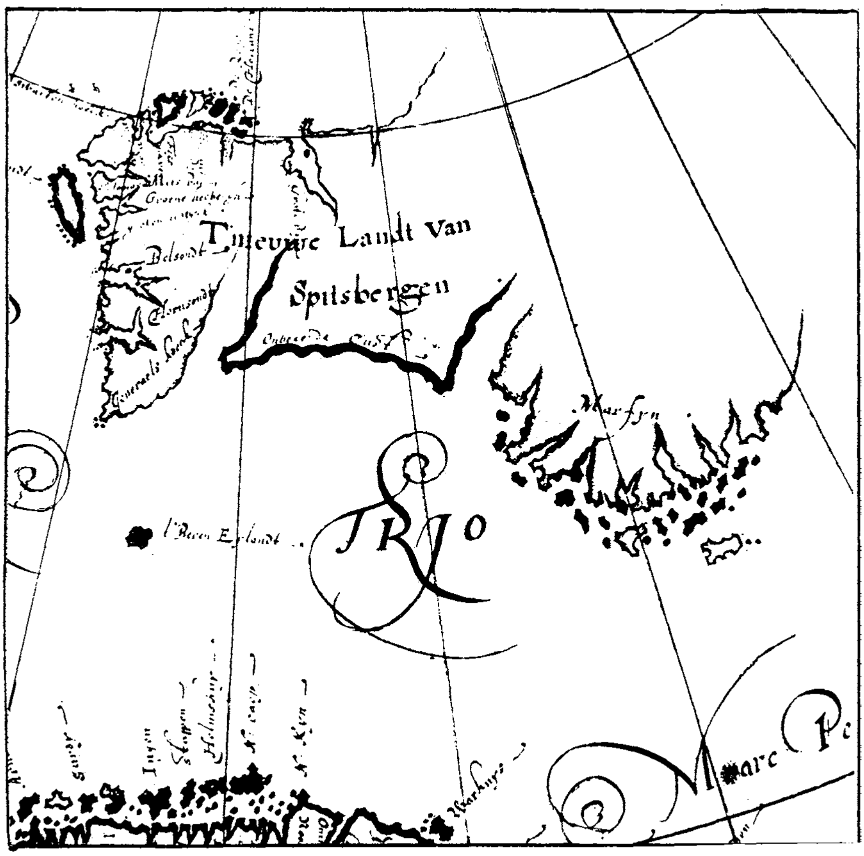

Fig. 3. *Part of* CAROLUS' *map of Spitsbergen from 1614.* (After WIEDER).

in the 10th century. ROMANOVSKY dismisses as an untenable theory that Spitsbergen apparently was discovered by the Scandinavians in the 12th century". BELOV here refers to A. SAVIN's work (1921). The title of V. ROMANOVSKY's paper, is not mentioned. What BELOV means with the reference to B. M. KEILHAU, I do not understand. In KEILHAU's book «Travels in East and West-Finmarken; also to Beeren-Eiland and Spitsbergen in the years 1827 and 1828» (1831) *nothing* is mentioned about the Russians coming to Spitsbergen in the 13th century; on the contrary he emphasizes that BARENTS discovered the island in 1596 (KEILHAU 1831, p. 226–227).

BELOV continues on p. 66–67: "That the Russian Pomors travelled to Grumant was known in Western Europe in the first part of the 16th century, as can clearly be seen from the Dutch and English geographical maps of the Polar Sea. Thus on MERCATO's map from 1569 there are drawn north of Scandinavia, seven islands, which he calls «The Holy Russians». The Dutch captain JORIS CAROLUS, sailed several times to Spitsbergen at the end of the 16th and the beginning of the 17th century. He drew on his map of Spitsbergen, (published in 1614), to the east of what he knew as Spitsbergen, firstly an «unknown land», – apparently

Edgeøya – and still further east «Marfa's island» (= Marfin[1] ostrov), which probably is the same as either Kong Karls Land or Nordaustlandet" (Fig. 3).

"From the end of the 16th and the first half of the 17th century", BELOV continues on p. 67: "the first written evidence of the heroic Russian expeditions to Grumant are to be found. Thus THENNISZ CLAESZ – one of the members in W. BARENTS' Dutch expeditions – wrote that in the sea round Vestspitsbergen, which BARENTS' ship visited in 1596, he saw «crowds of drifting walruses without their heads, and also dead whales. We were surprised to see these headless walrus, as the Russians usually boiled the fat from the blubber». (Here referred to F. C. WIEDER 1919). According to the above mentioned, one may conclude that before the Dutch ships came to Spitsbergen, the Pomors had hunted both whale and walrus. The tusks of walruses were at that time more valuable than ivory. Unfortunately CLAESZ' report is very short".

STAVNIZER does not dismiss the achievement of the Scandinavians in the discovery of Spitsbergen quite so categorically. Firstly, he gives a detailed report of what the west Europeans, especially the Scandinavians, knew and thought about the presence of a land situated north of Finnmark. He writes, amongst other things, that in the «Annals from Iceland» it is mentioned that "Svalbard was found in 1194". Later he mentioned the evidence that the Russian Pomors certainly knew of Svalbard, long before it was discovered by BARENTS in 1596. "This land was visited and used by the brave Russian Pomors several centuries before BARENTS, according to some, before the 12th century." He writes on p. 8: "They thought that is was an extension of Greenland and called it «Gruland», «Grunant» or «Grumant»".

According to STAVNIZER, that the Russians knew about Spitsbergen in the 14th century can be judged from the traditions of the STAROSTIN family. They "hunted on «Grumant» for hundreds of years". (STAVNIZER p. 12). BELOV also writes about this, only in greater detail. "The STAROSTINs hunted on Spitsbergen for a long time, the best known representative of the family being IVAN STAROSTIN, who wintered on Spitsbergen 32 times, died there in 1826, and was buried in Grønfjorden. One of his descendants – a farmer from Volagodsk – ANTON STAROSTIN, sent a petition in 1871 to the Russian government in which he asked for the permission to be "the only hunter on Spitsbergen". He supported the petition with the reference: "so far as I know, according to my family traditions my ancestors sailed to Grumant even *before* the foundation of the Solovets monastery". As the Solovets monastery (Fig. 1) was founded in 1425 it looks as if the ancestors of STAROSTIN hunted on Spitsbergen before that time". (BELOV, p. 67). BADIGIN also mentions IVAN STAROSTIN. But in his more imaginative report, STAROSTIN becomes his own grandfather who had been wintering for 39 years on Spitsbergen and was therefore called «The czar of Spitsbergen». (BADIGIN, p. 269).

A far more interesting and important document is referred to by all the four authors, particularly by STAVNIZER (p. 12–14) and IVANOV (p. 10–11). "In the archives of Copenhagen", writes STAVNIZER, "there is preserved an interesting

[1] It should be mentioned that "Marfa" is a common Russian woman's name.

letter from the Danish King FREDRIK II to a merchant LUDVIG MUNK in Trondheim. The increase of the ice round Greenland had isolated from Europe the colonies on Greenland. For a long time nothing was known about the fate of the many thousand people who had moved to Greenland. An inpenetrable ice-frontier isolated Greenland from the rest of the world and all attempts to break through the ice had failed.

King FREDRIK II (1534–88) determined at all events to come in contact with his colonies on Greenland. He therefore gave orders to make inquiries in Norway, if there were any people, who would try to reach Greenland. In reply the merchant LUDVIG MUNK wrote to the king, that a Russian captain from the Malmusa (a name the Norwegians used for Kola at that time (Fig. 1)) knew the way to Greenland–(Spitsbergen ?). The King then wrote to MUNK:

To Ludvig Munk,

About a Russian, who visited Greenland, I learnt from your report, that last summer some citizens of Trondheim met a Russian captain Pavel Nisjezov, in Vardø; he lives in Malmusa, and usually sails to Greenland every year at Varfalamea-mass. Pavel Nisjezov told them that, if they paid him something for his trouble, he might possibly tell them about that country and take their ships there. Therefore I ask you to find out how much money is necessary for an investigation of the above mentioned country, and in addition, to let me know if it is possible to find some citizens in Trondheim who wish to offer their ships for such a voyage.

Notwithstanding how heavy the expences will be in connection with such a journey and the investigation of the above mentioned country, we are most graciously willing to cover all the expences, and will pay them with pleasure. We wish to leave you to negotiate with the above mentioned Russian captain, asking him to join in the service of this enterprise, and also to make an appointment with some of the citizens of Trondheim, in order that they shall put their ships at your disposal, to undertake the journey in the coming autumn.

March 11th, 1576 FREDRIK II.

Unfortunately, it has not been possible to discover whether LUDVIG MUNK really carried out the King's order, and if PAVEL NISJEZOV took part in the expedition. Neither does there exist any statement about this brave representative of the Russian Pomors, who had sailed to «Grumant» long before BARENTS". (STAVNIZER, p. 12–14).

As mentioned above, both BELOV (p. 268–69), IVANOV (p. 10–11) and OBRUCHEV (p. 111–112) mention the same letter with similar comments.

OBRUCHEV in his book (1964) discusses a remarkable letter which a German physician and geographer MÜNSTER from Nürnberg sent to the Portugese King JOHAN II, on the 14th of July 1493, on the request from King MAXIMILIAN I.

In this letter, originally written in Latin, but now known in the complete text only in Portugese, Dr. MÜNSTER tried to persuade King JOHAN to send, an expedition westwards together with King MAXIMILIAN to find a shorter way to China's wealth.

Thus, in fact, this letter has nothing directly to do with Spitsbergen. But in a subordinate proposition we find a remarkable passage, which, according to OBRUCHEV and some other Russian historians, shows that Russian hunters knew Spitsbergen in the 15th century.

In this passage, written in a stiff, old-fashioned language, MÜNSTER mentioned (expressed in a more modern idiom) the following: "You (= King JOHAN II) are already glorified as a great sovereign by the Germans, Italians, Russians, and Poles and also by the people who live under the severe star of the Arctic Pole. The last mentioned people also glorified the great Duke of Moscowia, because some years ago, under the severeness of the same star, a large island Grulanda was discovered, the coast of which stretched for 300 legna (= about 1 800 km) and on which were situated large settlements, the people being subject to the above mentioned Duke of Moscowia."

In an interesting historical examination OBRUCHEV tries to show that MÜNSTER, with his many contacts with various other geographers, merchants and travellers, and with his interest in maps, would be in a position to get information about the Pomors' discovery of «Grulanda» and their settlements there. The contact between Russia and Europe was relatively well established at that time and Russian missions visited the different capitals of Europe.

According to OBRUCHEV MÜNSTER was probably in touch with some of these Russian missions and could easily get information from them about Moscowia's polar possessions. OBRUCHEV mentioned also that the name «Grulanda», used in MÜNSTER's letter, was closer to the names given to Spitsbergen by the Pomors, («Grumand», «Grunt» or «Gruland») than the original Norwegian name «Grønland».

OBRUCHEV concluded that «Grulanda», mentioned by MÜNSTER, was in fact Spitsbergen, discovered by Russian hunters as early as in the 15th century, but regarded by them as a part of Greenland. According to OBRUCHEV, MÜNSTER mentioned in this letter to King JOHAN II the discovery of a settlement on «Grulanda» (= Spitsbergen), as an example of the possibility of discovering new lands, if an expedition was sent westwards.

These are the facts, on which the Russian scientists base their statements that the Pomors discovered Spitsbergen long before BARENTS.

Let us now turn to what is known about the Russian hunters on Grumant in the 17th, 18th and 19th centuries.

According to West European literature it is known that in the 16th century the Pomors had a considerable fleet which consisted of good seafaring ships, of various types. The Englishman BOVIO, who in 1556 often met Russian boats along the coast of Murman and near Novaja Zemlja wrote that: "The Russians are brave and clever sailors, and their ships go faster than the English ones". (STAVNIZER, p. 21). According to other statements the Russian hunting fleet on the coast of Murman at the end of the 16th century consisted of about 7,000 vessels

Fig. 4. *Part of* BARENTS' *map, showing the way he sailed to Spitsbergen i 1596. The map was printed in 1598, after* BARENTS' *death.* (*The broken line indicates the way* BARENTS' *ship sailed*). (After WIEDER).

with a crew numbering at least 30,000 men – all Russians (STAVNIZER, p. 22). After the conquest of Novgorod by IVAN III in 1474, the czar became interested in the further extension of the hunting in the Polar Sea. He gave some northern monasteries, which previously had hunted extensively, privileges in the form of duty-free trading with fat of sea-animals. However, the Pomors were illiterate, and therefore unfortunately we do not have any accounts of their voyages and hunting. STAVNIZER (p. 22) recorded that they certainly did not limit their hunting to the coast of Murman and round the island Kildin, but went further north-

Fig. 5. Pomors on board their boat – named "lodja" – sailing in Svalbard waters. (After STAVNIZER).

wards as early as the 13th–16th century perhaps as far as Medved (the name given to Bjørnøya by the Pomors) and Grumant. The first West European accounts of meeting between whalers and Pomors on Svalbard derive from 1697 (BELOV, p. 68, STAVNIZER p. 24), with reference to these, record that while the West European whalers hunted along the west and partly the north coast of Vestspitsbergen, the Pomors hunted along the more inaccessible east coast of Storfjorden, Edgeøya, Hopen and possibly also Nordaustlandet. The ice situation made access to these parts of the archipelago difficult for the whalers, and only the clever Pomors, accustomed to sailing among the icefloes, dared to go there. The Pomors were not interested in catching whales; by preference they hunted walrus, seal, polar bear, reindeer, arctic fox and whitefish and gathered eiderdown. However, no documents exist confirming that the Pomors *really* did hunt on the east coast of the archipelago at the beginning of the 17th century or even earlier.

On the contrary, the Russian sources point out that at the beginning of the 17th century, the Pomors greatest interest was to go on hunting expeditions eastwards to Vaigach, Novaja Zemlja and Siberia (STAVNIZER, p. 22). This is easily understandable, as the way eastwards followed the coast, and passed between numerous islands (Figs. 1 and 11). In addition, Siberia was a rich country where the Pomors not only could hunt themselves, but also could exchange valuable articles with the natives. Thus it seems reasonable to suppose that the above mentioned hunting fleet of about 7,000 vessels was first and foremost used to go eastwards for hunting and trading.

However, at the beginning of the 17th century a fundamental change in the whole condition took place. The West European ships in constantly increasing numbers, began to seek a "way to China and India" along the coast of Siberia. The Russians, perhaps not without reason, were afraid that a further development of this traffic would result in foreign occupation of territories in Siberia, or foreign trading companies exploiting the rich Siberian markets. Therefore, in 1616 the local «voevody» (= princes) sent a petition to the czar MIKAIL FJODOROVICH in Moscow with a request to prohibit all sea traffic (including Russian) along the north coast of Siberia. The czar accepted the petition and put it into effect, by issuing a very drastic «ukas» (= decree); all sea communications with Siberia were forbidden, under the menace of the death penalty and destruction of both ship and property (STAVNIZER, p. 23; BELOV, p. 524). "In this way", writes STAVNIZER (p. 23) "the road northeastwards was shut for several centuries". "And the Pomors", he continues, "were thus forced to go westwards to the remote Grumant" (STAVNIZER, p. 24).

Russian historians imply that the Pomors knew the road to Grumant from earlier experience and were well aware of the archipelago and its riches. Among other things BELOV tells of a Dutch map dated 1619, on which a course was marked for sailing from Novaja Zemlja to Bjørnøya, and further to Spitsbergen. He suggested that the Dutch did not use the route themselves, and that they had apparently seen it on a Russian map, or heard about it from the Pomors (BELOV, p. 69). However, it did not occur to BELOV that this route marked on the map, was precisely the one that BARENTS had used, when he went from Spitsbergen to Novaja Zemlja, and that this route still can be found on some old Dutch maps (Fig. 4)! Thus we know nothing about the Pomors travels to Svalbard from the beginning of the 17th century or earlier.

On the other hand we know for certain that when the English, Dutch and other whaling-nations, about 1618, divided the hunting territories on the west coast of Spitsbergen between themselves, the Russians did not take part in this division, and according to STAVNIZER (p. 16): "at that time they hunted in the inaccessible east coast areas". Or perhaps they simply did not hunt on Spitsbergen at all? As mentioned above, the first contact between the Pomors and the Dutch whalers took place in 1697, when according to STAVNIZER the Pomors for the first time left the hunting places on the east coast and began to seek new grounds on the west coast (STAVNIZER, p. 24). That the Pomors long before this time should have hunted along the west coast seems very improbable. The whalers took good care of their «hunting territories» and were prepared to use weapons to keep away intruders. If the Pomors had tried to hunt along the west coast, it would certainly have been mentioned in the extensive literature about the whaling years in Svalbard. Quite a number of ships and people visited the archipelago every year. STAVNIZER mentions that in the course of 100 years the Dutch alone sent 14,176 ships to hunt at Spitsbergen (STAVNIZER, p. 17). However, the Russian hunting on Grumant began to dominate towards the end of the 17th century and continued through the whole of the 18th century. "In the 18th century", writes STAVNIZER (p. 25), "when most of the foreign whalers left Spits-

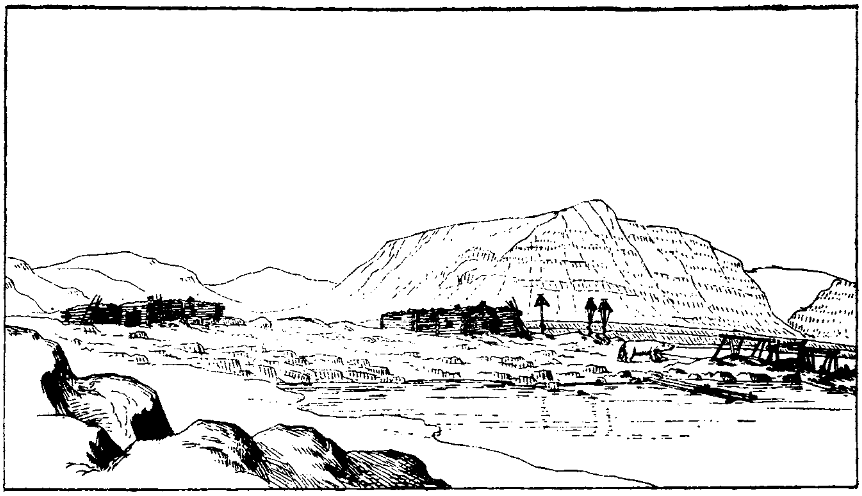

Fig. 6. *A Pomor settlement at Edgeøya.* (After KEILHAU).

bergen, hundreds, even thousands of Pomors sailed to the hunting grounds at Grumant" (Fig. 6).

PETER the Great became interested in the whale hunting and in 1723 he founded the state «Kola Whaling Company». A row of houses and sheds were built, the ships were chartered, crews hired (funnily enough all the officers were Dutch!) and so on. Despite this, the Russian whaling in Spitsbergen was unsuccessful (STAVNIZER, p. 25).

In 1747 for the first time the Department of commerce in St. Petersburg (Leningrad) took an interest in the hunting at Grumant, and began collecting information about it from the administration in Arkangelsk. But even then it was difficult to get the necessary information. It was not until the state and private monopolies on hunting had been dissolved, in the latter half of the 18th century, that a renewed rise in the Russian hunting on Spitsbergen occurred, now mainly paid for by the monasteries and merchants in Archangelsk. At that time, according to reports, up to two thousand hunters wintered each year. (STAVNIZER, p. 33), (Fig. 12). At the end of the 18th century forced registration of all the hunters was introduced and they were required to present their passports before departure. According to the registration books during the years 1797–1799 precisely 23 ships sailed north with altogether about 380 hunters (STAVNIZER, p. 34) – a relatively small number!

From the beginning of the 19th century the Russian hunting decreased quickly. KEILHAU (1831) who among others, went to Svalbard in 1827, emphasized this strongly. He visited some of the Russian hunting huts – a few were in a relatively good order (Fig. 6), but many lay in ruins. He gave, in addition to his work, an account of the Russian hunting stations, which he got to know about through Norwegian hunters (KEILHAU, 1831). Even in the 1850s some Russian hunters wintered on Svalbard. However, it came to an end, in 1875 ANTON STAROSTIN died in Vologda district – he was the last Pomor, who hunted on Spitsbergen. (STAVNIZER, p. 38).

Given above is a short summary of what is known, and what has been suggested about Russian hunting on Svalbard. In the following I will try to analyse the known evidence and give my opinion on the development of the Russian hunting in this area.

My opinion is that the basis for the Russian investigators' views, that the Pomors had discovered Svalbard perhaps as early as in the 10th century or at any rate long before BARENTS, is only of a speculative nature.

The first argument is that as the Pomors were good sailors and clever navigators in the ice, and had good sea-faring boats, built to go through ice, it would be «very natural to suppose», that they had discovered places other than Novaja Zemlja, Vaigach, Siberia, and had sailed not only along the coast of Murman and the Norwegian coast to the Balticum, but had also gone north and discovered Bjørnøya and Grumant. This is not inconceivable, but unfortunately there is no proof. On the other hand several facts suggest that the supposition is quite improbable.

Firstly, all the courses that are known for certain to have been used by the Pomors, closely followed the coast. The islands they discovered – Novaja Zemlja, Vaigach and others – are separate from the mainland by relatively narrow straits (Figs. 1 and 11).

Secondly, to sail northwest or northwards from the White Sea or Murman, straight into the desolate sea, without any land within sight, was certainly not to be undertaken lightly. The Pomors had neither especially large boats nor any idea that about 1,000–1,500 km away some islands existed amongst the sea ice. The navigation was difficult, as they sailed partly across the current (Fig. 7). BELOV and STAVNIZER maintained that the Pomors probably sailed along the ice barrier, where they got protection from the northern winds whilst catching walrus and seal, and thus reached Bjørnøya and Svalbard.

Even this cannot be excluded, but sailing along the constantly moving ice barrier, which could at any time crush the boats, was not very tempting. And in any case, it was a long way to Spitsbergen.

Thirdly, if one regards the hunting situation in the 13th–14th centuries and even in the 15th and 16th, there was no lack of walrus and seal along the long, winding, and at that time, rather desolate north Russian coasts. It seems hardly probable that a hunter would take the chance to sail across open seas in the hope of finding new land and new hunting grounds, when walrus and seal were to be found everywhere else.

On the other hand, it is possible of course that some boats might have been driven to Svalbard by a storm, or by the ice, thus discovering the archipelago just by chance. But all this is only *supposition* and *proof is totally lacking* that the Pomors knew Svalbard many hundreds of years ago. I believe that even if Svalbard was discovered by chance, it was certainly not systematically exploited as a hunting ground. Why travel thousands of kilometres, when quite sufficient hunting existed just outside one's own house? Hunting is primarily a means of livelihood and subsistence, not pleasure.

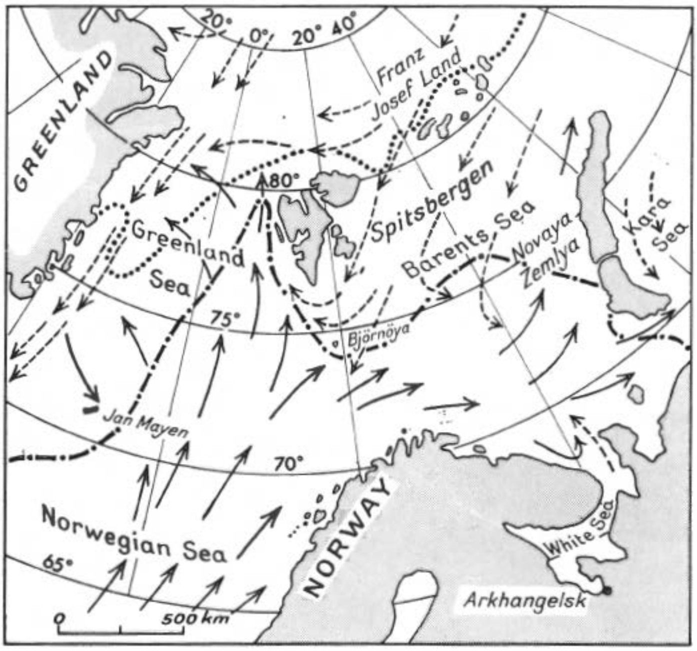

Fig. 7. *The map shows areas of the Norwegian Sea, the Greenland Sea and the Barents Sea between Greenland and Novaja Zemlja. The warm and the cold currents are indicated by solid and broken arrows respectively, and the maximum and minimum extension of the pack-ice is drawn by a broken and dotted line respectively.* (After INGSTAD).

In my opinion also the written evidence to which the Russian authors refer, cannot be depended on.

Let us look at the old maps, which BELOV mentions. Nothing is proved by the fact that MERCATOR on his map of the area north of Norway drew seven islands with the name «Holy Russian». Strange drawings are to be found on all old maps; for example, on the map of MERCATOR a continent is depicted around the North Pole. The name «Holy Russian» has no connection with Spitsbergen or Grumant. The Russians have never regarded Grumant as «holy», and none of the Russian names on the single island in the archipelago are reminiscent of the name «Holy Russian». It is impossible to know what MERCATOR meant by these islands, but they are very unlikely to have had any connection with the Russians' Grumant.

With regard to the map of J. CAROLUS (Fig. 3) where he drew a large island east of Spitsbergen, called «Marfyn» (not «Marfin ostrov» as BELOV writes), this name had already been used on earlier maps by PONTANUS and HONDIUS, both published in 1611 (WIEDER, 1919). On all these maps «Marfyn» is situated, not only far eastwards but also far to the south of Spitsbergen – somewhat more to the south or about the same latitude as Bjørnøya. Thus there is no reason for the supposition that it could represent either Nordaustlandet or Kong Karls Land. On the map of CAROLUS «Marfyn» is situated beside and to the southeast of a large island, which is shown to lie directly east of Vestspitsbergen (Fig. 3) and is called "unknown coast" (not "land" as BELOV writes). WIEDER indicated that

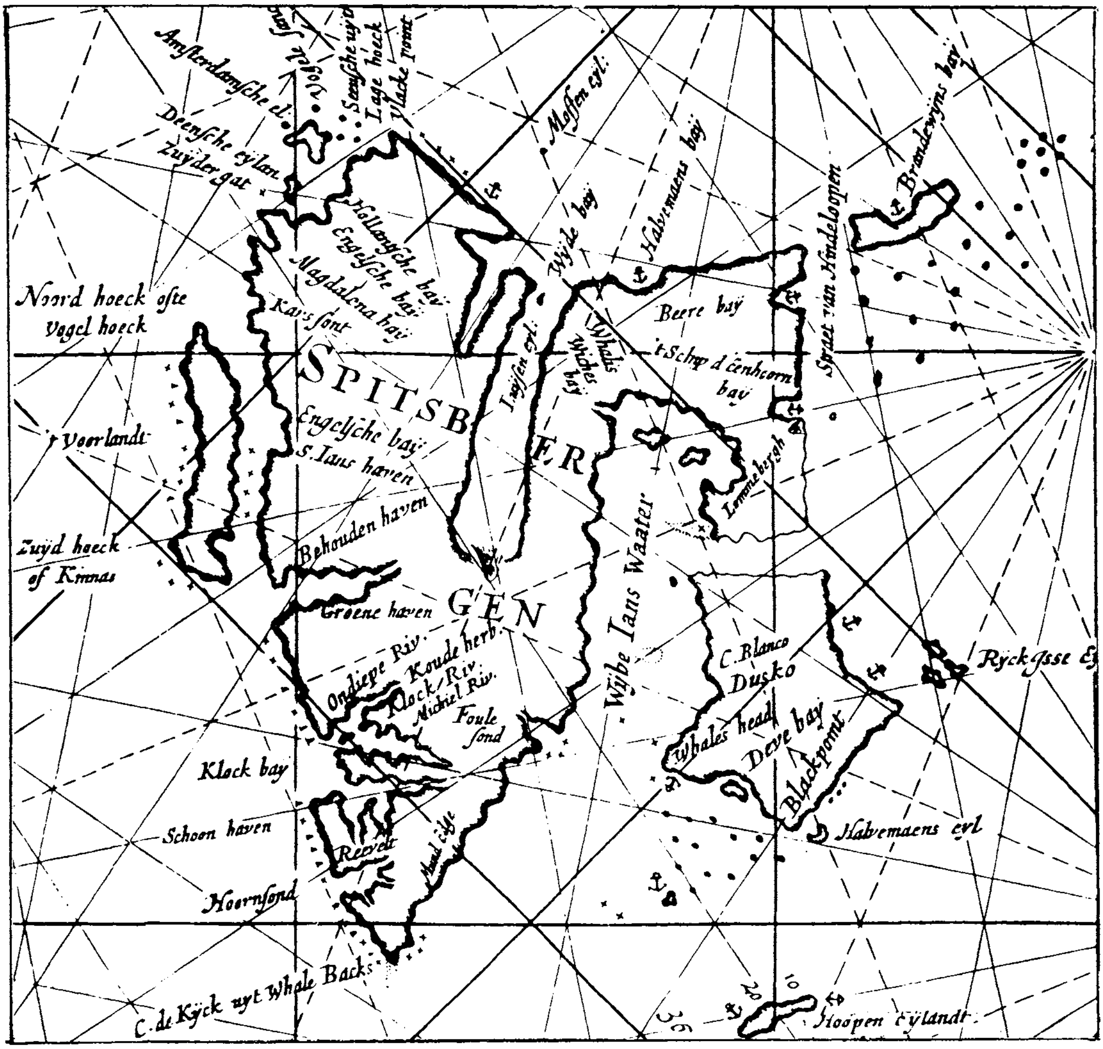

Fig. 8. *Part of* HENDRICK KONCHER's *map of Spitsbergen from 1663.* (After WIEDER).

«Marfyn» may have been either a part of Novaja Zemlja, wrongly depicted on the map, or a non-existing island. There is thus no reason to suppose that «Marfyn» refers to any Russian name connected with Spitsbergen.

With regard to the headless walrus and dead whales which one of BARENTS' companions, THEUNISZ CLAESZ, referred to in his diary, it is quite plain that BELOV's interpretation is incorrect. He maintains that this proved that the Pomors had hunted on Spitsbergen before BARENTS. It must be admitted that CLAESZ does not express himself very distinctly, but if one reads his diary more thoroughly it is clear that he could not possibly have meant that the Russians had hunted on Spitsbergen. CLAESZ was not on BARENTS' ship, but on that of RIJP. After both the ships had returned from Spitsbergen to Bjørnøya, BARENTS sailed towards Novaja Zemlja, while RIJP went back to Spitsbergen for the second time.

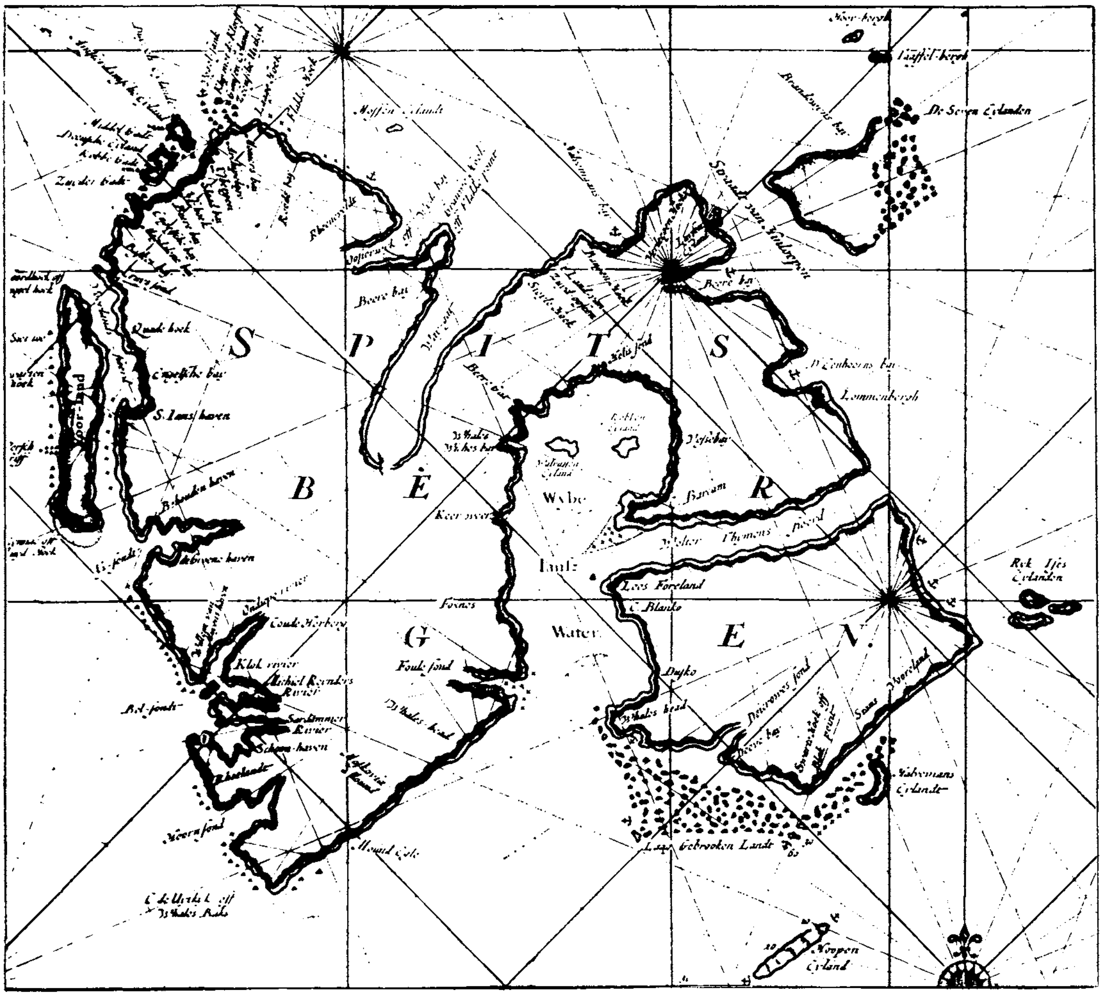

Fig. 9. *Part of* JOHANNES VAN KEULEN's *map of Spitsbergen from 1682.* (After WIEDER).

CLAESZ writes about this: "Thereupon we sailed once more in a northly direction from the equinoctial line up to 81° to Greenland (= Spitsbergen. A.H.), which country *was never before visited by any man as we, and it is to be feared that after our visit nobody will ever come there;* we remained there for 12 weeks". From this it follows quite clearly that CLAESZ had not seen any traces of other human beings in Spitsbergen, and with regard to his talk about walruses without heads, he could not be alluding to the Russian's hunting in Spitsbergen. If we make a somewhat longer quotation from CLAESZ' diary, we will understand more fully what he really meant. He writes: "... On the coast I also found two teeth of a walrus which the Russians sell at high prices, for sometimes they cut the head off a walrus and throw the body into the sea again as they merely want the teeth. In Moscowia these teeth are considered to be as much worth as silver and they think the ivory of these teeth are of a better quality and whiter than the ivory of elephants' teeth though the latter are of much larger dimensions. We saw (in Moscowia) some walruses without heads floating and also a few whales. We were astonished at seeing these walruses without heads as the Russians used to make train-oil out of the fat just as those from Cap Verde do out of the huge turtles which give an excellent clear train-oil". I have added the word "in Moscowia" to make the meaning intelligible. It is obvious, according to my understanding, that CLAESZ from the sentence starting with "In Moscowia", is no longer referring to the conditions in Spitsbergen, but to those near the *Russian coast*, which he apparently had visited on some earlier occasion. Thus, when he mentions "We saw some walruses without heads", he obviously refers to what he saw in the *Russian waters*, not in Svalbard. This is in accordance with CLAESZ' own statement that Spitsbergen "never before has been visited by other people."(All the quotations from WIEDER, 1919, p. 18–19).

It is quite remarkable that BELOV should base his conclusions on such vague remarks as those of CLAESZ, despite the clear statement of CLAESZ himself that Spitsbergen had *never previously been visited by any other men*. BELOV in a tabulation of the most important events in the polar region, stated that in the year 1596: "In the course of his (= BARENTS') third journey (1596) he reached a place in Spitsbergen where *tracks were to be found from the frequent visits* of Russian sailors to the archipelago". (BELOV, p. 523). Here one may really talk about «wishful thinking»!

STAROSTIN's petition to the government in 1871 with a request to monopolize hunting on Spitsbergen, understandably contains all possible supporting arguments for his case. It is uncertain whether one can trust the STAROSTINS' family traditions, which are not supported by written documents, but based only on verbal communication. That STAROSTIN's ancestors had hunted before the foundation of the Solovets monastery, is quite possible, but it is impossible to tell whether it was on Novaja Zemlja or Grumant. At any rate one cannot take STAROSTIN's petition as a proof; only as a piece of uncertain evidence.

The most important document is doubtlessly the letter from King FREDRIK II to merchant MUNK in Trondheim in 1576. But even then we do not know much about what the Russian captain PAVEL NISJEZOV (see the above mentioned letter) really meant about Greenland. Was it actually Spitsbergen (= Grumant), or somewhere else, perhaps even Novaja Zemlja, which, according to previous ideas and maps, formed some sort of connection between Greenland and Russia (KEILHAU 1831, p. 225).

Thus it may be stated that even this interesting letter is no proof in itself, without a support of more evidence from old archives.

Now turning to MÜNSTER's letter to King JOHAN II of Portugal, treated in OBRUCHEV's book (1964) it must be admitted that OBRUCHEV's explanation is possible, but not particularly probable.

Firstly one has no evidence, that MÜNSTER really had been in touch with Russian representatives sent to Europe. As far as I know, none of his other papers mention anything concrete about such contacts.

Secondly, as mentioned above (p. 97) the Pomors who hunted in the Polar

Fig. 10. *An English map of Spitsbergen compiled by* Edge *in 1625. Bjørnøya is here called «Cherrie Island»*. (After Wieder).

Sea – and eventually also in Spitsbergen – were originally in contact only with Novgorod – and independent republic, not assigned to Moscowia. The city was conquerred by Ivan III in 1478. Münster's letter is written in 1494 – about 16 years after the conquering of Novgorod. It is rather improbable that in such a short time the information about hunting and settlements in so far off a part of the Novgorod territory could have reached Moscow, and that the Russian representatives sent to Europe really could have given any information about Spitsbergen to MÜNSTER.

Thirdly the name «Grulanda» used in MÜNSTER's letter, can hardly be regarded as a misinterpretation of the Pomors' name «Grumant». It is much more probable that this name really refers to Greenland which, for example, appeared as «Grylanda» on an old Portuguese map, published about 1550 (BJØRNBO, 1912, p. VII).

A more indirect argument, which can be used not only against OBRUCHEV's, and all other Russian historians, who supposed that the Pomors' settlements were more or less frequent on Spitsbergen long before BARENTS, is as follows:

In all Russian descriptions of the Pomors' hunting on Novaja Zemlja, Vaigach, Siberia and also on Spitsbergen, it is always mentioned that one of the first things the Pomors did when arriving at their wintering places was to set up one or more large wooden crosses. They were erected in very conspicuous places on a high point, or steep beach and so on, to be used as navigation marks. Those overwintering, and any visitors could easily find their way to the settlements. In some cases large crosses were set up on particularly important parts of the coast f. inst. the entrance to fjords or straits, thus helping the sailors to find their way to various parts of the islands.

In other words numerous crosses around and close to the settlements were erected in places *especially easily seen from the sea*. If the Pomors had hunted on Spitsbergen hundreds of years before 1596 and, as OBRUCHEV and others emphasize, had large settlements there, it is completely inconceivable that all the numerous Dutch, English and other whale-hunters who visited Spitsbergen every year for nearly a hundred years (from about 1600 to 1697) did not see any traces of the crosses, houses or the Pomors themselves. In my opinion this argument is of such indisputable value, that even if the Pomors had occasionally visited Spitsbergen before BARENTS, it is certain that no settlements existed there earlier than the end of the 17th century.

Finally it can be mentioned, that OBRUCHEV in his interesting paper several times cautions the reader to be careful not to draw premature conclusions, as the material available is rather uncertain and disputable. But in spite of that, he himself categorically rejects the common explanation of the Western historians, that MÜNSTER with the name «island Grulanda» in fact meant the Greenland of our days (HARRISSE 1892, HENNING 1950 and others). Instead he declared that *without doubt* Spitsbergen was discovered by Pomors as early as in the 15th century (p. 138).

If we now turn to the Russian names for Spitsbergen and Bjørnøya, in my opinion they do not suggest that the Pomors discovered the islands earlier than BARENTS. The Pomors called Bjørnøya «Medved» or «Medvisji ostrov», which means «The Bear» or «Bear Island». It would have been a remarkable coincidence if both the Russians and the Dutch had given the island the same name quite independently. The appearance of the island is not in any way reminiscent of a bear; the name could not have been given for this reason. Not many bears lived on the island even in old days. Furthermore the polar bear, which the Pomors called «uskuji», was a fairly well known animal to the Pomors, who would hardly have thought of calling the island after such a "common" animal. On the other hand, many of the Dutch probably had not seen a polar bear before, and it was therefore to them an unusual creature! It seems to me most likely, that the Pomors heard the name «Beeren-Eiland» firstly from the foreigners and then translated it into Russian.

With regard to the Russian names «Grumant», «Grjuman», «Grulan», «Grunt» and so on, there exist many variations, and it is quite reasonable to assume, along with the Russian investigators, that they are misinterpretations of the name «Grønland». If the Russians really discovered the island in the 10th–11th century, it is quite impossible that they could have thought it was «Grønland». As is known, the name Grønland was given to the country by EIRIK RAUDE at the end of the 10th century; and a long time would have passed before the name reached the Pomors, living by the White Sea. But it is of course quite probable that the name «Grønland», in Greenland's days of vigour, at the end of the 12th century, also was known to the Russians.

This implies that the Pomors certainly did not discover the island as early as the Russians claimed, and at any rate not before the 12th–13th century. Otherwise it would have been given a ***Russian name***. As we know all the islands in the Svalbard archipelago were given Russian names at some later date, quite independently of the Dutch or English names: Vestspitsbergen was called «Bolshoi Berunt» (Big Berunt); Edgeøya – «Malyi Berunt» (Small Berunt); Nordaustlandet – «Polunochnyi ostrov» (Midnight island) and Hopen – «Pjatigorje» (Five hills) (Fig. 14).

The European seafarers who tried to find the way eastwards along the coasts of Siberia, however, were quite familiar with «Greenland», which on old maps stretched far eastwards (as mentioned above, on some maps as far as Novaja Zemlja). When BARENTS discovered Svalbard in 1595 – he believed that he had reached some parts of Greenland (STAVNIZER, p. 11).

After BARENTS' death during the winter 1596–97, his crew came in contact with the Pomors on Novaja Zemlja, and later in Kola – and they then probably told the Pomors about their discoveries. Thus the Pomors got to know about both «Bear Island» and «Greenland», situated to the northwest of Novaja Zemlja.

This cannot be considered as «proof» but only as supposition, corresponding better with our present knowledge, than with the Russian theories.

If we look at the first hectic decades in the history of whaling at Svalbard, we find a lot of other confirmatory evidence for my suppositions.

As mentioned, the first meeting between the Pomors and the Dutchmen took place at the end of the 17th century. Before that time, according to Russian sources, the Pomors hunted «in difficult inaccessible territories», in the eastern part of Svalbard, where the whalers did not dare to go. It seems quite logical until one starts thinking more critically. Firstly, we know Dutch and English maps from the first half of the 17th century, where the eastern parts of the archipelago are relatively correctly depicted. This shows that the whalers had frequently visited this part of Svalbard (Figs. 8, 9 and 10), (WIEDER 1919; AAGAARD

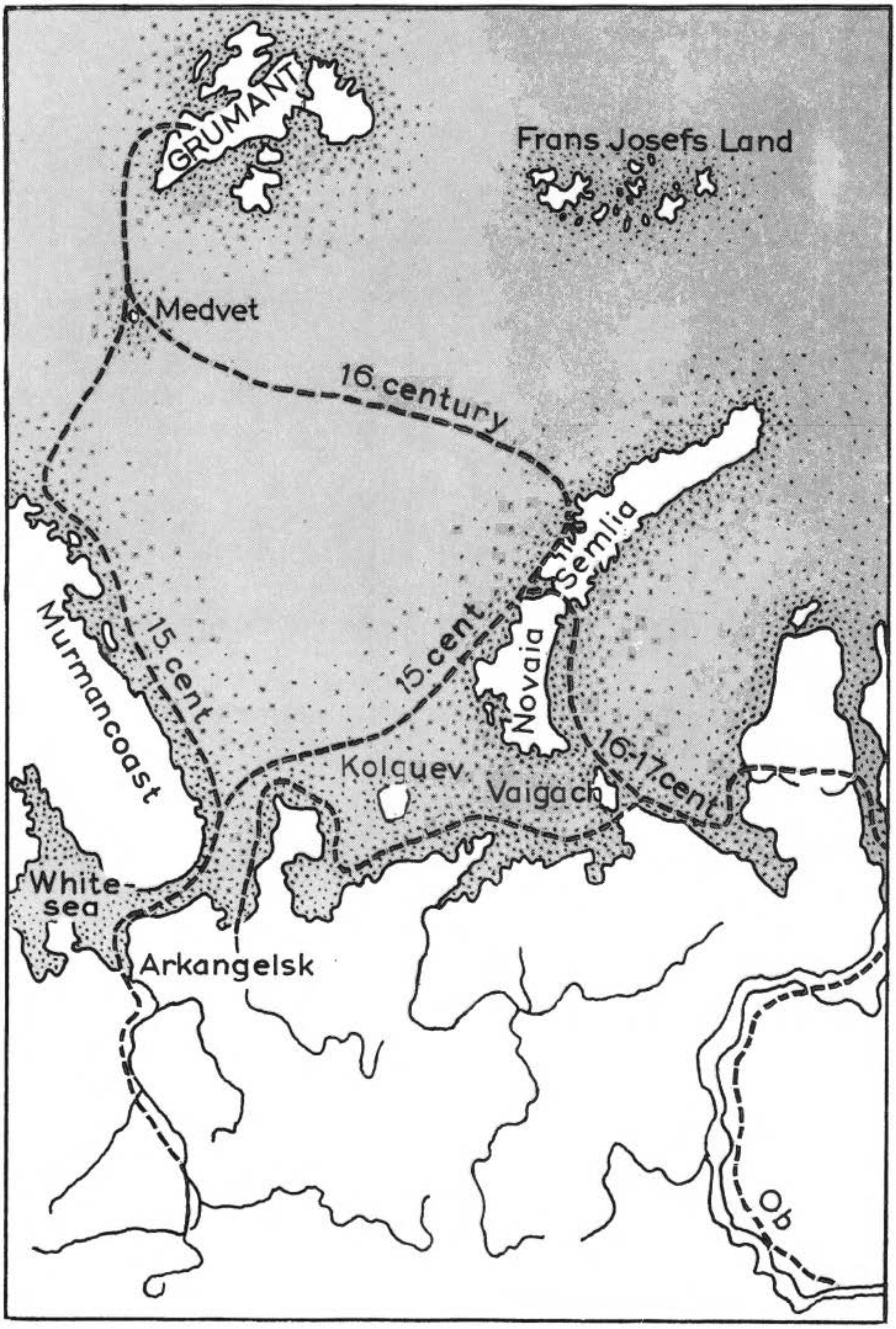

Fig. 11. *The map shows Pomors' journeys during the 16th and 17th centuries. (Broken line – the route of the Pomors).* (After BELOV).

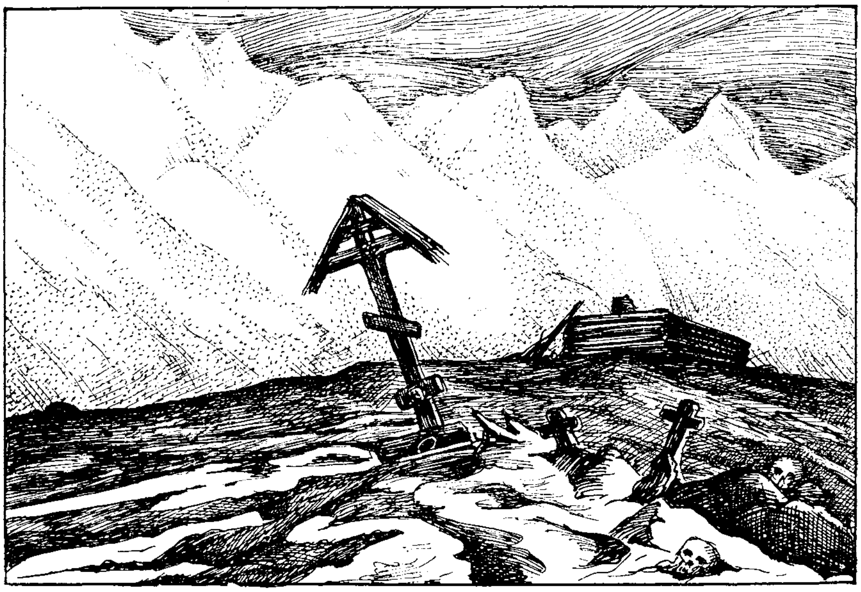

Fig. 12. *An abandoned Pomor cottage at Novaja Zemlja.* (*Redrawn after a picture from 1881*). (After BELOV).

1933, p. 37). However, far more important are the Russian assertions that the Pomors had hunted on Grumant, perhaps as early as in the 12th–13th century. Is it reasonable to suppose that they preferred to seek «the most difficult inaccessible» parts of the archipelago? Certainly the Pomors could not have been so stupid as to try to force their boats in between the icefloes in Storfjorden, instead of sailing in the open sea to the rich and easily accessible walrus sites on the west coasts? Strange to tell, on the map depicted by BELOV (p. 109) showing "the ways for the Russian advancement towards Spitsbergen, Novaja Zemlja and Magnezya in the 16th and 17th century", the Russian routes are directed not towards the east – but towards the *west coast* of Svalbard – directly to Bellsund! (Fig. 11). One may perhaps point out (even though I have not seen it in any Russian paper) that the Pomors might have left the west coast when West European whalers arrived there. But even this possibility is very unlikely. Firstly, meetings and eventual conflict between the Dutch, the English and the Pomors, would certainly have been recorded but such accounts are totally lacking. Secondly, the whalers themselves would surely have told even about the abandoned Russian stations. The question about wintering was of great interest to the Dutch and English, for the latter would gladly have established «a constant population» on the island. It was even asserted that they had asked the czar to transfer some Lapps from Siberia to Spitsbergen (HOLMSEN, G. 1912, p. 22). If the whalers had seen Russians overwintering, they would certainly have come in contact with them and at any rate mentioned it in their books. Therefore, I think that if the Russians really had hunted at Bjørnøya or Vestspitsbergen, the whalers would have seen them and have written about them in one of their numerous papers

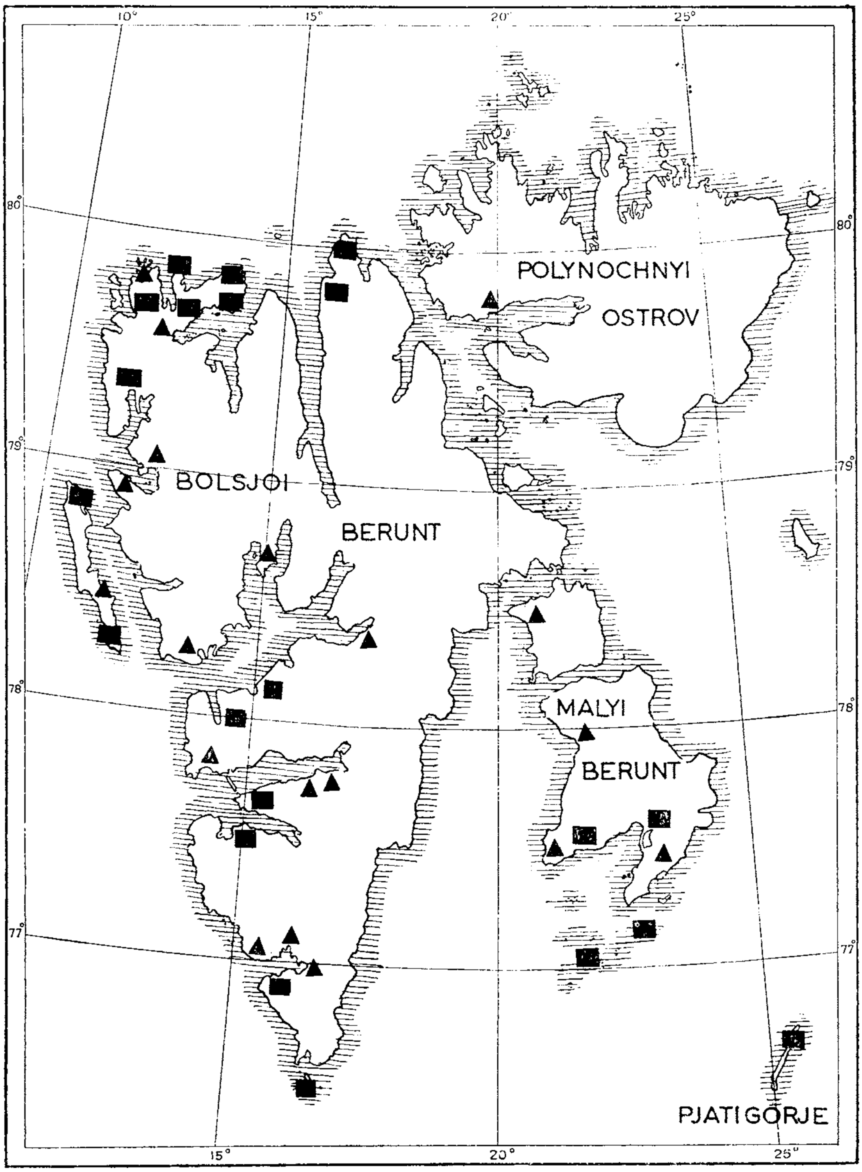

Fig. 13. *The Russian hunting-settlements* (*black squares*) *and field-cottages* (*black triangles*) *at Grumant* (*Spitsbergen*). *The names of the different islands given on the present map are the ones used by the Russians.* (Redrawn after STAVNIZER).

about the hunting at Svalbard. The enormous numbers of walrus, which the Englishmen found on Bjørnøya at the beginning of the 17th century, do not indicate that extensive hunting had gone on previously.

Thus it seems to me most likely that even if the Pomors did discover Svalbard earlier than BARENTS – they had not utilized the island systematically as a hunting place. When the hunting expeditions towards the northeast and east were stopped by the czar's «ukas» in 1619 - the Pomors had to seek for new hunting places (STAVNIZER, p. 24). They either remembered their ancestors' old reports about the polar regions towards north and northwest or, what seems more likely, the narratives, told by BARENTS' crew or other whalers and travellers, about Bjørnøya and «Greenland», and they tried to take up the hunting there.

In this connection it may be mentioned that the interest for Spitsbergen greatly increased in Russia at the beginning of the 17th century. "The court in Moscow has given an order for the translation of a Dutch account of Spitsbergen into Russian . . . under the name «Historical description of the territory Spitzberga, its first discovery, position, nature, animals and other sights»" (BELOV, p. 68).

The Pomors hunting on Svalbard began apparently towards the end of the 17th century. The Pomors brought with them their experience from Novaja Zemlja to Svalbard. Their winter-quarters in both places were very alike – and adorned with numerous crosses (Fig. 6, 12). The hunting flourished in the 18th century, but decreased towards the end of it and died out towards the middle of the 19th century. The reasons for this decrease were probably firstly the decline of the walrus stock, but also partly the state monopoly and restrictions, state control and, possibly, fewer clever seamen or poor navigators.

Whether the Russian hunting was so widespread as for instance emphasized by STAVNIZER, is also uncertain. There does not exist, as far as I know, *any exact date* in connection with travels to Svalbard before the end of the 18th century, and at that time the number of ships was quite moderate; on an average 8 ships with about 125 men each year.

Nevertheless, there existed in the previous century and at the beginning of the present century innumerable more or less well preserved ruins of Russian "stations" all over Svalbard (Fig. 13). And the large Russian crosses were among the most characteristic features of the country. In 1827 KEILHAU visited well kept and recently occupied stations both on Bjørnøya and Edgeøya (Fig. 6). Now only ruins remain; earthern mounds with some timber and bricks. Scandinavian archeologists began exploration some years ago. One may hope that they will continue this interesting work, for the question regarding when and who discovered Svalbard can probably only be solved by careful archeological investigations of these remains.

Literature

Бадигин, К., 1953: Путь на Грумант. Поморская быль. Русские северные мореходы. Исторический очерк. Москва.

(BADIGIN, K., 1953: *Way to Grumant.* Picture of Pomors real life. Supplement: Russian Polar Sea sailors – a historical account. 332 p. Illustrated. Moscow).

Белов, М., 1956: Арктическое мореплаванье с древнейщих времен до середины XIX века. Первый том «Истории открытия и освоения северного морского пути». Москва.

(BELOV, M., 1956: *Arctic navigation from the oldest times to the middle of the 19th century.* Vol. I. "The history of discovery and utilization of the Northern Sea Route". 592 pp., with maps and illustrations. Moscow.)

BJØRNBO, A. A., 1912: Cartographia Groenlandica. Vol. I, II. *Meddel. om Grønl.* **48.** København.

Филипов, А. М., 1901: Датский документ о посещении Шпицбердена русскими в XVI веке. Литературный Вестник. Том 1, кн. IV. С.-Петербург (= Ленинград).

(FILIPOV. A. M., 1901: *A Danish document about the Russians' visits to Spitsbergen in the 16th century*. Literaturnyi Vestnik. **I**, (4). St. Petersburg (= Leningrad).

HARRISSE, H., 1892: *The discovery of North America*. Paris-London.

HEINTZ, A., 1964: Russernes syn på oppdagelsen av Spitsbergen. (The Russians' opinion about the discovery of Spitsbergen.) *Norsk Geograf. Tidsskr.* **XIX**, (3–4), 175–203, with maps and illustrations. Oslo.

HENNING, R., 1956: *Terrae incognita*. Vol. **II**. 2nd edition.

HOLMSEN, G., 1912: *Spitzbergen, Natur und Geschichte*. 125 p. With maps and illustrations. Berlin-Halensee.

INGSTAD, H., 1933: *Landet med de kalde kyster*. (The country with the cold coasts.) 442 p., with maps and illustrations. Oslo.

Иванов, И. М., 1935: Шпицберген. Огиз-Севкрайгиз. Москва.

(IVANOV, I. M., 1935: *Spitsbergen*. Illustrated. Ogis-Sevkrajgis. Moscow.)

KEILHAU, B. M.: *Reise i Øst- og Vest-Finnmarken samt til Beeren-Eiland og Spitsbergen i årene 1827 og 1829*. (Travel in East and West-Finnmarken also to Beeren-Eiland and Spitsbergen in the years 1827 and 1829.) 247 p., 1 map and 3 figures. Christiania.

MATHISEN, T., 1954: Svalbard in International Politics 1871–1925. The solution of a unique international problem. 211 p. *Norsk Polarinst. Skr.* Nr. 101. Oslo.

Обручев, С. В., 1964: Русские поморы на Шпицбергене в XV веке и что написал о них 1493 г. Нюренбергский врач. Издет. «Наука». Москва.

(OBRUCHEV, S. V., 1964: *Russian Pomors on Spitsbergen in the 15th century and what a Nürenberg physician wrote about them in 1493*. 144 p., with maps and illustrations. "Nauka" Moscow.)

Савин, А., 1921: Россия и Шпицберген. Вестник Наркоминдела № 5-6. Москва.

(SAVIN, A., 1921: *Russia and Spitsbergen*. Vestnik Narkomindela, (5–6). Moscow.)

Ставницер, М., 1946: Русские на Шпицбергене. Главсевморпуть. Москва-Ленинград.

(STAVNIZER, M., 1948: *The Russians on Spitsbergen*. 148 p., with illustrations. Glavsevmorput'; Moscow–Leningrad.)

WIEDER, F. C., 1919: *The Dutch Discorvery and Mapping of Spitsbergen, 1656–1829*. 124 p., 44 tables with maps. Amsterdam.

AAGAARD, B., 1933: *Den gamle hvalfangst*. (The old whale fishery.) 167 p., with maps and illustrations. Oslo.

Iakttagelser over dyrelivet på Svalbard i 1964

(Observations of the animal life in Svalbard in 1964)

AV

NATASCHA HEINTZ og MAGNAR NORDERHAUG

Abstract

The present observations of aminal life in Svalbard in 1964 are based on records received from Norsk Polarinstitutt's fieldparties and other persons visiting Svalbard in 1964.

Tab. 1 gives a review of reindeers (*Rangifer t. spitsbengensis*) observed. The amount of reindeer-calves seen was rather limited. Tab. 2 gives the observations of muskoxen (*Ovibos m. moschatus*). One record from Revneset where a herd of eleven animals, consitings of six ad. and five juv. is rather interesting. Polar foxes (*Alopex lagopus*) were met at most places, several litters were recorded, each with two to three cubs. A rather uncertain observation of a young walrus (*Odobaenus rosmarinus*) from Moffen is recorded.

Eiders (*Somateria mollisima*) were registrated along the coasts of Vestspitsbergen and near Kapp Linné and in Kongsfjorden the number of ducklings was quite large. Mainly male king eiders (*Somateria spectabilis*) were seen. In Hornsund the greater part of the pink-footed geese (*Anser f. brachyrhychus*) were not breeding, otherwise they were met in quite large numbers at different places. Less than 50 pale-breasted brent geese (*Branta bernicla*) stayed in Hornsund, otherwise only some few finds from the rest of Vestspitsbergen are registrated. 276 used nests of barnacle geese (*Branta leucopsis*) were found between Stormbukta and Olsholmen, this being the main breeding area for these geese at Svalbard. Two whooper swans (*Cygnus cygnus*) were recorded from Hornsund. At least six hatches of ptarmigan (*Lagopus mutus hyperboreus*) were met this summer. The following less common birds were registrated: northern golden plover (*Pluvialis apricaria*), ringed plover (*Charadrius hiaticula*), dunlin (*Calidris alpina*), sanderling (*Crocethia alba*), pomatorhine skua (*Stercorarius pomarinus*) possibly breeding, great black-backed gull (*Larus marinus*) and wheatear (*Oenanthe oenanthe*).

Innledning

Svalbards dyreverden har i århundrer tiltrukket seg interesse, for det er den som var grunnlaget for all virksomhet som fantes der nord frem til vårt århundre. Det ble jaktet på hvalross, de forskjellige hval- og selartene i havet og på rein,

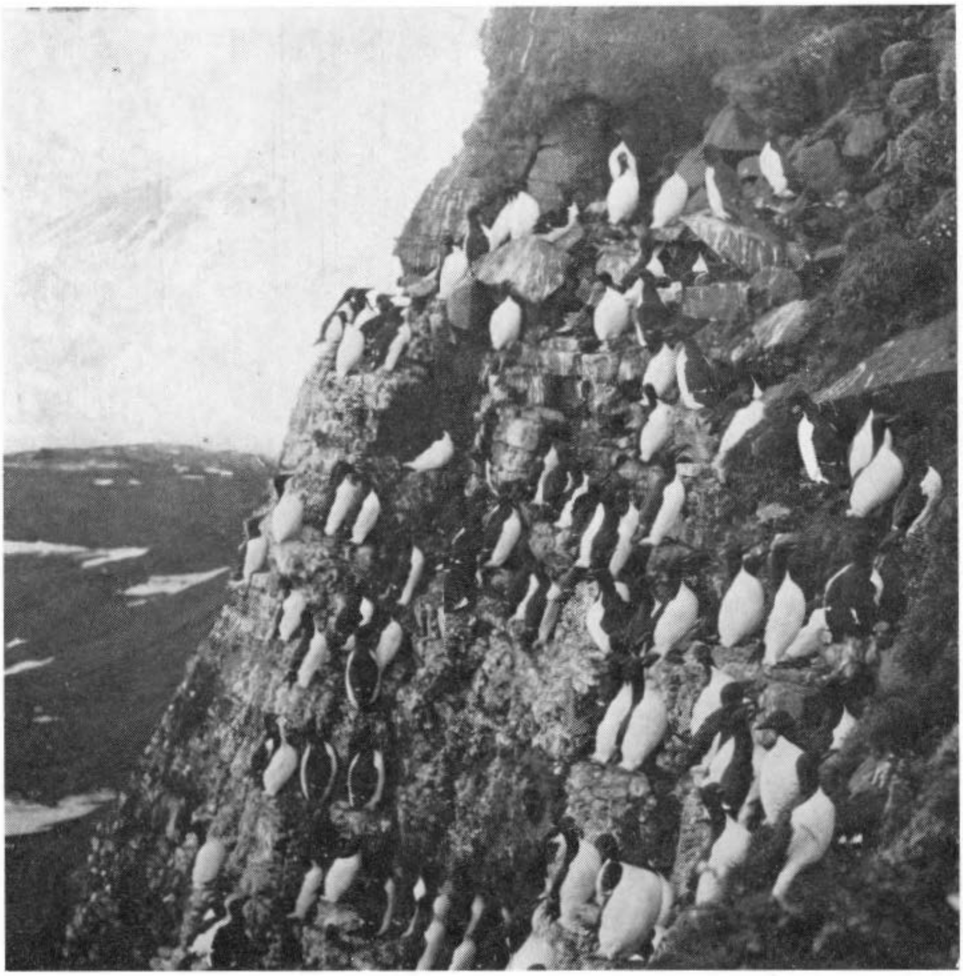

Fig. 1. *Norsk Polarinstitutt foretar også registreringer av fuglefjell i de områder hvor instituttets medarbeidere ferdes. Disse registreringene har vist at det finnes en mengde særlig mindre fuglefjell, som tidligere ikke var kjent. Bildet her viser en polarlomvi* (Uria l. lomvia) *koloni på østkysten av Vestspitsbergen.*

Norsk Polarinstitutt has during the later years registrated several bird rocks not previously known. The Brünnich's guillemots are found breeding in many places at Svalbard, i. a. also at the east coast of Vestspitsbergen. Photo: J. NAGY.

rev og isbjørn på land. Dessuten gav fangst av fugl og sanking av egg og dun verdifulle bidrag. At fangsten har vært for sterk er ikke vanskelig å se nå. De store hvalartene er forlengst og antagelig for alltid borte fra Svalbardfarvannene, og hvalrossen er i dag ytterst sjelden. Reinen hadde antagelig også vært helt eller nesten helt bort om den ikke ble fredet i 1925, umiddelbart etter at Norge overtok overhøyheten over Svalbard. Når det gjelder fuglene, ser vi at de samme tendenser gjør seg gjeldende, og det har for en rekke arters vedkommende vært nødvendig å beskytte dem ved hjelp av fredning. I dag er det særlig isbjørnen diskusjonen dreier seg om. Den er til nå bare fredet på Kong Karls Land, hvor den har et av sine beste ynglesteder. Fra mange hold hevdes det, at isbjørnstammen blir for hårdt beskattet, og dette kan lett resultere i at også isbjørnen snart bli en sjelden gjest i våre arktiske områder. De finnes også som mener at isbjørnbestanden er stor nok. Ja, det hevdes også at bestanden faktisk er for stor og det er nødvendig med en forholdsvis enda større beskatning, for isbjørnen gjør, etter deres mening et for stort innhugg i selforekomstene. For alle disse problemer gjelder det at vi i grunnen ennå ikke kjenner Svalbards dyreverden godt nok. Med den økte vitenskapelige og turistmessige aktivitet som vi allerede nå kan merke, og som sikkert vil tilta i årene fremover, kommer hele spørsmålet om beskyttelse av Svalbards dyre- og planteverden enda sterkere i forgrunnen. Det er ikke tvil om at det trenges et effektivt og målbevisst naturvern på Svalbard, om ikke landets flora og fauna skal bli sterkt skadelidende ved den økte aktivitet. Vi må jo ikke glemme at på tross av sitt gunstige klima, så ligger Svalbard meget langt mot nord. Vi befinner oss her i virkeligheten ved livets yttergrenser, hvor både gjenvekst og fornyelse tar meget lang tid.

Det er i erkjennelse av at vi trenger å få langt mer omfattende og detaljert kjennskap til opptreden, fordeling og antallet av de forskjellige dyre- og plantearter på Svalbard, at Norsk Polarinstitutt har tatt opp arbeidet med registreringer av fauna og flora. Arbeidet har foreløpig vært utført på tre måter. Først og fremst har vi siden sommeren 1962 sendt med alle Norsk Polarinstitutts feltpartier observasjonsskjemaer for biologi og bedt våre medarbeidere notere mest mulig av hva de ser. Resultatene av dette arbeidet har vært meget godt, tatt i betaktning av at disse observasjonene er foretatt ved siden av de egentlige oppgavene partiene har arbeidet med. De innkomne data for somrene 1962 og 1963 er publisert (N. HEINTZ 1964, 65).

For det annet har Norsk Polarinstitutt støttet og organisert partier som har arbeidet med bare rent biologiske oppgaver. Det har først og fremst vært ornitologiske studier, men de seneste årene har det vært foretatt undersøkelser både over Svalbardrøyen (*Salmo alpinus*) og Svalbardreinen (*Rangifer tarandus spitsbergensis*).

For det siste og tredje har vi tatt kontakt både med utenlandske ekspedisjoner og med folk som bor i Longyearbyen, for å få eventuelt de opplysninger og iakttagelser de måtte ha samlet. Dette registeringsarbeidet er imidlertid ennå bare i sin begynnelse. Men jo større aktiviteten blir på Svalbard, jo viktigere er det å ha konkrete data om hvor store de forskjellige bestandene er, slik at vi bedre kan vite hvordan vi skal kunne beskytte dem og eventuelt utnytte dem.

I det foreliggende arbeidet er innledningen og avsnittet om pattedyr skrevet av N. HEINTZ, mens avsnittet om de ornitologiske observasjonene er skrevet av M. NORDERHAUG, som selv i de siste 3 sommere har arbeidet med ornitologi i Hornsundområdet.

Takk

Begge forfattere vil gjerne takke alle som har bidratt med opplysninger og observasjoner, det gjelder både det materialet vi har fått fra Polarinstituttets medarbeidere og fra andre. En av forfatterne (M. N.) vil spesielt gjerne få takke sine to assistenter LAGE LJØTERUD og BJØRN MATHIASSEN for deres store innsats under feltarbeidet sommeren 1964.

Pattedyr

Svalbardreinen (*Rangifer tarandus spitsbergensis*) ble sett på en rekke steder som det vil fremgå av tabell 1. Det så ikke ut til å være særlig mange kalver, bortsett fra en observasjon fra Ulladalen i Van Keulenfjorden, hvor det i en flokk på

Tabell 1.
Observasjoner over rein (*Rangifer tarandus spitsbergensis*) sommeren 1964

Lokalitet	Datum	Antall dyr	Observert av	Anmerkninger
Vårsolbukta–Fridtjovhamna	1–14/8	10–12 ad.	W. INGEBRETSEN	sett i området
Ved Ytterdalsåta	»	8 ad., 2 juv.	»	–»–
Ulladalen	10/8	8 ad., 3 juv.	J. NAGY	
»	18/8	16 ad., 10 juv.	»	
Van Keulenfjorden, sydsiden	/7– /8		O. LIESTØL	spor og ekskrementer på mange steder
Adventdalen	9/7	2 ad.	O. BJERKE/ J. H. ERIKSEN	
Inngangen Olav V Gruve, Endalen	13/7	1 ♂	»	
Adventdalen, Mälardalen	24/6	4 ad.	E. S. NYHOLM	
Adventdalen, Fivelflyane	25/6	1 ♂, 1 ♀	»	
–»–	»	23 ad.	»	sett på 10 km avstand
Bolterdalen	28/6	3 ad.	»	
Hotellneset	2/7	6 ad.	»	
Adventdalen	6/7	1 ad.	»	
Mellom Mälardalen og Fivelflyane	6/7	23 ad.	»	
De Geerdalen	13/7	1 ad.	»	kadaver, ant. skutt, hud på hornene
Fallbekken, Hollendarelven	29/7	1 ad.	J. F. VOISIN/ H. MAJOR	skjelett
Todalselven	/7	1 juv.	»	skjelett, små horn
Vindodden	13/7	5 ad.	E. S. NYHOLM	
SW-siden, Sassendalen	14/7	3 ad.	»	
Lernerøyene	14/7	3 ♀♀, 3 juv.	T. GJELSVIK	
Langs Roosstranda	15/7	ca. 30 ad.	»	
Sjøvernbukta	17/7	ca. 15 ad.	»	
Mellom Sjøvernbukta og Fridtjovbreen	18/7	ca. 10 ad.	»	
Ved Sverrefjellet	19/7	ca. 15 ad.	»	
Nordsiden Sjøvernbukta	22/8	4 ad.	O. BJERKE/ J. H. ERIKSEN	sett fra helikopter
Sørsiden Sjøvernbukta	22/8	3 ad.	»	–»–
Sørdalen	/7– /8	ca. 100 ad.	I. AHLÉN	fantes i området

26 individer var 10 kalver. I. AHLÉN (Universitetet i Lund) rapporterte at han på Reinsdyrhalvøya hadde funnet 16 reinkadavre, hvorav en del var fra siste vinter. Alle disse dyrene var omkommet fordi de hadde viklet seg inn i løs ståltråd, som har ligget på Reinsdyrflya siden siste verdenskrig. Norsk Polarinstitutt vil sommeren 1965 søke å få denne tråden fjernet og gravet ned. E. S. NYHOLM (Universitetet i Oulu) opplyste at han i midten av august i De Geerdalen fant et kadaver som antagelig hadde blitt skutt. Dyrets horn var nemlig ennå helt hudkledde og blodet friskt.

Moskusdyr (*Ovibos m. moschatus*). Det var forholdsvis sparsomt med observasjoner av moskudyr sommeren 1964, som det fremgår av tabell 2. Den mest interessante iakttagelsen ble gjort av H. MAJOR og J. F. VOISIN, som på Revneset i nærheten av Louiseelva så en flokk på 11 individer, hvorav det var 5 juv. (antagelig kalver og ungdyr). Dette skulle tyde på en ganske god ungeproduksjon blant moskusdyrene i dette området.

En enslig hann (et voksent individ) som ble sett av O. BJERKE, J. H. ERIKSEN, H. MAJOR, J. F. VOISIN og E. S. NYHOLM på forskjellige steder i Adventdalområdet, er sikkert en gammel hann, som er blitt støtt ut av flokken. Ellers ser det ut til at det delvis er de samme dyrene som er blitt sett av de forskjellige observatører innen samme området.

Tabell 2.
Observasjoner over moskusdyr (*Ovibos m. moschatus*) sommeren 1964

Lokalitet	Datum	Antall dyr	Observert av	Anmerkninger
Vårsolhytta–Camp Bell	4/8	1 ♀	W. INGEBRETSEN	kadaver, antagelig død sist vinter
Adventdalen	9/7	5 ad.	O. BJERKE/ J. H. ERIKSEN	
Inngang Olav V Gruve	13/7	1 ♂	»	
Adventdalen	»	11 ad.	»	sett i kikkert
Endalen	/7	1 ♂	H. MAJOR/ J. F. VOISIN	holdt seg ved inngang gruve 5 i flere dager
Revneset, ved Louiseelva	7/8	6 ad., 5 juv.	»	
Adventdalen, Fivelflyane	25/6	1 ad. 13 ad.	E. S. NYHOLM	sett hver for seg
Mälardalen	6/7	1 ad.	»	
Adventdalen, Fivelflyane	6/7	4 ad. 1 ad.	»	sett hver for seg
Adventdalen, 2 km fra Fivelflyane	7/7	6 ad. 1 ad.	»	sett hver for seg
De Geerdalen	13/7	1 ad.	»	

Isbjørn (*Thalarctos maritimus*). Spor sett etter isbjørn på Mayerbreen i Krossfjorden i juli/august av T. VAN AUTENBOER. De endelige tall for vinterfangsten for sesongen 1964/65 foreligger ikke ennå, men de foreløpiger oppgavene tyder på at ca. 400 bjørn er skutt. Dette er et meget høyt tall, som gir grunn til uro.

Polarrev (*Alopex lagopus*). Spredte individer og kull ble observert på de forskjellige stedene Polarinstituttets folk ferdes. Ved Ny-Ålesund og i Kongsfjord- og Krossfjordområdet ble det registrert flere hi med 2–3 unger i hvert kull. De fleste hiene lå i uren under fuglefjell. På Danskøya ble registrert rev og likeledes ved Sverrefjell i Bockfjorden.

Fjordsel (*Phoca hispida*). Tidlig på sommeren, mens det ennå fantes fjordis, ble det registrert 9/7 ca. 300 individer på isen i Van Keulenfjorden og 13/7 ca. 40 individer ved Lernerøyene. I Krossfjorden oppholdt det seg hele sommeren et forholdsvis stort antall snadd på isflakene foran breene. Ellers ble spredte individer registrert over hele Svalbardområdet.

Storkobbe (*Erignatus barbatus*). 1 individ ble sett 14/7 ved Wulffberget i Liefdefjorden og 1 individ skutt i Van Keulenfjorden.

Hvalross (*Odobaenus rosmarinus*). Ved Moffen ble det 22/8 sett et ungt individ, antagelig av hvalross (W. INGEBRETSEN).

Fugl

Det ornitologiske observasjonene er omtalt regionalt sørfra og nordover. Materialet er naturlig nok størst i området fra Stormbukta til Kapp Borthen, hvor Polarinstituttets ornitologparti arbeidet. De enkelte observatørers navn er anført i hvert tilfelle. Der det ikke står oppgitt noen observatør, er registeringen foretatt av Polarinstituttets ornitologparti.

Havhest (*Fulmarus glacialis*). I Isfjordområdet registrerte J. F. RICHARD og J. F. VOISIN en regelmessig flyverute ut fra Sassendalen, via Revneset og Hotellneset mot Grønfjorden. Det er antagelig en typisk fluktveg til og fra hekkeplassene inne i landet.

Havelle (*Clangula hyemalis*). Fra Hornsund til Stormbukta 3/8 ca. 240 individer; ved Elveflya nord for Hornsund 23/8 74 individer. Hekking ble ikke påvist i dette området. Russekjegla, Kapp Linné to par hekket (K. Z. LUNDQUIST). Omkring Ny-Ålesund medio juli ca. 40 individer (J. HUS, Ø. DALLAND, T. SIGGERUD). Ved Kapp Borthen 25/8 5 flokker på fra 8 til 2 individer i åpen sjø på flukt sydover. Ansamlingene av havelle i Stormbuktområdet og på Store Dunøy står antagelig i forbindelse med flukt sydover. Der ble sett: 14/7 12 individer; 27/7 22 ind.; 27/8 57 ind.; Nordre Dunøy 27/8 ca. 90 ind.; kyststrekningen Peder Kokkfjellet–Kapp Borthen 25/8 ca. 200 stykker, noe under halvparten av disse var i myting.

Ærfugl (*Somateria mollissima*). I Hornsundområdet hekket ærfuglen på Emoholmane, Ærfuglholmen og Dunøyane, men ungeproduksjonen i området var minimal, antagelig på grunn av polarmåkens herjinger. O. LIESTØL nevner forøvrig fra Van Keulenfjorden at Sterneckøya nå helt er overtatt av polarmåke, slik at ingen ærfugler hekker der mer.

I Hornsundområdet var for 37 eggkull gjennomsnittet 2.3 og for 14 ungekull var gjennomsnittet 2.6.

Lenger nord på Vestspitsbergen synes polarmåken å gjøre seg mindre gjeldende, og som det fremgår av tabell 3, ble observasjoner av gode ungekull gjort en rekke steder. I denne forbindelse kan nevnes at I. AHLÉN i en rapport til Norsk Polarinstitutt sier at etter hans undersøkelser er polarmåkens beskatning av ærfuglene på øyene i Kongsfjorden av helt underordnet betydning. Beskatningen øker når ærfuglen blir forstyrret, f. eks. av mennesker, slik at de forlater redet i all hast. Derimot påpeker AHLÉN, at på de øyene som har landforbindelse med fastlandet via isbroer under hekketiden, tar polarreven alt, både egg og unger, slik at ingen hekking foregår der.

Tabell 3.
Observasjoner av ærfugl (*Somateria mollissima*) på Svalbard sommeren 1964

Lokalitet	Datum	Antall dyr	Observert av	Anmerkninger
Mellom Ålesundneset og Reinodden	20/7–21/7	–	O. LIESTØL	mange ungekull
Indre del av Van Keulenfjorden	/7– /8	–	»	mange ungekull
Blautneset	8/8	34 ad., 15 juv.	J. NAGY	
Linenes	22/8	20 ad., 50 juv.	»	
Kapp Linné	2/7	400 ♂♂, 300 ♀♀, 200 reir	K. Z. LUNDQUIST	
Ny-Ålesund	25/7	129 juv.	T. SIGGERUD	ved fyret
»	»	21 ♂♂, 158 ♀♀, 183 juv.	O. BJERKE J. H. ERIKSEN	ved fyret
Kohnøya	17/7	13 reir	T. VAN AUTENBOER	fra 1–4 egg i reiret
Moseøya, Sørgattet	27/6	ca. 600 ♂♂, ca. 800 ♀♀, ca. 400 reir	K. Z. LUNDQUIST	
Bockfjorden	19/7	4 ♀♀, 12 juv.	T. GJELSVIK	
»	23/7	21 ♀♀, 37 juv.	»	4 flokker
Øyene i Kongsfjorden	/7	ca. 2300 ♀♀	I. AHLÉN	rugende på 18 øyer

Praktærfugl (*Somateria spectabilis*). I den nordre drivisdekkete delen av Stormbukta 4/8 registrert minst 1500 «ærfugl» og nær land var det meste av dette praktærfugl-hanner. I en flokk på ca. 200 individer var omtrent ⅔ praktærfugl-hanner, mens resten var hunner og hanner av vanlig ærfugl. Stormbukta er forøvrig kjent som tilholdsted for praktærfugl i myting. På strekningen Stormbukta–Hornsund ble i samme tid sett ca. 300 individer, de fleste praktærfugl-hanner. Ved Dunøyane 14/7 7 hanner. Danskegattet 5/7 2 hanner (LUNDQUIST). Sør for Hornsund registrert 2 kull, som må antas å være praktærfugl. I to ferskvann ved Gjeslingane og Bjørnbeinflyane 4/8 sett 2 hunner med henholdsvis 4 og 5 unger.

Kortnebbgås (*Anser fabalis brachyrhynchus*). I området mellom Stormbukta og Hornsund ble bestanden anslått til ca. 290 individer, og av disse var ca. 270 ikke hekkende. Mellom Sofiakammen og Torellbreen holdt ca. 190 individer til, og av disse var ca. 115 ikke hekkende. Ved Reinodden 21/7 150 mytende individer (LIESTØL). Kapp Linné 2/7 en flokk på 15 kortnebbgjess (LUNDQUIST). Brautflya og Svendsenhamna 8/8 til sammen 60 voksne individer; Bourbonhamna 12/8 40 individer; Reinodden 22/8 50 individer (J. NAGY). Vestsiden av Fuglehuken 29/6 ca. 100 voksne individer og 15 reir (LUNDQUIST). Ved Ny-Ålesund 12/8 8 kortnebbgjess (O. BJERKE, J. H. ERIKSEN); 14/9 5 unger (RICHARD, VOISIN). Omkring Lernerøyane 14/7 10 voksne, 3 unger; Liefdefjorden 13/7 flere mytende individer (T. GJELSVIK). I Hornsundområdet var for 23 ungekull gjennomsnittet 2,5 og antallet unger i kullene varierte fra 1–5.

Ringgås (*Branta bernicla*). I Hornsundområdet ble bestanden anslått til under 50 individer, 6 par hekket sannsynligvis på Dunøyane. Ved Bjørndalsmunningen 18/8 et par med to unger (RICHARD, VOISIN). Leirholmen, Kongsfjorden 1/7 3 stykker fløy fra N til S; Storholmen 4–5/7 3 stk.; Sigridholmen 9/7 2 rugende ringgjess; innerst i Woodfjorden 12/7 5 antagelig rugende fugler (I. AHLÉN). På den nordligste delen av Sørkappøya 31/8 ca. 100 ringgjess, tilsammen antagelig over 120 individer på hele øya. Fuglene var tydeligvis på trekk sydover.

Hvitkinngås (*Branta leucopsis*). Mellom Stormbukta og Olsholmen nord for Kapp Borthen registrert 276 brukte reir. Dette området må nå betraktes som det viktigste tilholdssted for hvitkinngjess på Svalbard. På øyene vest for Danskøya 27/6 funnet 15 reir (LUNDQUIST). I 1963 ble ingen hvitkinngjess sett her. Bockfjorden 29/7 8 individer (GJELSVIK). I Hornsundområdet var for 26 ungekull gjennomsnittet 2,4, og antallet unger i kullene varierte fra 1–5.

Sangsvane (*Cygnus cygnus*). I området Hornsund–Elveflya ble i tiden 13/7–28/8 sett to, muligens tre sangsvaner. To av individene ble sikkert artsbestemt 14/7. Fuglene var fullt utfarget.

Heilo (*Pluvialis apricaria*). Isbjørnhamna 11/7 en heilo. Adventdalen 9/7 to individer (BJERKE, ERIKSEN); Hollendardalen, Sabine Land 30/7 hørt et individ (RICHARD, VOISIN).

Rype (*Lagopus mutus hyperboreus*). Tabell 4 viser registreringer av rypene.

Tabell 4.
Observasjoner av rype (*Lagopus mutus hyperboreus*) på Svalbard i 1964.

Lokalitet	Datum	Antall fugl	Observert av	Anmerkninger
Hornsundområdet	/7– /8	–	M. NORDERHAUG	gamle ekskrementer
Heimfjellhumpane	10/7	1 ad.	J. NAGY	
Neymayerberget	26/7	1 ad., 9 juv.	»	et kull
Jurakammen	4/8	1 ad.	»	
Basilika	12/8	2 ad., 14 juv.	»	to kull (?)
Basilikarabbane	21/8	1 ad., 10 juv.	»	et kull
Hannaskogdalen	8/8	–	J. F. RICHARD, J. F. VOISIN	to–tre sandbad
Ekmanfjorden	25/8	7 ad.	H. HILL	
Engelskbukta	18/8	12–14 ad., en del juv.	W. INGEBRETSEN	flere kull (?)
Ny-Ålesund, 8 km Ø	19/7	1 ad.	O. BJERKE, J. H. ERIKSEN	
Rättvikfjellet	25/8	1 ad.	J. HUS, Ø. DALLAND	
Kollerfjorden	11/8	11 juv.	T. VAN AUTENBOER	et kull (?)
Wulffberg, Liefdefjorden	–	1 ad., 8–9 juv.	T. GJELSVIK	et kull

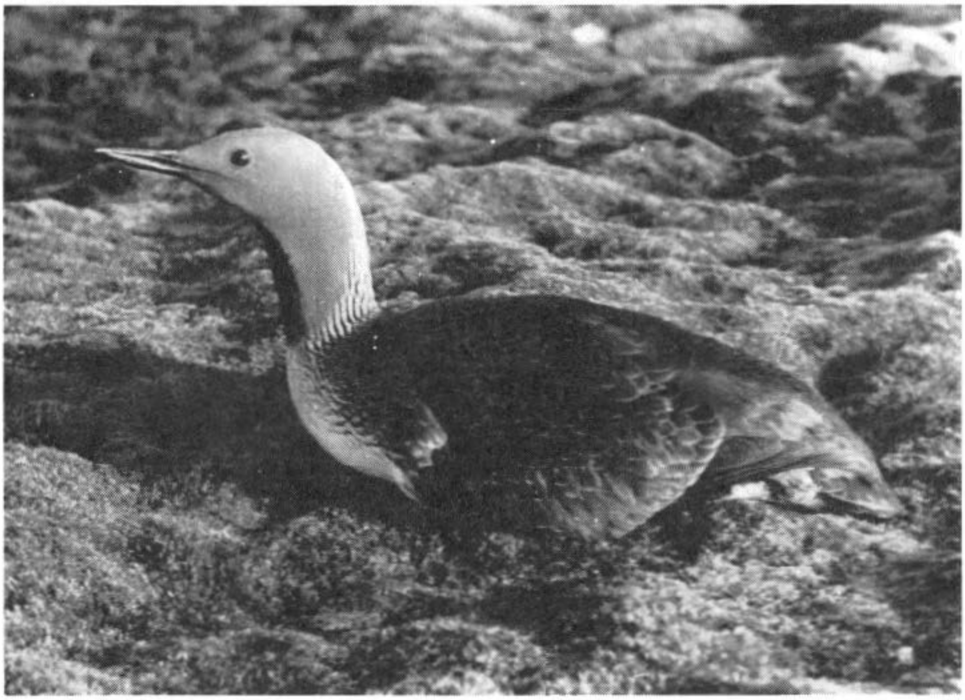

Fig. 2. *Smålom* (Gavia stellata) *på redet på Sørkappøya.*

The red-throated diver nesting at Sørkappøya. Photo: S. SIEDLECKI.

Sandlo (*Charadrius hiaticula*). Sørkappøya 31/8 9 individer, sannsynligvis på høsttrekk. Isbjørnhamna 25/7 et individ; Elveflya 14/7 et individ. Isdammane, Adventdalen «mange sandlo» (RICHARD, VOISIN). Ny-Ålesund 17/7 15–20 sandlo (SIGGERUD); Ny-Ålesund hele sommeren flere individer (HUS, DALLAND).

Steinvender (*Arenaria interpres*). Sørkappøya 31/8 ca. 10 individer, sannsynligvis på trekk sydover. Isbjørnhamna 30/8 3–5 individer; Dunøyaene 27/8 3–5 individer; Kapp Borthen 25/8 5 individer. Ny-Ålesund 17/7 en steinvender (SIGGERUD).

Fjæreplytt (*Calidris maritima*). Strekningen Stormbukta -Hornsund i august 4 kull; fra Hornsund til Elveflya i august 6 kull. Forøvrig virket hekkingen i området noe mer sparsom enn i 1963. På Elveflya 22/8 registrert trekk ca. 600 individer i området, mens dagen etter var antallet under det halve. Olsholmen 25/8 20 rastende fjæreplytt. Sabine Land 19–24/8 arten vanlig, også oppe i dalene (RICHARD, VOISIN). Krossfjorden 10/8 20 stykker. 22/8 10 stykker (T. VAN AUTENBOER).

Myrsnipe (*Calidris alpina*). Sørkappøya 31/8 en myrsnipe. Longyearbyen 11/9 5–6 individer (RICHARD, VOISIN). Krossfjorden 10/8 antagelig 3 myrsniper (VAN AUTENBOER).

Sandløper (*Crocethia alba*). Elveflya 22/8 et individ.

Polarsvømmesnipe (*Phalaropus fulicarius*). Isbjørnhamna til Elveflya medregnet Dunøyane i løpet av sommeren 15 ad. og 3 reirlokaliteter registrert. Dette var noe mer enn i 1963. En ringmerket hann med to unger sett ved Rotjesfjellet. Den var trolig blitt merket ved Isbjørnhamna i 1963. Månevann, Ny-Ålesund 15/7 4 ad. og en unge (HUS, DALLAND). Ny-Ålesund 17/7 6 individer (SIGGERUD).

Polarjo (*Stercorarius pomarius*). Mellom Stormbukta og Hornsund 4–5/8 3 individer; mellom Rotjespynten og Elveflya 21–23/8 4 individer; Olsholmen 25/8 et individ. På strekningen Kapp Borthen–Peder Kokkfjellet 25–26/8 omkring 40 individer, men vanskelig å foreta nøyaktige tellinger, da fuglene stadig var på vingene. Minst et par polarjo så ut til å hevde territorium, og en ungfugl ble sett, så det er mulig at arten har hekket her i 1964. Polarjo er tidligere aldri blitt funnet hekkende på Svalbard (LØVENSKIOLD 1964). Adventdalen 8/7 et ind.; Daudmannen 16/8 et individ (RICHARD, VOISIN).

Tyvjo (*Stercorarius parasiticus*). Stormbukta til Hornsund sommeren 1964 10 par; Isbjørnhamna til Torellbreen 23 par; Dunøyane minst 2 par. Den relativt store konsentrasjonen nord for Hornsund må antas å ha sammenheng med de store alkekongekoloniene som finnes her. Hekkefunn foreligger fra Svendsenhamna, Blautneset og Reinodden (NAGY); Ny-Ålesund (HUS, DALLAND, SIGGERUD); Todalen, Sabine Land (RICHARD, VOISIN). Krossfjorden 11/7–12/8 to–tre individer sett daglig (VAN AUTENBOER).

Polarmåke (*Larus hyperboreus*). Isbjørnhamna til Hyttevika 13/7 186 individer; Olsholmen 25/8 ca. 40 ad., mange tomme reir, men ingen unger. Van Keulenfjorden vanlig (LIESTØL); Ingeborgfjellet, Bellsund og Engelskbukta, Forlandsundet tallrik og hekkende (W. INGEBRETSEN). Blautneset 23/8 40 ad., 10 unger; Storbukta 24/8 23 ad., 4 unger (NAGY). Ny-Ålesund juli/august ca. 40 individer (SIGGERUD). Krossfjorden 10/7–22/8 ca. 10 individer sett daglig (VAN AUTENBOER). Danskøya 25 individer, 6 reir; Likholmen 20 individer, 3 reir (LUNDQUIST). Arten hadde flere steder en forbausende lav ungeproduksjon. I en mindre koloni i Hornsund var det 13/7 12 reir, men bare to av disse inneholdt egg, et egg i hvert reir.

Svartbak (*Larus marinus*). Kapp Dunér, Bjørnøya 6/7 minst 3 par. Sørkapp 31/8 en svartbak; Breineset, sør for Hornsund 4/8 et individ; Fjørholmen 27/8 et individ; Nordre Isøya 26/8 to stykker; Kapp Borthen 25/8 tre stykker. Storbukta 14/7 et individ (NAGY).

Sabinemåke (*Xema sabini*). I havområdet mellom Hammerfest og Bjørnøya 6/7 fulgte et individ etter båten (HUS, DALLAND, RICHARD, VOISIN). Fra Svalbard foreligger ingen observasjoner av denne arten fra 1964. Dens viktigste tilholdssted på Svalbard ser forøvrig ut til å være i områdene ved Longyearbyen og Ny-Ålesund.

Ismåke (*Phagopila eburnea*). Ingen nye reirfunn, men spredte observasjoner ble gjort fra Hornsund til Krossfjorden.

Polarlomvi (*Uria lomvia*). Sofiakammen, Hornsund 11/7 klekkingen påbegynt. 19 reir ble undersøkt: 8 reir hadde egg, et reir hvor egg var halvklekket og 10 inneholdt unger som var 3–4 dager gamle.

Steinskvett (*Oenanthe oenanthe*). Isbjørnhamna 12/7 en hunn funnet død (inntørket). Vingemålet – 104 mm – gir god overensstemmelse med Grønlandsrasen *O. o. leuchorrhoa.*

Snøspurv (*Plectrophenax nivalis*). I Isbjørnhamna pågikk klekkingen i et reir 8/7, og 12/7 ble utfløyne unger observert i samme område.

Litteratur

HEINTZ, N., 1963: Iakttagelser over dyrelivet på Svalbard sommeren 1962. *Norsk Polarinst. Årbok 1962.* 80–93. Oslo.

— 1965: Iakttagelser over dyrelivet på Svalbard i 1963. *Norsk Polarinst. Årbok 1963.* 157–169. Oslo.

LØVENSKIOLD, H. L., 1964: Avifauna Svalbardensis. *Norsk Polarinst. Skr.* Nr. 129. Oslo.

NORDERHAUG, M., 1965: Ornitologiske feltarbeider på Vestspitsbergen 1963–64. *Sterna,* **6**, (4), 185–193. Stavanger.

— 1965: Geese studies in Svalbard in 1963. *Norsk Polarinst. Årbok 1963.* 255–257. Oslo.

— M. A. OGILVIE and R. J. F. TAYLOR, 1965: Breeding success of Geese in Vestspitsbergen 1964. *The Wildfowl Trust.* 16th ann. Report 1963–64. Reading.

Ornithologische Beobachtungen in Svalbard

VON

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Abstract

This paper deals with some ornithological observations made in Svalbard during the summers of 1961, 1963, and 1964. *Podiceps auritus, Bucephala islandica,* and *Larus glaucoides* have been watched there for the first time. Other more important observations are: *Histrionicus histrionicus, Melanitta nigra, Falco rusticolus, Vanellus vanellus* and *Tringa totanus.*

Der folgende Beitrag ist als Ergänzung zu der 1964 erschienenen „Avifauna Svalbardensis" von H. L. LØVENSKIOLD gedacht. Es handelt sich ausschliesslich um feldornithologische Beobachtungen, die während meiner Expeditionen in den Jahren 1961, 1963 und 1964 gemacht wurden (vgl. S. 139 dieser Zeitschrift). Wir haben darauf verzichtet, Belegstücke zu sammeln und waren statt dessen bemüht, Beobachtungen seltener Arten möglichst durch mehrere Teilnehmer bestätigen zu lassen. Meist ist dies auch gelungen. Wo nicht, wird im Text besonders darauf hingewiesen. Als Bestimmungs-Grundlage diente das bekannte Werk von PETERSON, MOUNTFORT and HOLLOM „Die Vögel Europas". Durch das freundliche Entgegenkommen von Prof. G. NIETHAMMER und Dr. H. KRAMER war es mir ferner möglich, im Museum A. Koenig, Bonn, aufbewahrte Bälge in Svalbard vorkommender Vögel zu untersuchen. Dafür möchte ich auch an dieser Stelle meinen verbindlichen Dank aussprechen.

Ingesamt habe ich in Svalbard 44 Arten gesehen.

1. *Gavia immer,* Eistaucher
2. *Gavia stellata,* Sterntaucher
3. *Podiceps auritus,* Ohrentaucher
4. *Fulmarus glacialis,* Eissturmvogel
5. *Bucephala islandica,* Spatelente
6. *Clangula hyemalis,* Eisente
7. *Histrionicus histrionicus,* Kragenente
8. *Melanitta nigra,* Trauerente
9. *Somateria m. mollissima* ⪌ *mollissima borealis,* Eiderente
10. *Somateria spectabilis,* Prachteiderente
11. *Anser brachyrhynchus,* Kurzschnabelgans
12. *Branta bernicla hrota,* Ringelgans
13. *Branta leucopsis,* Weisswangengans
14. *Falco rusticolus,* Gerfalke
15. *Lagopus mutus, hyperboreus* Eisschneehuhn
16. *Vanellus vanellus,* Kiebitz
17. *Pluvialis apricaria altifrons,* Goldregenpfeifer
18. *Charadrius hiaticula,* Sandregenpfeifer
19. *Arenaria interpres,* Steinwälzer
20. *Calidris canutus,* Knutt

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21. *Calidris maritima,* Meerstrandläufer
22. *Calidris alpina,* Alpenstrandläufer
23. *Crocethia alba,* Sanderling
24. *Phalaropus fulicarius,* Thorshühnchen
25. *Phalaropus lobatus,* Odinshühnchen
26. *Catharacta skua,* Grosse Raubmöwe
27. *Stercorarius pomarinus,* Mittlere Raubmöwe
28. *Stercorarius parasiticus,* Schmarotzer-Raubmöwe
29. *Stercorarius longicaudus,* Kleine Raubmöwe
30. *Larus hyperboreus,* Eismöwe
31. *Larus marinus,* Mantelmöwe
32. *Larus glaucoides,* Polarmöwe
33. *Xema sabini,* Schwalbenmöwe
34. *Pagophila eburnea,* Elfenbeinmöwe
35. *Rissa tridactyla,* Dreizehenmöwe
36. *Sterna paradisaea,* Küstenseeschwalbe
37. *Plautus alle,* Krabbentaucher
38. *Uria aalge hyperborea,* Bäreninsel-Trottellumme
39. *Uria lomvia,* Dickschnabellumme
40. *Cepphus grylle mandti,* Gryllteiste
41. *Fratercula arctica* / *Fratercula a. naumanni* } Papageitaucher
42. *Hirundo rustica,* Rauchschwalbe
43. *Oenanthe oenanthe,* Steinschmätzer
44. *Plectrophenax nivalis,* Schneeammer

Gavia immer. Im Jahre 1961 hielt sich ein noch nicht ganz ausgefärbtes Exemplar den ganzen Sommer über auf dem grossen Teich beim Fussballplatz von Longyearbyen und auf dem Adventfjorden auf. Zuerst war das Tier recht scheu, später konnte man sich ihm jedoch auf ~ 50 m nähern, ohne dass es aufflog. 1963 und 1964 habe ich es nicht mehr gesehen.

Auf Bjørnøya waren 1964 mindestens vier Stück vorhanden, von denen sich drei die meiste Zeit über auf dem Laksvatnet aufhielten. Zu einer Brut ist es aber nicht gekommen. Wenn ein Gelege vorhanden war, so dürfte es, wie alle anderen im Gebiet des Laksvatnet, den Füchsen zum Opfer gefallen sein.

Podiceps auritus. Als wir am 20.7. 1964 in der Nähe des nordwestlichen Gåsvatnet (Bjørnøya) rasteten, fielen mir zwei kleine Vögel auf, die auf dem See schwammen und tauchten. Vom Ufer aus konnte ich dann erkennen, dass es zwei Ohrentaucher waren. Sie blieben zunächst an der gleichen Stelle. Als ich mich jedoch auf ~ 30–40 m näherte, tauchten sie weg, bis sie eine kleine Bucht am Nordende des Sees erreicht hatten. Durch das höhere Ufer gedeckt, konnte ich bis auf wenige Meter an die Vögel herankommen. Doch dann flogen sie plötzlich auf, als ich gerade mein Fernglas einstellte. Sie verschwanden in Richtung Ellasjøen. Meine beiden Kameraden, H. KAISER und K. KRUMSIEK, beide Bonn, sahen wohl die Vögel, doch waren sie zu weit entfernt, um sie ansprechen zu können. Ich habe sie jedoch ~ zwei Minuten lang mit dem Fernglas sehr deutlich beobachtet und bin mir – auch nach einem Vergleich mit einigen Bälgen aus dem Museum Koenig – sicher, dass mir keine Fehlbestimmung unterlaufen ist.

M. W. ist dies der erste Nachweis des Ohrentauchers für Svalbard.

Bucephala islandica. Am 13.7. 1961 bemerkte ich von unserem Boot aus zwei kleinere Enten, die nach Kopfform und Färbung nur Schell- oder Spatelenten sein konnten. Sie hielten sich in Gesellschaft von vier Eiderenten dicht am Ufer des Tempelfjordens bei Kapp Schoultz auf. Wir stoppten sofort den Motor und beobachteten sie aus ~ 40 m Entfernung mit unseren Gläsern. Deutlich war zu erkennen, dass es sich um ein Pärchen handelte, und die Kopfform des ♂ völlig der des Spatelentenerpels entsprach. Auch der halbmondförmige Wangenfleck war gut zu sehen und wurde von uns allen (F. Hörl, München, C. Samtleben, Hamburg, G. Tidten, Münster i. W., und mir) unabhängig voneinander erkannt. Das ♀ vermochte ich dagegen nicht von einem Schellentenweibchen zu unterscheiden. Da sich aber die ♀♀ beider Arten weitgehend gleichen, ist anzunehmen, dass es sich auch hier um eine Spatelente gehandelt hat. Als wir den Motor wieder starteten, um noch näher heranzufahren, flogen die Enten auf und liessen uns, einmal scheu gemacht, nicht mehr nahe genug herankommen. Wir haben sie auch später niemals wieder gesehen.

Ich zweifle nicht daran, dass zumindest das ♂ eine Spatelente gewesen ist, obwohl diese Art noch niemals in Svalbard beobachtet worden ist.

Clangula hyemalis. Nach Løvenskiold (S. 91) soll kein Zweifel daran bestehen, dass die Eisente im Wijdefjorden brütet, obwohl sich dafür bis heute noch kein Nachweis erbringen liess. Auch wir sahen dort keine brütenden Exemplare, doch hielten sich den ganzen Juli 1963 über (und wahrscheinlich auch noch länger) an dem mit dem Meere in Verbindung stehenden Teich im Vogtdalen 24 Eisenten (14 ♂, 10♀) auf, sodass hier in der Tat ein Brutplatz vermutet werden kann.

Auf Bjørnøya sind 1964 fast alle Gelege von Füchsen zerstört worden. Es wurde nur ein einziges ♀ mit 5 Jungen gesehen.

Histrionicus histrionicus. Am 17.7. 1961 überraschte ich in einer kleinen Bucht bei Vindodden (Sassenfjorden) einen Schwarm von 16 Prachteiderenten, die sofort aufflogen. Dadurch wurde ich auf eine kleine Ente aufmerksam, die sich unter den Prachteiderenten befunden hatte, aber ruhig weiterschwamm. Es handelte sich um einen Kragenentenerpel, den ich mehrere Minuten lang auf eine Entfernung von anfangs 15–20 m, später 40–50 m mit freiem Auge bei guter Beleuchtung einwandfrei erkennen konnte. Auch Fangstmann H. Nøis hat im Juli 1961 mehrere Male auf den Teichen im Sassengebiet einen Kragenentenerpel (vermutlich das gleiche Exemplar) gesehen (mündl. Mitt. Juli 1963).

Nach Løvenskiold (S. 97) ist die Kragenente bisher erst einmal mit Sicherheit in Svalbard festgestellt worden und zwar im Jahre 1906.

Melanitta nigra. Mindestens vom 24.7. bis zum 22.8. 1961 hielt sich auf dem kleinen Teich südlich der Fiskekløfta im Mimerdalen (Billefjorden) ein ♀ mit fünf Jungen auf. Die Tiere wurden immer zutraulicher und liessen sich selbst von einem Amphibienfahrzeug, mit dem wir mehrere Male den Teich durchquerten, nicht vertreiben.

Am 10.7 1963 stellten F. Hörl und ich ein brütendes ♀ auf Coraholmen (Ekmanfjorden) fest. Das Nest befand sich in einem *Dryas*-Rasen in der *Cassiope*-Tundra und enthielt sieben Eier.

Somateria mollissima. Wie uns Fangstmann E. Nøis erzählte, bevorzugt die Eiderente in Nord Spitsbergen als Brutplatz kleine, den Fjorden vorgelagerte Inseln, weil hier das Wasser gewöhnlich eher eisfrei ist als im Fjordinneren. Auf diesen Inseln ist dann auch oft eine grosse Brutdichte zu verzeichnen. So zählten

F. Hörl und ich am 18.7. 1963 auf einer nur ~ 50 m² grossen Fläche auf der Gråhuken vorgelagerten Bakeninsel 48 Nester. Davon enthielten:

7 Nester	1 Ei
9 »	2 Eier
21 »	3 »
4 »	4 »
3 »	5 »
2 »	8 »
1 Nest	6 »
1 »	7 »

Einige Junge fingen gerade an, auszuschlüpfen. Am 25.7. waren die meisten schon geschlüpft, und wir zählten nur noch 54 Eier.

Die Enten hatten hier sehr unter den Eismöwen zu leiden. Von diesen sassen stets mehrere auf der Bake und passten auf verlassene Nester und Küken auf. Das konnte jedoch eine Ente nicht daran hindern, ihr Nest nicht einmal 1 m neben dem einer Eismöwe zu errichten und friedlich neben dem Eismöwenweibchen zu brüten.

Anser brachyrhynchus. Im Jahre 1961 hielten sich mindestens vom 10.7.–8.8. an dem grösseren See auf der Nordseite des unteren Sassendalen 32 Kurzschnabelgänse auf, zu denen sich in der zweiten Julihälfte noch zwei Weisswangengänse gesellten. Einen Brutnachweis konnten wir jedoch nicht erbringen. Dagegen haben 1964 auf den Diabas-klippen oberhalb von Hyperitfossen auf der Ostseite des De Geerdalen Kurzschnabelgänse gebrütet. Hier stellten Dr. J. Nagel, Bonn, und K. Krumsiek sechs Nester fest, von denen drei je 2–3 Eier enthielten. Ein Jahr zuvor waren diese, dem Fuchse leicht zugänglichen Nester noch nicht vorhanden. Möglicherweise haben die Gänse die Stelle als Ausweich-Brutplatz benutzt, denn Ende Juni 1964 lag in den höheren Lagen noch überall Schnee, und viele Fjorde (u. a. Ekmanfjorden, Dicksonfjorden und Tempelfjorden) waren noch völlig zugefroren. – Auch im Adventdalen sahen wir 1964 im Gegensatz zu den anderen Jahren mehrfach Kurzschnabelgänse.

Dem frühen Wintereinbruch 1964 dürfte es wohl auch zuzuschreiben sein, dass die ersten aus Spitsbergen zurückkehrenden Kurzschnabelgänse schon am 15.8. auf Bjørnøya gesichtet wurden, während sie sonst nach Løvenskiold (S. 126) dort meist nicht vor dem 20.9. eintreffen.

Weitere Beobachtungen:

4.7. 1963	4 Exemplare	bei	Bjonahamna (Tempelfjorden)
23.8. 1963	19 »	»	Kapp Wijk (Dicksonfjorden)
24.8. 1963	24 »	»	Kapp Smith (Dicksonfjorden), darunter 9 Junge

Die bevorzugte Futterpflanze der Gänse im Sassendalen war *Arctophila fulva* (Trin.) Rupr., das „Hengegras", das in der Umgebung des Sees grössere Bestände bildet und stets fast restlos abgeweidet war.

Branta bernicla. Vom 21.–23.8. 1963 beobachtete ich auf einem Teich auf der Hochebene des Dickson Landes zwischen Mimerdalen und Lyckholmdalen ein Paar mit sieben Jungen. Das grössere Tier, wohl das ♂, schwamm gewöhnlich laut rufend vor dem in Kiellinie folgenden kleineren und den Jungen einher. Die Gänse mussten sich hier schon längere Zeit aufgehalten haben; denn alle moosigen Stellen am Ufer waren dicht mit Kot bedeckt. Das verlassene Nest habe ich jedoch nicht gefunden.

Branta leucopsis. Auf einem Felsen am Steilhang des nordöstlich an Fredheim (Sassen) angrenzenden Berges stellte C. SAMTLEBEN am 10. und 11.7. 1961 eine brütende Weisswangengans fest. Als er sie uns einen Tag später zeigen wollte, hatte sie jedoch das Nest verlassen, und es waren auch keine Eier mehr vorhanden. Offenbar hat sich die Gans durch das mit den geologischen Arbeiten verbundene Hämmern gestört gefühlt, obwohl die Arbeiten in über 100 m Entfernung durchgeführt wurden.

Falco rusticolus. Am 15.7. 1961 sahen F. HÖRL und ich auf der Nordostseite des Sassendalen, ~ 6 km von der Küste entfernt, einen Gerfalken, der einen Eissturmvogel verfolgte. Die Vögel kamen in schnellem Flug vom Coloradofjellet herunter, brausten in ~ 10–15 m Höhe genau über uns hinweg, wobei das Rauschen der Schwingen deutlich zu hören war und flogen weiter in Richtung Küste. Offensichtlich war der Eissturmvogel bemüht, die See zu erreichen, wo er mit seinen Gleitkünsten dem Falken überlegen ist. Wahrscheinlich ist ihm dies auch geglückt; denn solange wir die Vögel mit dem Fernglas beobachten konnten, gelang es dem Falken nicht, den Eissturmvogel zu schlagen.

Es ist nach dieser kurzen Beobachtung schwer zu sagen, zu welcher Rasse der Falke gehörte. Mit Sicherheit steht nur fest, dass es sich um die graue Phase handelte, und der Falke nicht wesentlich grösser als der Eissturmvogel war. Ich möchte daher annehmen, dass es ein Islandfalke (*Falco r. islandicus* BRÜNN.) war. Dieser Ansicht ist auch der finnische Ornithologe Fil. lis. E. NYHOLM, Utajärvi, der – von mir auf den Falken aufmerksam gemacht – ihn 1963 ebenfalls am Coloradofjellet sah (mündl. Mitt. Juni 1964). Nach LØVENSKIOLD (S. 155) sollen jedoch alle bisher untersuchten Gerfalken aus Spitsbergen zu *candicans* GM., der Grönland-Rasse, gehören.

H. NØIS erzählte uns, dass er während der von ihm in Spitsbergen verbrachten 34 Jahre insgesamt sechs Gerfalken im Sassengebiet und in Nordwest-Spitsbergen (u. a. im Wijdefjorden) erlegt habe und zwar sowohl graue wie weisse. Brütend habe er jedoch keinen angetroffen.

Vanellus vanellus. Am 27.7. 1964 scheuchten O. MUNKEBYE, Bruborg, und ich einen Kiebitz an einem Teiche bei Kapp Ruth (Bjørnøya) auf. O. MUNKEBYE berichtete, dass sich auch schon zwei Jahre zuvor bei der Radiostation ein Kiebitz aufgehalten habe.

Pluvialis apricaria. Den nordischen Goldregenpfeifer habe ich sowohl in Spitsbergen, als auch auf Bjørnøya gesehen. Im Adventdalen kann man ihn wohl regelmässig antreffen. Hier haben Frau H. GRØNDAL, Wien, und ich am 29.7.

1963 bei Førstehytta ein sehr schön gezeichnetes ♂ beobachtet. Einen Tag später sah ich ein ♀ im Brutkleid auf einer Schotterbank im Helvetiaelva sitzen, das durch lautes Rufen auf sich aufmerksam machte. 1964 hielten sich bei der Førstehytta sogar zwei Vögel, offenbar ein Pärchen, auf, und auch im Helvetiadalen sahen wir wieder ein Exemplar. Ein Brutnachweis gelang uns jedoch nicht.

Auf Bjørnøya waren 1964 wiederholt zwei Goldregenpfeifer in der Umgebung des Laksvatnet zu sehen, die aber mit Sicherheit nicht gebrütet haben.

Arenaria interpres. Am Westufer des Wijdefjordens bei Gråhuken hielten sich im Juli 1963 kurze Zeit drei Exemplare auf, und ein weiteres Stück beobachteten wir am 17.7. 1964 am Kai von Longyearbyen. Auf Bjørnøya haben wir 1964, vor allem im nördlichen Inselteil, mehrfach Steinwälzer gesehen, doch keine brütenden.

Tringa totanus. Dozent Dr. H. REMMERT, Kiel, berichtete mir, dass er am 30.6. 1963 einen Rotschenkel bei Ny-Ålesund (Kongsfjorden) beobachtet habe. Bisher ist diese Art nach LØVENSKIOLD (S. 180) nur einmal in Spitsbergen festgestellt worden und zwar 1950 bei Longyearbyen.

Calidris canutus. Einem Knutt sahen W. HONEGGER, Tübingen, und ich am 1.7. 1963 am Schuttplatz von Longyearbyen.

Calidris alpina. Zu welcher Rasse die in Spitsbergen vorkommenden Alpenstrandläufer gehören, kann durch feldornithologische Beobachtungen nicht entschieden werden, obwohl die Vögel im allgemeinen recht zutraulich sind. Unter den adulten Vögeln im Sommerkleid kommen solche vor, bei denen der schwarze Brustfleck etwa dem der Nominatform entspricht. Bei den meisten Tieren ist der Brustfleck jedoch kleiner, ± verwaschen oder ausgefranst. Vereinzelt gibt es sogar Exemplare, bei denen der Brustfleck völlig fehlt und die Unterseite hell und mit feinen Streifen versehen ist (wir haben solche Vögel den ganzen Sommer über beobachtet).

Am häufigsten scheint der Alpenstrandläufer im Adventfjorden Gebiet südöstlich von Longyearbyen zu sein, wo man ihn zu beiden Seiten der in das Endalen führenden Strasse regelmässig und oft aus nur 3–4 m Entfernung beobachten kann. Auch an der Moskuslaguna und unterhalb der Førstehytta haben wir stets mehrere Exemplare gesehen. Seltener ist er in der Colesbukta bei Kapp Laila und in Sassen.

Crocethia alba. In Svalbard habe ich, gemeinsam mit H. KAISER vier Sanderlinge gesehen, davon zwei am 23.6. 1964 am Schuttplatz bei Longyearbyen und zwei am Aumaelva auf der Südwestseite von Bjørnøya. Obwohl LØVENSKIOLD (S. 198) berichtet, dass die Art noch nicht auf Bjørnøya beobachtet worden sei, so ist unser Nachweis doch nicht der erste, da O. MUNKEBYE bereits 1962 einen Sanderling bei der Funkstation gesehen hat (münd. Mitt. 26.7. 1964).

Phalaropus lobatus. An der Tümpeln unterhalb der Førstehytta (Adventfjorden) hielten sich 1963 und 1964 stets mehrere Odinshühnchen zusammen mit Thorshühnchen auf. Wir zählten bis zu acht Stück, suchten aber immer vergebens nach einem Nest. Dennoch möchte ich annehmen, dass sie hier gebrütet haben. *P. lobatus* scheint etwas scheuer als *P. fulicarius* zu sein, da die Odinshühnchen uns nicht näher als 7 m heranliessen, während wir die Thorshühnchen auf 2–3 m Entfernung ohne Schwierigkeit photographieren konnten.

Catharacta skua. Während unseres ganzen Aufenthaltes auf Bjørnøya im Juli und August 1964 trafen wir in dem Seengebiet auf der Westseite der Insel regelmässig bis zu acht Grosse Raubmöwen an. Meist nahmen sie wenig Notiz von uns; nur als wir einmal dort Pflanzen einlegten, kamen alle acht herangeflogen und umkreisten uns mehrere Male in geringerer Entfernung. Eine Brut hat jedoch mit Sicherheit nicht stattgefunden.

Stercorarius pomarinus. Im Gegensatz zur Grossen war die Mittlere Raubmöwe 1964 nur ein gelegentlicher Durchzügler auf Bjørnøya. Ich sah nur einmal drei vorüberziehende Exemplare und zwar am 23.7. bei Kapp Posadowsky.

Stercorarius longicaudus. Von der Kleinen Raubmöwe, die wir verschiedentlich im Isfjorden Gebiet (Adventfjorden, Sassen) und auf Bjørnøya sahen, fand ich am 7.7. 1961 auf einer kurzgrasigen Stelle in der Tundra des Adventdalens zwischen En- und Todalen ein Nest, das ein Ei enthielt.

Larus glaucoides. Die Polarmöwe ist zwar schon einmal von Spitsbergen angegeben worden, doch soll dieser Bericht nicht zuverlässig sein (vgl. LØVENSKIOLD, S. 254). Dagegen haben wir mit Sicherheit eine Polarmöwe gesehen. Als D/S „Lyngen“ am 18.6. 1964 den Bellsund passierte, fiel mir plötzlich eine helle Möwe auf, die sich durch ihre wesentlich geringere Grösse deutlich von den zahlreichen Eismöwen unterschied, die ebenfalls dem Schiffe folgten. Ich hatte sofort den Verdacht, dass es sich um eine Polarmöwe handeln könnte und machte H. KAISER darauf aufmerksam. Nach einiger Zeit flog sie so nahe über uns hinweg, dass wir unsere Ferngläser nicht mehr scharf einstellen und den roten Augenring schon mit freiem Auge deutlich erkennen konnten. Da auch der Schnabel auffallend klein war, habe ich keinen Zweifel, dass wirklich eine Polarmöwe vorlag.

Xema sabini. Am 29.6. 1963 flog eine Schwalbenmöwe bei den Bootsschuppen von Longyearbyen in wenigen Metern Entfernung an F. HÖRL und mir vorüber. Zwei weitere Exemplare sah Dr. H. REMMERT am 23.7. bei Gråhuken und im August 1963 an der Blomstrandhalvøya (Kongsfjorden).

Pagophila eburnea. 1961 hielten sich im Mimerdalen schätzungsweise über 100 Elfenbeinmöwen auf. Sie wurden in unserem Basislager gegenüber von Pyramiden bald zur Plage, da sie fast täglich mehrere Male bis unter das Vordach des Zeltes kamen und über unseren Proviant herfielen. Selbst unser Lager im inneren Mimerdalen bei der Fiskekløfta verschonten sie nicht. – Im Juli 1963 haben wir mehrfach Elfenbeinmöwen im Wijdefjorden und bei der Gråhuken-Hütte im Woodfjorden gesehen.

Nyctea scandiaca. An einer Hütte in Hiorthhamn (Adventfjorden) ist der Kopf einer Schneeule angenagelt, die – nach Auskunft des Gastwirtes in Longyearbyen – in einem der Jahre kurz nach dem Krieg bei Revneset erlegt worden ist.

Hirundo rustica. Am 27.6. 1963 suchten auf dem Kohlefrachter M/S „Wenny" mit dem wir nach Spitsbergen fuhren, ~ 150 km westlich Bjørnøya zwei schon ziemlich matte Rauchschwalben Zuflucht und fuhren bis zur Breite des Sørkapp Spitsbergens mit.

Oenanthe oenanthe. Während unseres Aufenthaltes in Bjonahamna (Tempelfjorden) Anfang Juli 1963 kam fast täglich ein sehr schönes ♂ zur Hütte geflogen, das wir uns vom Fenster aus eingehend betrachten konnten.

In Longyearbyen ist der Steinschmätzer wohl regelmässiger Brutvogel. Nachdem hier schon 1954 und 1957 ♀♀ mit Jungen beobachtet worden waren (vgl. LØVENSKIOLD, S. 357), sah auch ich am 28.7. 1963 ein ♀, das Futter im Schnabel trug. Wenige Tage später, am 4.8., stellte ich in Betontrümmern unweit der Bäckerei vier Jungvögel fest. Sie sassen nebeneinander auf einer Eisenstange und waren offenbar gerade ausgeflogen. Sie hielten sich in der Umgebung der Bäckerei noch mehrere Tage auf. Es war uns jedoch nicht möglich, ihren Fortzug abzuwarten, da wir in der Colesbukta geologische Arbeiten durchzuführen hatten. Er muss aber vor dem 18.8. erfolgt sein, denn als wir an diesem Tage zurückkehrten, waren schon keine Vögel mehr vorhanden. – Ende Juni bis Anfang Juli 1964 sahen wir wiederum mehrfach Steinschmätzer in Longyearbyen und zwar mindestens zwei verschiedene Exemplare.

Auf Bjørnøya haben wir dagegen nur einmal kurze Zeit einen Steinschmätzer beobachten können (7.7. 1964, südlich des Miseryfjellets).

Alle Steinschmätzer, die ich in Svalbard sah, waren wesentlich dunkler als die Nominatform gefärbt. M. E. entsprechen sie völlig *Oenanthe oe. leucorrhoa* (GM.) [= *Oe. oe. schiøleri* (SALOM.) – (vgl. VAURIE (1959, S. 341)].

Literatur

LØPPENTHIN, B., 1923: Die Vögel Nordostgrönlands zwischen 73° 00′ und 73° 30′ N. Br. *Medd. om Grønland.* 91, Nr. 6. København.

LØVENSKIOLD, H., L., 1964: Avifauna Svalbardensis. *Norsk Polarinst. Skr.* Nr. 129. Oslo.

PETERSON, R., G. MOUNTFORT and P. HOLLOM, 1954: Die Vögel Europas. Hamburg und Berlin.

VAURIE, CH., 1959: The Birds of the Palearctic Fauna (Passeriformes). London.

Beiträge zur Flora Svalbards

VON
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Abstract

It is reported about some findings of vascular plants in Svalbard. New for Bjørnøya are *Stellaria humifusa* ROTTH. and *Saxifraga aizoides* L., new for Spitsbergen is *Salix glauca* L. ssp. *callicarpaea* (TRAUTV.) BØCH. Most of the rarer species of Bjørnøya are wider spread than it was assumed so far. *Carex amblyorhyncha* KRECZ. was found on the northern slope of the lower Sassendalen (Spitsbergen) in large quantities.

In den letzten Jahren führte ich drei Expeditionen nach Svalbard durch. 1961 wurden das Sassengebiet und Billefjorden, 1963 das südliche Isfjordengebiet (Adventfjorden bis Grønfjorden) sowie das nordwestliche Ufer des Wijdefjordens und 1964 der Adventfjorden und Bjørnøya aufgesucht. Im Vordergrund standen geologisch–paläontologische Untersuchungen. Soweit es die Zeit erlaubte, habe ich jedoch auch floristische Studien betrieben. Die wichtigsten Beobachtungen seien im folgenden mitgeteilt.

A. Bjørnøya

Bjørnøya ist schon wiederholt von Botanikern aufgesucht worden, zuletzt 1957 von O. I. RØNNING, dem wir auch eine ausführliche Flora verdanken (RØNNING, 1959). Eine volle Vegetations-Periode hat jedoch noch kein Florist auf der Insel verbracht. So ist es nicht verwunderlich, dass ich während meines Aufenthaltes vom 5.7.–18.8. 1964 nicht nur zahlreiche neue Wuchsorte der selteneren Arten, sondern auch zwei für Bjørnøya neue Arten, *Stellaria humifusa* ROTTH. und *Saxifraga aizoides* L. feststellen konnte.

Equisetaceae

Equisetum arvense L. Wesentlich häufiger als E. *variegatum* SCHLEICH. Das Hauptvorkommen befindet sich zwischen dem Engelskelva und dem Miseryfjellet. Fertile, bleiche Frühjahrstriebe sind jedoch auffallend selten, während die

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für die var. *boreale* (Bong.) Rupr. (vgl. Hadač 1944, S. 11) typischen, ährentragenden, grünen und verzweigten Sprosse häufiger vorkommen.

E. scirpoides Michx. Ebenso wie Rønning (1959, S. 5) habe ich die Art nur südlich des Miseryfjellets gefunden, wo sie aber wesentlich häufiger ist, als angenommen wurde. Sie wächst sehr oft in trockeneren Flechtenrasen, wo sie leicht übersehen werden kann. Vereinzelt kommt sie zwischen Varde 25 und dem Russeelva und zwischen Miseryfjellet und dem Grautauget vor, häufiger westlich des Blåsen, in der Umgebung des Svera und der Gåsvatna. Der Schwerpunkt der Verbreitung liegt jedoch im Gebiet um den Ellasjøen, wo die Pflanze schon mehrfach festgestellt worden ist.

Salicaceae

Salix herbacea L. und *S. polaris* Wg. Beide Arten sind sehr häufig. Im Nordteil der Insel herrscht *S. herbacea*, im Südteil *S. polaris* vor. Insgesamt gesehen überwiegt jedoch *S. herbacea.*

S. reticulata L. Wenn auch wesentlich seltener als die beiden vorigen Arten, so kommt diese Weide doch an zahlreichen Stellen vor und ist auch nicht nur auf die Hügel des südlichen Inselteiles beschränkt. Am häufigsten ist sie zwischen dem Russehamna und dem Ellasjøen. Hier steht sie mehrfach zwischen dem Miseryfjellet und dem Ørvella (hauptsächlich um die Basis S), ferner zwischen dem Svera und dem Skurven, im Skurvedalen und an mindestens sechs weiter voneinander entfernten Stellen am Ost- und Westufer des Ellasjøen. Im Norden hat sie einen kleineren Wuchsort südöstlich von Emmaholmen und mehrere zwischen Haussvatnet und Laksvatnet.

Caryophyllaceae

Sagina intermedia Fenzl. Diese Art kommt meist einzeln oder in wenigen Exemplaren beieinander vor, ist aber, wie schon Rønning (1959, S. 21) vermutet hat, über die ganze Insel (mit Ausnahme der höheren Erhebungen) verbreitet. Am häufigsten ist sie im Permokarbon-Gebiet des Nord- und Ostteiles.

Cerastium cerastoides (L). Brit. Ausser an der von Rønning (1959, S. 23) angegebenen Stelle an der Kvalrossbukta kommt die Art noch am Westufer des Ellasjøen in der Nähe des Abflusses und an dem Ort vor, wo früher die Ellahytta stand. Insgesamt sind drei kleinere Rasen vorhanden. Die ökologischen Verhältnisse – lehmiger, spärlich bewachsener und recht feuchter Boden – entsprechen weitgehend den an den Wuchsorten der Art in den Alpen herrschenden, doch sind die Pflanzen von wesentlich gedrungenerem Wuchs.

Stellaria humifusa Rotth. Diese, bisher auf Bjørnøya noch nicht festgestellte Art kommt in grösserer Menge auf Kapp Nordenskiöld, in geringerer Anzahl zwischen diesem und der Framnes vor, beide Male in *Puccinellia phryganodes*-Rasen.

Cruciferae

Arabis alpina L. Eine auf den Südteil der Insel beschränkte Art, die bisher nur vom Sørhamna, der Kvalrossbukta und dem Ellasjøen angegeben wird. Sie ist aber keineswegs so selten, wie es den Anschein hatte. So kommt sie in grösserer Menge am Osthang des Antarcticfjellets, in geringerer auch am Südhang vor, ferner steht sie vereinzelt an den Steilhängen nördlich des Russeelva, zahlreicher zwischen Ymerdalen und Svartkulpen und am Skurven. Ein weiterer Wuchsort mit sehr üppigen Exemplaren befindet sich am Westabfall des Alfredfjellets oberhalb von Hamnevika.

Draba alpina L. An gelbblühenden *Draba*-Arten führt RØNNING (1959, S. 33). *D. alpina*, *D. oblongata* R. BR. und *D. belli* HOLM auf. Auch ich habe drei verschiedene Formen gefunden, die sich durch folgende Merkmale auszeichnen:

1 Rosettenblätter schmal, deutlich zugespitzt, mit verhältnismässig wenigen unverzweigten bis sternförmig verzweigten Haaren besetzt. Blumenkronblätter blassgelb, Schötchen länglich-elliptisch bis zugespitzt, mit ~ 1 mm langem Griffelrest, völlig kahl.
2 Rosettenblätter breiter, weniger deutlich zugespitzt und stärker behaart als bei 1, verzweigte Haare überwiegen. Blumenkronblätter intensiv gelb, Schötchen länglich elliptisch, jedoch stärker abgerundet als bei 1 und auch der Griffel meist etwas kürzer. Schötchen zerstreut mit kurzen, unverzweigten Haaren bezetzt.
3 Rosettenblätter und Schötchen im allgemeinen von gleicher Form wie bei 2, doch wesentlich stärker behaart. Bei den Blättern überwiegen sternförmige Haare, während die Schötchen nur mit unverzweigten Haaren besetzt sind.

Form 1, die nach dem von RØNNING (1964, S. 48) gegebenen Bestimmungs-Schlüssel typischer *D. alpina* entspricht (von den blassgelben Blumenkronblättern abgesehen), habe ich nur am Skurven beobachtet. Form 2 ist sehr häufig und über die ganze Insel verbreitet, während Form 3 hauptsächlich auf exponierten Felsen an der Ostküste zwischen Miseryfjellet und Sørhamna vorkommt. Form 2 leitet wegen ihrer etwas abgerundeten Blätter und Schötchen zu *D. oblongata* über, doch fehlen ihr die für diese Art typischen kleinen Blumenkronblätter. Einwandfreie *D. oblongata* habe ich auf der Insel nicht gefunden und auch RØNNING (1959, S. 33) spricht von grossen Bestimmungs-Schwierigkeiten. Form 3 zeigt vor allem durch ihre behaarten, bisweilen ziemlich breiten Schötchen Anklänge an *D. belli*. Aber auch hier reichen die vorhandenen Merkmale nicht aus, die Pflanzen mir Sicherheit der Art zuzuweisen. RØNNING (1959, S. 36) hat jedoch auch echte *D. belli* auf Bjørnøya festgestellt.

Eine sichere Bestimmung der Zwischenformen ist vorerst nicht möglich. RØNNING (loc. cit.) nimmt an, dass zumindest ein Teil von ihnen hybridogenen Ursprungs sein könnte. Solange diese Frage jedoch nicht geklärt ist, seien sie unter *D. alpina* aufgeführt.

D. norvegica GUNN. Im Gegensatz zu RØNNING (1959, S. 37) der nur ein einziges Exemplar fand, habe ich die Art recht häufig beobachtet und zwar sowohl an der Nord- und Ostküste, als auch im Gebiet um den Ellasjøen und der Fagervatna. Bevorzugt werden offenbar kurzgrasige, nitratreiche, nicht allzu feuchte Wuchsorte. Die üppigsten Exemplare habe ich auf Kapp Olsen und oberhalb der Fauskevika gefunden. Die meisten Pflanzen fruchteten schon Ende Juli–Anfang August, sodass RØNNING, der die Insel vier Wochen später aufsuchte, möglicherweise nur noch verdorrte, nicht mehr zu identifizierende Stücke antraf.

Saxifragaceae

Saxifraga tenuis (WAHLENB.) H. SM. RØNNING (1959, S. 40) ist sich nicht sicher, ob diese Art tatsächlich auf der Insel vorkommt, oder es sich bei den bisher gesammelten Pflanzen nur um juvenile *S. nivalis* L. handelt. Es ist jedoch einwandfreie *S. tenuis* vorhanden, die völlig mit den in Spitsbergen vorkommenden Pflanzen übereinstimmt. Die Art ist nicht so häufig wie *S. nivalis*, doch weit verbreitet. Die meisten Wuchsorte befinden sich zwischen dem Russehamna und dem Ellasjøen. Hier kommt die Pflanze mehrfach im Gebiet der Sørlia südöstlich von Oppgangsdalen, im Sumpfgebiet östlich des Grautauget, am südlichsten der Gåsvatna und häufig am Ostufer des Ellasjøen vor. Im südlichsten Teil der Insel habe ich die Art sehr vereinzelt im Revdalen, im östlichen Teil an mehreren Stellen im Seengebiet nördlich des Miseryfjellets und im nördlichen Teil am Lakselva westlich des Laksvatnet gefunden.

S. hirculus L. Der Meinung von RØNNING (1959, S. 41), dass die Art auf der ganzen Insel gemein sei, kann ich mich nicht anschliessen. Sie kommt nur südlich der Linie Miseryfjellet–Oswaldfjellet vor, dort allerdings an vielen Stellen.

S. aizoides L. Büschel steriler Pflanzen sollen zwar schon von NATHORST am Ellasjøen beobachtet worden sein, doch glaubt RØNNING (1959, S. 43), dass eine Verwechslung mit den ähnlich aussehenden juvenilen Exemplaren von *S. hirculus* vorliegt. Ich teile diese Ansicht, denn auch ich habe am Ellasjøen – wie alle anderen Botaniker auch – nur *S. hirculus* gefunden. Dagegen kommt *S. aizoides* mit Sicherheit am Osthang des Blåsen auf offenem, lehmigem Boden gemeinsam mit *S. oppositifolia* L. vor. Die zahlreichen Pflanzen sind üppig entwickelt, blühen und fruchten reichlich.

Chrysosplenium tetrandum (LUND) FRIES. Diese, bisher nur in der Umgebung von Kapp Levin festgestellte Art, kommt am Nordostfuss des Miseryfjellets zwischen Kapp Levin und Jutulsetet im feuchten Moosrasen fast aller Rinnsale in grösserer Menge vor. Weitere, allerdings kleinere Wuchsorte befinden sich unterhalb des Kars zwischen Hambergfjellet und Fuglefjellet und am Südwestufer des westlichsten der Fagervatna.

Hippuridaceae

Hippuris vulgaris L. Nach RØNNING (1959, S. 44) soll diese Art nur an vier Stellen an der Nordküste vorkommen. Sie ist jedoch im Westteil der Insel viel häufiger. Hier habe ich mindestens 15 Wuchsorte festgestellt. Der südlichste

Fundpunkt befindet sich am Südwestufer des westlichen Fagervatnet, mehrfach kommt die Art in den Teichen bei Kapp Ruth vor, und von hier aus erstreckt sich das Verbreitungsgebiet bis zur Nordküste.

Compositae

Taraxacum brachyceras Dt. Neben den von Rønning (1959, S. 45) bezeichneten Stellen hat die Art einen sehr reichhaltigen Wuchsort in einem kleinen Tal nahe der Küste zwischen Røedvika und Fauskevika.

Juncaceae

Juncus biglumis L. Rønning (1959, S. 17) nimmt an, dass die Art auf Bjørnøya ausserordentlich selten ist, da bisher nur zwei Fundorte mit jeweils nur sehr wenigen und meist sterilen Exemplaren bekannt geworden sind. Es ist richtig, dass die Art im Südteil nur sehr vereinzelt vorkommt. Im westlichen Seengebiet ist sie jedoch ausgesprochen häufig und kommt sogar noch ~ 200 m südlich der Radiostation vor. Als Wuchsorte bevorzugt sie die Ränder kleiner Rinnsale und Wasserlachen, oft steht sie aber auch am Rande von Polygonfeldern. Meist kommt sie in kleinen Trupps, nicht selten aber auch in Beständen von über hundert Stück vor. Im Vergleich zu den in Spitsbergen vorkommenden Pflanzen sind die der Bjørnøya auffallend klein. Nur selten werden sie mehr als 5 cm hoch. Im Sommer 1964 blühten und fruchteten zahlreiche Exemplare.

Luzula confusa (Hartm.) Lindeb. Einwandfrei zu dieser Art gehörende Pflanzen, die in Spitsbergen so häufig sind, habe ich auf Bjørnøya nicht gefunden, häufiger dagegen Zwischenformen, die zu *L. arcuata* (Wahlenb.) Sw. überleiten.

Gramineae

Alopecurus alpinus Sm. Ein zweiter Wuchsort dieser, bisher nur vom Ellasjøen bekannten Art befindet sich am Oberlauf des Ørvella zwischen Oppgangsdalen und Fallvindsdalen.

Arctophila fulva (Trin.) Rupr. Bisher nur vom Engelskelva und nordöstlich vom Ellasjøen angegeben. Neue Fundorte: Teich südwestlich der Røedvika zwischen Miseryfjellet und Russehamna, Sumpfgebiet nordöstlich des Grautauget, Teich südwestlich von Tunheim, Abfluss des Skutilen. 1964 blühte bis zum 18. August keine Pflanze.

Puccinellia phryganodes (Trin.) Scribn. & Merr. Dieses Gras ist längs der Küste zwischen Rifleodden und Tunheim weit verbreitet, hat mehrere Fundstellen zwischen Kapp Forsberg und Kapp Posadowsky und kommt auch vereinzelt an mehreren Stellen an der Westküste vor. Auch von dieser Art wurden 1964 nur sterile Pflanzen gefunden.

Phippsia concinna (Th. Fr.) Lindb. Der bisher zweite Wuchsort im nördlichen Inselteil befindet sich zwischen Haussvatnet und Laksvatnet.

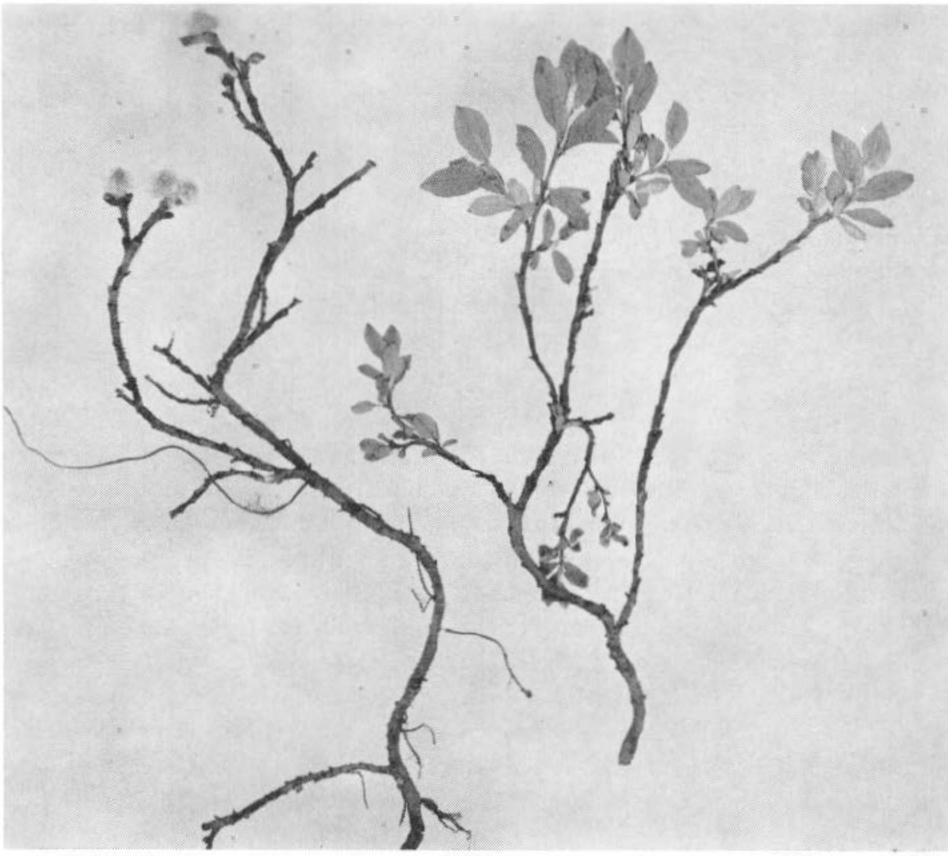


Abb. 1. Salix glauca L. *subsp.* callicarpaea (TRAUTV.) BØCH. *Links: Zweig mit kurz vor der Blüte stehenden ♂ Kätzchen (27.6. 1964). Rechts: Beblätterter Zweig (30.7. 1963). Adventdalen.*

B. Spitsbergen

In Spitsbergen habe ich nur sehr wenig Zeit zum Botanisieren gehabt und musste mich ausserdem meist an solchen Orten aufhalten, die in floristischer Hinsicht unergiebig waren. Es können daher nur Gelegenheitsbeobachtungen mitgeteilt werden.

Salicaceae

Salix reticulata L. In Menge am Südwestfuss des Tempelfjella mit *Erigeron humile* GRAH., ferner auf Gipshukodden unweit der Fangsthütte und an zwei Stellen im Mimerdalen unweit der Fiskekløfta, hier ebenfalls mit *E. humile.*

S. glauca L. subsp. *callicarpaea* (TRAUTV.) BØCH. Bei einer Exkursion nach Helvetiadalen am 30.7. 1963 machte mich Frau H. GRØNDAL, Wien, auf eine Weide aufmerksam, die von E. HULTÉN, Stockholm, als *S. glauca* subsp. *callicarpaea* bestimmt wurde (vgl. HULTÉN 1964, S. 350). Es wurden nur zwei, wenige Meter voneinander entfernt stehende Exemplare gefunden. Sie trugen bereits voll entwickelte Blätter (Fig. 1). An einigen Kätzchenresten war jedoch zu erkennen, dass es sich um männliche Pflanzen handelte. Am 27.6. 1964 suchte ich den Wuchsort noch einmal auf und fand einen weiteren Strauch mit zahlreichen, kurz vor der Blüte stehenden ♂ Kätzchen (Fig. 1). In jenem Jahre herrschte in Spitsbergen ein aussergewöhnlich kühles Frühjahrs- und Sommerwetter, und es kann daher wohl angenommen werden, dass bei normalen Witterungsbedingungen die Weide um diese Zeit bereits blüht. Der Standort befindet sich ~ 100 m nördlich des Adventelva, ~ 2,5 km westlich der Einmündung des Helvetiadalen. Die Weide wächst in ziemlich feuchter Tundra mit folgender Begleitflora:

Dryas octopetala L.	4
Luzula confusa (Hartm.) Lindeb.	3
Graminee, wahrsch. *Festuca rubra* L.	3
Salix polaris Wg.	1
Polygonum viviparum L.	1
Stellaria crassipes Hult.	1
Pedicularis hirsuta L.	1

In der Tabelle fehlen zwei Moose, wovon das eine die dominierende Begleitpflanze darstellte, und zwei Flechten. Ich hatte sie zur Bestimmung eingesammelt, doch ging der Beutel später auf Bjørnøya verloren. Der pH-Wert in der Rhizosphäre der Weide betrug 5,5 (gemessen mit Merck's Indikatorenpapier).

Caryophyllaceae

Stellaria media (L.) Vill. Eingeschleppt bei Pyramiden, aber nicht blühend.

Ranunculaceae

Ranunculus pallasii Schlecht. An Gräben unterhalb der Førstehytta (Adventfjorden).

R. spitsbergensis (Nath.) Hadač. In Menge an nassen Stellen unterhalb des Tenoren (Adventfjorden).

R. pedatifidus Sm. Am Südwestfuss des Tempelfjella unterhalb des Vogelfelsens und am Abhang des sich nordöstlich von Fredheim (Tempelfjorden) erhebenden Berges.

Cruciferae

Draba oblongata R. Br. Nach Rønning (1964, S. 50) ist das Vorkommen dieser etwas zweifelhaften Art in Svalbard unsicher. In der Umgebung der Fangsthütte bei Gråhuken kommt jedoch eine *Draba* vor, die in allen Einzelheiten der von Rønning (loc. cit.), gegebenen Beschreibung von *D. oblongata* entspricht und auch deutlich von *D. alpina* L. unterschieden ist. Ich habe diese *Draba* sonst an keiner Stelle gefunden.

Barbarea vulgaris R. Br. Mit Heu eingeschleppt am Ufer des Mimerelva (Billefjorden) gegenüber von Pyramiden. Es waren 1961 zwei blühende Pflanzen und drei einjährige Rosetten vorhanden. Mitte August begannen die Pflanzen zu fruchten, sodass möglicherweise die Samen noch reif und keimfähig werden und die Rosetten von der Aussaat des Vorjahres stammen.

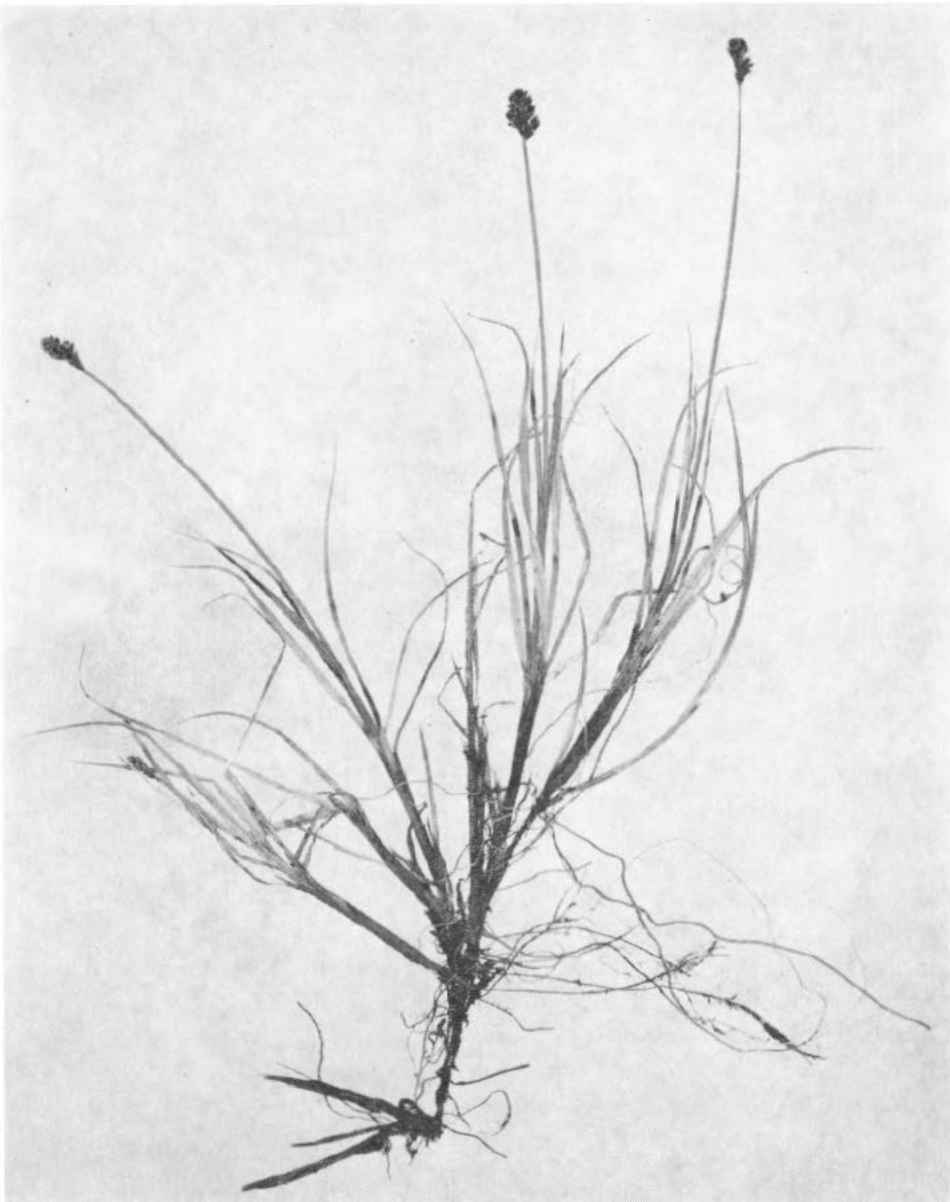


Abb. 2. Carex amblyorhyncha KRECZ. *8.8. 1961, unteres Sassendalen (Nordseite).*

Saxifragaceae

Saxifraga foliolosa R. BR. An einer nur wenige m² grossen Stelle in der Nähe des östlichen Cañons im inneren Mimerdalen blühten im August 1961 ~ 50 Exemplare dieser in Spitsbergen nur sehr selten blütentragenden Pflanze. 1963 hatten an der gleichen Stelle wieder alle Pflanzen geblüht, während sämtliche in der Umgebung wachsenden lediglich vegetative Vermehrungsorgane trugen.

Chrysosplenium tetrandum (LUND) FRIES. Ziemlich selten an den Teichen beim

Fussballplatz bei Longyearbyen, bei Fredheim, am Ufer des grössten Teiches im unteren Sassendalen (Nordostseite) und am Fuss des schon erwähnten Vogelfelsens am Tempelfjella.

Rosaceae

Potentilla nivea L. subsp. *subquinata* (LGE.) HULT. Unterhalb des eben genannten Vogelfelsens.

Papilionaceae

Trifolium pratense L. Eingeschleppt bei Pyramiden (1961), aber nicht blühend.

Compositae

Achillea millefolium L. Wie vor.
Matricaria maritima L. Wie vor, doch blühend.

Liliaceae

Tofieldia pusilla (MICHX.) PERS.. In zwei kleinen Rasen auf Kapp Smith (Dicksonfjorden), davon der eine mit mehreren gerade aufblühenden Pflanzen am 23.8. 1963. Die Art ist hier schon von DAHL & HADAČ (1946, S. 9) gefunden worden.

Juncaceae

Juncus castaneus SM. In nur wenigen Stücken an einer sumpfigen Stelle unterhalb der Diabasklippen beim Hyperitfossen auf der Ostseite des De Geerdalen zusammen mit *Ranunculus spitsbergensis.* Die Pflanzen haben hier nur eine maximale Länge von 10 cm.

Cyperaceae

Carex amblyorhyncha KRECZ. Diese Segge ist bisher nur einmal von Spitsbergen angegeben worden und zwar vom Sassendalen, wo sie NATHORST im Jahre 1882 gesammelt haben soll (vgl. SØRENSEN 1937, S. 169 unter *C. pseudolagopina* SØR.). Auf der Nordseite des unteren Sassendalen oberhalb des grösseren Teiches hat sie auch mein Freund F. HÖRL, München, im Sommer 1960 festgestellt. Sie wächst dort in einem kleinen Sumpf auf einer postglazialen Meeresterrasse zusammen mit *C. parallela* (LAEST). SOMMERF., *C. maritima* GUNN., *C. subspathacea* WORMSK., *C. saxatilis* L., *Juncus triglumis* L., *Cardamine nymani* Gand., *Eutrema edwardsii* R. BR. und *Saxifraga foliolosa* R. BR. 1961 suchten wir die Stelle noch einmal auf und fanden die Pflanze in grosser Menge auch ~ 1 km weiter südöstlich unter ähnlichen Wuchsortverhältnissen. In warmen Sommern werden die Früchte Anfang August, in normalen Jahren Mitte bis Ende August reif.

Gramineae

Puccinellia phryganodes (TRIN.) SCRIBN. & MERR. Blühend Anfang August 1961 an den Küstenfelsen von Gipshukodden gegenüber den Gåsøyane.

Literatur

DAHL, E. og E. HADAČ, 1946: Et bidrag til Spitsbergens flora. *N. Svalb. og Ishavs-Unders. Medd.* Nr. 63. Oslo.

HADAČ, E., 1944: Die Gefässpflanzen des „Sassengebietes" Vestspitsbergen. *N. Svalb- og Ishavs-Unders. Skr.* Nr. 87. Oslo.

HULTÉN, E., 1964: *Salix glauca* subsp. *callicarpaea* in Spitsbergen. *Sv. Bot. Tidskr.* **58**, 350. Stockholm.

RØNNING, O. I., 1959: The Vascular Flora of Bear Island. *Acta borealia* **A. 15**. Tromsø.

— 1964: Svalbards flora. *Norsk Polarinst. Polarhåndbok* Nr. 1. Oslo.

SEIDENFADEN, G. and T. SØRENSEN, 1937: The Vascular Plants of Northeast Greenland from 74° 39′ to 79° 00′ N. lat. *Medd. om Grønland.* **101**. Nr. 4. København.

Plantefunn fra Vestspitsbergen sommeren 1964

(Plant finds from Vestspitsbergen the summer 1964)

AV

PER SUNDING[1]

Abstract

A brief survey is given of the botanical investigations carried out by the geological and topographical fieldparties in the summer 1964. Interesting finds were made of *Betula nana, Saxifraga hyperborea, Potentilla rubricaulis* and *Empetrum hermaphroditum.* Vascular plants have been found to a height of 1250 m (*Saxifraga cernua*) and 1190 m above sea level (*Saxifraga oppositifolia*).

De geologiske og topografiske partier ved Norsk Polarinstitutts ekspedisjon til Svalbard sommeren 1964 ble bedt om å holde øynene åpne også for ting av botanisk interesse under sitt arbeid i marken. Dette hadde de til fulle gjort, og et rikt materiale av pressete planter og notater ble brakt hjem. Til dels var det fjerntliggende og vanskelig tilgjengelige lokaliteter som var blitt besøkt, og funnene fortjener å bli gjort kjent. I det følgende vil det bli gitt en kort oversikt over det meste av det medbrakte materialet. For kritiske arter er det bare tatt med angivelser basert på herbariemateriale.

Innsamling og pressing av planter og notering av interessante funn, høydegrenser o. l., ble gjort av følgende personer ved ekspedisjonen i 1964 (i parentes de forkortelser som er brukt i listen over funnene nedenfor): topograf OLE BJERKE (O. B.), stud. real. ØYSTEIN DALLAND (Ø. D.), geolog AUDUN HJELLE (A. H.) og Mr. JEAN-FRANÇOIS RICHARD og Mr. JEAN-FRANÇOIS VOISIN (R. & V.). I tillegg er tatt med en del funn gjort av stud. real. BJØRN BRAATEN (B. B.) under hans deltagelse i Arctic Rover Moot 1962 (se Norsk Polarinstitutt, Årbok 1962). BRAATEN botaniserte særlig i området mellom Adventfjorden og Sassenfjorden, dvs. i samme område hvor EMIL HADAČ arbeidet i 1939. (HADAČ 1944). Av BRAATENS funn er derfor vesentlig tatt med de sjeldnere arter eller funn som nærmere utfyller HADAČ' undersøkelser.

Besøkte lokaliteter

Hollendardalen (mellom Grønfjorden og Colesbukta)
Fossildalen (ved Colesbukta)

[1] Universitetets Botaniske Hage, Oslo.

Vestalfjellet (sydvest for Colesbukta)
Høgsnyta (nord for ytre del av Reindalen)
Gangdalen (nordover fra Reindalen)
Gangdalstoppane (ved Gangdalen)
Gangskardet (mellom Todalen og Gangdalen)
Adventdalen
Janssonhaugen, Helvetiadalen, Arnicadalen (ved Adventdalen)
Janusfjellet, Diabasodden, De Geerdalen, Vindodden, Sveltihel, Lusitaniadalen (mellom Adventdalen og Sassenfjorden)
Sassendalen
Centralen (syd for Kongsvegen og Sveabreen)
Engelskbukta (ved Forlandsundet, syd for Brøggerhalvøya)
Ny-Ålesund
Feiringfjellet (nord for Kongsfjorden)
Ole Hansenkammen (øst for Krossfjorden, ved innløpet til Møllerfjorden)
Kronprins Olavs Fjell (nord for Kollerfjorden)
Signehamna (ved Lilliehöökfjorden)
Sejerstedfjella (ved Dei Sju Isfjella, nord for Førstebreen)
Wagnerfjellet (syd for Woodfjorden)
Bukkehornet, Skirshorg (vest for Wijdefjorden, ved Vestfjorden)

Plantefunn

Lycopodium selago L.
Helvetiadalen (B. B.)
Signehamna, fuglefjell på sydsiden (A. H.)

Alopecurus alpinus Sm.
Gangdalstoppane, over 400 m (R. & V.)
Gangskardet, 410 m (R. & V.)

Deschampsia caespitosa (L.) PB.
Ny-Ålesund, innført, vanlig i og nær byen (Ø. D.)

Poa abbreviata R. Br.
Ny-Ålesund, her og der på kalkrik bunn eller på gjødslet mark, f. eks. på toppen av fuglesteiner (Ø. D.)

Phippsia algida (Sol.) R. Br.
Centralen, like vest for varden, 1000 m (Ø. D.)
Wagnerfjellet, på toppen, 1030 m (O. B.)

Eriophorum scheuchzeri Hoppe
Ny-Ålesund, 1 km SSØ for Gåsebu (mellom Ny-Ålesund og Kongsvegen) (Ø. D.)

Eriophorum triste (TH. FR.) HADAČ et LÖVE
(*E. angustifolium* ROTH var. *triste* TH. FR.)
Ny-Ålesund, 1 km SSØ for Gåsebu (Ø. D.)

Carex maritima GUNN.
(*C. incurva* LIGHTF.)
Ny-Ålesund, 1 km SSØ for Gåsebu (Ø. D.)

Carex saxatilis L.
Ny-Ålesund, 1 km SSØ for Gåsebu (Ø. D.)

Luzula arctica BLYTT
(*L. nivalis* (LÆST.) BEURL.)
Gangskardet, 650 m (R. &.V)
Arnicadalen (B. B.)
Ny-Ålesund, vanlig (Ø. D.)
Kronprins Olavs Fjell, på fyllitt på sydvestsiden, 725 m (Ø. D.)

Luzula confusa (HARTM.) LINDEB.
Gangdalen, 420 m (R. & V.)
Gangskardet, 515 m (R. & V.)
Kronprins Olavs Fjell, på fyllitt på sydvestsiden, 725 m (Ø. D.)

Salix polaris WAHLENB.
Gangskardet, 410 m (R. & V.)
Kronprins Olavs Fjell, på fyllitt på sydvestsiden, 680 m (Ø. D.)

Salix reticulata L.
Ny-Ålesund, ved klopp over elven 1,5 km syd for Brandalspynten (Ø. D.)

Betula nana L.
Fossildalen, ved Kapp Laila-hyttene (R. & V.)
Adventdalen, «flere steder» (uten nærmere stedsangivelse) (R. & V.)
Arnicadalen (B. B.)

Koeniga islandica L. var. *arctica* HADAČ
Ny-Ålesund, vanlig i selve byen og rundt Månevannet (Ø. D.)

Oxyria digyna (L.) HILL
Gangskardet, 410 m (R. & V.)
Signehamna, fuglefjell på sydsiden (A. H.)

Rumex acetosa L.
Ny-Ålesund, innført nær kullkaien (Ø. D.)

Arenaria pseudofrigida OSTF. et DAHL
Ny-Ålesund, vanlig på tørr kalkgrunn rundt byen; svært vanlig på kullkaien inne i selve byen (Ø. D.)

Cerastium arcticum LANGE
Gangskardet, 650 m (R. & V.)
Feiringfjellet, på fyllittgrus på sydsiden, 900 m (Ø. D.)

Stellaria media (L.) VILL.
Ny-Ålesund, innført (Ø. D.)

Silene acaulis (L.) JACQ.
Sejerstedfjella, ved sydvestenden av fjellet (A. H.)

Ranunculus hyperboreus ROTTB.
Ny-Ålesund, vanlig i byen og rundt Månevannet (Ø. D.)
Papaver dahlianum NORDH.
Gangdalstoppane, 730 m (R. & V.)
Gangskardet, 650 m (R. & V.)
Bukkehornet, like øst for varden, 1100 m, blomstrende (O. B.)
Draba nivalis LILJEBL.
De Geerdalen, ved Hyperittfossen (B. B.)
Draba daurica DC.
Sejerstedfjella, ved sydvestenden av fjellet (A. H.)
Draba alpina L.
Ole Hansenkammen, på kalkgrus på toppen, 800 m (Ø. D.)
Sejerstedfjella, ved sydvestenden av fjellet (A. H.)
Draba bellii HOLM
Sveltihel (B. B.)
Draba oblongata R. BR. (inkl. *D. micropetala* HOOK.)
Signehamna (A. H.)
Braya purpurascens (R. BR.) BGE.
Sveltihel (B. B.)
Lusitaniadalen (B. B.)
Ny-Ålesund, i selve byen og sydøstover (Ø. D.)
Cardamine bellidifolia L.
Helvetiadalen (B. B.)
Kronprins Olavs Fjell, på fyllitt på sydvestsiden, 800 m (Ø. D.)
Saxifraga oppositifolia L.
Signehamna, fuglefjell på sydsiden (A. H.)
Wagnerfjellet, 980 m, blomstrende (O. B.)
Bukkehornet, ved varden, 1190 m, blomstrende (O. B.)
Bukkehornet, like øst for varden, 1100 m, blomstrende (O. B.)
Saxifraga nivalis L.
Feiringfjellet, på fyllittgrus på sydsiden, 900 m (Ø. D.)
Signehamna, fuglefjell på sydsiden (A. H.)
Sejerstedfjella, ved sydvestenden av fjellet (A. H.)
Saxifraga tenuis (WAHLENB.) H. SM.
Engelskbukta (Ø. D.)
Signehamna, fuglefjell på sydsiden (A. H.)
Saxifraga hieraciifolia WALDST. et KIT.
Ny-Ålesund, rundt Månevannet. Vanlig under fuglefjell innerst i Kongsfjorden og i Kjærsvika ved Kvadehuken (Ø. D.)
Saxifraga foliolosa R. BR.
Engelskbukta, ved noen småtjern 2,5 km nordvest for bukten (Ø. D.)
Saxifraga hirculus L.
Ny-Ålesund, under fuglefjell ved Kjærsvika (Ø. D.)
Ny-Ålesund, spredt mot Kvadehuken (Ø. D.)

Saxifraga flagellaris WILLD. ssp. *platysepala* (TRAUTV.) PORS.
(se HULTÉN 1964)
Sveltihel (B. B.)
Saxifraga cernua L.
Gangdalstoppane, over 400 m (R. & V.)
Gangskardet, 650 m (R. & V.)
Skirshorg, sydvestvendt på grus på vesttoppen, ca. 50 m fra varden, 1250 m, ett eksemplar uten blomster, men med yngleknopper (Ø. D.)
Saxifraga rivularis L.
Signehamna, fuglefjell på sydsiden (A. H.)
Saxifraga hyperborea R. BR.
Ny-Ålesund, vanlig rundt byen, især i retning sydøst (Ø. D.)
Signehamna, fuglefjell på sydsiden (A. H.)
Saxifraga groenlandica L.
(*S. caespitosa* L.)
Gangskardet, 590 m (R. & V.)
Ole Hansenkammen, på toppen, fuglegjødslet, 800 m (Ø. D.)
Sejerstedfjella, ved sydvestenden av fjellet (A. H.)
Chrysosplenium tetrandum (N. LUND) TH. FR.
Ny-Ålesund, på nordvestsiden av Månevannet (Ø. D.)
Ny-Ålesund, under fuglefjell 5 km i retning av Kvadehuken (Ø. D.)
Potentilla hyparctica MALTE
(*P. emarginata* PURSH.)
Sejerstedfjella, ved sydvestenden av fjellet (A. H.)
Potentilla rubricaulis LEHM.
Diabasodden (B. B.) (se RØNNING 1961)
Dryas octopetala L.
Sejerstedfjella, ved sydvestenden av fjellet (A. H.)
Empetrum hermaphroditum HAGERUP
Hollendardalen, ved Fallbekkdalen (R. & V.)
Fossildalen, ved Kapp Laila-hyttene (R. & V.)
Adventdalen, den innerste del av dalen (B. B.)
Polemonium boreale ADAMS
(*P. humile* WILLD.)
Vestalfjellet, sydskråningen (R. & V.)
Janssonhaugen (R. & V.)
Janusfjellet, på nord- og nordvestskråningen (R. & V.)
Mertensia maritima (L.) S. F. GRAY var. *tenella* TH. FR.
Vindodden (B. B.)
Sassendalen, ved munningen av Sassenelva (B. B.)
Ny-Ålesund, nokså vanlig på sandstrender i Kongsfjorden (Ø. D.) (se SUNDING 1961)
Pedicularis dasyantha (TRAUTV.) HADAČ
Ny-Ålesund, på en kalkrygg som strekker seg fra Gåsebu (mellom Ny-Ålesund og Kongsvegen) sydøstover mot Kongsvegen (Ø. D.)

Pedicularis hirsuta L.
Sejerstedfjella, ved sydvestenden av fjellet (A. H.)
Erigeron unalaschkensis (DC.) VIERH.
(*E. humile* GRAH.)
Helvetiadalen (B. B.)
Arnica alpina (L.) OLIN
Adventdalen (uten nærmere stedsangivelse) (B. B.)
Taraxacum arcticum (TRAUTV.) DAHLST.
Ny-Ålesund, i sandskrent mot sjøen 4 km i retning av Kvadehuken (Ø. D.)

Blant de arter som har vært nevnt ovenfor, finner man to relativt nyoppdagete taxa i Svalbards flora, *Saxifraga hyperborea* og *Potentilla rubricaulis*. For disse er utbredelsen på Svalbard ennå lite kjent i deltalj (RØNNING 1961 og 1964), og alle nye voksestedsangivelser vil være av interesse. Finnestedene for *Betula nana* og *Empetrum hermaphroditum* er likeledes meget interessante, da det her dreier seg om sjeldne arter i Svalbards flora som, såvidt man vet, har en svært begrenset utbredelse.

Ellers vil alle bidrag til kjennskapet om utbredelsen av Svalbards plantearter bli hilst velkommen – selv for hva man kunne være fristet til å kalle «vanlige» arter, idet utbredelsesforholdene fremdeles er relativt dårlig kjent. Også når det gjelder kjennskapet til de arktiske planters økologi, kan man på denne måten få mange verdifulle opplysninger, f.. eks. i angivelsene av artenes høydegrenser (jfr. også SUNDING 1962 og 1965). Mens blomsterplanter tidligere var funnet til en høyde av 1100 m o. h. på Svalbard, er nå *Saxifraga cernua* funnet i 1250 m's høyde på Skirshorg og *Saxifraga oppositifolia* i en høyde av 1190 m o. h. på Bukkehornet. Både funnene på disse to fjelltoppene i Andrée Land og funnene av *Papaver dahlianum* og *Saxifraga oppositifolia* 1100 m o. h. på Astronomfjellet i Ny Friesland (SUNDING 1965), kan tyde på at det ikke er bare i selve Isfjords-området blomsterplantene stiger høyt til fjells. Man har regnet med at blomsterplantene vil ha lavere høydegrenser i retning mot øst på Vestspitsbergen og mot Nordaustlandet, men denne forskjellen kan vise seg å være mindre enn tidligere antatt. Dette er imidlertid et spørsmål som først kan tas opp etter at man har fått mer utførlige opplysninger om blomsterplantenes høydegrenser i de forskjellige deler av Svalbard.

Litteratur

HADAČ, E., 1944: Die Gefässpflanzen des «Sassengebietes» Vestspitsbergen. *Norges Svalbard- og Ishavsunders. Skr.* Nr. 87. Oslo.
HULTÉN, E., 1964: The Saxifraga flagellaris complex. *Sv. Bot. Tidskr.* 58, 81–104. Uppsala.
RØNNING, O. I., 1961: Some new contributions to the flora of Svalbard. *Norsk Polarinst. Skr.* Nr. 124. Oslo.
— 1964: Svalbards flora. *Norsk Polarinst. Polarhåndbok* Nr. 1. Oslo.
SUNDING, P., 1961: Noen plantefunn fra Svalbard sommeren 1960. *Blyttia* **19**, 125–129. Oslo.
— 1962: Høydegrenser for høyere planter på Svalbard. *Norsk Polarinst. Årbok 1960.* 32–59. Oslo.
— 1965: Plantefunn fra Vestspitsbergen sommeren 1963. *Norsk Polarinst. Årbok 1963.* 169–172. Oslo

Bremålinger i Norge 1964

AV

OLAV LIESTØL

Abstract

The result of regime measurements on Storbreen in 1964 shows an accumulation of 116 gr/cm², an ablation of 95 gr/cm², and a resultant positive material balance of 21 gr/cm². On Hardangerjøkulen they show respectively, 185 gr/cm², 141 gr/cm², and a surplus of 44 gr/cm². This positive balance is due first and foremost to the low summer temperature.

Table 1 gives the results of all regime measurements, which were carried out by Norges Vassdrags- og Elektrisitetsvesen and by Norsk Polarinstitutt. It can be seen that all the glaciers had a positive material balance, with the exception of the two glaciers in east Jotunheimen, where the accumulation had been unusually small. The results are also illustrated graphically in Fig. 8.

Ice front fluctuations have been measured for 13 glaciers, and all are either in retreat or are stationary.

Storbreen

På Storbreen ble akkumulasjonen målt i begynnelsen av mai. Nedbøren i distriktet hadde i vinterens løp vært under normalen. Dette ga seg utslag i at snømengden var mindre enn gjennomsnittet for de 15 år målingene har pågått. På grunn av den usedvanlig kalde sommer falt en stor del av nedbøren som snø også i sommermånedene. Man fikk derfor en stor tilleggsakkumulasjon som dog ikke bragte totalen opp på et normalt nivå. Dette tillegg er ikke målt, men beregnet ut fra observasjoner på nærliggende meteorologiske stasjoner. Fig. 1 viser snødypets størrelse i g/cm² og fordeling på breen i slutten av ablasjonssesongen. I gjennomsnitt ble akkumulasjonen 116 g/cm²

Gjennomsnittstemperaturen for månedene juli til og med september var 1,3° under normalen. Bare to somre har vært kaldere siden målingene begynte, nemlig 1952 og 1962. Følgen ble en meget beskjeden ablasjon, bare 95 g/cm² mot et gjennomsnitt på 176 for de foregående 15 år.

Resultatet av materialbalansemålingen ble derfor, på tross av den lave akkumulasjonen, et overskudd på 21 g/cm² i gjennomsnitt for hele breen.

Fig. 2 viser skjematisk hvorledes materialhusholdningen har vært på Storbreen i 1963–64. Av dette diagram kan man også se at snøgrensa lå på ca. 1660 m o. h. For at breen skal holde seg i likevekt må snøgrensa teoretisk ligge på ca. 1690 m o. h.

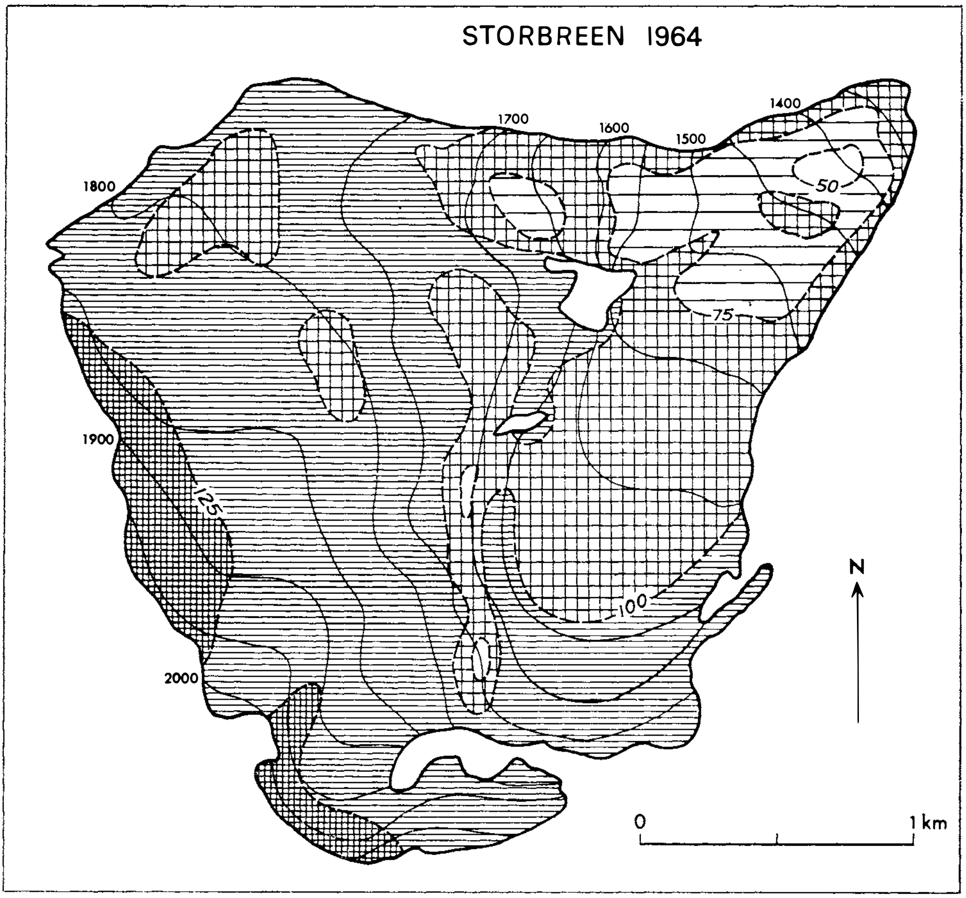


Fig. 1. *Akkumulasjonskart over Storbreen i Jotunheimen.*

Accumulation map of Storbreen in Jotunheimen.

Året 1963–64 viser som man ser et overskudd for breen. Da vinternedbøren og dermed akkumulasjonen er under normalen, må overskuddet skyldes den tidligere nevnte lave ablasjon.

Hardangerjøkulen

Undersøkelsene på Hardangerjøkulen som gjøres etter oppdrag fra Norges Vassdrags- og Elektrisitetsvesen, ble fortsatt i 1964. Målingene startet med en tur til breen 14. februar. Målestengene ble ettersett og målt, og plater festet til foten av stengene for at man senere kunne korrigere for komprimering av snølaget. Nye stenger ble satt ned til erstatning for dem som var bøyet eller kommet bort i løpet av vinteren. Målingen av akkumulasjonen ble foretatt de siste dager av april. Bestemmelsen av snøens egenvekt ble foretatt i tre sjakter gravet i henholdsvis 1510, 1655 og 1800 m o. h. Snødybdene ble målt ved sondering med en aluminium snøsonde. I de øvre områder skilte ikke siste sommers overflate seg ut som noe fast lag som man kunne måle ned til. Imidlertid var det et hardt

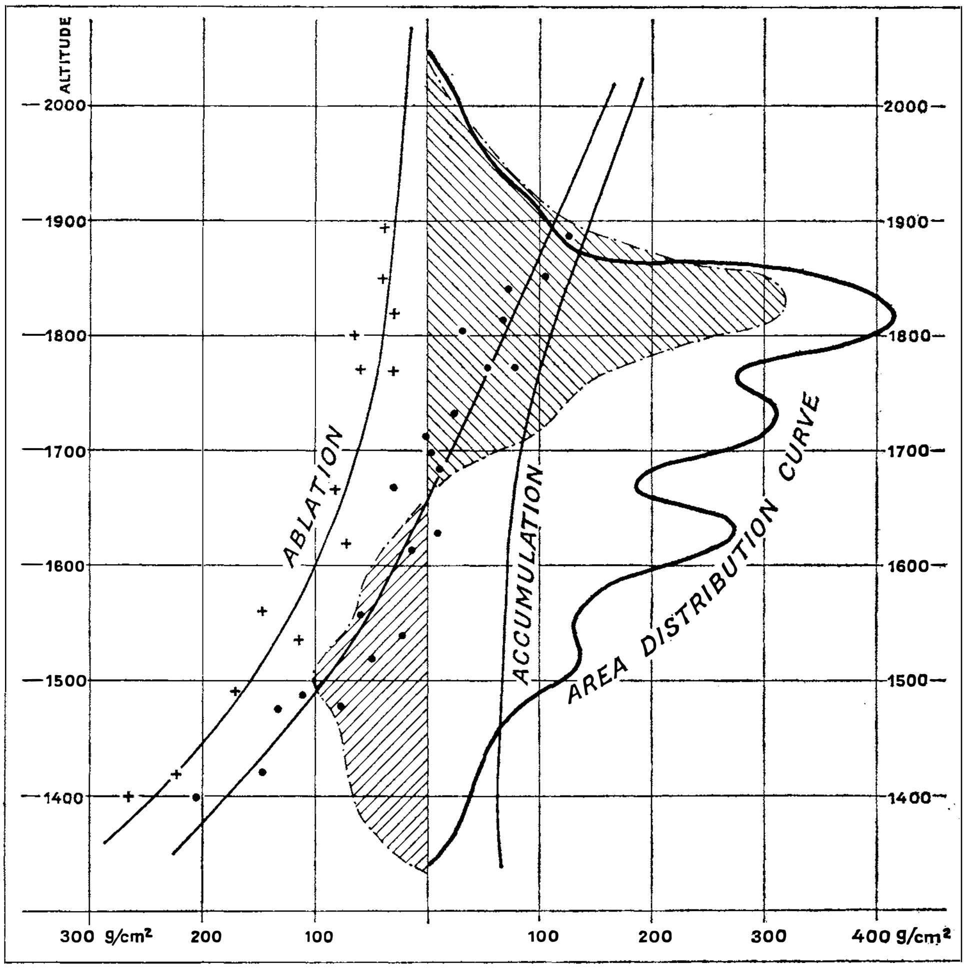


Fig. 2. *Materialhusholdningen på Storbreen 1963–64.*

Mass budget of Storbreen, 1963 to 1964.

skare- og islag et par dm høyere opp. Dette bød en markert motstand ved nedramming av sonden, og var derfor vel egnet som referanseflate.

Av kartet ser man at de øvre og sentrale deler av breen har en relativt jevn overflate. Snøen blir derfor også meget jevnt fordelt. Det er likevel tydelig at der er en vindtransport av snø ned fra det høyeste området og ryggene på sidene ned mot midten av breen. Man får derfor ikke en økning av snødybden helt til topps, men en avtagen mot de øverste områder. Stort sett blåser snøen vekk fra de konvekse områder og samler seg i de konkave. Men dette er ikke noen fast regel. Avblåste partier kan man finne på ganske uventede steder.

På Hardangerjøkulen hvor nedbøren alt overveiende kommer inn med sykloner fra vest, og dermed med konstant vindretning, må man kunne regne med et nokså likt fordelingsmønster for akkumulasjonen fra år til år. Kartet Fig. 4 viser fordelingen slik den er målt 1/5 1964. Av flybildene fra sommeren 1961 kan man få stor hjelp til bedømmelse av snøfordelingen. En del av det mer detaljerte

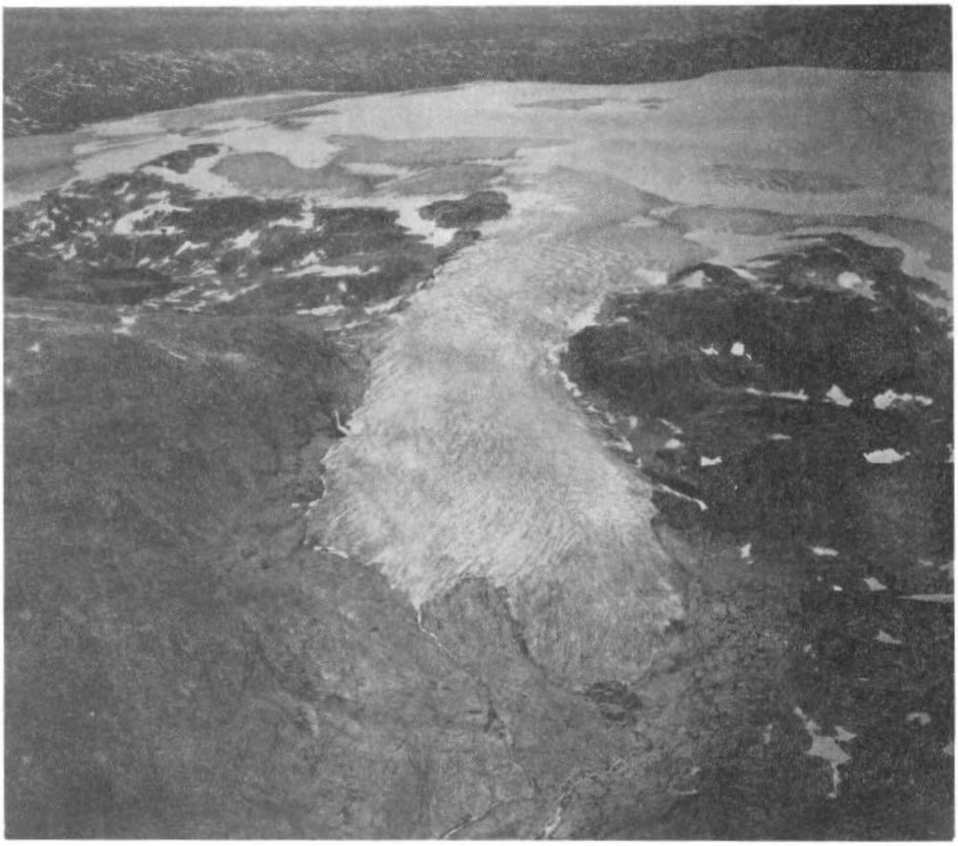


Fig. 3. *Flyfotoet viser Rembesdalsskåki, den undersøkte vestlige utløper fra Hardangerjøkulen.* Photo: B. LUNCKE 21/8 1955.

The photograph shows Rembesdalsskåki, the investigated western outlet from Hardangerjøkulen.

mønster er tegnet inn etter disse bilder. I brefallet og i de verste sprekkområder er det umulig å få målt snødybden. Områdene er imidlertid små i forhold til resten, slik at eventuelle feil i beregnede verdier for disse felt har lite å bety for den samlede akkumulasjon.

I tillegg kom det etter 1. mai stadige snøfall i løpet av sommeren. Dette tillegg er det umulig å få målt; da måtte man ha en observatør på breen hele tiden. Sommerakkumulasjonen kan imidlertid beregnes, men verdiene er ennå ikke så pålitelige som man kunne ønske. Kalkulasjonen bygger på 2 perioder (20/9 63 til 14/2 64 og 14/2 64 til 1/5 64) hvor akkumulasjonen er målt og sammenlignet med nedbørsobservasjoner i tilsvarende perioder. For beregning av den del av nedbøren som faller som snø, er temperaturen på Slirå blitt benyttet. Det er regnet med at nedbør som faller ved temperatur under +1°C vil akkumuleres som snø. Ved beregningen av temperaturen for de forskjellige høydenivåer er følgende gradienter benyttet: mai 0,72, juni 0,74, juli 0,73, august 0,67 og september 0,62 grader pr. 100 m. Akkumulasjonen er beregnet for høydene 1300, 1600, 1700 og 1800 m o. h.

Ablasjonen ble målt ved besøk på breen i slutten av juli, og i slutten av sep-

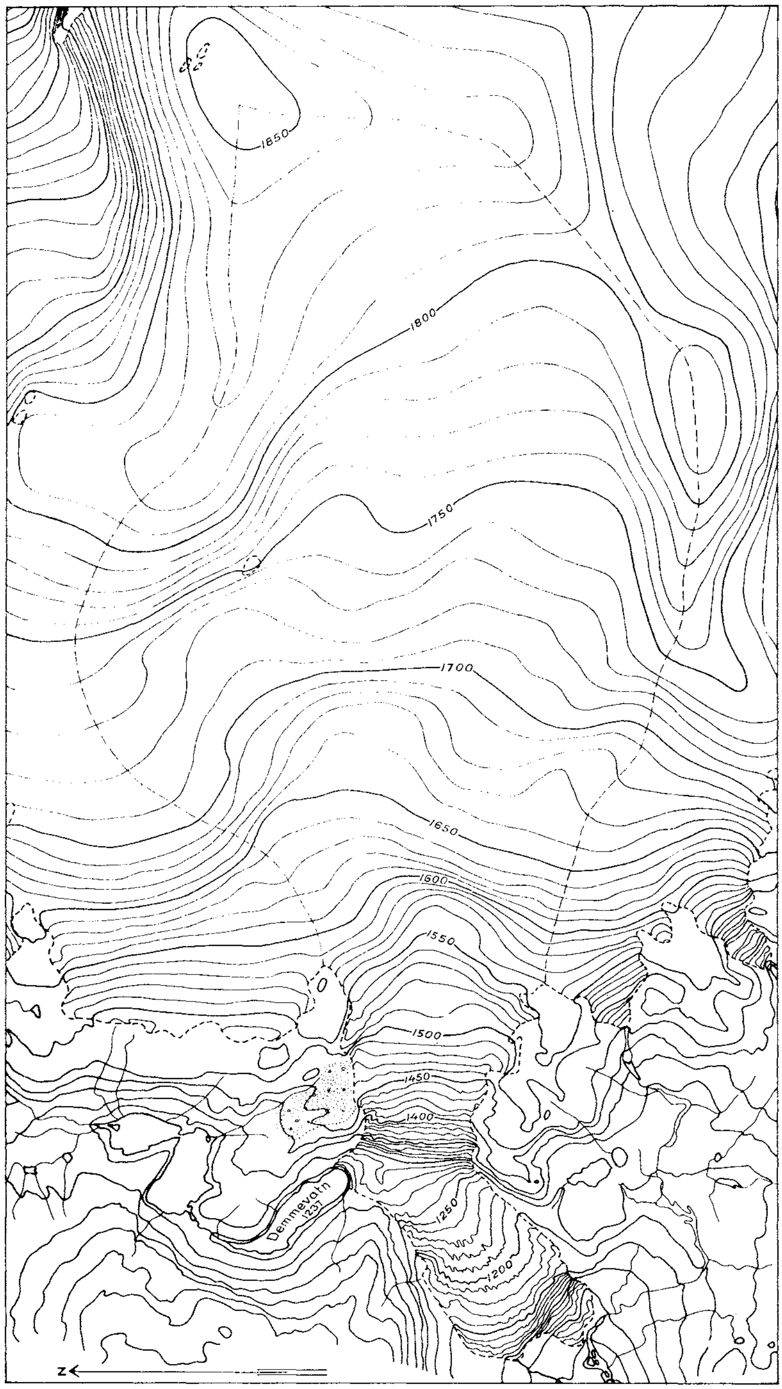


Fig. 4. *Kart over den undersøkte del av Hardangerjøkulen, konstruert av Widerøes Flyveselskap A/S på grunnlag av flyfoto fra august 1961.*

Map of the investigated part of Hardangerjøkulen constructed by Widerøes Flyveselskap A/S, based on aerial photograps from August 1961.

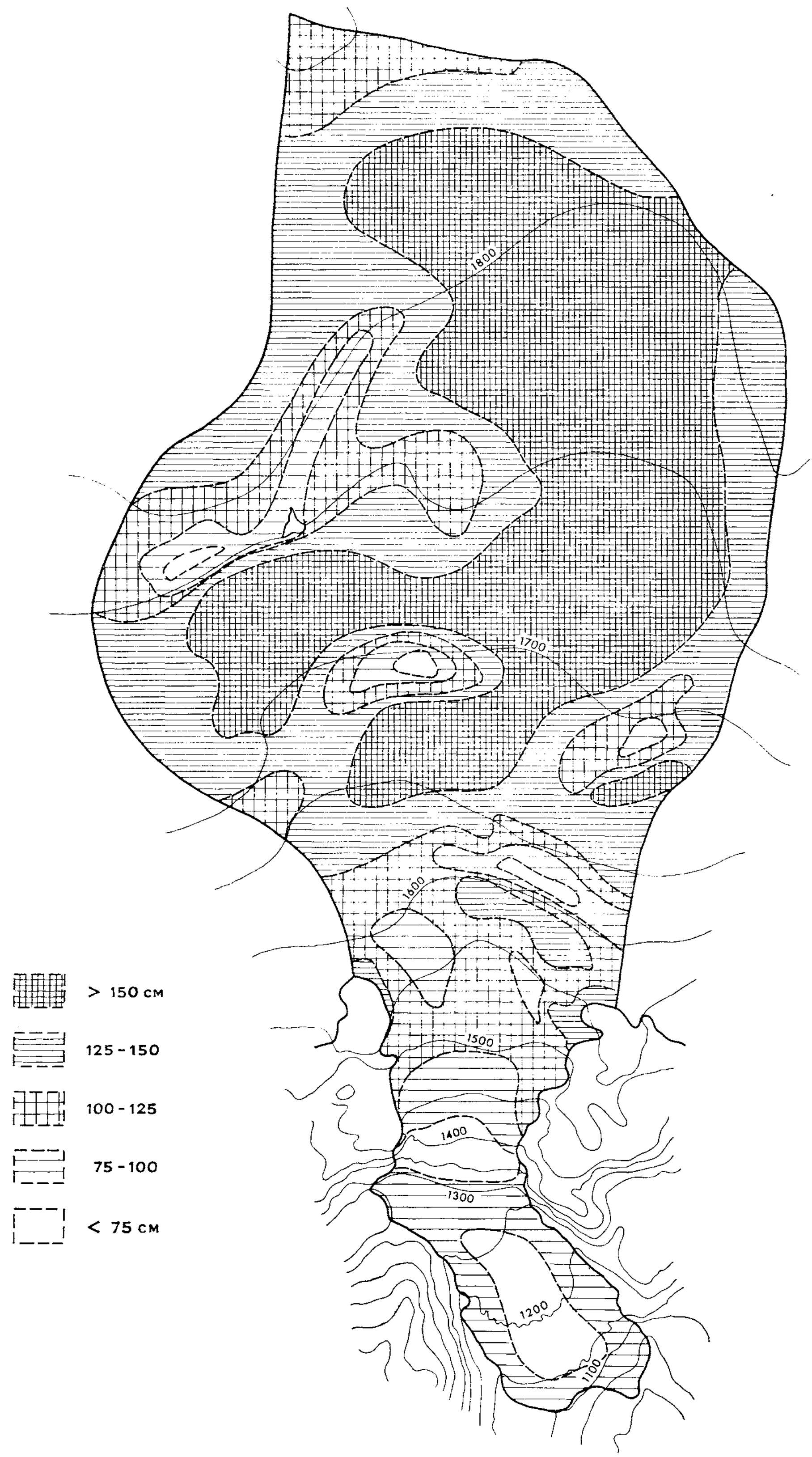


Fig. 5. *Akkumulasjonskart tegnet på grunnlag av snømålinger inntil 1. mai 1964.*
Accumulation map based on snow measurements up to 1st May 1964.

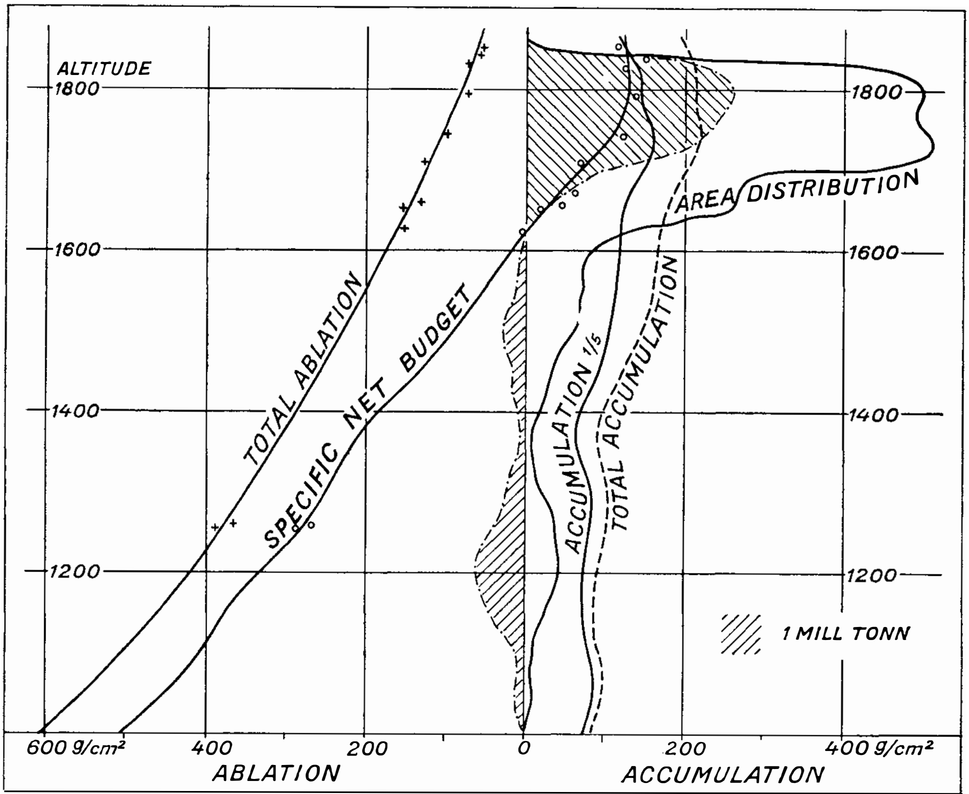


Fig. 6. *Diagrammet viser akkumulasjonens, ablasjonens og nettobudsjettets variasjon med høyden over havet.*

Diagram showing the variations in accumulation, ablation and net budget with height above sea level.

tember. Et forsøk ble også gjort i begynnelsen av juli, men dårlig vær hindret all måling. Av de 26 staker som var satt opp året før, var bare 14 tilgjengelige for måling denne sommer. De andre var enten brutt ned eller blitt borte på annen måte.

Den totale ablasjon er vanskeligere å få tak i, spesielt i en sommer som den i 1964. Stadig nye snøfall avbrøt ablasjonen så å si gjennom hele sommeren. Denne snømengde har det som før nevnt vært umulig å måle, slik at man har måttet ty til beregninger. Dette tillegg er avsatt grafisk på Fig. 6 og beløper seg til i gjennomsnitt til 48 g/cm². Den totale ablasjon blir derfor atskillig større enn det man direkte måler på ablasjonsstengene og beløp seg i år til $137 + 48 = 185$ g/cm² i gjennomsnitt over hele breen. Fig 7 viser temperaturens gang på Slirå og Fannaråki sommeren 1964. Disse temperaturer er brukt til beregninger av ablasjon på henholdsvis Hardangerjøkulen og Storbreen. Som man uten videre kan se er korrelasjonen mellom dem usedvanlig god. Man kunne derfor uten større feil brukt bare den ene av dem for beregninger på begge breer.

På Fig. 6 er den spesifikke netto-materialbalanse (dvs. breens øking eller minking i forhold til forrige år) tegnet inn. Denne kurven bygger på stakeavlesinger og

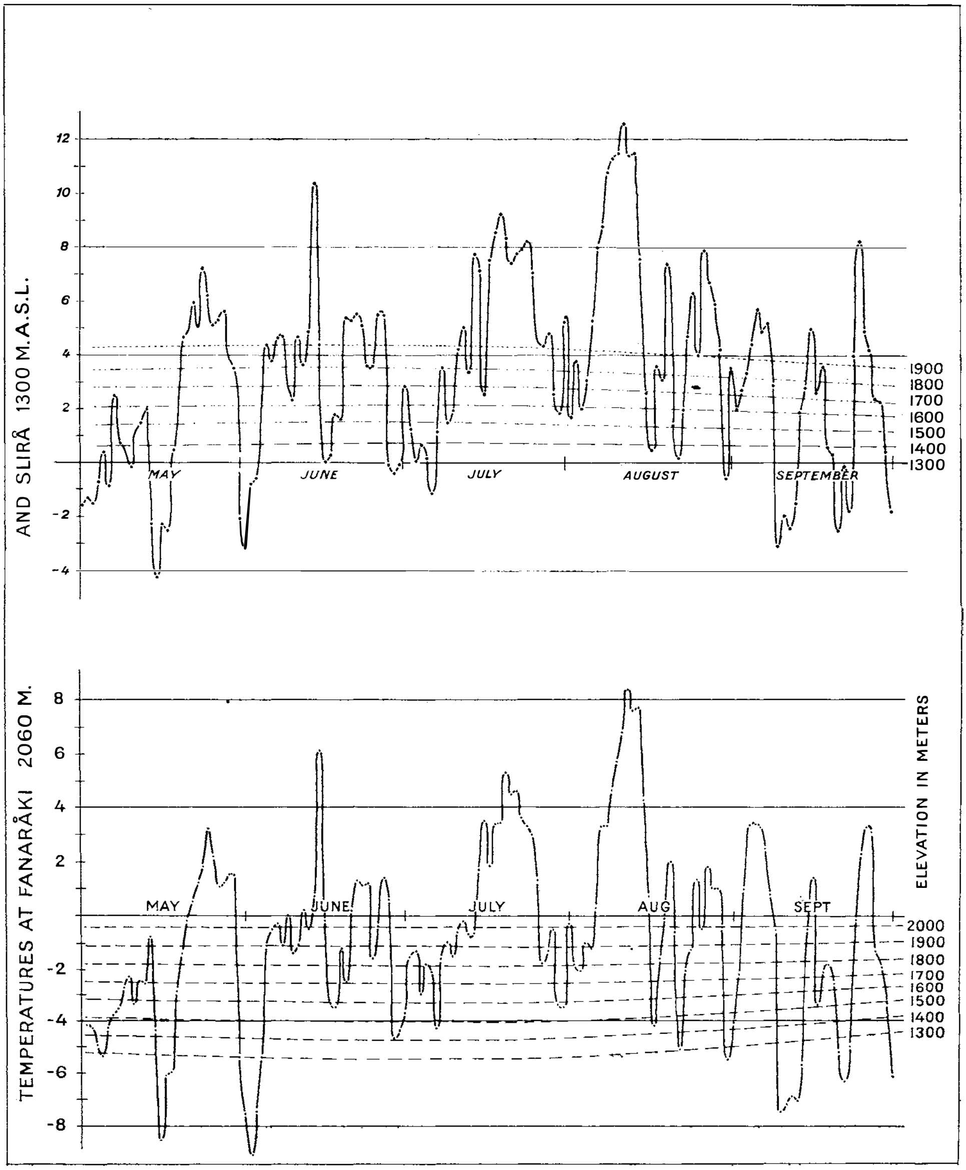


Fig. 7. *Diagrammene viser temperaturens gang på Fanaråki og Slirå sommeren 1964. De stiplede linjer angir 0°C på nivået for de forskjellige høyder over havet.*

The diagrams showing the temperature patterns at Fanaråki and Slirå in the summer of 1964. The dotted lines indicate the 0°C level for different heights above sea level.

målingene på de enkelte staker er avsatt som ringer. Man kan, ved hjelp av den hypsografiske kurve, direkte ut av diagrammet beregne den samlede eller gjennomsnittlige (spesifikke) materialbalanse. Dette er her gjort og fremstilt ved de skraverte arealer. De oppgitte verdier er imidlertid beregnet etter et ablasjonskart over breen, da dette gir mere nøyaktige verdier.

Ved siden av Hardangerjøkulen har Norges Vassdrags- og Elektrisitetsvesen

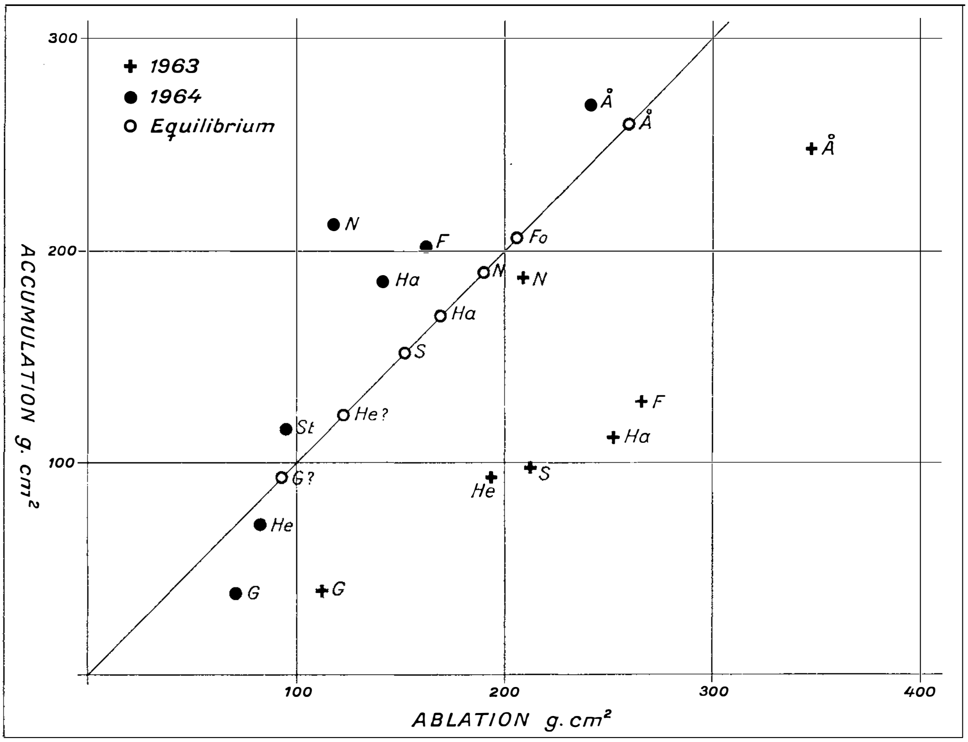


Fig. 8. *Diagrammet viser forholdene ved de forskjellige undersøkte breer i Sør-Norge 1963 og 1964. På diagonalen er breenes «normale» likevekt avsatt. Punkt på oversiden av diagonalen representerer breer med overskudd, på undersiden representerer de breer med underskudd i regimet. F = Folgefonni, G = Gråsubreen, Ha = Hardangerjøkulen, He = Hellstugubreen, N = Nigardsbreen, S = Storbreen.*

Diagram showing the relationship between the different investigated glaciers in southern Norway in 1963 and 1964. The glaciers' normal balance is shown by the diagonal. Points above the diagonal represent glaciers with a positive material balance, those below a negative balance.

foretatt målinger på 8 andre breer; 6 i Sør-Norge og 2 i Nord-Norge (Glasiohydrologiske undersøkelser i Norge 1964. Meddelelse nr. 14 fra Hydrologisk avdeling 1965). Nedenfor er resultatet av alle undersøkelsene i Norge satt opp i tabell 1.

Tabell 1

Bre	Akkumulasjon g/cm²	Ablasjon g/cm²	Balanse g/cm²
Folgefonnen	201	163	+ 38
Hardangerjøkulen	185	131	+ 44
Ålfotbreen	269	231	+ 28
Nigardsbreen (Jostedalsbreen)	213	118	+ 95
Storbreen (Jotunheimen)	116	95	+ 21
Hellstugubreen »	71	83	—12
Gråsubreen »	39	71	—32
Blåisen (Nordland)	230	167	+ 63
Storsteinfjellbreen »	185	120	+ 65

Som man ser har det vært overskudd for alle breer så nær som de to i Øst-Jotunheimen. Overskuddet skyldes først og fremst den lave sommertemperatur. Vinternedbøren og dermed akkumulasjonen var omtrent normal på Vestlandet, litt over i Nord-Norge, men meget under normalen i Jotunheimen. Dette siste er skyld i det underskudd som Hellstugubreen og Gråsubreen viser.

Fig. 8 viser skjematisk forholdene ved de forskjellige undersøkte breer i Sør-Norge 1963 og 64 i relasjon til et normalår når breen er i likevekt. Diagonalen representerer likevekt hvor akkumulasjonen akkurat oppveies av ablasjonen. På denne er de forskjellige breers «normale» balanse avsatt. Dette er selvsagt beregnede verdier som for enkelte breer må taes med stort forbehold. Man får her tydelig illustrert breenes «maritimitet». Breenes totale balanse øker utover mot kysten. Som man ser er den ca. 3 ganger større på Ålfotbreen enn på Gråsubreen lengst øst i Jotunheimen. Siste år var dette ennå mer aksentuert da forholdet når det gjelder akkumulasjonen var som 7 til 1. Målingen av bretungenes fram- eller tilbakegang i meter ble i år målt ved 13 breer og resultatet sees av nedenstående oppstilling:

Jostedalsbreen	
Austerdalsbreen	—28
Nigardsbreen	—55
Fåbergstølbreen	—60
Lodalsbreen	—50
Stigholtbreen	—41
Briksdalsbreen	— 7
Folgefonnen	
Bondhusbreen...........	— 6
Jotunheimen	
Storbreen	—11
Hellstugubreen	— 6
Styggedalsbreen	— 8
Møre	
Trollkyrkjebreen.........	0
Veslebreen	0
Finnebreen	— 2

Som man ser har ingen breer i år hatt framgang. Man kan imidlertid vente at noen av de raskest reagerende breer som f. eks. Briksdalsbreen snart igjen vil støte fram på grunn av de siste års overskudd i materialbalansen.

Fra Sydpolen til «Utilgjengelighetens pol»

(From The South Pole to The Pole of Inaccessibility)

AV

OLAV DYBVADSKOG

Abstract

During the Antarctic summer of 1964–65 the writer joined the U.S. Antarctic Research Programme in a traverse from the Amundsen–Scott South Pole Station to the Pole of Inaccessibility. The expedition was made up of eleven men using three sno-cats. The scientific programme included seismology, gravimetry, magnetism, glaciology and meteorology. The writer was responsible for the study of surface features of the snow and for meteorological observations. Sections through the sastrugis in the area showed that they were mainly the result of wind erosion. Observations furthermore indicated that the sastrugis had been formed in less than one year, in some places during a very short period. Thus their lineation may not always indicate the prevailing wind direction.

«Ta på sikkerhetsbeltene og gjør klar til landing! Vi vil være på Sydpolen om 5 minutter. Temperaturen er — 39°C, og det blåser frisk bris til liten kuling.» Det var en av mannskapet som kom bak i lasterommet på det store transportflyet, et C-135 Hercules, og ga oss denne konsise ordren.

Endelig var vi framme etter en reise på 33 000 kilometer for min del, fra Oslo via Island, Washington DC, Hawaii, New Zealand og McMurdo, den amerikanske stasjonen på vestsiden av Rosshavet.

Et år var gått siden Norsk Polarinstitutt gjennom Utenriksdepartementet mottok innbydelsen fra National Science Foundation i U.S.A. til å sende med en deltaker på en amerikansk ekspedisjon i Antarktis. Reisen ble organisert av Norsk Polarinstitutt og finansiert dels over statsbudsjettet, dels med bidrag fra «Komitéen til bevarelse av polarskibet Fram» og fra «Roald Amundsens minnefond». Forberedelsene tok sin tid, og først i juli ble det endelig bestemt at jeg skulle reise.

Og nå *var* jeg altså her. Det var «midt på natta», men det var tidlig november, forsommer, og sola skinte fra en skyfri himmel.

Den vitenskapelige lederen på Amundsen-Scott South Pole Station, en buldrende og gestikulerende spansk-amerikaner, som senere viste seg å være vennligheten selv, møtte oss og viste oss hvor vi skulle bo. «Frokost får dere mellom 6 og 6.20 i morgen tidlig», sa han.

I vår bolig på Sydpolen tilbrakte vi ca. 4 uker. Boligen var hva amerikanerne

Fig. 1. *Ekspedisjonens deltagere. Stående: J. Gliozzi, J. Beitzel, B. Redpath, R. Koski og C. Bentley. Sittende: E. Parrish, R. Cameron, O. Dybvadskog, N. Peddie og E. Picciotto. S. Kane sluttet seg til ekspedisjonen senere.*

The members of the expedition with the exception of S. Kane, who joined in later.
Photo: E. PICCIOTTO.

kaller «Jamesway». Den ser ut som en sylinder som er kløyvd på langs og lagt med snittflaten ned. Veggene består av to lag med seilduk med noe isolasjonsmateriale imellom. Gulvet er av tre. Det er plass til 20 mann i en slik teltbrakke. Ellers ligger de fleste bygningene på Sydpolen i tunneler under snøoverflaten. Der var det soverom for det faste personellet på ca. 25 mann. Der var kjøkken og spisesal, spesialrom for de forskjellige vitenskapelige oppgaver, fritidsrom, et lite sykehus, verksted, og vaskerom med dusj og vannklosett. Matvarene var lagret i tunnelene. Der hadde en hele året det beste fryserom en kunne tenke seg, med temperaturer som aldri kom over ÷ 30°C. Sydpolen ligger inne på selve platået, 2800 m o. h. Midlere årstemperatur er ÷ 50°C, varmeste målte temperatur ÷ 17°C.

I løpet av de fire ukene på Sydpolen ble jeg godt kjent med de andre ni ekspedisjonsdeltakerne, som alle hadde sine spesielle oppgaver.

Dr. CHARLIE BENTLEY var leder den første halvdelen av ekspedisjonstida og leder for de seismiske undersøkelsene. Han hadde tidligere deltatt i tre «traverser». Dr. RICHARD CAMERON var leder den siste halvdelen av tida, og leder for den glasiologiske delen av programmet. Han hadde tidligere overvintret en gang og deltatt i en sommerekspedisjon til Antarktis. JOHN BEITZEL var assistent for BENTLEY, og ledet de seismiske undersøkelsene etterat denne hadde reist. BRUCE REDPATH var også assistent for BENTLEY, og han var dessuten ekspedisjonens radiomann. JAMES GLIOZZI var assistent for CAMERON. Han hadde også eget forsknings-program i glasiologi. På grunn av sykdom måtte han forlate ekspedisjonen på halvveien og arbeidet resten av sesongen på Sydpolen og Byrd Station. SCOTT KANE overtok etter GLIOZZI som assistent for CAMERON. Han var elektroingeniør og ydet verdifull hjelp når det gjaldt det elektroniske utstyret. Han hadde overvintret på Sydpolen før. NORMAN PEDDIE foretok magnetiske observasjoner, målte feltstyrke, inklinasjon og deklinasjon, og var vår navigatør. Han hadde siste år overvintret på Byrd Station. Professor dr. E. PICCIOTTO var geokjemiker fra Belgia. Han hadde tidligere deltatt i en rekke ekspedisjoner til Antarktis, en vinter som leder på den belgiske stasjonen. Dr. PICCIOTTO er spesialist på isotopundersøkelse. RAYMOND KOSKI og EDMOND PERRISH var mekanikere. KOSKI hadde tidligere vært med på en travers. OLAV DYBVADSKOG – forfatteren – er glasiolog og hadde tidligere foretatt glasiologiske målinger på flere norske breer.

Tiden på Sydpolen ble brukt til å forberede ekspedisjonen. Det meste av utstyret vi skulle ha med, hadde vært brukt på en ekspedisjon 2 år tidligere og befant seg på Sydpolen. Alt måtte sees over, kjøretøyene overhales og rengjøres, og utstyret måtte lastes inn.

Jeg fant også tid til å forberede det vitenskapelige programmet som jeg skulle være ansvarlig for. De meteorologiske instrumentene jeg skulle bruke ble prøvd. For å finne stratigrafien i sastrugiene (skavlene) gravde jeg dem ut og lot forskjellige vegger stå igjen, så de dannet et slags rom uten tak. Rommene ble etter tur dekket til med en presenning. I det lyset som falt gjennom veggene, kom stratigrafien tydelig fram. Jeg tok så bilder av dette med forskjellig eksponeringstid. På stasjonen fantes et brukbart mørkerom, så jeg kunne få framkalt filmene og se hva som ga det beste resultat.

Vår ekspedisjon var et ledd i et større program som skal strekke seg over 4–5 år. I løpet av denne tiden skal tre kjøretøyer ta seg fram i siksak gjennom Dronning Maud Land, fra Sydpolen og fram til den belgiske stasjonen «Roi Baudouin» ved kysten. Første året, som jeg var med på, gikk turen fra Sydpolen til «Utilgjengelighetens pol», som er det stedet i Antarktis som ligger lengst fra kysten. Kjøretøyene vi brukte var tre sno-cats (Fig. 3). Den ene var en mer ordinær type, som hadde påmontert utstyr for boring av hull ned til 40 m. De andre to var større og av mer spesiell art. Det er bare laget tre stykker av denne typen i alt, og de er beregnet spesielt for dette formålet. De hadde overbygg over det hele. I den ene var det innrettet et kjøkken samt to soveplasser. I den andre var det utstyr for de seismiske målingene. Der var det også innrettet soveplasser. Sno-

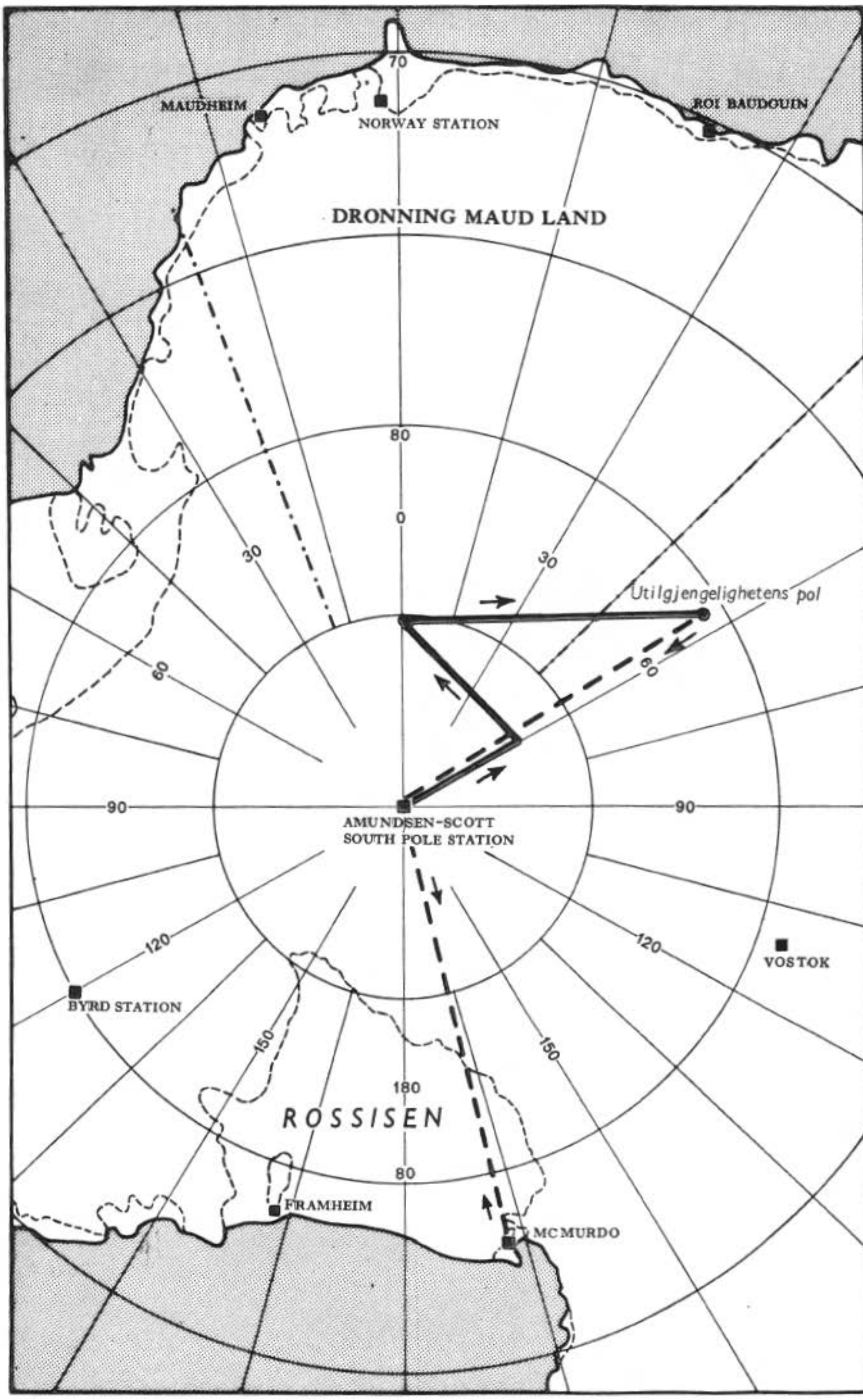


Fig. 2. *Kart over Antarktis. Den helt opptrukne linjen angir traktorruten fra Amundsen–Scott South Pole Station til «Utilgjengelighetens pol». Den stiplete linjen viser flyruten. Ekspedisjonens medlemmer ble først fløyet fra McMurdo til Sydpolen og siden fra Utilgjengelighetens pol og tilbake til Sydpolen, og videre til McMurdo.*

The members of the expedition were flown from McMurdo up to the South Pole (2.800 m a.s.l.). From there on they travelled by vehicles zig-zaging across Dronning Maud Land to the Pole of Inaccessibility (3.718 m a.s.l.). They returned to the South Pole and then to McMurdo by aircraft.

Fig. 3. *En av ekspedisjonens tre sno-cats med en rollytrailer og to sleder på slep.*

Sno-cat pulling a rollytrailer and two sledges. Photo: O. Dybvadskog.

cat'ene med ekstrautstyr kostet hver over 100 000 dollar. Bak den minste av dem hadde vi vanligvis to sleder, og bak hver av de store en slede og en rollytrailer (Fig. 3). De sistnenvte hadde fire hjul som kunne fylles opp med ca. 2000 l dieselolje i hvert. Alt i alt kunne vi på denne måten ta med 16 000 l dieselolje. Alle kjøretøyene med sleder og rollytrailere fullt lastet veide ca. 75 tonn. En vanlig dag når vi kjørte ca. 45 km, brukte vi mellom 500 og 600 l dieselolje.

Opprinnelig hadde vi planlagt å starte ekspedisjonen 1. desember. En tid trodde vi at vi skulle kunne komme i gang tidligere, men p.g.a. uforutsette vanskeligheter gikk starten først 4. desember. En dag oppdaget vi nemlig at oljetrykket på et av kjøretøyene var forsvunnet, og det viste seg at vi måtte ha en helt ny motorblokk. Denne ble pr. radio bestilt fra Australia.

Hovedprogrammet for ekspedisjonen var å måle høyder over havet og istykkelser. Til det første brukte vi 12 barometer. For hver 45. km ble det tatt seismiske målinger. I områdene imellom ble for hver 9. km tatt utfyllende målinger med gravimeter. På ekspedisjonen ble det også foretatt observasjoner av det magnetiske felt, retning og styrke. I glasiologi hadde vi et nokså stort program, mye større enn vanlig på en slik ekspedisjon. Snøkjerner ble tatt ned til 10 m. Disse prøvene skulle senere brukes til å bestemme alderen av snøen ved hjelp av to forskjellige radioaktive isotoper. Prøvene skal også brukes til å bestemme innholdet av støv i de forskjellige lagene. I borhullene som ble brukt for de seismiske målingene, ble først temperaturen målt ned til 40 m. Dertil ble den spesifikke vekt av snøen målt ned til 40 m ved hjelp av en ny metode basert på refleksjonen av protoner fra hydrogenkjernene i snøen. Mitt hovedprogram besto som nevnt i undersøkelser av overflateformene, de såkalte sastrugier, barkhaner og dyner. Dessuten foretok jeg en del undersøkelser av snødriften. Jeg hadde også de meteorologiske observasjonene hver sjette time og dessuten for hver 9 km stopp.

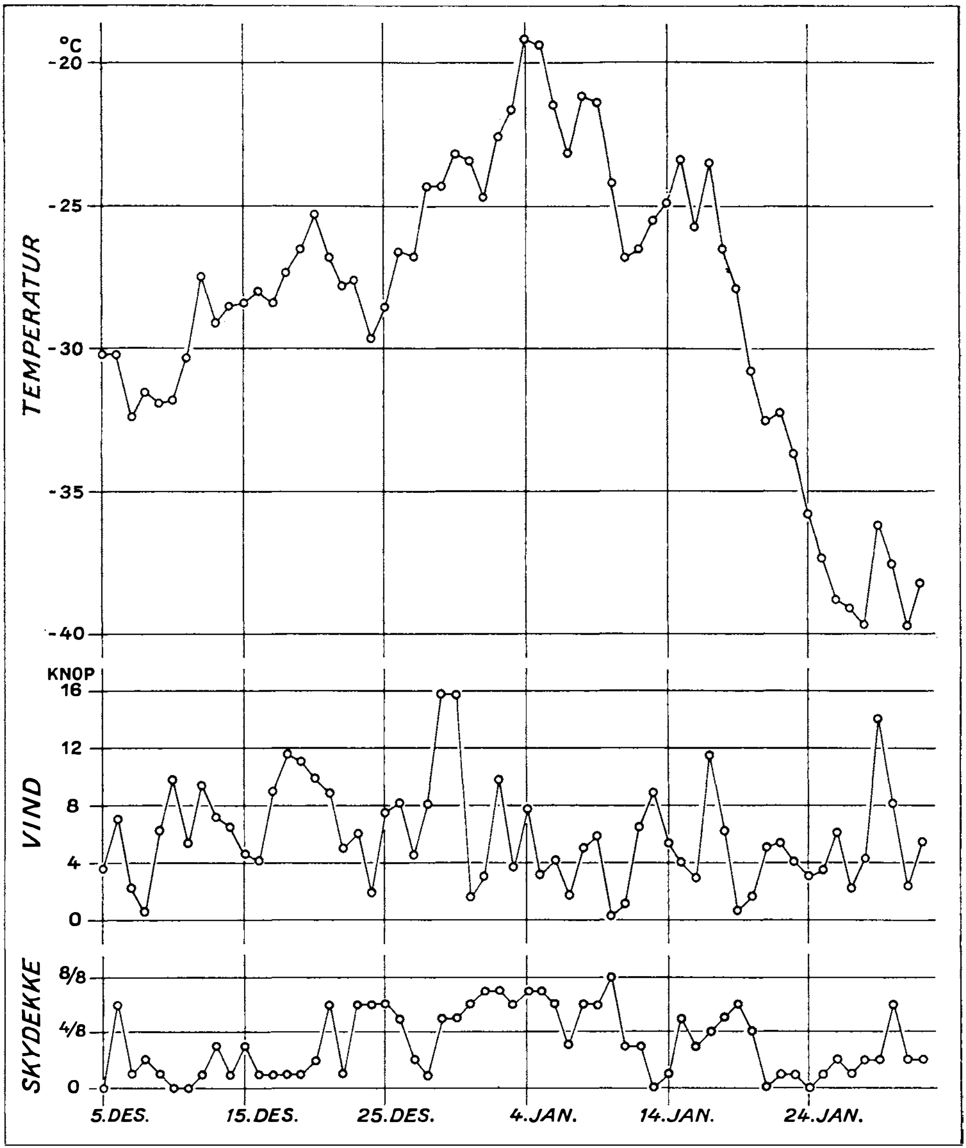


Fig. 4. *Døgnmidlene for skydekke, vind og temperatur, slik det ble registrert under ekspedisjonen.* Daily averages for cloudiness, wind and temperature as observed during the traverse.

En vanlig dag ble stort sett preget av beinhard rutine. Kl. 5–6 om morgenen sto vi opp, spiste og utførte en del målinger. I 9–10 tida kjørte vi ut. Alt etter hva overflateformene tillot av hastighet, brukte vi 8–14 timer på å kjøre 45 km. For hver 9. km stoppet vi og foretok diverse observasjoner. Når vi så kom fram, var det å arbeide 3–4 timer før vi gikk til køys etter å ha spist i 23-tida. Matlagingen gikk på omgang. Midt på dagen hadde vi ikke noe ordentlig måltid, men spiste det den enkelte fant for godt. Som en skjønner, ble det svært lange arbeidsdager.

Vanligvis ble det ikke tid til mer enn 4–6 timer søvn i døgnet. Vi sov delvis i telt og delvis i kjøretøyene.

Det er vanlig å tro at i moderne tid med alle de tekniske hjelpemidlene en har til rådighet, blir strabasene mye mindre enn da en brukte hundespann og ski som framkomstmiddel. I virkeligheten tror jeg de blir like store om enn av et annet slag. I våre dager koster ekspedisjonene så enormt i forhold til tidligere. En er nødt til å ha et stort program for å utnytte den kostbare tida så godt som overhodet mulig.

Orienteringen foregikk ved hjelp av solkompass i godt vær, og magnetisk kompass i dårlig vær. Når vi overnattet, ble posisjonen alltid bestemt ved bruk av teodolitt. Noe punkt å orientere ut fra finnes ikke i dette nesten flate og sprekkefrie området. Dette førte til en morsom opplevelse da vi hadde kjørt ca. 350 km og skulle ta en ny retning vestover. Om kvelden hadde kjøretøyene kjørt opp i omtrent riktig retning. Dette visste ikke kjøreren på den vogna jeg var med, så dagen etter da vi kjørte ut som siste vogn, svingte han til venstre og tok et spor som førte i den retning han mente var den rette. Fordi vi brukte barometer til høydemålingene kjørte vi med 9 kms avstand, så de andre vognene var ikke å se. Etter 9 km kjøring hadde vi radiokontakt med de andre. Der skulle vi finne et flagg som markerte hvor de andre hadde tatt sine målinger, men ikke noe flagg var å se. Dette ble da meldt over radio, og vi fant ut at de hadde glemt å sette ned flagg. Etter å ha utført de målingene som skulle foretas, kjørte vi nye 9 km. Heller ikke der var det noe flagg å se. Da vinden denne dagen var forholdsvis sterk, fant vi ut at flaggene hadde reist sin vei. Plutselig fikk vi se spor etter to rollytrailere. Ettersom den ene av de to rollytrailerne som var med, var bak vår sno-cat, skjønte vi fort at vi hadde tatt feil spor. Istedenfor å reise etter de andre vestover, hadde vi kjørt tilbake i sporene fra dagen før, i retning Sydpolen. Episoden ga Ray Koski som kjørte den dagen, tilnavnet «Wrong Way Koski».

Det finnes ikke noe område i vår verden som er mer blottet for liv enn dette isødet vi kjørte gjennom. Det eneste som lever der er mikrober. Derfor var det en kjærkommen avveksling da vi en dag, omtrent 1400 km fra kysten, fikk besøk av to skuaer. Skuaen er en fugl på størrelse med en måke. Den lever vanligvis av pingvinunger som er kommet bort fra foreldrene, eller av åtsler som den kan finne. På den lange turen fra kysten hadde de små muligheter for å finne noe å spise. For å rette på dette, serverte vi dem tunfisk i olje før de fløy videre.

Andre avvekslinger inntraff også, men de var ikke like hyggelige. Rett som det var hadde vi vanskeligheter med kjøretøyene. Den ene differensialen etter den andre gikk i stykker. Startere klikket, og mellomakslinger og styreanordninger sviktet, så det foregikk stadig reparasjonsarbeider. Opprinnelig hadde vi ventet første forsyning med fly tidlig i januar, men på grunn av uventet stort brenselsforbruk måtte vi ha forsyninger allerede før jul, og den 23. desember ble dagen. Vi visste ikke om flyet skulle lande eller om sakene skulle kastes ned i fallskjerm. Brev til de nærmeste ble skrevet, men dessverre ble det ingen landing. Sakene ble kastet ned med eller uten fallskjerm. Våre brev måtte vente til neste forsyningsfly som landet i januar. Dr. Bentley og Gliozzi dro da tilbake, og en ny mann, Scott Kane, sluttet seg til ekspedisjonen. Senere fikk vi enda et flyslipp, fordi vi

Fig. 5. *Sastrugiene (skavlene) var undertiden over en meter høye. Da de dessuten var temmelig harde, skapte de store vanskeligheter for kjøretøyene.*

The sastrugis were sometimes more than one meter high. Being rather compact, they were a source of much trouble for the vehicles. Photo: O. DYBVADSKOG.

da hadde ødelagt den siste reservedifferensialen til den minste sno-cat'en, og måtte få en ny.

Før vi dro fra McMurdo, fikk vi vite at laveste temperatur som tillater et fly å ta av fra en snøflate er ÷ 46°C. Vi visste også at temperaturen normalt faller temmelig fort om høsten. I dagene omkring den 20. januar var det et nokså stort fall i temperaturen. For å få oversikt plottet jeg derfor døgnmidlene inn på et diagram (Fig. 4). Det viste at hvis temperaturfallet fortsatte like sterkt, ville vi nå et døgnmiddel tilsvarende denne kritiske verdien (÷ 46°C) omtrent i månedsskiftet januar/februar. På grunn av uhellene med kjøretøyene hadde vi bare i heldigste fall muligheter til å nå fram til «Utilgjengelighetens pol» til denne tid. Fra den 20. januar og utover ble så temperaturen daglig plottet inn på diagrammet. Vi så til vår skrekk at verdiene fulgte uhyggelig nøyaktig den opptrukne ekstrapolerte temperaturkurven. Den 25. januar gikk fremste differensialen på den minste sno-cat'en i stykker. Ettersom alle reservedifferensialer var brukt opp, måtte de to andre kjøretøyene ta de to sledene som denne sno-cat'en hadde hatt å dra på, og kjøre videre på denne måten, mens den vesle sno-cat'en hadde drift bare på de bakerste beltene. Snøen var på denne strekningen nokså løs, og sammen med den ekstrabelastning det ble på de største to sno-cat'ene, ble farten temmelig lav. Den 26. målte vi temperaturer helt ned i ÷ 44°C, med et døgnmiddel på nesten ÷ 39°C. Om kvelden var vi 50 km fra endepunktet. Kl. 11 dagen etter startet vi på den siste etappen. Jeg kjørte den dagen i den fremste av de store sno-cat'ene. Da vi var ca. 10 km fra endepunktet, fikk vi en ny stopp. Det var den fremste av differensialene som streiket også på dette kjøretøyet. Vi besluttet å kople fra rollytraileren og kjøre fram til endepunktet med bare sledene på slep. Nærmere midnatt var vi framme ved den russiske sommerstasjonen på «Utilgjengelighetens pol», men ennå hadde ikke den siste sno-cat'en kommet inn. Den hadde vanskeligheter med et av beltene, og da den hadde bare 600–700 m igjen til endepunktet, ville den ikke mer. Som en kuriositet må det nevnes at dr. PICCIOTTO, som den dagen fyllte 44 år, derfor måtte gå til fots fram til den «utilgjengelige» pol.

Den russiske stasjonen ga et eiendommelig førsteinntrykk. På avstand så den nærmest ut som en kirke (Fig. 6). Kommer en nærmere, ser en at stasjonen består av en 7,5 m lang og 3 m bred brakke. I den ene enden er det et tårn, og på toppen av dette står en byste av Lenin. Innvendig er det i den ene enden et 2,5 × 3 m stort rom som har elektrisk komfyr, elektrisk snøsmelter og 4 køyer. Resten av huset er opptatt av en dieselmotor. I den ene enden på dieselmotoren er det borutstyr for å bore ned til 60 m. Det er dette utstyret som gjør at huset må ha tårn. I den andre enden av maskinen er det en elektrisk generator som skaffer strøm. I dette rommet er det dessuten en reserve-radiosender. Stasjonen ble dratt opp på slede fra Vostok i slutten av 1958. Siden har russerne besøkt stasjonen bare én gang, nemlig sør-sommeren 1963/64. De la da igjen en beskjed skrevet på engelsk, som fortalte oss hvorledes vi kunne få startet dieselmotoren, hvorledes vi skulle betjene radioen, og hvor vi kunne finne noe mat. Det skulle være mat der for 3 mann i fire måneder. Utenfor var det en radiomast og et bur for meteorologiske instrumenter. Minimumstermometeret sto på ÷ 82°C. Det hadde sannsynligvis vært kaldere om vinteren, men instrumentet kunne ikke gå lavere. Rimeligvis ligger minimumstemperaturen på denne stasjonen mellom ÷ 90° og ÷ 95°C. Maksimumstermometeret sto på ÷ 25°C. Det skulle altså tilsvare varmeste dag denne sommeren. Senere bestemte vi årsmidlet til å være ÷ 58°C, ved å måle temperaturen dypt i snøen. Men området er ikke spesielt bare på grunn av sine lave temperaturer. Ved å måle på noen staker russerne hadde satt igjen, fant vi ut at gjennomsnitts-årsnedbøren siden 1958 var ca. 25–30 mm. Det er tørrere enn den tørreste ørken i verden. Når en vet at isdypet på dette stedet er ca. 3000 m, er det lett å regne ut at det, forutsatt samme nedbørsmengde, må ha tatt over 100 000 år å bygge opp et slikt isdekke. Den andre dagen etter at vi kom til «Utilgjengelighetens pol» ble været dårlig. Det skyet til, sikten ble begrenset, og det begynte å blåse. Heldigvis medførte vinden en stigning i temperaturen. På dette tidspunkt så vi med stor spenning fram til den dagen vi skulle bli hentet. Flyet skulle fly fra McMurdo til Sydpolen, derfra til oss, og så tilbake samme vei. Det betød at vi måtte ha godt flyvær samtidig både i McMurdo, på Sydpolen og på «Utilgjengelighetens pol». For øyeblikket var det dårlig

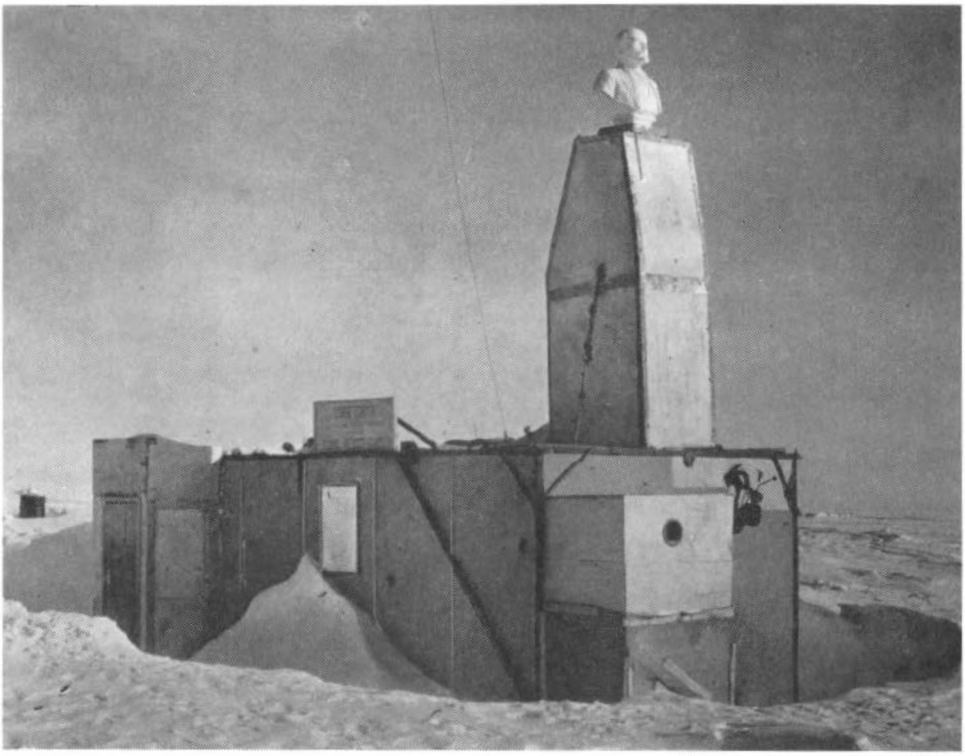


Fig. 6. *Den sovjetiske sommerstasjon på «Utilgjengelighetens pol» med byste av Lenin som landemerke på toppen av huset.*

The Soviet summer-station at the Pole of Inaccessibility. The Russians were the first to reach this place in 1958. On top of the station a tower with a statue of Lenin. Photo: O. DYBVADSKOG.

vær både i McMurdo og hos oss. Den fjerde dagen forsøkte vi å få et fly til å hente oss, men dessverre var det ikke mulig på grunn av maskinvanskeligheter. Først ved 14-tida den femte dagen fikk vi melding over radio om at flyet var på vei. Vi hadde på dette tidspunkt svært liten vind, tynt skydekke med dårlig sikt i horisontal retning, men vi fant ut at vi kunne tilråde landing. Det er vanskelig å skildre den stemningen som hersket blant oss det siste døgnet mens vi ventet på at flyet skulle komme. Mer enn én var besatt av ubehag ved tanken på muligheten for en tvungen overvintring på denne stasjonen. Bare flyturen tilbake til McMurdo via Sydpolen ble om mulig en enda større påkjenning. Allerede starten ble dramatisk nok. Flygeren var ikke i stand til å få løftet nesen på flyet. For å få maskinen til å lette måtte vi stable oss oppå luken bakerst i flyet, stikk imot alle forsiktighetsregler. Etter et voldsomt rykk kom vi så på vingene, og kunne innta de vanlige plassene igjen. Da merket vi at vi fløy unormalt lavt. Årsaken var at tuppene på frontskiene pekte ca. 40° nedover og var ikke til å få i riktig stilling. Flygeren manøvrerte oppover og gjorde så et voldsomt stup i håp om å få løsnet dem. Dette gjentok seg et par-tre ganger. Vi ble hengende i sikkerhetsselene, men bagasjesurringene røk, og tunge kasser for mellom gulv og tak. Blant utstyret var et gravimeter til 10 000 dollar som ble ødelagt. Med flere tonn utstyr løst bak i flyet var situasjonen før landingen på Sydpolen meget kritisk. Men etter et par forsøk klarte flygeren å få slått frontskiene i riktig stilling ved å la dem berøre bakken. Dermed ble mannskapet på Sydpolen som hadde tatt oppstilling med kamera klar for å få bilder av crashlandingen, heldigvis snytt. På den videre tur til McMurdo ble skiene holdt på plass med en kjetting.

Å komme tilbake til McMurdo var en behagelig overgang. På selve ekspedisjonen hadde vi igrunnen ikke så lave temperaturer, og heller ikke var høyden over havet i seg selv avskrekkende, men kombinasjonen av temperaturen, høyden og de lange arbeidsdagene var ganske hard. Ved slike temperaturer reagerer kroppen som om en var mye høyere enn hva høydemålingene egentlig viser. I McMurdo var det ÷ 5 til ÷ 10°C. Enhver bevegelse som på ekspedisjonen grunnet høyden og temperaturen kunne være en anstrengelse, gikk her lekende lett.

McMurdo er egentlig en for stor stasjon til å være direkte trivelig. Den er selve inngangsporten til isødet, med en utrolig stor aktivitet. Fly og helikopter er stadig i lufta. Beltebiler og vanlige biler kjører omkring. På havna ligger isbrytere og transportskip på opptil 10 000 tonn. Derfor var det med stor glede jeg sammen med CAMERON mottok en invitasjon til å besøke Scott Base, som er den newzealandske basen ca. 3–4 km fra McMurdo. Ekstra hyggelig var det også en dag jeg sammen med dr. CRARY, dr. CAMERON og en newzealandsk glasiolog var ute på isshelfen og foretok en del observasjoner.

Men dagene gikk. Snart måtte vi reise fra denne verdensdelen som på tross av at den er det mest ugjestmilde område i verden, ser ut til å ha slik dragning på enkelte mennesker. I tre måneder hadde vi vært der. Fra vinduet på det store Super Constellation-flyet fikk vi siste glimt av McMurdo, Rossisen, Mt. Erebus med sin karakteristiske røyksøyle og Victoriafjellenes gigantiske rekke.

Planene for neste år er å fly de som skal være med på ekspedisjonen ned til «Utilgjengelighetens pol». En må regne med at de må være der ca. 2–3 uker for å sette kjøretøyene i stand igjen før de kan kjøre videre. På den tida av året vil temperaturen ligge mellom ÷ 40 og ÷ 50°C. Høyden over havet er 3718 m. Under slike forhold blir det neppe noen behagelig opplevelse å bo delvis i telt og delvis i de kjøretøyene som en må reparere på. Forhåpentlig vil disse deltakerne først få en akklimatiseringsperiode på den mer komfortable Sydpol-stasjonen som ligger bare 2800 m o. h.

Å reise helt ned til Antarktis for å drive forskning på vindblåst snø kan synes meningsløst så lenge en har mer enn nok snø her hjemme. Ser en det imidlertid i sammenheng med snøforskningen i sin helhet, blir bildet annerledes. Vindblåst snø er en meget vanskelig materie å forske på. I et land som Norge hvor terrenget er så kupert, varierer vinden svært mye både i retning og styrke. I Antarktis har en så store flater at de nesten kan regnes som uendelige. Retningen på vinden er temmelig konstant, bare styrken varierer omtrent på samme måte som her. Dessuten er temperaturen så lav at snøkrystallenes mekaniske egenskaper er svært konstante. Antarktis kan derfor sees på som et stort laboratorium for snøforskning. Skal en få noe ut av slik forskning, nytter det ikke å reise bare ett år og tro at en skal få avgjørende resultater. For å komme noen vei må en vie årrekker på dette studiet. Når så lite er gjort hittil, kommer det av at ingen har drevet med slike oppgaver over en lengre periode. Som snøforsker må en arbeide under hardere fysiske forhold enn nesten noen annen vitenskapsmann. Følgelig blir det gjerne til at det hvert år kommer nye folk, og mange av de samme feil blir gjort om igjen. Derfor vil ofte de vitenskapelige resultatene som blir oppnådd, stå i misforhold til de store beløp som årlig blir brukt.

Det meste av den faglige delen av mitt arbeide på denne ekspedisjonen er ennå ikke bearbeidet. Jeg vil likevel raskt summere opp det arbeidet som er gjort, uten å komme med endelige konklusjoner. Min oppgave kan settes opp slik:

1. Meteorologiske observasjoner av mer rutinemessig art.
2. Observasjoner av sastrugiene, deres retning, form, størrelse og utbredelse. Undersøkelser av deres stratigrafi ved hjelp av snitt som ble fotografert.
3. I den utstrekning det var mulig ble det tatt observasjoner av barkhaner, dyner og ripples.

Utbredelsen av sastrugiene er tidligere ikke undersøkt i deltalj. Så vidt jeg har kunnet bedømme i felten, er de avhengige av landskapets helling i forhold til den framherskende vindretning. Med sikkerhet kan en ikke uttale seg om dette før en har fått tilsendt resultatet av høydemålingene og målingene av terrengets hellingsretning, for med det blotte øyet er hellingen svært vanskelig å bedømme.

Stratigrafiundersøkelser ved å grave snitt og fotografere disse er ikke tidligere foretatt. En har etter hvert nærmest godtatt at sastrugiene er erosjonsformer uten å ta standpunkt til utviklingen i detalj.

Når det gjelderen alderen på sastrugiene, har en i noen tilfelle ment at de kan være flere år gamle. Under oppholdet på Sydpolen fikk jeg anledning til å se stratigrafien i snøen ved faste staker der en kjente snøens alder. Siste års snø skilte seg tydelig ut fra den eldre snøen i kornstørrelse og konsistens. På det grunnlaget kan en si at sastrugiene i det området vi passerte, neppe kunne være eldre enn ett år. På Utilgjengelighetens pol hadde jeg dessuten anledning til å se sastrugiene bli dannet i løpet av et par dager. Dette kan få konsekvenser for den betydningen sastrugiene blir tillagt når det gjelder bestemmelse av framherskende vindretning; sastrugiene kan nemlig dannes under en vindperiode fra en mer tilfeldig retning.

Ved et par anledninger ble det tatt bilder av barkhaner som beveget seg bortover overflaten. Bildene ble tatt fra faste standplasser med noterte tidsintervaller imellom, slik at bevegelsen kan rekonstrueres av bildene. Det samme ble gjort med ripples. En får dessverre liten tid til spesialundersøkelser på en travers hvor arbeidsrytmen blir bestemt av et annet hovedprogram, i dette tilfelle seismikk. Til gjengjeld kommer en over et stort område og får sett mange former og en kan få laget et snitt over et hittil ukjent område.

En norsk ekspedisjonsdeltaker i Antarktis må i våre dager finne seg i å bli sett på som en representant for en nasjon som har gitt opp forskning i dette området. I gamle dager da ekspedisjonsvirksomheten der nede i første rekke bar preg av å være oppdagelsesreiser, viste vi at vi kunne være blant de fremste på området. Maudheimekspedisjonen 1949–52 viste at vi i samarbeid med andre nasjoner kunne utføre vitenskapelig arbeid som fremdeles tjener som mønster for moderne forskning i Antarktis. Også de som deltok i den norske ekspedisjonen til Norway Station i 1956–60, gjorde det klart at vi kunne hevde oss blant de fremste nasjoner på Antarktisforskningens område. I dag eksisterer ikke noen norsk stasjon der nede. De siste år har utviklingen i dette polarområdet vært enorm. De større nasjonene, som Sovjet-Samveldet og U.S.A., bruker årlig veldige beløp på forskningen i Antarktis, men også mindre nasjoner satser ganske mye, og har vist at de kan utføre arbeid som i flere henseender er på høyde med det som de større nasjonene presterer.

Skulle jeg derfor til slutt driste meg til å komme med et ønske, måtte det være at også vi snart fikk vår egen vitenskapelige stasjon i Antarktis. Venter vi for lenge, vil vi for alltid bli akterutseilt i utforskningen av dette kontinentet hvor vi har så ærerike tradisjoner.

Dei høgste fjella på Svalbard

(The highest mountains on Svalbard)

AV

JOHANNES HUS og EINAR SKIRDAL

Abstract

Both Newtontoppen and Perriertoppen, which lie in Ny Friesland in the north-east of Vestspitsbergen, have been reckoned from time to time by different authors as the highest mountain on Svalbard.

In 1963, the heights of these two mountains were measured, among other things, by Norsk Polarinstitutt. The base level was the mean tide level measured in Wijdefjord and Billefjord. The height transfer to the points in the triangulation net is demonstrably sound.

From the computation we have reached the following conclusion: Newtontoppen and Perriertoppen are of equal height – 1717 m a.s.l.

Dei høgste fjella på Svalbard er snødekte. Høgdene på desse fjella er rekna til høgste punktet på snødekket.

Newtontoppen, som ligg i Ny Friesland, nordaust på Vestspitsbergen, har gjerne vorte rekna som høgste fjellet på Svalbard. Perriertoppen, som ligg i same området, om lag 22 km nordvest for Newtontoppen, har om lag same høgda. Dette har ført til at Perriertoppen også har vorte rekna som høgste fjellet på Svalbard.

Nedanfor er sett opp dei høgdene som ymse forfattarar har sett på desse to toppane:

Forfattar	Newton-toppen	Perrier-toppen	Merknad
G. DE GEER (1923)	1717 m		s. 11
R. POMMIER (1947)	1717 »	1720 m	s. 43–46
Y. VALLETTE (1947)	1717 »	1730 »	kart M = 1 : 200 000
D. MASSON-SMITH (1962)	1712 »	1708 »	s. 62

I tillegg til desse, har også M. DESORBAY, iflg. D. MASSON-SMITH (1962, s. 62), fått Perriertoppen til å vera høgst.

D. MASSON-SMITH (1962, s. 62) har teke for seg grannsemda på observasjonsresultata frå cambridgemålingane som han refererar til, og seier m. a.: «Generally,

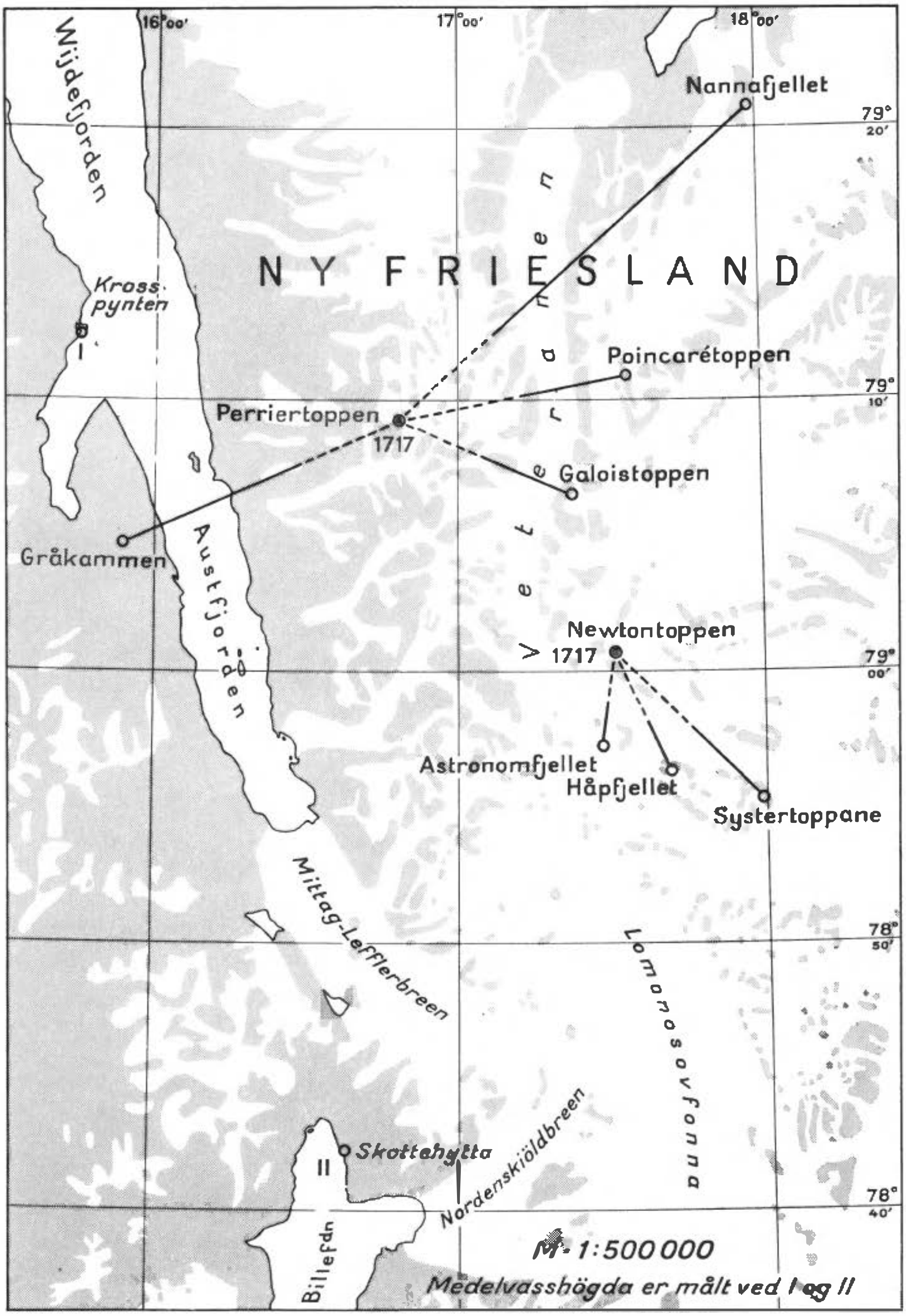


Fig. 1. *Dei opne ringane viser observasjonstadene der det er målt mot Newtontoppen og Perriertoppen. Medelvasshøgda vart målt ved stasjon I og II.*

The figure shows the positions of observation stations in relation to Newtontoppen and Perriertoppen. The mean tide level was measured at stations I and II.

the error of the elevations of the stations near the coast are about 1 m, while those in the interior may be as large as 10 m». Newtontoppen ligg i det indre av det området det her er tale om, medan Perriertoppen ligg noko nærare kysten (Kart M = 1:125 000).

I 1963 triangulerte og passpunktmålte Norsk Polarinstitutt m. a. deler av Ny Friesland, og høgdene på Newtontoppen og Perriertoppen vart då målt. Høgdegrunnlaget er medelvasshøgda målt ved Krosspynten i Wijdefjorden i tida 29/7–1/8 1959 og medelvasshøgda målt ved Skottehytta, innerst i Billefjorden, i tida 12/7–16/8 1963.

Høgdeoverføringa er gjort med nivellement og tosidige høgdevinkelmålingar og viser seg å vera god. Ei direkte høgdeoverføring av medelvasshøgda i Wijdefjorden til medelvasshøgda i Billefjorden gjev såleis eit «gap» på berre 0,19 m.

Fig. 1 viser korleis dei stadene som her vert nemnt lig i høve til kvarandre.

Utrekningane av Norsk Polarinstitutt sine høgdeobservasjoner har gjeve dette resultatet for Newtontoppen og Perriertoppen:

Observert		Avstand km	Høgd på Observasjonsplassen, m	Søkt høgd, m	
Frå	Til				
Astronomfjellet	Newtontoppen	6,38	1487,30	1716,56	*1716,60*
Systertoppane	—»—	14,82	1188,84	1716,84	
Håpfjellet	—»—	8,64	1259,61	1716,58	
Poincarétoppen	Perriertoppen	16,22	1451,00	1717,08	*1716,64*
Galoistoppen	—»—	13,25	1420,92	1716,24	
Nannafjellet	—»—	31,83	733,82	1718,68	
Gråkammen	—»—	20,40	994,83	1716,07	

Høgdene viser seg altså, etter våre observasjonar, å verta svært like for desse to fjella. Då høgda er målt til toppen av snødekket, må ein vel rekne med at denne kan ymsa noko med nedbørmengda, skavledanning på toppane og avsmelting. Men då fjella ligg nokså nær kvarandre, må ein vel ha lov til å tru at tjukkleiken på snødekket aukar eller minkar likt på båe to.

Konklusjonen vår vert difor at *Newtontoppen og Perriertoppen er like høge – 1717 m o. h.*

Litteratur

DE GEER, G., 1923: Mission Suédoise pour la mesure d'un Arc de Méridien au Spitsberg. Entreprises en 1899–1902. **II**, *IXieme section, Topographie et géologie.* Resultats des travaux cartographiques, 8–12. Stockholm.

MASSON-SMITH, D., 1962: Cambridge survey of central Vestspitsbergen. II. The tirangulation of central Ny Friesland. *Geographical Journal.* **CXXVIII**, (I), March 1962, 59–62. London.

POMMIER, R., 1947: Au Spitzberg Inconnu. *France Illustration* (67), 11. jan. 1947, 43–46. Paris.

Kart: Nouvelle Frise, M = 1:200 000. Målt av den franske Spitsbergenekspedisjonen 1946. Redigert i 1947 av YVES VALLETTE.

Spitsbergen, Southern Ny Friesland, 1962, M = 1:125 000. From surveys and compilation by the Cambridge Spitsbergen Expeditions 1949–1958 under the direction of W. B. HARLAND and D. MASSON-SMITH.

The weather in Svalbard in 1964

BY

VIDAR HISDAL

The following description of some salient features of the large scale atmospheric circulation pattern over the Svalbard area is based on a study of the weather maps for 1964. The pressure systems most closely connected with these circulation patterns and the character of the resulting air flow are briefly indicated. Words like cold, cool, normal and mild characterize the temperature conditions in relation to the average conditions for the period 1947–63, the basis of these indications being mainly the temperature observations from Isfjord Radio.

1964	
1–22 Jan.	A series of well-developed cyclones approaches from the southwest. Comparatively mild air from the south and cold air from the east or north alternate as the cyclones pass.
23–28 Jan.	A very cold northerly air-stream between a high pressure area over the Polar Basin and Greenland, and depressions to the east.
29 Jan.–4 Feb.	The weather is governed by cyclones passing between northern Norway and Svalbard. Most of the period temperatures somewhat below normal.
5–7 Feb.	A cold northerly air-stream again enter the Svalbard area.
8–17 Feb.	Cyclones from the southwest bring milder air. Mostly southerly winds and temperatures above normal.
18–27 Feb.	Northerly winds in the rear of depressions to the east. Cold.
28 Feb.–14 March	Weak depressions at the start of the period, stronger depressions towards the end, pass over or close to Svalbard. Milder.
15–18 March	Great temperature changes as a frontal zone separating air masses of very different temperatures moves over the Svalbard area.
19–22 March	Northerly winds and cold.
23–31 March	Cyclones from the southwest pass. Mild.
1– 6 Apr.	The cyclonic paths are shifted southwards. Advection of air from the north gives considerably lower temperatures.
7–20 Apr.	Southerly to easterly winds between a high pressure area north of Siberia and a low pressure area towards southwest. Mostly mild.
21–22 Apr.	A depression passes north of Svalbard. Mild.
23 Apr.–1 May	Most of the time a northerly air-stream between an anticyclone over the Greenland area and cyclones moving east of Svalbard. Cold.

2– 8 May	Svalbard is situated near the southern boundary of an extensive high pressure area. Easterly winds and cool.
9–11 May	A weak depression passes Svalbard from the southwest. Milder.
12–16 May	A low pressure area becomes stationary over the Norwegian Sea. Easterly to northerly winds and comparatively mild.
17–27 May	Relatively weak highs and lows pass. Temperatures about the normal.
28 May–12 June	An extensive high pressure area moves towards Svalbard from the east and governs the air circulation most of the period. Cool.
13 June–1 July	Passages of cyclones and high pressure ridges alternate. Temperatures about or slightly below the normal for the season.
2–14 July	The pressure field is weak. Moderate winds or calms. Temperature conditions as before.
15–17 July	A cyclone form the southwest passes. About normal temperatures.
18–23 July	Southwesterly winds between an anticyclone to the southeast and a depression in the Polar Basin. Mostly cool.
24 July–3 Aug.	Cyclones from the southwest bring mild air over Svalbard.
4– 8 Aug.	A cyclone moves from the Hudson Bay area into the Arctic Basin. Temperatures about or slightly below normal.
9–14 Aug.	A weak, anticyclonic pressure field, followed by cyclonic disturbances towards the end of the period. Cool.
15–30 Aug.	A high pressure area that has built up to the west of Svalbard, moves slowly eastward. Temperatures above normal.
31 Aug.–7 Sept.	Svalbard is situated between an anticyclone to the north and cyclones passing to the south and east. Weak winds and slightly below normal temperatures.
8–26 Sept.	Easterly winds in connection with intense cyclonic centres travelling south of Svalbard. Mild at the start of the period, more northerly winds and cool towards the end.
27 Sept.–1 Oct.	Weak depressions pass from the west. Milder.
2– 7 Oct.	Most of the time a cold northerly air-stream in the rear of depressions moving over the Barents Sea.
8–12 Oct.	Easterly winds between a high pressure area to the north and a well-developed depression to the south. Gradually milder.
13–19 Oct.	Cyclones from the west and, later on, from the southwest pass. Temperatures slightly above normal.
20 Oct.–18 Nov.	A series of intense cyclonic centres moves over or south of Svalbard. Advection of mild air in the front of the cyclones, cold, northerly air-streams in the rear.
19–28 Nov.	Easterly winds between a polar anticyclone and cyclones passing to the south. Cold during most of the period.
29 Nov.–4 Dec.	Depressions from the west and southwest pass. Considerably milder.
5– 9 Dec.	The cyclones travel farther south and the pressure field over the Svalbard area is weak. Temperatures about the normal for the season.
10–12 Dec.	A cyclone passes from the south. Mild air in the front of the cyclone, cool in the rear.
13–18 Dec.	An intensive depression south of Svalbard. Mild.
19–24 Dec.	A depression from the southwest passes Svalbard, and the temperature continues to be high for the season.

25–31 Dec. Northerly winds between a high pressure ridge over the Polar Basin and a low pressure area to the southeast. At the end of the period the circulation pattern is dominated by a depression to the southwest, and the air-stream veers east. Colder.

In the table below are given preliminary monthly mean temperatures for Isfjord Radio for 1964 as well as their deviation from the means of the period 1947–63. (The final data for 1964 are not yet available. They will be published later in "Norsk meteorologisk årbok 1965".)

Mean temperatures (°C) Isfjord Radio

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1964 means	−13.4	−13.7	−8.9	−10.4	−3.6	0.4	3.6	4.4	0.9	−3.3	−7.9	−6.5
Deviation of 1964 means from 1947–63 means	− 2.8	− 2.6	3.1	− 1.6	−0.3	−1.4	−1.0	0.1	−0.2	−0.8	−2.0	2.8

It appears from the table that most of the months were colder than normal. The only noteworthy exceptions are formed by the months of March and December.

Adolf Hoel - noen minneord

AV

SØREN RICHTER

ADOLF HOEL ble påkjørt av en bil kort før jul 1963 og stygt skadet. Den 85 år gamle, men seige og livskraftige mann, som mente han ennå hadde meget arbeide ugjort, kjempet for livet, men måtte til slutt gi tapt og sluknet den 19. februar 1964.

En merkelig livsskjebne var slutt. ADOLF HOEL ble født i Sørum 15. mai 1879 som sønn av en overkonduktør ved statsbanene. Hans hug stod til naturvitenskapene, og selv om han måtte tjene sitt levebrød som lærer i studietiden, tok han cand. real. eksamen i 1904 med meget god karakter. Kvartærgeologien var hans store interesse, og han foretok flere studiereiser i Nord-Trøndelag og Nord-Norge. I 1907 ble HOEL ansatt som geolog ved GUNNAR ISACHSEN's ekspedisjon til Spitsbergen, bekostet av fyrsten av Monaco. Det synes som om denne ferd ble utslagsgivende for hans senere liv og virke. Her var et «no man's land» som burde sikres for Norge. Landet var stort, fjellene hadde verdifulle mineraler og norske fangstfolk og fiskere, som flakket vidt omkring på ishavet, kjente øygruppen som sin egen lomme.

Året etter var HOEL tilbake med en mindre ekspedisjon, som han selv ledet. I 1909 og 1910 deltok han som geolog ved GUNNAR ISACHSEN's Spitsbergen-ekspedisjoner bekostet av den norske stat. Så trer han selv frem som ekspedisjonsleder, men i noen år fremover har han sine fortjente medarbeidere kapteinene ARVE STAXRUD og SVERRE RØVIG som medledere. Fra 1919 er han selv eneleder.

I 1928 ble «HOEL's polarkontor» en fast statlig institusjon: Norges Svalbard- og Ishavsundersøkelser. Meget var hendt i forveien. Spitsbergen var blitt en del av kongeriket Norges område den 14. august 1925, og HOEL's forarbeide var ikke det minst viktige i denne sak. «Svalbardkontoret», som det nye institutt populært ble kalt, ble snart en kjent institusjon, også internasjonalt. Med små bevilgninger, men med energi og innsatsvilje bygget HOEL opp et kontor som det stod respekt av. Alle svalbardfarere, også utlendinger, søkte Svalbardkontoret for råd og dåd, og hit gikk man ikke forgjeves.

HOEL arbeidet også for en utvidet norsk interessesfære på Ishavet. Noe i retning av det gamle Norgesvelde synes å ha demret for ham. Nordøst-Grønland, som for HOEL var et typisk «norsk område», ble annektert i 1931. Det ble kalt Eirik Raudes Land. Svalbardkontoret hadde 5 ekspedisjoner hit, hvorav HOEL personlig ledet de 3. Danmark protesterte mot den norske anneksjon, og tvisten ble innbragt for Den Internasjonale Domstol i Haag. Utfallet gikk Norge imot. Meget tyder på at fra den dag var HOEL's tiltro til internasjonale domstolers kompetanse til å avgjøre den slags tvister svekket, og man må sannsynligvis se hans senere politiske forhold i forbindelse hermed.

I 1929 hadde Svalbardkontoret også en ekspedisjon til Frans Josefs Land. Her hadde norske fangstekspedisjoner gjennom en årrekke vært enerådende, og nå skulle øygruppen okkuperes. Men bevilgningene strakk ikke til, og de to altfor små skuter ble liggende fast i drivisen uten å komme inn til land. Året etter ble ekspedisjonen gjentatt, men med større og bedre skuter, og nå lykkes det å nå inn til land. Men det var forsent, Sovjet-Samveldet var kommet i forkjøpet. Ekspedisjonene til Svalbard fortsatte imidlertid frem til utbruddet av Den annen verdenskrig.

Ved krigens slutt i 1945 ble HOEL fenglset som landssviker, en menneskelig tragedie. HOEL var vel når alt kommer til alt ingen politiker, det var ikke hans felt; og han fattet neppe helt konsekvensene av sin holdning. Men sannsynligvis har troen på at Nasjonal Samling helhjertet ville støtte hans planer på Ishavet, bidratt vesentlig til at han sluttet opp om NS. Dommen som først falt i 1949, var svært lindrig, og domspremissene hadde også mange anerkjennende ord om hans virke. Men HOEL var satt på porten i sitt kontor, og det var kanskje det som var tyngst å bære for ham. Han falt imidlertid til ro et i rastløst forfatterskap, små og store artikler på en rekke felter kom på løpende bånd. Det viktigste og største arbeide var den store Svalbardhistorie på henved 2000 manuskriptsider. HOEL's dyktige førstesekretær KJELD MYKLEBUST, kunne fortsette arbeidet etter HOEL's bortgang, og verket vil forhåpentlig foreligge trykt innen et år.

ADOLF HOEL var personlig en beskjeden og stillfarende mann som gjorde lite vesen av seg. Hans styrke lå i å organisere ekspedisjonene, noen leder i felten var han ikke. Sine ordrer ga han helst gjennom en mellommann, og nedskriveren av disse linjer husker godt et hjertesukk fra HOEL: «VON KROGH var uunnværlig for meg». Den gamle sjøulk, hydrografen kommandørkaptein VON KROGH, som fulgte HOEL på de fleste av hans ekspedisjoner, kunne tumle mere og mindre gjenstridige ishavsskippere og få dem til å lystre ordre. Men HOEL var en utmerket ekspedisjonsmann og hadde en egen evne til å følge med i og vite alt som foregikk ombord. Han gikk selv i spissen hvor det gjaldt krevende arbeide, sparte seg aldri. Han virket ikke imponerende, i sine vanligvis alt for store vindtøysklær så han nærmest ut som en tuftekall, men han var sterk som en bjørn og sprek som få. Jeg tror nok han likte seg best når han kunne streife rundt i fjellene med geologhammer og assistenter. Han var gjerne den første på land om morgenen og den siste ombord om aftenen. Hadde dagen vært utbytterik og de andre ekspedisjonsdeltagere også var fornøyd, tødde dosenten opp utover kvelden og ble den mest liketille og gemyttlige sjef. Da ble det gjerne en «night-cap» eller to, og timene kunne bli små mens HOEL trakk frem minner om underlige personer og merkelige hendelser i sitt mangeårige ekspedisjonsliv. Den knastørre dosent berettet da med en saklig nøyaktighet som kunne ha en grotesk komisk virkning.

ADOLF HOEL var en sammensatt natur som det var vanskelig å bli helt klok på. Men det som ledet hans virke, var utvilsomt en dypt rotfestet interesse for norsk fangst og forskning i polarstrøkene. Hans innsats på dette felt vil for alltid bli husket.

Bibliografi over Adolf Hoels arbeider

AV

GUNNAR HOLMSEN og SØREN RICHTER

Den marine grænse ved Velfjorden. – Chri.a Vidensk. Selsk. Forh. 1906. Nr. 4. Kri.a 1906. 15 s.

Frostisen. – Det norske geogr. selsk. aarb. 1906–1907. Kri.a 1907. S. 127–51.

Kvartærgeologiske undersøkelser i Nordre Trondhjems og Nordlands amter. – Archiv. f. Mat. og Naturv. Kri.a 1907. S. 28–80.

Expédition norvegiénne au Spitsberg. – La Géographie. B. 18. Paris 1908. S. 408.

Geologiske iagttagelser paa Spitsbergenekspeditionerne 1906 og 1907 udrustede af Fyrst Albert af Monaco og ledede af ritmester Isachsen. – Norsk geol. tids. B. I. Kri.a 1910. 28 s. 4 pl. (Foreløbig Meddelelse.)

Fra Okstinderne. – Den norske turistf. aarb. 1909. Kri.a 1909. S. 102–15.

Okstinderne. Fjeldgrunden og Bræerne. – Norges geol. unders. Nr. 57. Kri.a 1910. 50 s.

Etnas siste udbrud. – Naturen. B. 34. Bergen 1910. S. 193–209.

Une nouvelle expédition norvegiénne au Spitsberg. – La Géographie. B. 23. Paris 1911. S. 460–63.

La nouvelle expédition norvegiénne au Spitsberg. – La Géographie. B. 24. Paris 1911. S. 249–53.

Les nappes de lave, les volcans et les sources thermales dans les environs de la Baie Wood au Spitsberg. Par: Hoel, A., et O. Holtedahl. – Skrifter utg. av Vidensk. Selsk. i Kri.a I. Nr. 8. Kri.a. 1911. 37 s.
Også utg. som: Expédition Isachsen au Spitsberg 1909–1910. Résultats Scientifiques. B. 2. Nr. 1.
(Hoel har skrevet om vulkanene og de varme kilder, Holtedahl om lavadekkene.)

La région de Mt. Lusitania au Spitsberg. Par: Hoel, A., et Aug. Dubois. – Bull. de la Soc. Neuchâteloise de Geogr. B. 21. Neuchâtel 1911. 77 s.

Spitsbergens Landformen und ihre Vereisung. Par: Hoel, Adolf, und Erich von Drygalski. – Abhandl. des Kgl. Bayerische Akad. der Wiss. B. 25. München 1911. 61 s.

En slædetur paa Spitsbergen under ritmester Isachsens ekspedition i 1909. – Den norske Turistforenings Aarbog 1912. Kri.a 1912. S. 1–33.

Résultats généraux de l'expédition norvegiénne au Spitsberg 1911–1912. Par: Hoel, Adolf, et Arve Staxrud. – La Géographie. B. 27. Paris 1913. S. 99–108.
Die norwegische Hilfsexpedition für Schröder–Strantz. – Die Woche. B. 15. Berlin 1913. S. 392–93.
Notis zu K. Schneider: Die vulkanischen Erscheinungen der Erde. – Centralblatt für Mineralogie etc. Jhg. 1913. Stuttgart 1913. S. 498.
Description du champ d'opération. (Exploration du Nord-Ouest-du Spitsberg. 2. Partie). Par Isachsen, Gunnar et Adolf Hoel. – Résultats Camp. Scient. . . . Monaco. B. 41. Monaco 1913. 95 s. 20 pl. f°.
Géologie. Exploration du Nord-Ouest du Spitsberg. – Résultats Camp. Scient. . . . Monaco. B. 42. 27 pl. Monaco 1914. 63 s. f°.
Nouvelles observations sur le district volcanique du Spitsberg du Nord. Avec 13 pl. et 4 cart. – Skrifter utg. av Vidensk. Selsk. i Kri.a. I. No. 9. Kri.a 1914. 33 s.
Résultats généraux de l'expédition norvegiénne au Spitsberg en 1913. – La Géographie. B. 29. Paris 1914. S. 177–82.
Bjørnøens kulfelter og mineralforekomster. – Trykt som manuskript Stavanger 1915.
Résultats de l'expédition norvégienne au Spitsberg en 1914. Par: Hoel, Adolf et Arve Staxrud. – La Géographie. B. 30. Paris 1915. S. 277–79.
D'ou vient la renne du Spitsberg ? – La Géographie. B. 30. Paris 1915. S. 443–48.
Hvorfra er spitsbergenrenen kommet ? – Naturen. 1916. Bergen 1916. S. 1–7.
Spitsbergen. Norges fremtidige kulkammer. – Nordmandsforbundet. Aarg. 9. Kri.a 1916. S. 323–37.
Observations sur la vitesse d'ecoulement et sur l'ablation du glacier Lilliehoek au Spitsberg 1907–1912. – Skrifter utg. av Vidensk. Selsk. i Kri.a. I. B. 1, nr. 4. Kri.a 1916. 29 s. – Er også trykt som: Expédition Isachsen au Spitsberg 1909–1910. Résultats Scient. B. 2. No. 14.
A/S Svalbard Kulgruber, Spitsbergen. – Trykt som manuskript. Kri.a 1916. 23 s.
Nephelin-bearing pegmatitic dykes in Seiland. (Hoel, Adolf and J. Schetelig.) – Festskrift til prof. Amund Helland på hans 70 års fødselsdag 11. okt. 1915. Kri.a 1916. S. 110–31.
L'etat des glaces autour du Spitsberg pendant l'éte 1915. – La Géographie. B. 31. Paris 1916. S. 189–96.
Anmeldelse av P. A. Øyens avhandling: Kvartærstudier i Trondhjemsfeltet III. – Geol. Fören. i Stockholm Förhandl. B. 58. Stockholm 1916. S. 481–85.
Søren Zachariassen. En av våre eldste ishavsskippere. – Det norske geogr. selsk. aarb. 1914–1916. Kri.a 1916. S. XVII–XIX. Port.
Isforholdene paa Spitsbergens vestkyst sommeren 1915. – Det norske geogr. selsk. aarb. 1914–1916. Kri.a 1916. S. 111–33.
The Arctic Coal Co.s Kulfelter paa Spitsbergen. – Tidsskr. for Bergv. Aarg. 4. Kri.a 1916. S. 78–84.
Litt om kul, verdens kulforbruk og kulforraad. – Naturen. B. 41. Bergen 1917. S. 160–71, 210–18.

Spitsbergenkullene og Brændselsnøden. – Teknisk Ukebl. Aarg. 35. Kri.a 1917.

Bjørnøya. Av A. Hoel, A. Kvalheim og C. Schive, med bidrag av Gabriel Smith. – Trykt som manuskript. Kri.a 1918. 59 s.

Rapport préliminaire de l'expédition norvégienne de 1917 au Spitsberg. – La Géographie. B. 32. Paris 1918–1919. S. 96–101.

Rapport préliminaire de l'expédition norvégienne de 1918 au Spitsberg. – La Géographie. B. 32. Paris 1918–1919. S. 231–35.

La question du Spitsberg. Une opinion norvégienne. – France–Scandinavie. Kri.a 1919. S. 65–69.

Spitsbergens kul- og malmforekomster, deres økonomiske betydning og fordeling mellem de forskjellige nationer. – Norsk geol. tidsskr. B. 5. Kri.a 1920. S. 417–20. (Referat av foredrag.) Også i naturen. Bergen 1920.

Une carte oublie de Spitsberg. – La Géographie. B. 34. Paris 1920. S. 145–46.

Rapports sur les recentes expéditions norvégiennes au Spitsberg (1919–1921) presentes par leur chef: M. Adolf Hoel. – Revue de Géogr. ann. T. 9. Paris 1922. S. 1–48.

Store Norske Spitsbergen Kulkompani Aktieselskab 1916–1922. Litt historikk. – Trykt som manuskript 4^{to}. 19 tekstfig., derav 3 karter. Kri.a 1922. 19 s.

Spitsbergens og Bjørnøyas kulforekomster og deres betydning for vort land. (Foredrag i Stortinget 26/6 1922.) – Teknisk Ukebl. Årg. 69. Kri.a 1922. S. 285–87. – Også trykt på engelsk i Anglo–Norw. Trade Journ. B. 8. London 1922. S. 171–73.

Spitsbergen–Bjørnøykullene og Norges Brændselforsyning. (Foredrag i Polyteknisk Forening 14/11 1922.) – Ref. i Tekn. Ukebl. Årg. 69. Kri.a 1922.

Spitsbergen and Bear Island (Svalbard). – The Norway Year Book. B. 1 og 2. – Chria. 1924 og Oslo (Chri.a)1939.

Kulforekomsterne på Svalbard. – Norsk tidsskr. for sjøvesen. Aarg. 42. Horten 1924. S. 163–84.

Navigerings- og havneforhold m. v. på Spitsbergen. Krogh, R. von og A. Hoel. – Lommealmanakk for sjømenn 1925. Årg. 2. Oslo 1924. S. 186–94.

Forord til: Mittelholzer, Walter, Im Flugzeug dem Nordpol entgegen. Junkerische Hilfexpedition für Amundsen nach Spitsbergen 1923. – Zürich 1924.

Hints to explorers in Spitsbergen. – Practical Hints to Scientific Travellers. Ed. by H. E. Brouwer. B. 2. The Hague 1925. S. 53–101.

Svalbard (Spitsberg et Bjørnøya) et l'exploitation houilliere. – La Norvége. Numero Special de «La Vie Technique et Industrielle». Paris 1925. S. 64–68.

Norges overtagelse av Svalbard. – Norge. Tidsskr. om vårt land. Årg. 1. Oslo 1925. S. 20.

Svalbards oppdagelse og historie. – Norge. Tidsskr. om vårt land. Årg. 1. Oslo 1925. S. 38–41.

The coalfields of Svalbard (Spitsbergen and Bear Island). – Power resources of the world available and utilised. B. I. London 1925. S. 1008–1040.

Svalbard and its Coal Industry. – Economical and Financial conditions in Norway. Quarterly Rev. 1925. 6 s.

The coal deposits and coal mining of Svalbard (Spitsbergen and Bear Island). – Resultater av de Norske Statsunderstøttede Spitsbergenekspedisjoner. Nr. 6. Oslo 1925. 92 s.

Kampen om oljen. Utdrag av foredrag holdt i Oslo Rederiforening. – Skibsfart. Årg. 1. Oslo 1926. S. 8–11.

Svalbard and its coal industry. Economical and Financial Conditions in Norway. – Quarterly Review. 1925. Oslo 1925. S. 1–6.

Forslag til Kongelige Forskrifter vedrørende fredning, jakt, fangst og fiske på Svalbard i henhold til Lov om Svalbard av 17/7 1925. – Norge. Tidsskr. om vårt land. Årg. 2. Oslo 1926. S. 74–91.

The coal industry of Svalbard. – Norway. A monthly comment. on Norway's selling, buying and shipping. B. 2. Oslo 1926. S. 00–00.

Om ordningen av de territoriale krav på Svalbard. – Norsk geogr. tidsskr. B. 2. Oslo 1928. S. 1–24. – Også utg. som: Meddelelse nr. 2. Norges Svalbard- og Ishavsundersøkelser. Oslo 1928. 24 s.

Suverenitetsspørsmålene i polartraktene. – Nordmandsforbundet. Årg. 21. Oslo 1928. S. 79–84, 131–36. – Også som: Meddelelse nr. 3. Norges Svalbard- og Ishavsundersøkelser. Oslo 1928. [12 s.]

Om utforskningen av Svalbard. (Memorandum fra Den norske regjering vedrørende ordningen av kartlegningen og de videnskapelige undersøkelser på Svalbard.) – Norsk geogr. tidsskr. B. 2. Oslo 1928. S. 122–25. Memorandumet er også trykt i følgende utenl. tidsskrifter: La Géographie, Paris; Geogr. Journ., London; Geograph. Rev., New York; Bull. Soc. Geogr. Ital., Roma.

Renen på Svalbard. – Naturfredning i Norge. Årsberetning 1929. S. 19–20.

Dyrelivet på Svalbard. – Norsk Jeger- og Fiskerforen. Tidsskr. Årg. 58. Oslo 1929. S. 386.

Moskusokser til Svalbard. – Norsk Jeger- og Fiskerforen. Tidsskr. Årg. 58. Oslo 1929. S. 326–28.

Jan Mayen. En oversikt over øens natur, historie og betydning. (Utarbeidet av Norges Svalbard- og Ishavsundersøkelser.) – Norsk geogr. tidsskr. B. 2. Oslo 1929. S. 411–44. – Også som: Meddelelse nr. 7. Norges Svalbard- og Ishavsundersøkelser.

Videnskapelige arbeider på den italienske ekspedisjon. – Norsk geogr. tidsskr. B. 2. Oslo 1929. S. 469–70.

The Norwegian Svalbard Expeditions 1906–1926. – Resultater av De Norske Statsunderstøttede Spitsbergenekspedisjoner. Nr. 1. Oslo 1929. 104 s.

Overføring av moskusokser til Svalbard. - Norge. Tidsskr. om vårt land. Årg. 6. Oslo 1930. S. 15–18.

Bericht über die von den Svalbard- und Eismeerforschungen Norwegens ausgeführten Arbeiten. – Intern. Archiv für Photogram. B. 7. Leipzig 1930. S. 125–27.

Trues våre arktiske interesser? – Samtiden. 1931. Oslo 1931. S. 233–46.

Rein, moskusokse og hare på Svalbard. – Naturfredn. i Norge. Årsber. 1930. Oslo 1931. S. 233–46.

Norway's economic Interest in East Greenland. – Norway. Norwegian trade review. Sept. 1931.

Les intérests économiques de la Norvége au Groenland. - Norw. trade rev. Nouv. ser. B. II. Oslo 1931. 13 s. (Også trykt på tysk, engelsk, spansk, hollandsk og italiensk.)

Norwegian Polar Year Stations in Greenland 1932–1933. – Polar Record. Nr. 4. Cambridge 1933. S. 105.

Norwegian Expedition to Spitsbergen and East Groenland. – Bulletin of the Arctic Inst. Nr. 12. Leningrad 1933. S. 443.

Arve Staxrud. – Norsk geogr. tidsskr. B. 4. Oslo 1933. S. 345–46.

Carsten Borchgrevink. – Norsk geogr. tidsskr. B. 5. Oslo 1934. S. 69–71.

P. A. Øyen 1863–1932. Bibliografi. – Norsk geol. tidsskr. B. 13. Oslo 1934. S. 304–10.

Bemerkninger til direktør Sverdrups foredrag i Polyteknisk Forening 17. april 1934. – Økonomisk Revue. Nr. 16. Oslo 1934.

The Discovery of King Karls Land, Spitsbergen. – Geogr. Rev. B. 25. New York 1935. S. 476–78.

Ein ukjend norsk landfinnar på Svalbard. – Norsk Aarbok 1935. Bjørgvin 1935. S. 10–14.

Die Entdeckung von König-Karl-Land. – Polarforschung. Jhg. 6. Kiel 1936. S 4–5.

«Krassinferden». – Tillegg til: Hovdenak, G.: Roald Amundsens siste ferd. Oslo 1934. S. 211–303.

Det eldste billede av norsk bebyggelse på Svalbard. – Norsk geogr. tidsskr. B. 5. Oslo 1935. S. 367–371.

Den fotogrammetriske målemetode og dens anvendelse, særlig ved bruk av fly. (Ref. av Th. Weens og A. Hoels foredrag i Polytekn. Foren. 29/1 1935. – Teknisk Ukebl. Årg. 82. Nr. 6. Oslo 1935.

Das Festungsprofil auf Spitsbergen, Karbon-Kreide. (Hoel, Adolf, og Anders K, Orvin.) – Skrifter om Svalbard og Ishavet. Nr. 18. I. Vermessungsresultate. Oslo 1937. 59 s.

Expeditionen von Norges Svalbard- og Ishavsundersøkelser im Sommer 1935. – Polarforschung. Ing. 7. Kiel 1937. S. 3–5.

Kong Leopold og Dronning Astrid Land. – Norsk geogr. tidsskr. B. 7. Oslo 1938. S. 184–86.

Spitsbergens Geschichte und Erforschung. – Forschungen und Fortschritte. Jhg. 14. No. 31. Berlin 1938. S. 357–58.

Norske skib leiet av utenlandske ekspedisjoner til polartraktene. – Polarårboken 1938. Oslo 1938. S. 19–26.

Die Verwendung von Luftfahrzeugen bei der wissenschaftlichen Erforschung der Polargebiete. – Zeitschr. der Ges. für Erdk. zu Berlin. 1938. Berlin 1938. S. 161–75.

Nachtrag zum Beitrag: «Die Verwendung von Luftfahrzeugen . . .». – Zeitschr. des. Erdk. zu Berlin. 1938. Berlin 1938. S.

Coal-mining in Svalbard. – Polar Rec. Nr. 16. Cambridge 1938. S. 74–85.

Verdens første internasjonale utstilling for polarforskning. – Den internasjonale utstilling for polarforskning i Bergen 1940. Bergen 1939. – Også trykt på tysk.

International polar exhibition and conference, Bergen 1940. – Geogr. journ. Vol. 94. London 1939. S. 508.

Verket om stedsnavnene på Svalbard ferdig. Over 10 000 navn vitenskapelig behandlet. – Polarårboken 1939. Oslo 1939. S. 61–71.

Operations in Svalbard and East Greenland. Carried out by Norges Svalbard- og Ishavsundersøkelser and earlier Norwegian expeditions. – International Union of Geodesy and Geophysics. Seventh general Conference, Washington 1939. Oslo 1939.

Vår stilling på Grønland idag. – Ragnarok. Årg. 5. Sarpsborg 1939. S. 00–00.

Fangstmannen ser fremover. – Ragnarok. Årg. 6. Sarpsborg 1940. S. 00–00.

Hvorledes Norge erobret den økonomiske og politiske makt på Svalbard. – Ragnarok. Årg. 6. Oslo 1940. S. 169–76.

Gunnar Isachsen. Obituary. – Norsk geogr. tidsskr. B. 8. Oslo 1940. S. 1–5.

Oppdeling av polartraktene mellem forskjellige makter og norske landerhvervelser i disse områder. – Norge i Ishavet 1941. Oslo 1941. S. 18–22.

Norge og Grønland. En kort oversikt over de viktigste begivenheter i Norges forhold til Grønland. – Ragnarok. Årg. 7. Sarpsborg 1941. S. 00–00.

Die Ortsnamen in Svalbard. – Veröffentl. des deutschen wissenschaftl. Instituts zu Kopenhagen. – Reihe I: Arktis nr. 9. Berlin 1942. 16 s.

Norges interesser i polartraktene. – Foredragsserien Norges Nyreising. Nr. 6. Oslo 1942. 20 s.

Über die Erschliessung der Polarregionen. – Der Norden. Monatsschr. der nordischen Gesells. Årg. 20. Berlin 1943. 8 s.

Nord-norske fangstfolk som geografiske oppdagere og forskere i de arktiske egne. Et pionerarbeide av stor betydning. – Hålogalandårboken 1944. Oslo 1944. S. 85–112.

Ishavsfangst – Fangstnæring. – Norsk fiskeri- og fangsthåndbok. B. I. Del III. Oslo 1949. S. 707–861.

Lo Svalbard. – La Vie del Mondo. B. 12. Milano 1950. S. 419–70.

Ingeniør Alfred Koller. In memoriam. – Norsk polar-tid. 1951. Oslo 1951. S. 10–11.

La Groenlandia. – La Vie del Mondo. B. 13. Milano 1951. S. 1249–68.

Et oppgjør med landsmenn. – Oslo 1951. 111 s.

Norsk Ishavsfangst. En fortegnelse over litteratur. – Meddelelse nr. 69. Norsk Polarinstitutt. Oslo 1952. 23 s.

En merkelig tysk aksjon på Spitsbergen i 1933. – Norsk polar-tid. 1952. Oslo 1952. S. 28–32.

Grønland i støpeskjeen. – Norsk geogr. tidsskr. B. 13. Oslo 1953. S. 36–45.

Alcuni recordi sulla spedizione polare del generale Nobile con l'aeronave «Italia» nel 1928. – Il Polo. Årg. 9. Macerata 1953. S. 7–17.

La spedizione polare del dirigible «Italia». – Estratto dalla rivista «Nuova Antologia». N. 1841. Roma 1954. S. 29–51.

Le isole Færøer. – La Vie del Mondo. B. 16. Milano 1954. S. 1203–30.
Trekk fra Svalbards okkupasjonshistorie. – Polarboken 1955. Oslo 1955. S. 47–72.
Norges Svalbard- og Ishavsundersøkelsers ekspedisjoner til Svalbard og Grønland under de to verdenskriger. – Polarboken 1956. Oslo 1956. S. 178–90.
Organisasjon av isbrytertjenesten i Norge. – Skipsfart. Årg. 30. Oslo 1956. S. 31–35.
Le frastagliate coste della Norvegia. – La Vie del Mondo. B. 18. Milano 1956. S. 65–78.
Il vulcanismo in Islanda. – La Vie del Mondo. B. 19. Milano 1957. S. 293–306.
Hallvard Devold. En merkelig livsskjebne. – Polarboken 1957. Oslo 1957. S. 152–56.
Glaciers and snowfields in Norway. (Hoel, Adolf and Werner Werenskiold.) – Skrifter nr. 114. Norsk Polarinstitutt. Oslo 1962. 291 s.
Glaciological Bibliography of Norway. (Hoel, Adolf and Johs. Norvik.) – Skrifter nr. 126. Norsk Polarinstitutt. Oslo 1962. 242 s.
Isfjell på kysten av Øst-Finnmark. – Norsk geogr. tidsskr. B. 18. Oslo 1961–1962. S. 228–38.
Svalbards historie. Under trykning. 1965.

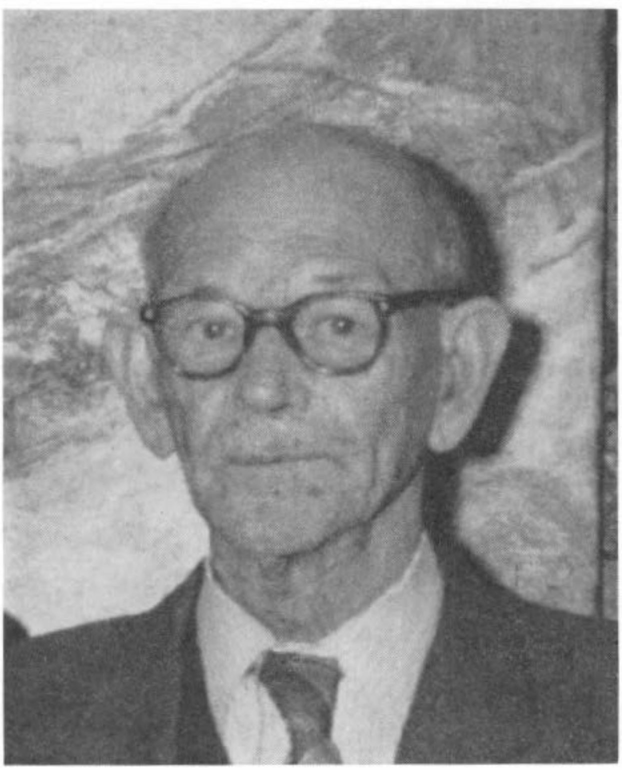
Hoels forfatterskap rekker videre enn de titler vi har anført. Vi vet han gav utkast til deler av den norske regjerings motinnlegg og duplikk vedrørende Grønlandsprosessen i Haag, samt til de mundtlige innlegg for domstolen. Han oppholdt sig som kjent i Haag under hele den mundtlige prosedyre. Vi tenker videre på «The Placenames of Svalbard», hvor «Svalbardkontoret» står som utgiver; men hvor Hoel var den drivende kraft. Han var også en flittig bidragsyder til aviser og tidsskrifter. Aviser falt utenfor rammen av vår artikkel, og alle de mindre tidsskriftartikler, som stort sett er av propagandistisk karakter, har vi heller ikke kunnet finne plass til.

Wilhelm Solheim

AV

SIGURD G. HELLE

Det tynnest ut i veteranrekkja av polarkartleggjarar her i landet. – Den siste som fall bort, var topograf ved Norsk Polarinstitutt, ingeniør WILHELM SOLHEIM. Han døydde på Rikshospitalet den 4. august 1964 etter ei sjukelege på fleire månader.



WILHELM SOLHEIM vart fødd den 5. august 1890 i Manger i Hordaland. I 1912 tok han eksamen ved Kristiania elementærtekniske dagskole med tilleggskurs. Han var landmålar ved Ing. Dahls Opmaaling i tida 1913–17, og etterpå var han så om lag eit år ved Teknisk opmaalings byraa. Våren 1918 vart SOLHEIM tilsett som topograf ved De norske statsunderstøttede Spitsbergenekspeditioner, og med dette hadde han funni det sporet som han kom til å følgja resten av levetida si. I 1928 vart Spitsbergenekspedisjonane organiserte i fastare former i Norges Svalbard- og Ishavs-undersøkelser som så i 1948 vart skipa om til Norsk Polarinstitutt, og SOLHEIM følgde heile tida med som topograf.

Det er vel snautt om nokon har vori med på så mange vitskapelege polarekspedisjonar som WILHELM SOLHEIM. Fyrste gongen han drog av garde, var i 1918 og siste i 1961 som 71-åring. I alt vart det 26 ekspedisjonsturar på han – til Vestspitsbergen, Bjørnøya, Jan Mayen og Aust-Grønland. Dessutan dreiv han i mange somrar med bremålingar i Jotunheimen, og etter krigen var han med på oppmålinga av brende byar og tettbygde strok i Finnmark. Lista over ekspedisjonsverksemda hans talar for seg sjølv.

SOLHEIM fekk oppleva både den gamle og den nye tida på Svalbard. I ungdomen sin måtte han – som så mange andre – ro mil etter mil langsmed kysten av Vestspitsbergen. Seinare vart påhengsmotorar tekne i bruk, og det var nok eit stort framsteg. På landjorda måtte han ofte traska og gå time etter time for å nå arbeidsplassane sine som i dei fleste tilfelle er fjelltoppar for ein landmålar i polartraktene. Det vart nok eit utruleg hardt slit mang ein gong. Fjellturane kunne i somme høve taka 20–30 timar. – På den siste ekspedisjonen SOLHEIM var med, fekk han høve til å prøva det moderne framkomstmiddelet – helikopteret, og det var litt av ei oppleving. Der han tidlegare hadde bruka timar for å nå målet sitt, tok det no berre nokre minutt, og han kunne au på stutt tid verta sett ned på fjelltoppar som ein før nærast måtte kalla utilgjengelege, anten av di dei låg så langt borte, eller av di dei var så bratte. Med helikopter kunne han dessutan koma utkvilt til fjells, medan har før ofte var sveitt og trøtt når han endeleg nådde fram.

Eg hadde fleire gonger høve til å vera saman med SOLHEIM på ekspedisjonar, og eg kan snautt tenkja meg nokon som lika ekspedisjonslivet betre enn nettopp han. Han kunne kosa seg i teltet etter ein strevsam dag, og det vart mange slike gjennom åra trass i skodd og dårleg vêr. SOLHEIM var alltid i godlag, og han hadde ei rekkje polarsoger og -skrøner å fortelja til stor moro for dei som var til stades.

SOLHEIM tok seg fyrst og fremst av dei trigonometriske netta på Svalbard. Nye ekspedisjonar kom heim med nytt observasjonsmateriale, og dette førte til små korreksjonar av dei tidlegare resultata. Ingen veit vel no kor mange gonger han har rekna ut koordinatverde for same punktet, og kor mange gonger det har komi nye rettingar. SOLHEIM streva mykje med utrekningane av observasjonstilfanget, og han var den einaste som hadde skikkeleg kjennskap til det geodetiske arbeidet på Svalbard.

SOLHEIM var likevel ikkje berre mannen som skaffa tala som trongst for kartlegginga. Han gjekk eit fotogrammetrisk kurs i Jena og var i høg grad ekspert i å konstruera kart både etter gamle metodar og ved hjelp av moderne kartkonstruksjonsmaskinar. Han har vori med og arbeidt ut ei mengd med kart.

SOLHEIM var ein svært praktisk mann både på kontoret og i felten. Den lange røynsla hans i polarkartlegging og dei store kunnskapane hans om kartlegging i det heile, hadde medarbeidarane hans mykje nytte av. – SOLHEIM var ein fredkjær og stillfarande mann som det følgde lite bråk med. Han arbeidde nokså mykje sjølvstendig og levde og anda for Svalbard som han såg på som det viktigaste arbeidsfeltet sitt.

Det er vanleg at folk vil ha fred og kvila ut når aldersgrensa er nådd, men SOLHEIM vart oppmoda om å halda fram med arbeidet sitt, og det gjorde han i vel åtte år til sjukdomen sette punktum. Ingen har vel hatt så lang arbeidsdag – 46 år – med polarkartlegging som SOLHEIM. Han var ein trugen slitar, og medan han enno var i fullt arbeid, fekk han påskjøning av H. M. Kongen – fortenestemedaljen i gull.

SOLHEIM har vori med på desse sommarekspedisjonane:

År	Vestspitsbergen	Bjørnøya	Jan Mayen	Aust-Grønland	Jotunheimen	Finnmark
1918	x					
1919	x					
1920	x					
1921	x					
1922	x	x				
1923		x				
1924	x	(x)				
1925	x					
1927					x	
1928	x					
1929				x		
1931				x		
1932				x	x	
1933	(x)			x		
1936	x					
1938					x	
1939	x					
1940					x	
1941					x	
1942					x	
1943					x	
1944					x	
1945						x
1946	x					
1947	x					
1948	x					
1949			x			
1950			x			
1952	x					
1954	x					
1956	x					
1958	x					
1959	x					
1961	x					

Norsk Polarinstitutts virksomhet i 1964

AV

TORE GJELSVIK

Organisasjon og administrasjon

Personale

I forbindelse med budsjettforslaget for 1964 hadde instituttet søkt om 4 nye stillinger; men samtlige ble avslått. Stillingene som operasjonssjef og karttegner III ble besatt fra 1. januar, og kontorsjefstillingen ble besatt fra 1. mai. En geolog II-stilling stod ubesatt hele året, og geofysiker II fra 20. august. Stillingen som hydrograf I ble midlertidig omgjort til førstehydrograf. 12 personer var midlertidig engasjert for kortere eller lengre tid. 4 av disse beskjeftiget seg med bearbeidelse av ekspedisjonsmaterialet fra Antarktis.

Den faste staben:

Direktør:	TORE GJELSVIK, dr. philos.
Førstehydrograf og ekspedisjonsleder:	KAARE Z. LUNDQUIST, o/kapt.
Operasjonssjef:	THOR SIGGERUD, cand. real.
Geolog I:	HARALD MAJOR, cand. real.
Geolog I:	THORE S. WINSNES, cand. real.
Geolog II:	AUDUN HJELLE, cand. real.
Geolog II:	JENÖ NAGY, stud. real. Ansatt som vitenskapelig assistent fra 1. februar 1963.
Geolog II:	Ubesatt.
Glasiolog I:	OLAV LIESTØL, cand. real.
Geofysiker II:	TORBJØRN LUNDE, cand. real. Fratrådt 20. august.
Meteorolog:	VIDAR HISDAL, cand. real.
Hydrograf II:	HELGE HORNBÆK
Førstetopograf:	SIGURD G. HELLE, cand. mag.
Topograf i særklasse:	HÅKON HILL, jordskiftekandidat.

Topograf I:	Johannes Hus, jordskiftekandidat.
Geodet I:	Einar Skirdal (Olsen), jordskiftekandidat.
Konsulent I:	Natascha Heintz, cand. real.
Bibliotekar:	Søren Richter, mag. art.
Kontorsjef:	Magne Botnen, cand. jur. Tiltrådt 1. mai.
Karttegner I:	Bjørn Arnesen
Karttegner II:	Bjarne Evensen
Karttegner III:	Magne Galåen
Konstruktør I:	Einar Neteland, tekniker.
Laborant I:	Willy Ingebretsen
Fullmektig I:	Eva Andersen
Fullmektig I:	Signe Øverland
Fullmektig II:	Martha Luncke. Fratrådt 30. september.
Fullmektig II:	Gudrun Edwardsen
Kontorassistent:	Kjell Johansen. Tiltrådt 25. august.
Vaktmester og bud:	Kirsten Danielsen

Midlertidig engasjerte:

Cand. real. Torgny E. Vinje.
Ingeniør Thor Askheim.
Ingeniør Wilhelm Solheim. Avgikk ved døden 4. august.
Topograf Wilhelm Flaata.
Topograf Ole Bjerke.
Fullmektig Eli Holmsen, timelønnet.
Meteorologassistent Øistein Skovholt.
Assistent Hans Rudolf Fritsch.
Assistent Olav Riise.
Cand. mag. Olav Dybvadskog, fra 1. oktober.
Bibliotekar Sigrid Rasmussen, fra 1. september.
Bjørn Reese.

Stipendier

Cand. mag. Olav Dybvadskog, stipend til bearbeidelse av glasiologisk materiale.

Cand. mag. Magnar Norderhaug, stipend til bearbeidelse av ornitologisk materiale samlet på Svalbard.

Tjenestefrihet og permisjon:

Thore S. Winsnes hadde fortsatt permisjon frem til 1. oktober for å virke som geolog for FN i Iran.

Gjesteforskere:

Dr. STANISLAW SIEDLECKI, Geologisk laboratorium, Det Polske Vitenskapsakademi, Kraków, har med norsk stipend fra Norges Teknisk-Naturvitenskapelige Forskningsråd oppholdt seg ved Norsk Polarinstitutt siden 1. juni og har deltatt i ekspedisjonen til Svalbard.

Dr. KRZYSZTOF BIRKENMAJER, Geologisk laboratorium, Det Polske Vitenskapsakademi, Kraków, oppholdt seg ved Norsk Polarinstitutt i september, oktober og november for å bearbeide sitt ekspedisjonsmateriale fra Svalbard fra 1962.

Oppnevnelse:

TORE GJELSVIK ble 7. august 1964 oppnevnt som medlem av Trafikkutvalget for Svalbard, og KAARE Z. LUNDQUIST tiltrådte senere som konsulent for utvalget.

Enn videre er GJELSVIK oppnevnt i et utvalg nedsatt av Norges Teknisk-Naturvitenskapelige Forskningsråd til å fremkomme med forslag om en intensivering av malmprospekteringen i Norge.

REGNSKAPET FOR 1964

Kap. 950 Poster:	*Bevilget*	*Medgått*
1. Lønninger	kr. 806 700	kr. 797 362
10. Kjøp av utstyr	» 15 000	» 14 675
15. Vedlikehold	» 2 000	» 0
20. Ekspedisjoner til Svalbard og Jan Mayen	» 795 000	» 743 835
21. Undersøkelse av statens kullfelter	» 50 000	» 49 642
26. Flytting til nye lokaler	» 275 000	» 196 976
27. Antarktisekspedisjonen 1956–60	» 146 000	» 115 804
29. Andre driftsutgifter	» 190 000	» 212 035
70. Stipend	» 30 000	» 30 000
	kr. 2 309 700	kr. 2 160 329
Kap. 31. Fyr og radiofyr på Svalbard	kr. 25 000	kr. 20 433
Kap. 3950	*Budsjettert*	*Innkommet*
1. Svalbard-busjettet	kr. 300 000	kr. 300 000
2. Inntekter (salg m. m.)	» 10 000	» 16 223
	kr. 310 000	kr. 316 223

Kommentar til regnskapet

Post 1. Bevilgningen ble redusert fra kr. 816 700 i forbindelse med etterbevilgning til post 20. Besparelsen skyldes ubesatte stillinger.

Post 15. Vedlikeholdsarbeid ble ikke utført p.g.a. flytting til nye lokaler.

Post 20. Bevilgningen ble øket fra kr. 500 000 ved en etterbevilgning for leie av private helikoptere, idet forutsetningen om militære helikoptere ikke lot seg realisere. Besparelsen skyldes vesentlig at betalingen for helikoptertjenesten ble redusert etter avtale med helikopterselskapet.

Post 26. Flyttingen skjedde så sent på året at det ikke var mulig på en fornuftig måte å disponere hele beløpet. Etter samtykke fra Finansdepartementet er differansen overført til 1965.

Post 27. På grunn av det store arbeidet som flyttingen av instituttet og etterarbeidet med den hittil største Svalbardekspedisjonen medførte, ble det vanskelig å følge opp andre arbeidsoppgaver på vanlig måte. Bl. a. av denne grunn ble bevilgningen til Antarktisekspedisjonen 1956–60 ikke brukt fullt ut.

Post 29. Overskridelsen på «Andre driftsutgifter» skyldes at det var bare budsjettert for første halvår, da man ved budsjettopplegget ikke hadde kjennskap til utgiftene i det nye bygget.

Post 70. Stipend. Stipendposten var opprinnelig på kr. 40 000, men ble redusert i forbindelse med etterbevilgningen til post 20.

Kap. 3950 post 2. Økningen i salgsinntektene skyldes den stigende interesse for Svalbard.

Flytting til nye lokaler

En begivenhet av den største betydning for Norsk Polarinstitutt fant sted i løpet av sommeren, da instituttet kunne flytte inn i de nye lokalene i Norges Vassdrags- og Elektrisitetsvesens administrasjonsbygning i Middelthuns gate 27B, Oslo. Bygget ligger med fin utsikt mot Frognerparken i vest og med Fridtjof Nansens fødested på Frøen som nærmeste nabo på nordsiden. Instituttet disponerer innpå 2000 m² i 1. og 2. etasje, samt i øverste kjelleretasje. Foruten hensiktsmessige kontor- og arbeidsrom for personalet, er det et stort biblioteksrom hvor instituttets omfattende samling av bøker og tidsskrifter om polarforhold og -ekspedisjonsvirksomhet endelig har fått plass; og sist, men ikke minst, i kjelleren finnes gode lokaler for instituttets omfattende ekspedisjonsutstyr. Til å være leiete lokaler kunne de neppe vært mer egnete for Norsk Polarinstitutts behov, og instituttet er så vel Vassdragsvesenet som statsmyndighetene meget takknemlig for at det fikk flytte til dette stedet.

Flyttingen ble forberedt av huskomitéen, bestående av THOR SIGGERUD, HELGE HORNBÆK og den nyansatte kontorsjef, MAGNE BOTNEN. SØREN RICHTER bistod når det gjaldt flyttingen av biblioteket. SIGURD G. HELLE, som i direktørens fravær på Svalbard ledet instituttet, og MAGNE BOTNEN med THOR ASKHEIM som transportsjef forestod selve flyttingen som begynte de siste dagene av juli. Også de etterfølgende innkjøps- og innredningsarbeider ble en omstendelig affære. De måtte foretas samtidig som instituttets hittil største ekspedisjon skulle avvikles, og ble en stor belastning på instituttets administrasjon, og kunne ikke avsluttes før året var ute. Som siste ledd i flyttingen ble den store kartkonstruksjonsmaskinen – stereoplanigrafen – flyttet, ved hjelp av en tekniker fra Zeiss-verkene og topografene. Dette var et kostbart og tidskrevende arbeid. Samtidig ble maskinen overhalt og justert. En stereoautograf som instituttet fikk som gave fra Norges Landbrukshøgskole, ble overført fra Vollebekk.

Ekspedisjonsvirksomheten

Svalbard

Isforholdene i 1964 var stort sett normale og voldte ingen uforutsette vanskeligheter for ekspedisjonen. Partiene som skulle til de indre deler av Van Mijenfjorden og Van Keulenfjorden, ble likevel noe hindret i begynnelsen av sesongen, og «H. U. Sverdrup» måtte forlate Svalbard før det ble isfritt i det opprinnelig påtenkte loddeområde Sørkapp–Bjørnøya. Der var heller ingen spesielle vanskeligheter for den alminnelige skipsfart på vestkysten og inn til byene, men Forlandsundet ble ikke farbart før etter midten av juli. Det var uvanlig store snemengder for årstiden på vest- og nordkysten. Værforholdene var dårlige i juli, mens de i august stort sett var gode.

Ekspedisjonen var den største instituttet noen gang har sendt ut og bestod av 22 større og mindre partier med til sammen 64 mann. Med 5 manns besetning på to helikoptere og 17 mann på to fartøyer ble det i alt 86 mann. 26 mann reiste opp og ned med ekspedisjonsfartøyene. En pulje på ca. 30 under ledelse av direktør TORE GJELSVIK reiste med charterfly fra Oslo til Alta, videre med buss til Hammerfest og derfra med kullbåten «Binny» til Longyearbyen. Endelig reiste en gruppe på 4 under ledelse av operasjonssjef THOR SIGGERUD sammen med helikoptermannskapet med kullbåten «Ingertre» fra Bergen. De som kom med kullbåt, reiste tilbake til Norge på samme måte.

De forskjellige partiene var plassert i områdene ved Bjørnøya/Sørkapp, Hornsund, Van Keulenfjorden, Van Mijenfjorden, Adventdalen, Ny-Ålesund, Krossfjorden/Sørgattet, Liefdefjorden og Woodfjorden.

Ekspedisjonsfartøyene. – M/S «Signalhorn» med BJARTE BRANDAL som fører ble overtatt av HELGE HORNBÆK og gikk fra Åndalsnes 1. juli etter innlasting av utstyret fra jernbanevogn. Den var tilbake samme sted 5. september.

På opptur ble landpartiene på Bjørnøya og vestkysten av Spitsbergen landsatt. Fra Longyearbyen ble de med kullbåt ankomne nordlige partier tatt med og satt ut.

HORNBÆK gikk fra borde i Woodfjorden 11. juli og kom ombord igjen 25. august for innsamling av partiene. EINAR NETELAND var ombord fra 29. juli for fyrettersyn. Forøvrig ble fartøyet benyttet til etterforsyninger av partiene og basen. De overvintrende fangstfolkene PAULSEN og SLETBAK samt BJØRNSVIK og JOHANSEN ble bragt til Longyearbyen med fangst og utstyr fra henholdsvis Bellsund (Fridtjovhamna) og Halvmåneøya.

Forskningsfartøyet «H. U. Sverdrup» ble overtatt av KAARE Z. LUNDQUIST i Oslo 15. juni og var tilbake samme sted 6. august. Det oppholdt seg i Svalbardfarvann 24. juni–29. juli og ble benyttet til opplodding og seismografiske målinger.

Hydrografparti 1 og 2. – Leder KAARE Z. LUNDQUIST med løytnant RAGNAR L. FESTØY som assisterende hydrograf, EINAR NETELAND som instrumentsjef, og assistenter GUNNAR BOLSTAD, ERIK B. DAHL, KJELL FRØYSLID og KÅRE LIEN. Tekniker FRITHJOF VEIM fra Jordskjelvstasjonen i Bergen fulgte med for å ta seg av

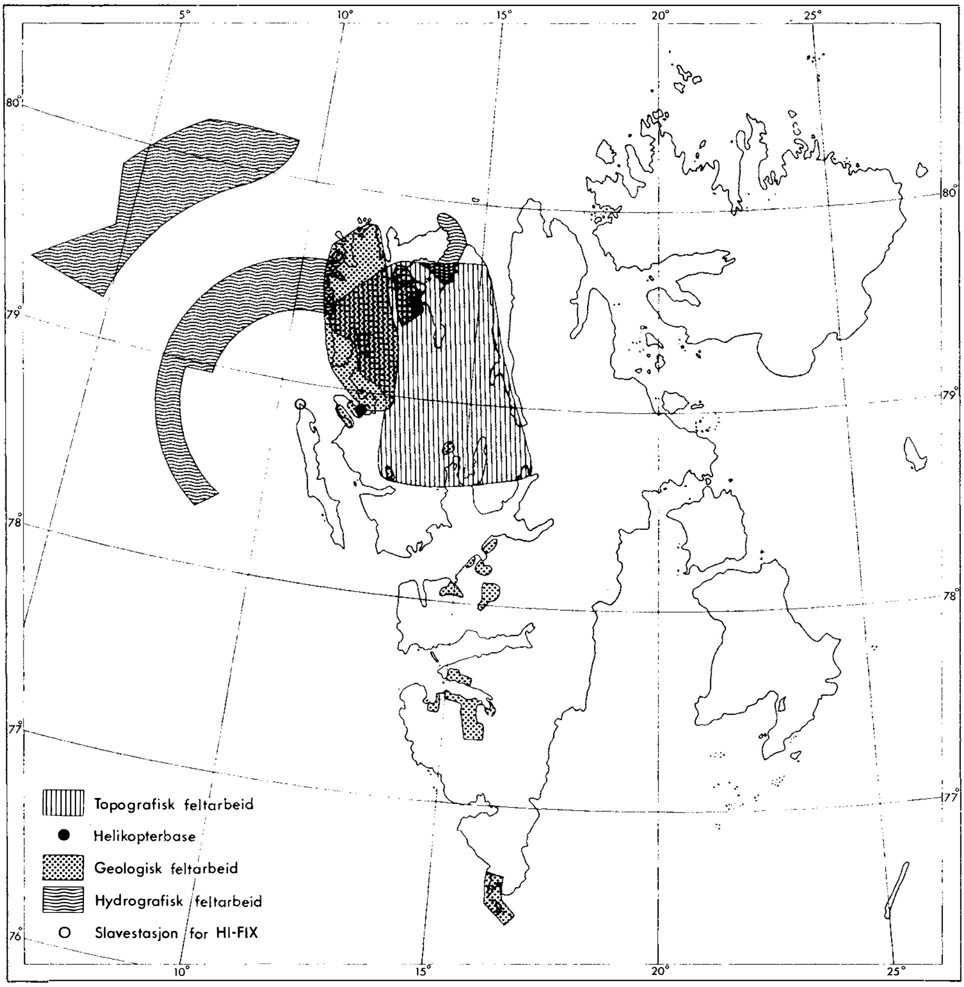


Fig. 1. *Kartet viser hvor Norsk Polarinstitutts forskjellige feltpartier arbeidet på Svalbard sommeren 1964.*

seismografiske målinger etter et program som var satt opp i samarbeid med Geologisk Institutt, Universitetet i Bergen.

To forsøk på landsetting av slavestasjonene for det elektroniske posisjonssystem Hi-Fix i det område som var det primære mål, nemlig Bjørnøya/Sørkapp/Hopen, ble stoppet av isen i den nordlige delen. Opploddingen foregikk derfor i sin helhet ut fra de samme stasjonspunkter som ble benyttet i 1963, på Fuglehuken og Amsterdamøya, og pågikk i tiden 30. juni–5. juli og 18.–28. juli. Isforholdene i området var meget bedre enn i fjor, slik at man fikk utvidet loddefeltet også nord- og vestover. Registreringer av sjøtemperaturen viste en langt større utbredelse av det varme Golfstrømvannet enn i 1963. I alt ble der gått ca. 1750 nautiske mil loddelinjer som dekket omkring 2500 mil².

Det oppstod ingen nevneverdige vanskeligheter med Hi-Fix-systemet. Dette var om våren blitt overhalt av leverandørens egne teknikere for å reparere de mangler som viste seg etter overtakelsen i fjor.

Bortsett fra én linje ble det seismografiske program gjennomført i sin helhet med tre linjer i ytre Andfjorden (ved avgang Harstad), en nordfra mot Reinsdyrflya, en ut mot Isfjorden og to mellom Sørkapp/Hopen og Bjørnøya, til sammen ca. 500 nautiske mil. En 450 meter lang kabel med mikrofoner ble slept etter fartøyet, og med jevne mellomrom ble det foretatt sprengninger av varierende styrke, som sammen med ekkoene ble registrert ombord.

Fartøyet deltok 14.–15. juli i ettersøkingen av et forsvunnet helikopter, som selv kom til rette etter en nødlanding i tåke på bretoppen nord for Krossfjorden. Videre utførte det et par alminnelige ekspedisjonsoppgaver.

Isforholdene i farvannet var stort sett normale for denne årstiden, mens værforholdene var dårlige med meget vind og regn.

Hydrografparti 3. – Leder HELGE HORNBÆK med assistenter PETTER LÅNAN, TOR STABENFELDT og SIVERT UTHEIM. Opploddingen foregikk med hydrograferingsbåten «Svalis» i ytre del av Woodfjorden med Mushamna som base. Området Liefdefjorden–Woodfjorden er nå ferdigloddet bortsett fra noen mindre undersøkelser.

Der var ingen is, men vind og sjøgang forårsaket 17 landliggedager og 10 dårlige dager; ellers var det usedvanlig gode siktforhold.

Helikopterbasen. – Leder THOR SIGGERUD med assistenter PER SCHELLENBERG og SIGMUND TVERMYR. Basen var lagt til Ny-Ålesund i tiden 15. juli–31. august, med innkvartering i hus og med bespisning i den tidligere arbeidermessen ordnet av Kings Bay Kull Comp. A/S.

Der ble anvendt to helikoptere, Alouette II og Alouette III, ført av INGE SKÅLMO og LEIF FURUHEIM. Mekanikere var JAN E. OLSEN, KJELL HOEM og KJELL KRISTIANSEN.

Helikoptrene ble benyttet i arbeidet av fire topografer som med hver sin assistent var fast stasjonert i basen, samt av geologpartiene 1–6, hvorav enkelte besøkte leiren leilighetsvis. En av geologene var stasjonert i Longyearbyen, de fem andre lå i egne leirer innen hovedarbeidsområdet. Dette strakte seg over hele nordvestdelen av Vestspitsbergen fra St. Jonsfjorden–Billefjorden i syd og Wijdefjorden i øst, og dekket et areal på ca. 8500 km^2.

Det ble fløyet 71,5 timer for topografene, ca. 100 timer for geologene og 10 timer for andre formål. P.g.a. forsinket levering av helikoptrene og visse tekniske vanskeligheter gikk ikke helikopteroperasjonen helt etter planen. Flygingene for geologene måtte derfor begrenses til forflytninger og rekognoseringer. Videre måtte topografenes stasjoner reduseres til omkring 50, noe som medførte at tettheten ble noe mer glissen enn forutsatt.

Det ble også gitt assistanse til en gruppe fra Norsk Rikskringkasting under deres opphold i Ny-Ålesund.

Topografparti 1–4. – Ledere HÅKON HILL, JOHANNES HUS, EINAR SKIRDAL og OLE BJERKE (engasjert) med assistenter henholdsvis KNUT LIE HANSEN, FREDRIK TRAMPE KINDT, ØYSTEIN DALLAND og JAN H. ERIKSEN.

De fire partiene samarbeidet delvis ute i terrenget, men var for det meste uavhengig av hinannen. Oppgaven delte seg naturlig i to områder, et vestre (Albert I Land og Haakon VII Land) og et østre (Andrée Land). Det første området med sin sterkt markerte topografi – spisse topper og skarpe rygger – gjorde det vanskelig å lande med helikoptrene, men takket være flygernes dyktige manøvrering og ved tilpassing av måleplanen, ble oppgavene gjennomført uten uhell. I det østre området var forholdene lettere med den mer avrundete topografi.

Det ble også foretatt endel utfyllende målinger i området mellom Forlandsundet og Ekmanfjorden.

I alt ble det triangulert over et område på ca. 8000 km². For å styrke det trigonometriske grunnlaget og for å binde sammen det vestre og østre triangelnett ble det målt fire basislinjer med tellurometer. To av linjene gikk i nord–syd retning, Ben Nevis–Loubetfjellet–Tre Brødre, og de to andre øst-vest, Diademet–Røros–Gyldenfjellet.

Det ble målt fra 48 stasjoner og bygget 21 nye varder foruten at endel gamle ble gjenreist. Arbeidet foregikk vesentlig i innlandsområdet i ca. 800–1300 meters høyde, og uten helikopterstøtte ville dette ikke ha vært mulig å gjennomføre i det hele tatt.

Geologparti 1. – Leder TORE GJELSVIK med assistenter BJARNE LIEUNGH og HAAKON AARS, utførte feltarbeid i Hecla Hoek-formasjonen og tilgrensende yngre formasjoner i området Bockfjorden–Loubetfjellet–Liefdefjorden i tiden 13. juli–5. august. Planene måtte omlegges på grunn av den forsinkete helikopterstøtten, og det ble vesentlig brukt snøscooter og båt. Forsøket på å trenge frem sørover mot Holtedahlfonna måtte oppgis, da det var for store vannmengder på breene, og snøscooterne klarte ikke engang å trekke seg selv i den dype, bløte snøen.

Alle spor etter sulfidmineralisering ble nøye undersøkt og en del funnpunktsavmerkninger foretatt. Undersøkelsen avslørte meget interessante lithologiske forhold mellom de basale lag av den umetamorfe sensiluriske–devonske serien og de underliggende Hecla Hoek-bergarter. På slutten av arbeidet ble det foretatt noen rekognoseringsturer med helikopter sørover til Eidsvollfjellet.

Geologparti 2. – Leder AUDUN HJELLE med assistenter EYVIND GRIMSTAD og LARS KIRKSÆTHER. Under feltarbeidet som varte fra 10. juli til 26. august, benyttet partiet dels helikopter og dels dory til transport. Leiren ble først henlagt til Signehamna, senere ved Tredjebreen og til slutt Bjørnehamna.

Partiets oppgave var å foreta en oversiktskartlegging i Albert I Land med henblikk på eventuelle økonomisk nyttbare forekomster av mineraler og bergarter. Sommerens feltarbeid viste at området syd for Førstebreen–Lilliehöökbreen hovedsakelig består av glimmerskifer og fyllitter, til dels overleiret av karbonatbergarter. Hovedfoldningsaksene viser en dominerende helling mot syd-sydøst, hvilket betinger at eldre, sterkere metamorfoserte bergarter blir mer og mer dominerende

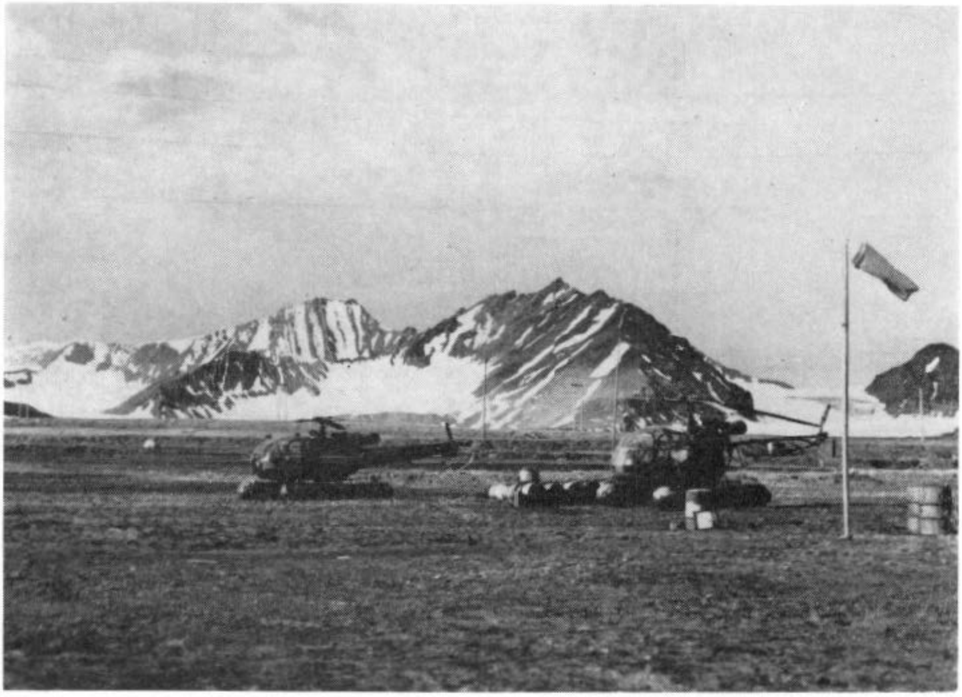


Fig. 2. *Helikopterbasen var sommeren 1964 lagt til Ny-Ålesund, hvor Norsk Polarinstitutts medarbeidere fikk bo i noen av husene tilhørende Kings Bay Kullkompagni. På bildet ser vi helikopterne som står på landingsplassen, klare til å starte opp på dagens tur.* Foto: T. SIGGERUD.

mot nord. I området mellom Førstebreen og Sjettebreen forekommer hovedsakelig glimmerskifre, gneiser av forskjellige typer og granitter. Granittiseringen viser økning fra Sjettebreen mot Danskøya, hvor det også forekommer klart gjennomsettende granittintrusjoner. Det er sannsynlig at det her opptrer minst to generasjoner av folding. Det ble ikke funnet forekomster av økonomisk verdi i det undersøkte området.

Geologparti 3. – Leder DAVID G. GEE (Storbritannia) med assistenter HANS EKENBERG (Sverige) og KJELL G. FINSTAD. I tiden 10. juli–22. august ble det arbeidet ut fra fem forskjellige leirer rundt nordvestkysten. Helikopter og delvis båt ble benyttet til transport under arbeidet.

Det geologiske feltarbeidet ble utført i områdene Mitrahalvøya, Nissenfjella og midtre delen av Albert I Land, nordre del av Vasahalvøya, ved Smeerenburgbreen og langs vestsiden av Liefdefjorden. Partiet konsentrerte arbeidet vesentlig om de stratigrafiske og strukturelle forholdene samt om opptreden av intrusjonene og utviklingen av metamorfose. Spor etter sulfidmineralisering ble spesielt undersøkt, men økonomisk nyttige forekomster ble ikke funnet. – Partiet samarbeidet i felten med partiene HJELLE og VAN AUTENBOER.

Geologparti 4. – Leder TONY VAN AUTENBOER (Belgia) med assistenter WALTER L. C. LOY (Belgia) og PER BØE. Partiet arbeidet ut fra forskjellige leirer i Krossfjorden med geologisk kartlegging og prospektering nord for de indre delene av

Fig. 3. *Tre geologiske feltpartier arbeidet sommeren 1964 i det nordvestlige området av Vestspitsbergen. Bildet viser den nordligste delen av Danskøya, sett fra Smeerenburgfjorden mot nordvest.* Foto: A. HJELLE.

Kongsfjorden mot området mellom Monacobreen og Lilliehöökbreen. Partiet fikk delvis helikopterstøtte til transport. – Undersøkelsene ble utført i samarbeid med partiene HJELLE og GEE, som arbeidet lenger vest og nord.

Geologparti 5. – Leder professor ANATOL HEINTZ med assistenter BJARNE LIE-UNGH og PER SCHELLENBERG. Partiet arbeidet ut fra sin leir i Ekmanfjorden i tiden 11.–29. august. Til fots og ved hjelp av helikopter foretok de undersøkelser og innsamling av materiale i devonlagene i Ekmanfjorden med sidedaler og morener, i fjellene mellom Ekmanfjorden og Woodfjorden samt mellom Dicksonfjorden og Austfjorden. Geologiske rekognoseringsflygninger ble dessuten foretatt i områdene mellom Ekmanfjorden og Woodfjorden og i området Kongsfjorden–Billefjorden–Austfjorden. Sammen med THOR SIGGERUD besøkte HEINTZ Goldschmidtfjella ved St. Jonsfjorden. Partiet samlet inn et stort materiale av urfisk og fisk fra devonlagene.

Geologparti 6. – Leder HARALD MAJOR med assistenter ODD NILSEN, JOOP LANGELAAR (Nederland) og JEAN FRANÇOIS A. VOISIN (Frankrike). Partiet hadde sitt hovedkarter i Longyearbyen. Da LANGELAAR viste seg å være en godt skolert geolog, kunne partiet arbeide i to grupper. Ved lengre transporter i felten ble det til dels brukt skip, motorbåt og helikopter.

I midten av juli ble der foretatt en sedimentologisk undersøkelse av lagene under kullfløtsene i Longyeargruvene, hvor det ble oppmålt 72 snitt. Det innsamlete observasjonsmateriale kan benyttes til å klarlegge de paleogeografiske

Fig. 4. *Når feltpartiene skal settes på land i slutten av juni – begynnelsen av juli, kan det fremdeles være fastis igjen i fjordene, slik at det er vanskelig å komme frem, som på bildet her.* Foto: S. MANUM.

forhold i den tid kullene ble dannet. I slutten av juli og i august ble forskjellige stratigrafiske enheter i tertiær målt opp og undersøkt på en rekke lokaliteter i Longyeardalen, Reindalen, Colesdalen og Hollendardalen. Avleiringene fra kritt ble undersøkt på Carolinefjellet, hvor lagrekken viste tegn på syklisk sedimentasjon. I midten av august foretok partiet dessuten orienterende undersøkelser ved Ny-Ålesund.

Ved siden av det geologiske feltarbeid deltok MAJOR i konferanser med bergmesterassistent HATLE om generelle prinsipper for behandling av funnpunktsanmeldelser og utmålskrav. I slutten av august var han med sysselmannen og bergmesteren for Svalbard på en rekognoseringstur.

Geologparti 7. – Leder JENÖ NAGY med assistenter HANS RUDOLF FRITSCH (Sveits) og ARNE OLAV EGNER. Partiet samarbeidet med MANUMS parti fra en felles hovedleir i Storbukta, Van Keulenfjorden. Under feltarbeidet ble det benyttet snøscooter og dory til transport i den utstrekning forholdene tillot det.

I området langs sydsiden av Van Keulenfjorden, langs Penckbreen og i Pilsudskifjella undersøkte partiet forskjellige deler av lagrekken mellom undre perm og undre kritt med hensyn til forekomst av mulige moderbergarter og reservoarbergarter for olje. Videre utførte partiet paleontologisk-stratigrafisk feltarbeid i lagrekken fra undre kritt i områdene Friherrefjella, Ulladalen og Pilsudskifjella. I disse områdene ble i alt ni profiler beskrevet. Samtidig ble det foretatt innsamling av fossiler og i mindre utstrekning også av bergartsprøver. I Pilsudskifjella ble det konstatert forekomst av kull både i undre kritt og i tertiær. Partiet avmerket her i alt åtte funnpunkter på kullene som viste sterk vekslende kvalitet.

Geologparti 8. – Leder DINAND L. J. NIEMANTSVERDRIET (Nederland) med assistenter JAN EGIL BAKKE og NILS ENGELSTAD. Da Van Mijenfjorden var islagt, ble NIEMANTSVERDRIET og utstyret satt ut med helikopter fra Longyearbyen til Kjellströmdalen, mens assistentene tok seg frem til fots. Geologisk feltarbeid ble utført på begge siden av Kjellströmdalen med oppmåling av flere snitt gjennom lag fra jura, kritt og tertiær. Partiet dro deretter ned til Sveagruva. Arbeidet var planlagt å fortsette på østsiden av Rindersbukta og Paulabreen, men sterkt snøfall skapte vanskeligheter slik at de indre områder ikke kunne nås. Arbeidet ble avsluttet med en lang tur langs sydsiden av Van Mijenfjorden.

Geologparti 9. – Leder dr. STANISLAW SIEDLECKI (Polen) med assistenter JOHN EINBU og TRULS ERIK JOHNSRUD.

Partiet utførte feltarbeid på den vestlige og nordlige delen av Bjørnøya fra 6. til 22. juli. Hovedvekten ble lagt på beskrivelse av litologisk-stratigrafiske profiler langs kysten mellom Kapp Olsen og Bogevika. Den undersøkte lagrekken tilhører mellom- og overkarbon samt undre perm. I disse avsetninger ble det konstatert bitumiøse lag, samt mulige reservoarbergarter for olje.

Fra 24. juli til 31. august drev partiet geologisk kartlegging på Sørkappøya, på den sydlige delen av Sørkappland og på øyene i farvannet omkring begge steder. Sommerens arbeid har vist at området består av to større strukturelle enheter, en synklinal med lag fra perm og trias som strekker seg over Sørkappøya til den sydlige delen av Øyrlandet, og en forkastningsgrøft med lag fra kritt og tertiær som opptar mesteparten av Øyrlandet. Det ble utført detaljerte stratigrafiske undersøkelser av hittil lite kjente formasjoner fra kulm, perm, trias og tertiær. – Partiet fant en bly-sinkmineralisering av ny type for Svalbard.

Geologparti 10. – Leder dr. SVEIN MANUM med assistenter FINN FAYE KNUDSEN og OLE PETTER WANGEN. Partiet hadde felles leir med NAGYS parti, og til transporter ble brukt dels snøscooter og dels dory.

Partiet undersøkte en rekke lokaliteter i områdene langs nord- og sydsiden av Van Keulenfjorden, omkring Penckbreen, Tirolerbreen og Zawadskibreen for innsamling av plantefossiler. MANUM forsøkte å finne nye fossil-lokaliteter i de kontinentale avsetninger fra rhät-lias, kritt og tertiær, og større innsamlinger ble foretatt der det fantes egnete avdekninger. Innsamlinger ble også foretatt i kulmprofilet ved Recherchefjordens østside. Foruten makrofossiler ble det samlet en rekke prøver med tanke på mikrofossilanalyse. - Det ble presset mange planter og gjort opptegnelser om floraen på en rekke lokaliteter.

Geokjemiparti. – Leder WILLY INGEBRETSEN, en tid med JAN ERIKSEN og ERIK B. DAHL som assistenter. I slutten av juli deltok INGEBRETSEN i arbeidet ved utsetningen av de forskjellige partiene, opprettelser av nøddepoter og hjalp til med leirarbeid i helikopterbasen.

Fig. 5. *Den polske geologen dr.* S. SIEDLECKI *ble på Bjørnøya gode venner med to isbjørnunger. Binnen var om vdren blitt skutt av folk fra den meteorologiske stasjonen, og ungene måtte klare seg som best de kunne og likte godt å få litt ekstra mat.* Foto: S. SIEDLECKI.

Partiet samlet inn hekkesedimenter for geokjemiske undersøkelser på strandflaten nord for Blomstrandbreen mot Kapp Guissez. I begynnelsen av august ble det flyttet med ekspedisjonsfartøyet til Bellsund, og fortsatte med innsamlingen av sedimentprøver fra bekkene i området Fridtjovhamna–Ytterdalen–Orustdalen. Som resultat av dette og fjorårets arbeid foreligger nå sedimentprøver fra de viktigste bekkene på strekningen Kapp Linné–Fridtjovhamna.

I midten av august ble partiet flyttet tilbake til Kongsfjordområdet, hvor det samlet bekkesedimenter ved Ny-Ålesund og langs kyststrekningen fra Kiærfjellet til indre delen av Engelskbukta.

Glasiologparti. – Leder OLAV LIESTØL med assistenter FINN HAGEN og EINAR ROSENQVIST. Partiet hadde base i «Slettebu» i Van Keulenfjorden.

Sommeren ble hovedsakelig benyttet til en fortsatt undersøkelse av Finsterwalderbreens materialhusholdning. Akkumulasjonen var større enn normalt, men den relativt milde, fuktige sommer bevirket at breen holdt seg omtrent i likevekt. Det ble foretatt en fire dagers tur til Recherchebreen i slutten av juli, hvor brefronten ble målt og dessuten endel undersøkelser gjort vedrørende breens lateraldrenering. I begynnelsen av august ble et område foran Nathorstbreen loddet opp. Den formodede eskerform ble funnet, men den var ikke så regelmessig som før antatt. Breens front ble også innmålt. Tilbakegangen siden 1962 var gjennomsnittlig ca. 200 m langs fronten.

Før hjemreisen i midten av august ble det i Longyearbyen foretatt befaringer og beregninger for Store Norske Spitsbergen Kulkompani A/S i forbindelse med breer som ligger over Gruve 7-området. Tidevannsmåleren ved kraftstasjoen ble nivellert inn.

Meteorologparti. – VIDAR HISDAL og TORGNY E. VINJE foretok spesielle meteorologiske undersøkelser med stasjon i «Slettebu». HISDAL målte den spektrale intensitetsfordeling av den diffuse himmelstråling ved hjelp av en gitter-monokromator tilkoplet et fotomultiplikatorrør med brukbart følsomhetsområde fra ca. 3200 til ca. 6000 Ångström. Antall måleserier som ble oppnådd, skulle gi et tilfredsstillende grunnlag for videre bearbeidelser. VINJE målte de forskjellige komponenter av strålingsbalansen på stedet ved hjelp av to pyranometre og en strålingsbalansemåler. Instrumentene var tilknyttet en punktskriver for kontinuerlig registrering.

Målingene ble utført på bar bakke ved stasjonen, men de vil også kunne benyttes ved en vurdering av energibudsjettet for Finsterwalderbreen.

VINJE foretok også regelmessige avlesninger av jordtemperaturen fra overflaten og ned til 20 cm's dyp. På grunn av den lave albedo (ca. 10%) var temperaturen like under overflaten til dels betydelig høyere enn lufttemperaturen i 2 meters nivået. I tilegg til disse spesielle undersøkelser ble det utført rutinemessige værobservasjoner hver tredje time fra 09–21 GMT. En tidevannstang ble også avlest med korte mellomrom.

Biologparti 1 og 2. – Leder cand. mag. MAGNAR NORDERHAUG med assistenter LAGE LJØTERUD og BJØRN MATHIASSEN, og stud. real. NILS GULLESTAD med assistent HANS PETTER GULLESTAD. Begge partiene arbeidet i Hornsundområdet med hovedstasjon i Isbjørnhamna.

NORDERHAUG fortsatte med ornitologiske undersøkelser mellom Stormbukta og Kapp Borthen. Et treårsprogram for studier av alkekongens biologi ble avsluttet. Dette omfatter studier av yngelbiologi, ernæringsundersøkelser og ringmerking. Gåseundersøkelsene fra 1962 og 1963 ble fortsatt og utvidet i samarbeid med den britiske The Wildfowl Trust Spitsbergen Expedition. De omfattet registering av ungeproduksjon og størrelsen av bestanden av hvitkinngås (*Branta leucopsis*) og kortnebbgås (*Anser brachyhynchus*). Studier av klimaets innvirkning på arktiske hekkefugler ble foretatt.

Det ble ringmerket 2828 fugl fordelt på følgende arter: Havhest (*Fulmaris glacialis*) 25, hvitkinngås (*Branta leucopsis*) 102, ærfugl (*Somateria mollissima*) 1, fjæreplytt (*Calidris maritima*) 9, polarsvømmesnipe (*Phalaropus fulicarius*) 2, tyvjo (*Stercorarius parasiticus*) 5, krykkje (*Rissa tridactyla*) 77, rødnebbterne (*Sterna macrura*) 19, alkekonge (*Plautus alle*) 2510, polarlomvi (*Uria lomvia*) 20, snøspurv (*Plectrophenax nivalis*) 58. Det ble kontrollert 173 tidligere ringmerkete fugler i området.

GULLESTAD fortsatte de biologiske studiene av røye (*Salmo alpinus*) fra de to foregående år. Undersøkelsene foregikk på begge sider av Hornsund, i Svartvatnet og Revvatnet. 242 fisk ble fanget. De varierte i vekt fra 5 gram til 3 kilo. Data vedrørende kondisjon, vekt, skjell og otolitter ble innsamlet. Videre ble det tatt et vannprøvesett og tre sett planktonprøver. Partiet fanget dessuten 500 alkekonger for ringmerking.

Andre norske ekspedisjoner til Svalbard

Den norske nasjonale komité for IQSY sendte fire mann med JON FRIHAGEN som leder til Isfjord Radio, Kapp Linne for opprettelse av en jordmagnetisk variometerstasjon. En av deltakerne, GEIR ARNESEN, overvintret for å passe stasjonen.

Norsk Polar Navigasjon A/S sendte i år tre partier for oljeundersøkelser. Ett dro på ski og med kjelker fra Hornsund til Longyearbyen. De to øvrige arbeidet ved Grønfjorden og på Brøggerhalvøya. Boring med mindre utstyr ble foretatt.

Utenlandske ekspedisjoner til Svalbard

American Overseas Petroleum Ltd., Norsk Caltex Oil A/S, foretok bare en mindre inspeksjonstur ved to mann.

Sovjet-russisk ekspedisjon sendt ut av Institutt for Arktisk Geologi i Leningrad. Den bestod av fem geologiske og ett geofysisk parti som fortsatte undersøkelsene fra året før. Det deltok så vidt vites 95 mann. Helikoptere og fartøy ble benyttet til transport.

Det franske selskap Bureau de Recherches Pétrolière (BRP) og datterselskapet Compagnie d'Exploration Pétrolière: 12 mann, hvorav 4 geologer, foretok oljeundersøkelser, særlig i området Sørkapp-Agardhbukta–Edgeøya. De hadde til disposisjon et ekspedisjonsfartøy, M/S «Kvitungen», et helikopter, et lite fly og dessuten tre beltekjøretøyer. I tilknytning til ekspedisjonen foretok et fransk fly med base i Norge overflyvninger for seismiske målinger, og forskningsskipet «Andromede» foretok marinseismiske undersøkelser i Storfjordenområdet.

University of Cambridge, Sedgwick Museum: 23 deltakere med W. B. HARLAND som leder foretok geologiske og botaniske undersøkelser i de nordlige og sentrale deler av Vestspitsbergen. Benyttet to motorbåter til transport.

Tysk ekspedisjon (fortsettelse av Deutsche Spitzbergenexpedition 1962 ved prof. dr. W. PILLEWIZER) med 18 deltakere og dr. LOTHAR STANGE som leder, ankom Ny-Ålesund og ble hentet igjen med forskningsfartøyet M/S «Meteor». Lå i egen leir og foretok glasiologiske, geografiske og geomagnetiske undersøkelser. – Fem av deltakerne med fysikeren ULLRICH VOIGT som leder, overvintrer i Ny-Ålesund.

Tysk ekspedisjon med 8 deltakere, ledet av dr. HANS J. SCHWEITZER fra Geologisch-Paleontologisches Institut und Museum, Bonn. Geologiske og botaniske undersøkelser Adventdalen–Tempelfjorden og Bellsund. Fire av deltakerne arbeidet også på Bjørnøya.

Fransk ekspedisjon med 16 deltakere, ledet av prof. JEAN CORBEL lå i egen leir ved Ny-Ålesund. De satte opp en lemmehytte. Foretok vesentlig geologiske, glasiologiske og botaniske undersøkelser og dessuten dykkerundersøkelser med froskemenn.

Svensk ekspedisjon fra Universitetet i Lund med 7 deltakere, ledet av fil. lic. INGEMAR AHLÉN arbeidet ved Ny-Ålesund og ved Reinsdyrflya. Vesentlig zoologiske undersøkelser.

Finsk ekspedisjon med fire deltakere, ledet av fil. lic. ERIK NYHOLM foretok ornitologiske undersøkelser ved Adventfjorden, Alkhornet og i Hornsund.

Engelsk ekspedisjon, bestående av M. A. OGILVIE og R. J. TAYLOR fra The Wildfowl Trust, Slimbridge, foretok ornitologiske undersøkelser på Kapp Linné og i Dunderdalen.

Dessuten en rekke klatreekspedisjoner og andre mer turistbetonte grupper.

Antarktis

TORBJØRN LUNDE deltok som glasiologisk ekspert i en sørafrikansk ekspedisjon til Bouvetøya i mars–april 1964. Hensikten med ekspedisjonen var å undersøke mulighetene for å opprette en meteorologisk stasjon på øya. Værforholdene var dårlige, og man klarte bare å gjennomføre en kortere landstigning ved hjelp av helikopter. Det ble ikke funnet noen brukbar løsning på problemet med å finne en egnet plass for en stasjon.

I oktober reiste OLAV DYBVADSKOG til Antarktis for å delta i den amerikanske ekspedisjonen «South Pole–Queen Maud Land Traverse» på dens første etappe til «The Pole of Inaccessibility». Ekspedisjonen skal foreta geofysiske undersøkelser, og hele det vitenskapelige program strekker seg over i alt fire sommersesonger. DYBVADSKOG skulle spesielt studere skavlenes form og dannelse.

Utenlandske ekspedisjoner til Dronning Maud Land

Den belgiske stasjonen, Roi Baudouin, ble åpnet igjen i 1964, og antallet øket dermed til tre:

1. SANAE, 70° 19′ S, 2° 22′ V, sørafrikansk ekspedisjon, 14 overvintrere.
2. Novolazarevskaja, 70° 46′ S, 11° 49′ Ø, russisk ekspedisjon.

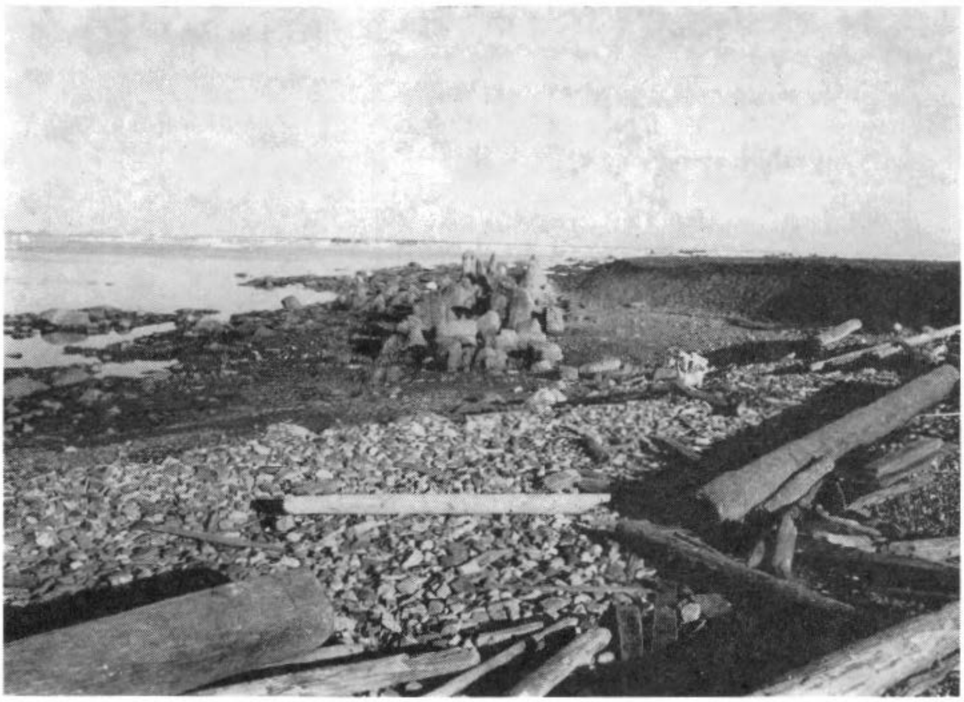


Fig. 6. *Stjernøya som ligger mellom Tokrossøya og Sørkappøya, hører til de aller sydligste områdene av Spitsbergen. Bergartene består her av permiske sedimenter, og sommeren 1964 ble området undersøkt av dr.* S. SIEDLECKI. Foto: S. SIEDLECKI.

3. Roi Baudouin, 70° 29′ S, 24° 19′ Ø, belgisk-nederlandsk ekspedisjon med 10 belgiske og 4 nederlandske overvintrere.

Stasjonene drives helårlig med til dels utvidete programmer om sommeren.

Breundersøkelser i Norge

Undersøkelsene ble som vanlig ledet av OLAV LIESTØL. På Hardangerjøkulen ble snødybder målt og målestengene ettersett i midten av februar. Akkumulasjonsmålinger på samme bre ble foretatt i slutten av april. Snømengden var ca. 80% av det normale. På Storbreen ble akkumulasjonen målt i begynnelsen av mai. Snømengden var her ca. 70% av det normale. I løpet av sommeren ble ablasjonen på Storbreen målt i alt tre ganger og på Hardangerjøkulen to ganger. På grunn av den kalde sommeren ble ablasjonen mindre enn vinterens akkumulasjon. Resultatet ble derfor et overskudd i materialbalansen som i gjennomsnitt beløp seg til 44 g/cm³ på Hardangerjøkulen og 21 g/cm³ på Storbreen.

I det forløpne året har RANDI PYTTE og TORMOD KLEMSDAL, som har arbeidet henholdsvis med Hellstugubreen og Gråsubreen i Jotunheimen, avlagt sin hovedfagseksamen. OLAV ORHEIM har fortsatt sin undersøkelse av Suphellebreen i Fjærland.

Fra de faste observatørene har Polarinstituttet fått inn måleresultater fra 11 forskjellige breer. Samtlige breer viser også i år fortsatt tilbakegang.

Bearbeidelse av materiale fra Svalbard

Hydrografisk avdeling

KAARE Z. LUNDQUIST foretok en del kartredigering og andre kartografiske arbeider samt utførte beregninger i forbindelse med Hi-Fix-systemet.

HELGE HORNBÆK la opp loddeoriginaler for munningen av Woodfjorden, farvannet ved Bjørnøya og havområdet utenfor nordvestkysten av Vestspitsbergen. Han foretok også korrektur av gamle tegneoriginaler for sjøkartene. Videre fortsatte han med montasjearbeid på ny utgave av sjøkart 503 og nytt sjøkart i målestokk 1:100 000 over nordvesthjørnet av Vestspitsbergen. Enn videre utførte han en del tidevannsberegninger.

EINAR NETELAND arbeidet vesentlig med ettersyn og overhaling av Hi-Fix-ustyret og tok seg også av instituttets radiomateriell.

Topografisk-geodetisk avdeling

Det ble laget en oversikt over flybildedekningen av Vestspitsbergen. Koordinatene for de fleste triangel- og passpunktene ble overført fra gamle ekstrakter til nye kartotekkort. Det ble foretatt beregninger av de gamle observasjonene på Mitrahalvøya og av observasjonene fra 1963 i Olav V Land, Ny Friesland og Bolterdalen–Foxdalen (Gruve 7-området ved Longyearbyen). Målingene som ble gjort sommeren 1964 i Albert I Land, Haakon VII Land og Andreé Land ble også beregnet. For hydrografene ble konstruert et kart over området Kapp Auguste Viktoria–Gråhuken i målestokk 1:50 000. Videre ble det laget kart over Mitrahalvøya (1:50 000). Som driftskart for framtidige Longyeargruve 7 ble følgende kart utarbeidet: tachymeterkart i målestokk 1:1000 over den vestre delen av Breinosas nordside og Bolterdalens øst- og vestside og Foxdalens vestside (1:4000), og videre et oversiktskart over samme områder og nærmeste omland i målestokk 1:10 000 (det siste kontruert av Norkart).

Arbeidet med et kart over Svalbard i målestokk 1:1 000 000 ble påbegynt, og det ble tegnet flere navnekart i målestokk 1:100 000. To kartblad over den vestlige delen av Spitsbergen i målestokk 1:500 000 ble utgitt på vårparten 1964.

Geologisk avdeling

HARALD MAJOR har ledet tegningen av manuskriptkart til det geologiske kartbladet Adventdalen (målestokk 1:100 000). Under trykningen av kartet har han stått for korrekturlesningen av de forskjellige prøvetrykkene. Kartet forelå ferdig trykt innen utgangen av 1964. MAJOR har videre arbeidet med kullpetrografiske studier av kullprøver fra Gruve 5 i Longyearbyen, og i alt 39 kullslip har blitt undersøkt. Han har deltatt i utarbeidelsen av Norsk Polarinstitutts funnpunktsanmeldelser i Grimfjellantiklinalen og har gitt instruks for avmerking av nye funnpunkter på Bjørnøya. MAJOR har også utført konsulentarbeid vedrørende forsøksdrift i Gruve 7 i Longyeardalen, og han har hatt tilsynet med utarbeidelse av driftskartene herfra. Videre har han utarbeidet en oversikt for Industridepartementet over Statens utmålsfelter på Svalbard.

THORE S. WINSNES, som frem til 1. oktober hadde permisjon for å arbeide for FN, har siden hjemkomsten fortsatt med bearbeidelse av sitt paleontologiske materiale fra karbonperm-avleiringene på Svalbard. Han har arbeidet med et manuskript som vil omhandle stratigrafien i de to nevnte systemene og innholdet av mikrofossiler i de forskjellige lagene.

THOR SIGGERUD har i løpet av høsten påbegynt en undersøkelse over mulig vekslende opptreden av radioaktive elementer i granittene i grenseområdet for granittene nord for Kongsfjorden. Sammen med prof. ANATOL HEINTZ har han skrevet en kort artikkel om forekomsten av triassiske lag innerst i St. Jonsfjorden, i et område som tidligere var antatt å være fra devon.

AUDUN HJELLE fortsatte bearbeidelsen av det materialet som han hadde samlet sommeren 1963 på Ny Friesland og Olav V Land og utarbeidet et manuskript over dette til Årbok 1963. Etter sommerens ekspedisjon har han studert en del av det materiale som han samlet i løpet av siste sommer, og han har utarbeidet et oversiktskart over Hecla Hoek-bergartene i området nord for Kongsfjorden.

JENÖ NAGY har foretatt en foreløpig korrelasjon av profiler fra undre kritt fra forskjellige lokaliteter på Vestspitsbergen. Han har artsbestemt en del av fossilene som han har samlet i krittlagene. Han har videre utarbeidet anmeldelsen av 10 funnpunkter i Grimfjellantiklinalen. Somrene 1962 og 1963 samlet NAGY en del bunnprøver på grunt vann forskjellige steder langs kysten av Vestspitsbergen. I løpet av 1964 bearbeidet han dette materiale og skrev et arbeid om det som ble trykt i Årbok 1963.

NATASCHA HEINTZ har utarbeidet en oversikt over alle kjente funn av mesozoiske øgler fra Svalbard og Norge, og dette arbeidet ble trykt som Meddelelser Nr. 91. Videre har hun skrevet en artikkel om øglespor på Svalbard til Polarboken 1963–64. I løpet av året har hun utført en del prepareringsarbeid og laboratorieundersøkelser av devonfisk fra Svalbard. Den anatomiske beskrivelsen av dette arbeidet er nå ferdig i manuskript.

Den polske geologen dr. STANISLAW SIEDLECKI har arbeidet med en sammenfattende undersøkelse over de stratigrafiske og tektoniske forhold som karakteriserer Sørkappøya og de nærliggende områdene. Han har i den forbindelse også bearbeidet nærmere en del av det materialet som han samlet inn sommeren 1964.

WILLY INGEBRETSEN har laget preparater av forskjellige bergarter for instituttets geologer, og han har hjulpet N. HEINTZ med å lage snitt av fossiler. Han har også utført en del fotografisk arbeid.

I løpet av året har den geologiske avdeling etter Industridepartementets anmodning avgitt uttalelser angående geologiske spørsmål i forbindelse med utmålskrav for olje basert på geologiske indikasjoner.

Geofysisk avdeling

OLAV LIESTØL har fortsatt bearbeidelsen av det innsamlete glasiologiske materiale.

VIDAR HISDAL har laget en kort beskrivelse av været på Svalbard i 1963 for

Årbok 1963. Han har utført en del arbeid i forbindelse med bygging av tilleggsutstyr til og kalibrering av en gitter-monokromator, som ble brukt på Svalbard under feltarbeidet sommeren 1964.

TORBJØRN LUNDE fortsatte frem til han sluttet ved instuttet 31. august, bearbeidelsen av de innkomne isobservasjonene fra Svalbard-området. For Årbok 1963 skrev han en artikkel om «Ice conditions at Svalbard 1946–63». Fra 1. september har TORGNY E. VINJE tatt på seg det løpende arbeidet i forbindelse med havisforsker-stillingen. Han publiserte også en artikkel om «On the cooling power in Norway».

Biologisk arbeid

NATASCHA HEINTZ har utvidet, supplert og delvis omarbeidet de observasjonsskjemaene for biologiske data som blir sendt med alle feltpartiene. Resultatene av observasjonsskjemaene for 1963 ble for den zoologiske delen gjort ferdig til trykking av N. HEINTZ, mens cand. real. PER SUNDING bearbeidet det botaniske materialet. Begge deler ble trykt i Årbok 1963. I samarbeid med MAGNAR NORDERHAUG besvarte N. HEINTZ en rekke forespørsler angående dyrelivet på Svalbard og forskjellige sider av fredningsarbeidet der. NORDERHAUG bearbeidet sitt materiale over alkekongens biologi og begynte på en utredning om Svalbardgåsens nåværende status. Han har i løpet av året vært i kontakt med en rekke biologer i Norge og utlandet for å samle opplysninger om Svalbards fuglefauna.

Bearbeidelse av materiale fra Antarktis

Kartarbeider

Arbeidet med konstruksjon av kart over Sør-Rondane fortsatte, og dessuten ble Lingetoppane og en kystlinje konstruert. To kartblad i kartserien Dronning Maud Land 1:250 000 ble utgitt i løpet av året. Det var L6 Glopeflya og M6 Hoelfjella Sør. Kartbladene J5 Mühlig-Hofmannfjella Nord og K5 Filchnerfjella Nord ble i løpet av året rentegnet.

Meteorologi

VIDAR HISDAL gjorde ferdig og leverte til trykning: «On the tides at Norway Station and adjacent coastal areas of Antarctica».

De meteorologiske stasjonene ombord på de norske hvalkokeriene ble som vanlig inspisert i løpet av høsten.

TORGNY E. VINJE publiserte i 1964 avhandlingene: «On the radiation balance and micrometeorological conditions at Norway Station, Antarctica» og «Climatological tables for Norway Station». Videre har han begynt på en analyse av registreringene fra det meteorologiske tårnet på Norway Station.

Bidrag til innsamling og bearbeidelse utført av andre forskere

Fra Norsk Polarinstitutt har følgende mottatt bidrag til forskningsoppgaver:

Lektor ODD LØNØ til innsamling av isbjørnmateriale i forbindelse med overvintring på Svalbard.

Lektor THOM ASKILDSEN til bearbeidelse av etnografisk materiale.

Geolog D. L. J. NIEMANTSVERDRIET (Nederland) til bearbeidelse av geologisk materiale fra Svalbard.

Biblioteket

I 1964 ble registrert ca. 3000 bøker, tidsskrifter og småtrykk som tilvekst til biblioteket. 74 nye bøker ble innkjøpt. Instituttet abonnerer på 21 tidsskrifter og mottar omkring 80 serier i regulær bytteforbindelse.

Årets store begivenhet har vært innflyttingen i nye tidsmessige lokaler. Bibliotekets flytting bød på en rekke problemer, da mange bøker tidligere var stuet bort og magasinert på forskjellige steder i den gamle bygningen og på leiet lager. Alt er nå blitt samlet i det nye huset og oppstilt enten i biblioteket eller i bokkjelleren.

Fra 1. september ble bibliotekar SIGRID RASMUSSEN engasjert midlertidig som biblioteksassistent.

I forbindelse med flyttingen er en biblioteksplan utarbeidet i samarbeid mellom bibliotekskonsulent TORBORG COLLIN og bibliotekaren. Alle serier blir ført over på kardex-kort, og hele biblioteket blir registrert etter den modifiserte form for U.D.C. som anvendes blant annet ved Scott Polar Research Institute i England. Tidsskriftrommet er ferdig ordnet, og her ligger utlagt siste årganger av ca. 90 tidsskrifter, som da er umiddelbart tilgjengelige for besøkende.

Konsulent- og informasjonstjeneste

Den økende interesse for polarområdene som har vært merkbar i de senere år, og det stigende behov for opplysninger som dette har medført, har etter hvert skapt en uholdbar situasjon ved Norsk Polarinstitutt, som hittil har vært den eneste norske institusjon til å gi opplysning om Svalbard og andre norske polarområder. Instituttet er ikke utbygget for en slik tjeneste, men har likevel søkt å holde det gående etter beste evne for ikke å skade landets anseelse, da en vesentlig del av forespørslene kommer fra utlandet. Arbeidet må i vesentlig grad utføres av instituttets forskerstab, hvis arbeidstid dermed stadig blir opprevet og forstyrret. Da instituttets hovedoppgave må ansees å være utforskning av norske polarområder, ikke bare ved en ekspedisjonsvirksomhet i sommertiden, men også ved bearbeidelse av det innsamlete materiale i den øvrige del av året, vil opplysningstjenesten ikke lenger kunne varetas på en forsvarlig måte med mindre det blir gjennomført en økning av personalet ved administrasjonen. Instituttet har gjentatte ganger gjort myndighetene oppmerksom på saken uten at noen løsning er funnet, og er ikke lenger i stand til å opprettholde denne tjeneste.

Nedenfor er nevnt en del større saker i forbindelse med informasjons- og konsulentvirksomheten.

I 1964 har SØREN RICHTER fortsatt sin konsulentvirksomhet vedrørende arktiske forhold, mottatt artikler og oppgaver til gjennomsyn og bedømmelse fra skoleelever, studenter ved universiteter og høyskoler og andre. Han er også medredaktør av Polarboken og bidragsyter til forskjellige leksika.

KAARE Z. LUNDQUIST har blant annet tatt seg av generelle spørsmål om Svalbard, mens spørsmål vedrørende Antarktisk for største delen er besvart av SIGURD G. HELLE. Sistnevnte har også ordnet med de fleste henvendelser om kart og flyfotografier.

NATASCHA HEINTZ har gjennomgått russisk faglitteratur og oversatt en del artikler for instituttets medarbeidere. Sammen med MAGNAR NORDERHAUG har hun besvart spørsmål angående dyreliv og fredning på Svalbard. Hun redigerte videre Årbok 1963 og bistod ved andre trykningsarbeider.

Et omfattende konsulentarbeid for Utenriksdepartementet ble utført i forbindelse med de fredningsbestemmelser for Antarktis og andre spørsmål som ble drøftet i juni i Bryssel på det III. konsultative møte under Antarktistraktaten.

THOR SIGGERUD deltok som rådgiver og kjentmann under en befaring på Svalbard i oktober for representanter for den europeiske romforskningsorganisasjon (ESRO) med henblikk på opprettelse av en telemetreringsstasjon på Svalbard. Han deltok videre, til dels sammen med direktøren, i drøftelser om saken mellom ESRO-representanter og norske myndigheter, samt i en rekke forberedende møter sammen med representanter for Utenriksdepartementet og Norges Teknisk-Naturvitenskapelige Forskningsråd. Instituttets arbeid i denne forbindelse tør ha hatt avgjørende betydning for at Ny-Ålesund er blitt utsett til stedet for en eventuell stasjon.

KAARE Z. LUNDQUIST deltok i Trafikkutvalgets befaring på Svalbard i september.

Norsk og utenlandsk presse, kringkasting og televisjonsselskaper har hatt en rekke artikler og programmer om Svalbard og har stadig henvendt seg til Norsk Polarinstitutt for assistanse.

Forelesnings- og foredragsvirksomhet

TORE GJELSVIK holdt i begynnelsen av januar et foredrag i Arktisk Forening, Tromsø, om Norsk Polarinstitutts ekspedisjonsvirksomhet på Svalbard. Om samme tema holdt han foredrag i Norsk Polarklubb, Oslo. I mars holdt han foredrag for et fullsatt møte i Den Norske Ingeniørforening, Oslo, om: «Svalbard – en norsk utpost i nord». Foredraget ble utførlig referert og kommentert i de fleste av landets aviser.

T. GJELSVIK og SØREN RICHTER holdt i desember et par forelesninger om Svalbard og andre norske interesseområder i Arktis på Forsvarets Høgskole.

T. GJELSVIK foreleste i vårsemesteret i malmgeologi ved Universitetet i Oslo.

NATASCHA HEINTZ holdt i mai foredrag om «Dinosaurier på Svalbard – en støtte for teorien om polvandring» i Det Norske Videnskapsakademi i Oslo.

OLAV LIESTØL holdt forelesninger i glasiologi i høstsemesteret og kollokvier for hovedfagstudenter i vårsemesteret ved Universitetet i Oslo. I november holdt han også tre forelesninger for hovedfagstudenter i glasiologi ved Universitetet i Bergen.

HARALD MAJOR holdt foredrag om «Fennoskandia – noe om geotermiske forhold» på Det VI Nordiske Vintergeologmøtet i Trondheim i januar.

THOR SIGGERUD holdt foredrag om «Radioaktiv varmetoning» på et symposium om jordskorpens geofysikk i januar i Bergen. Han har i Oslo, Gol og Rjukan folkeakademi holdt foredrag om Svalbard.

Reiser, kongress- og møtevirksomhet

TORE GJELSVIK, NATASCHA HEINTZ, AUDUN HJELLE, HARALD MAJOR og THOR SIGGERUD deltok i VI. Nordiske Vintergeologmøte i Trondheim i dagene 3., 4. og 5. januar. H. MAJOR og T. SIGGERUD var deretter 6., 7. og 8. januar på Det Nordiske Geofysikermøte i Trondheim.

T. SIGGERUD var 13. og 14. januar i Bergen på et symposium om «Jordskorpens geofysikk».

T. GJELSVIK deltok i tiden 1. til 13. juni i Det III. konsultative møtet under Antarktistraktaten. Møtet ble holdt i Bryssel.

SØREN RICHTER besøkte Jan Mayen 20. og 21. august i forbindelse med at det der var blitt innredet et lite museum.

T. GJELSVIK, SIGURD G. HELLE og TORGNY E. VINJE deltok i SCAR-møtet i Paris i tiden 24. til 28. august.

SIGRID RASMUSSEN besøkte i tiden 14. oktober til 2. november biblioteket ved Scott Polar Research Institute i Cambridge, England, for å sette seg inn i hvordan dette biblioteket var bygget opp og hvordan man der registrerte bøkene etter U.D.C.

N. HEINTZ var i tiden 21. november til 2. desember ved Scott Polar Research Institute for å studere instituttets samling av russisk arktisk litteratur. Hun besøkte også Sedgwick Museum i Cambridge.

HÅKON HILL var 1. og 2. desember i Stockholm for å studere en ny konstruksjonsmaskin fra Zeiss.

Besøk

Blant dem som i det forløpne året har besøkt Norsk Polarinstitutt var:

Direktør J. DUMONT, l'Office Polaire de Recherche Industrielle, Paris; ALINA og CZESTAV CENTKIEWICZ, Polen; DAVID G. STRATTON, England; ROBIN L. OLIVER, England; ARNI G. EYLANDS, Reykjavik; WILLIS L. TRESSLER, U.S. Naval Oceanographic Office, Washinton, USA; EDGAR M. CORTRICHT, U.S. National Aeronautics and Space Adm., Washington, USA; WILLIAM GRAVES, National Geographic Society, Washington, USA.

Dessuten har representanter for en rekke utenlandske ambassader i Oslo gjentatte ganger besøkt Polarinstituttet.

Publikasjoner

Skrifter:

Nr. 129 – HERMAN L. LØVENSKIOLD: Avifauna Svalbardensis. Part I–III.
Nr. 130 – JOHANNES LID: The flora of Jan Mayen.
Nr. 131 – TORGNY E. VINJE: On the radiation balance and micrometeorological conditions at Norway Station Antarctica.
Den norske Antarktisekspedijonen, 1956–60. Scientific results No. 6.
Nr. 132 – JORUNN OS VIGRAN: Spores from Devonian deposits, Mimerdalen, Spitsbergen.

Meddelelser:

Nr. 90 – GUNNAR ØSTREM og OLAV LIESTØL: Glasiologiske undersøkelser i Norge 1963.
Nr. 92 – NATASCHA HEINTZ: Mesozoiske øglefunn fra Norge og Svalbard.
Nr. 92 – ANATOL HEINTZ: Om rein og isbjørn på Svalbard.

Polarhåndbøker:

Polarhåndbok Nr. 1 – OLAF I. RØNNING: Svalbards flora.

Kart:

Svalbard. Vestspitsbergen, southern part. Sheet 1, 1:500,000.
» northern part. Sheet 2, 1:500,000.
Dronning Maud Land. Glopeflya L6, 1:250,000.
Hoelfjella Sør M6, 1:250,000.

Instituttets medarbeidere har dessuten i andre serier publisert:
TORE GJELSVIK: Norsk Polarinstitutt i Utvikling. Polarboken 1963–64.
NATASCHA HEINTZ: Spor etter øgler på Svalbard. Polarboken 1963–64.
TORBJØRN LUNDE: Meteorologisk problem på Bouvetøya. Polarboken 1963–64.
SØREN RICHTER har vært medredaktør av Polarboken 1963–64.

The activities of Norsk Polarinstitutt in 1964

Extract of the annual report

BY

TORE GJELSVIK

Staff

In 1964 the permanent staff of Norsk Polarinstitutt numbered twenty-nine persons. Twelve persons were temporarily engaged, four of them working only on data collected by the Norwegian expeditions to Antarctica.

New office premises

In August 1964 Norsk Polarinstitutt moved from the old observatory in Observatoriegaten 1, where it had had its office since 1934, to occupy part of a new office-building uptown. The new address of Norsk Polarinstitutt now is: Middelthunsgt. 27B, (Post box 5054), Majorstua, Oslo 3.

In the new building, that is the headquarters of Norges Vassdrags- og Elektrisitetsvesen, Norsk Polarinstitutt occupies parts of three floors in one wing. Here the staff after many years, has got ample space and good working facilities. The library is placed in a spaceous room and in the basement are located storage rooms for field-equipment, extra books and publications and a couple of workshops. In all Norsk Polarinstitutt now has at its disposal about 2000 m^2, while previously only about 800 m^2.

Expeditions to Svalbard

In the summer-season 1964 the ice conditions in Svalbard waters were rather normal. However, drift ice hampered the hydrographic survey planned to take place in the waters between Bjørnøya, Sørkapp and Hopen. In July the weather was rather poor, causing the two expedition helicopters, that were stationed in Ny-Ålesund, to be ground much of the time. When the field-parties got to work in the middle of July, unusual large amount of wintersnow still covered the ground in most parts of Vestpsitsbergen. During the immediately following melting period, crossing of glaciers was difficult, in places impossible. In August, however, the weather improved and the work could be fullfilled, according to the plans.

The expedition, headed by K. Z. LUNDQUIST numbered 86 men, including the crews of the two expedition vessels "H. U. Sverdrup" and "Signalhorn" and the helicopters, and was the largest expedition Norsk Polarinstitutt ever has sent to Svalbard. It left Oslo in the beginning of July and returned in the first days of September.

Hydrography

K. Z. LUNDQUIST assisted by R. L. FESTØY and E. NETELAND on "H. U. Sverdrup" surveyed the waters off the northwest coast of Vestspitsbergen. More than 1.700 nautical miles of echogrammes were obtained, covering an area of about 2.500 sq.miles.

H. HORNBÆK, using the hydrographic surveying-boat "Svalis" finished the soundings in the outer part of Woodfjorden, and thus the whole of Liefdefjorden–Woodfjorden is now covered by sounding.

Topography

O. BJERKE, H. HILL, J. HUS, and E. SKIRDAL based in Ny-Ålesund and with logistic support from the helicopters, carried out trigonometrical surveying in Albert I Land, Haakon VII Land and Andrée Land. An area of about 8.000 km^2 was covered and measurements were carried out from fourty-eight stations, while twenty-one new cairns were built. To improve the trigonometrical basement four base lines were measured with tellurometer, two running in east–west and two in north–south direction.

Geology

The task of the geologists T. VAN AUTENBOER (Belgium); D. G. GEE (Great Britain) and A. HJELLE was, with logistic support from the helicopters, to make general geological surveying and mineral exploration mainly of the coastal areas from Kongsfjorden and northwards.

T. VAN AUTENBOER covered the area between the inner part of Kongsfjorden, Monacobreen and Lilliehöökbreen.

D. G. GEE investigated Mitrahalvøya, Nissenfjella and the central part of Albert I Land. Later he visited the northern part of Vasahalvøya near Smeerenburgbreen and the west side of Liefdefjorden. He consentrated on studying the structures, the stratigraphy, the intrusions and the development of the metamorphism in the mentioned areas.

A. HJELLE carried out reconnaissence mapping in Albert I Land. He found that the area south of Førstebreen–Lilliehöökbreen mainly consists of micaschists and phyllites, partly overlain by carbonetites. The main folding axes show a predominant south–southeasterly dip, thus the older and more metamorphosed rocks are getting more and more dominant northwards. The area between Førstebreen and Sjettebreen was found mainly to be made up of micaschists, different types of gneisses and granites. The granitization is generally increasing from Sjettebreen towards Danskøya.

T. GJELSVIK investigated the area between Bockfjorden–Loubetfjellet and Liefdefjorden. Interesting lithological features were found in the basal layers between the nonmetamorphosed upper Silurian-Devonian sediments and the underlying metamorphosed Hecla Hoek layers.

A. HEINTZ (The University of Oslo) undertook detailed investigations of the Devonian layers in the Ekmanfjorden area and in the mountains between Ekmanfjorden and Woodfjorden, and Dicksonfjorden and Austfjorden. Together with T. SIGGERUD he visited Goldschmidtfjella in St. Jonsfjorden and they found that this area, earlier being thought to be made up of rocks of Devonian age, presumably consists of Triassic layers.

H. MAJOR examined the sedimentology of the coal-bearing beds in the Longyear Mine. Later he measured several profils in the Tertiary deposits in Longyeardalen, Reindalen, Colesdalen and Hollendardalen. Some preliminary investigations of the Tertiary beds in Ny-Ålesund were also undertaken.

J. NAGY worked on the southern shores of Van Keulenfjorden, where he examined different sections in age ranging from middle Lower Permian to Lower Cretaceous. Coal-bearing beds were found at Pilsudskifjella both in Lower Cretaceous and Tertiary deposits.

D. L. J. NIEMANTSVERDRIET (Netherlands) undertook detailed investigations of the Jurassic, Cretaceous and Tertiary beds on both sides of Kjellströmdalen.

S. SIEDLECKI (Poland) examined the Middle- and Upper Carboniferous and Lower Permian sequence between Kapp Olsen and Bogevika at Bjørnøya. Later he studied the sediments at Sørkappøya and Øyrlandet. He found that in this region two different structural units occur. Sørkappøya and the southern part of Øyrlandet consist of a syncline with Permian and Triassic sediments, while the larger part of Øyrlandet is built up of Cretaceous and Tertiary layers.

W. INGEBERTSEN sampled river sediments for geochemical prospecting on the coast plains north of Blomstrandbreen towards Kapp Guissez. Later he collected river sediments on the coast between Fridtjovhamna–Ytterdalen–Orustdalen; near Ny-Ålesund; and from Kiærfjellet to the inner part of Engelskbukta.

Palaeobotany

S. MANUM (The University in Oslo) collected plant fossils (macro- and micro) in Lower Jurassic, Cretaceous and Tertiary beds on the southern and northern shores of Van Keulenfjorden, and near Penckbreen, Tirolerbreen and Zawadskibreen.

Geophysics

O. LIESTØL continued his investigations of Finsterwalderbreen, and found that even if the accumulation of snow on the glacier had been larger than usual, the regime of the glacier was about normal, because the summer had been relatively mild and humid. Recherchebreen and Nathorstbreen were examined and the latter was found to have retreated more than 200 m per year since 1962.

V. HISDAL and T. VINJE carried out meteorological investigations in Van Keulenfjorden. The spectral distribution of the scattered sky radiation was measured using a grating monochromator, and the different components of the radiation balance were recorded. The earth temperature was read regularly down to a depth of 20 cm. In addition, the programme included ordinary synoptic observations of the meteorological elements and observations of the tides.

Biology

M. NORDERHAUG continued his studies of the little auk (*Plautus alle*) and the different geese-species occuring in the Hornsund area. He ringed about 2.800 birds.

N. GULLESTAD undertook further investigation of the biology of the Spitsbergen char (*Salmo alpinus*) in Revvatnet and Revelva. In this connection he caught 242 chars, and in addition he ringed about 500 little auks.

A group of four men sent by the Norwegian National Committee for ISQY put up an earth-magnetic variometric station at Isfjord Radio, Kapp Linné. The station was going to be run the whole winter, and one of the men stayed on to look after it.

Norsk Polarnavigasjon A/S continued their explorations for oil at Brøggerhalvøya and in Grønfjorden.

Foreign expeditions

Seven foreign scientific expeditions worked in Svalbard for longer or shorter periods during the summer 1964. One of the expeditions (from DDR) was going to winter in Ny-Ålesund. In addition one private American, two private French firms and one Soviet-Russian expedition explored for oil and minerals and also carried out more general geological investigations. Several climbing and touristic expeditions visited Svalbard i 1964.

Antarctica

T. LUNDE took part as glaciologist in a South-African expedition to Bouvetøya in March–April 1964. The purpose of this expedition was to investigate the possibilities for establishing a meteorological station on this remote island. However, due to poor weather it was only possible to go on shore once, and no suitable place for a meteorological station was found.

O. DYBVADSKOG took part in an American expedition travelling with snow-cats from the South Pole to the Pole of Inaccessibility. The program for the expedition was to carry out different geophysical investigations, and DYBVADSKOG specially studied the shape and formation of the salstrugi.

Expeditions in Dronning Maud Land

South Africa, Soviet-Russia and Belgium–Netherlands each maintained one scientific wintering station in Dronning Maud Land.

Glaciology in Norway

In February O. LIESTØL started the investigations at Hardangerjøkulen and partly assisted by O. DYBVADSKOG. He later several times visited both this glacier and Storbreen in Jotunheimen. All the glaciers examined during 1964 were retreating.

Preparations of data from Svalbard

Hydrography

The work on a new edition of chart No. 503 and a new chart covering the northwest corner of Vestspitsbergen was continued. The data from the soundings in Woodfjorden, the waters around Bjørnøya and off the northwest coast of Vestspitsbergen were prepared. The data obtained by using the Hi-Fix-system were calculated.

Topography-geodesy

Trigonometrical calculations partly based on old and partly on new data were accomplished for the following regions: Mitrahalvøya, Olav V Land, Ny Friesland, Bolterdalen–Foxdalen, Albert I Land, Haakon VII Land and Andrée Land. A map of Vestspitsbergen was drawn showing the areas that are covered by air photograps. Furthermore a map in scale 1:50.000 was constructed of the Kapp Auguste Viktoria–Gråhuken area, for the use of the hydrographers. The work on a new map of Svalbard in scale 1:100.000 was initiated and during the spring two map-sheets in scale 1:500.000 covering the western parts of Spitsbergen were published.

Geology

H. MAJOR has editied the geological map of Adventdalen (scale 1:100.000) that was printed late in 1964. He has further undertaken studies of the coal from Mine 5 and the new Mine 7 in Longyearbyen. A map showing all the areas claimed by the Norwegian Government has been compiled.

T. S. WINSNES has studied and described fossils and sediments from the Carboniferous and Permian layers.

T. SIGGERUD has undertaken a study of the variation of the radioactive elements in the granites from the areas north of Kongsfjorden. Together with A. HEINTZ he has published a short paper on the occurrence of Triassic sediments in the inner part of St. Jonsfjorden.

A. HJELLE continued working up the material he collected in Ny Friesland and Olav V Land in 1963, and prepared a paper for publication. In the autumn he took up work on the Hecla Hoek rocks from the area north of Kongsfjorden.

J. NAGY made preliminary correlations between profiles of Lower Cretaceous rocks from different localities at Vestspitsbergen. He also determined some Cretaceous fossils. In a short paper, (N. P. Årbok 1963) he described a series of bottom-samples he had taken at different places along the coast of Vestspitsbergen.

N. HEINTZ wrote a paper on Mesozoic reptiles from Svalbard and Norway (N. P. Meddelelser Nr. 91). She also finished a paper on Dinosaur-footprints from Svalbard and continued her study of Devonian agnathes from Spitsbergen.

S. SIEDLECKI (Poland) undertook a study of the stratigraphical and tectonical features of Sørkappøya and the surrounding areas.

Geophysics

O. LIESTØL continued to prepare the glaciological data collected at Svalbard and Norway.

V. HISDAL wrote a short paper on the weather at Svalbard in 1963 (N. P. Årbok 1963).

T. LUNDE prepared the ice-observations from the Svalbard waters and wrote a paper on ice-conditions at Svalbard 1946–63 (N. P. Årbok 1963). From 1st of September his work has been taken over by T. E. VINJE. He published a paper on the cooling power in Norway (N. P. Årbok 1963).

Biology

N. HEINTZ this year extended and partly changed the forms for observations of fauna and flora in Svalbard. The results obtained during the summer 1963 were published (N. P. Årbok 1963).

M. NORDERHAUG continued his study of the biology of the little auks and also took up work on the present status of the pink-footed goose. During the year he has taken contact with many biologists both in Norway and abroad for getting information on the birds at Svalbard.

Preparations of data from Antarctica

Map construction

Two map in the series "Dronning Maud Land, 1:250.000" were published and two other maps in the same series were made ready for publication. In addition the construction of a map of Sør-Rondane was continued.

Meteorology

V. HISDAL published a paper on the tides at Norway Station and adjacent coastal areas of Antarctica (N. P. Skrifter No. 133). T. E. VINJE published a paper on the radiation balance and micrometeorological conditions at Norway Station (N. P. Årbok 1963) and started a study of the registrations from the meteorological tower at Norway Station.

Notiser

Periglacial features of the Østerdalsisen outwash plain, Svartisen

Abstract. Kettle holes occurring in fine sediments around the glacier dammed lake of Østerdalsisen are thought to be formed by ice blocks drifting on to the shore at times of high water in spring. Ground ice concentrations are not thought to be responsible, although there is some evidence for ground freezing in erosion terraces above the lake delta.

Introduction

Østerdalsisen, the largest and southernmost glacier of the Svartisen cap, enters the trough of Svartisdalen–Østerdalen from a col on the northern side. The heads of both valleys are joined by a basin partly occupied by the glacier, whose eastern snout over flows the eastern edge of the depression. The western snout teminates in a lake, to the west of which lie the remains of lake sediments and outwash (Fig. 1). A tunnel draining the lake was opened in 1958. The consequent lowering of the lake level from that of the outwash surface produced a disasterous effect upon the latter; drainage from the valley sides directed itself across the outwash surface towards the lake, and the resultant erosion of the unconsolidated sediments was extremely rapid.

The old outwash surface is now in an advanced state of dissection, and the whole area has a "bad-land" appearance with dry wadis, sand screes and erosion terraces. The main stream, reversed from a point at the head of Østerdalen proper, is the only permanent water course crossing the sediments, discharging on to a wide delta before entering the glacier-dammed lake. On the northern and southern side of the lake, remain irregular dumps of lake sediments, ground moraine and wash material from the valley sides. On the lake shores, the sediments are "kettled".

Periglacial features

The highly dissected deposits of sand on either side of the glacier-dammed lake possess features which resemble kettle holes. The depths of these holes are variable but rarely exceed 1 m, while the diameters at the surface can be as great as 3 m. In many cases they intersect the water table and are therefore occupied by pools. Owing to the high mobility of the sediment when wet, the form and dimensions of each hole vary with time. The continuous downward movement of sand below the water surface imparts to the hole the symmetry of an inverted cone, at the same time causing an increase in the surface diameter and a decrease in the depth. This modification of the form is further assisted by the slumping of the sediment along slide planes concentric to the hole (Fig. 2). If, as the result of the lowering of the water table, the hole becomes dry, it may suffer decay due to wind action and the flow of sand under gravity. Rain wash, too, assists the

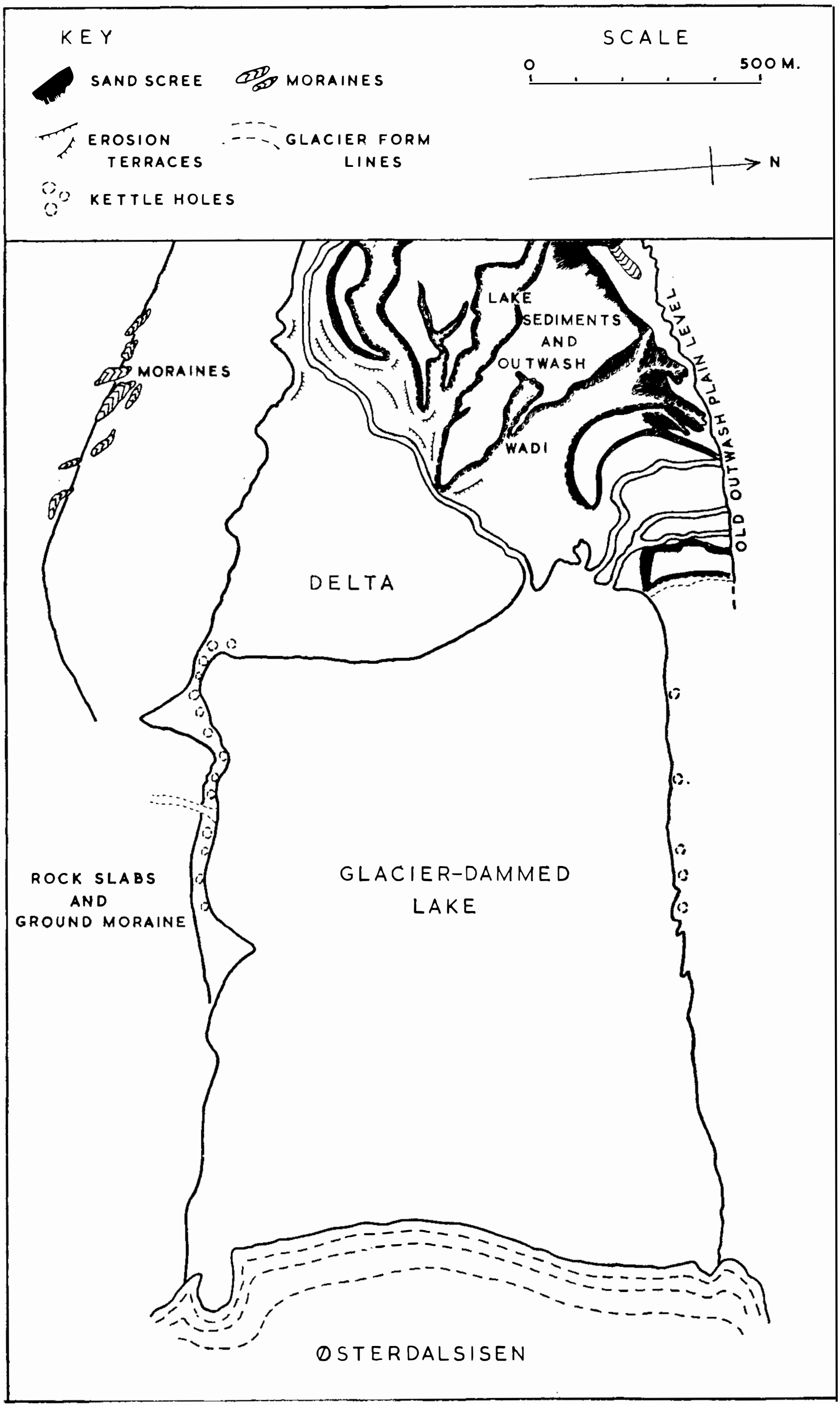


Fig. 1. *The map shows the glacier dammed lake and remains of the old outwash surface, with the positions of kettle holes and erosion terraces.*
(*Map from Cambridge Svartisen Expedition, 1963.*)

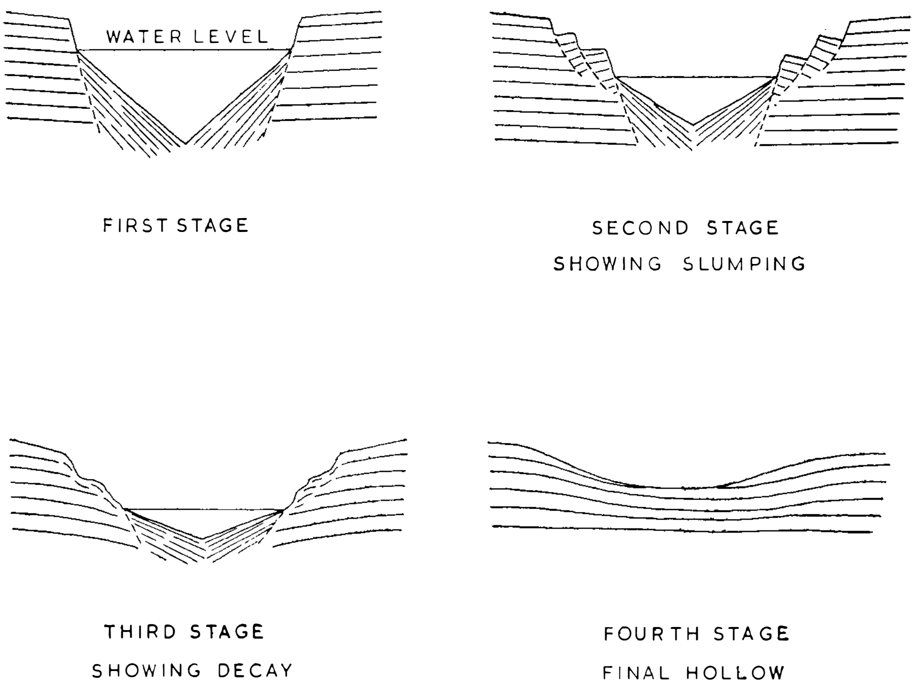


Fig. 2. *The schematic sections show the kettle holes in the process of modification.*

in-filling. Finally, the form assumed is that of a shallow basin. The total destruction of some holes can be observed in times of wet weather, when stream erosion becomes active. Those holes nearest to the lake may also be destroyed by wave action during the periodic rises in the lake level.

In all cases, the holes lie in close proximity to the lake and are rarely more than a meter above its surface. Herein lies the key to their explanation. During the rainy periods of the summer, the lake level can be observed to rise to the height of some of the holes. At the same time, blocks calving from the glacier drift towards the lake edge where they go aground. The fine sand when saturated assumes some of the properties of a clay, and its tenacious of things coming to rest in its surface. The ice blocks, then, sink into the sediment as the level of the lake is lowered once more. It may be safely assumed that, during the times of highest water levels in spring, ice blocks drift into corresponding higher levels on the shore, where the process of sinkage is the same, and the melting of the ice produces depressions, whose symmetrical shapes result from the physical properties of the sand.

The is no evidence to suggest that ground-ice concentrations are responsible for the kettling. If it were, then the holes could be expected to occur over the whole delta where the water table is at or near the surface. Furthermore, it is likely that snow cover provides an insultation against deep freezing.

Some sand and gravel structures, however, within the lower erosion terraces at the head of the delta, suggest that some ground freezing may occur in conjunction with compaction to produce microwaves and faulting in the terrace bedding. These structures appear to be unsimilar to those in the sediments at higher levels, where a type of cross-bedding is general, giving way to true varves towards the western end of the valley infill. The sand in the erosion terraces is almost always damp, and could, therefore, be subject to mild ground freezing.

Periglacial features on the old outwash surface and the occurence of fossil ice blocks within the higher lake sediments below this surface, have been described in the annual reports and theses of the Cambridge Expeditions to Svartisen of 1957 to 1964.

Bibliography

CAMBRIDGE SVARTISEN EXPEDITION: Interim reports, 1957–1964. Østerdalsisen outwash plain, formation and erosion history. Reports at: – *The Royal Geographical Society, The Scott Polar Research Institute and Norsk Polarinstitutt.*

FITZWILLIAMS, H. C., 1962: Erosional processes and features of the Østerdalsisen outwash plain, 1961 and 1962. (Unpublished student dissertation, Cambridge.)

HOLMSEN, G., 1949: En ny bredemt sjø i Svartisen. *Norsk Geogr. Tidsskr.* **12**, (4), Oslo.

LIESTØL, O., 1956: Glacier dammed lakes in Norway. *Norsk Geogr. Tidsskr.* **15**, (3–4), Oslo.

RHODES, C. R., 1960: The early effects of the Svartisdalen tunnel upon the Østerdalsisen outwash plain. (Unpublished student dissertation. Cambridge.)

THEAKSTONE, W. H., 1958: The moraines and kame terraces bordering the ice dammed lake of Østerdalsisen. (Unpublished student dissertation. Cambridge.)

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Glacial lake overflow channels, South Svartisen

Abstract. The past drainage connections, marked by four dry channels through the dividing watershed of two roughly parallel valleys, suggest that a glacier dammed lake may have existed in the higher valley at the end of the Pleistocene glaciation. This lake assumed different positions with retreat and decay of the ice dam.

Introduction

The eastern half of the Svartisen ice cap, known as Østisen, is bordered on its southern side by the trench of Svartisdalen–Østerdalen, which is a strike valley for most of its length. In the west, it is occupied by the 5 km long lake, Svartisvatn, whence the floor rises some 300 m to a low ridge below the eastern snout of Østerdalsisen, the largest glacier of Østisen, entering the trough from a col on the northern side. The valley floor then dips down below the western snout and its adjacent outwash before rising once more in a roche moutonne, which marks the head of Østerdalen proper.

To the south of the valley, lies the massif composed of Burfjell and Rausandfjell, cut in to the side of which is a kilometer wide, open valley, parallel to the main trough (Fig. 1). Its height in the west (above the Østerdalsisen outwash plain) is about 600 m, and in the east where it terminates in Mangholmvatn the height is 445 m above sea level. The longitudinal profile is quite irregular. Numerous joint controlled depressions are occupied by shallow lakes, all draining towards Mangholmvatn, whose shape also appears to be related to structure. Furthermore, in the east, the valley descends to Mangholmvatn in a series of steps. The lake itself is cut in an embayment between Burfjell on the west and Rausandfjell on the east, and its drainage system is separated from that of the Svartisdalen–Østerdalen trough by a low ridge, which at most is about 100 m, high at its eastern end above the surface of Mangholmvatn. The existence of dry channel through the ridge, especially in the east, indicate past connections between the Mangholmvatn drainage system and that of the main trough.

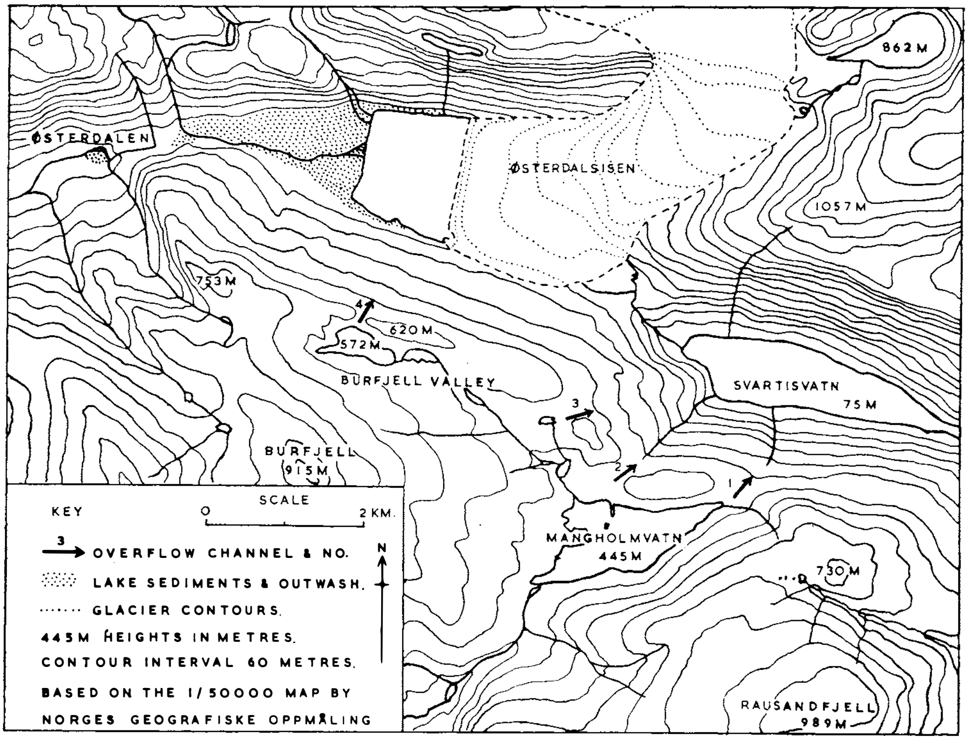

Fig. 1. *Map showing the positions and text numbers of the overflow channels.*

Mangholmvatn

Mangholmvatn and Svartisvatn now lie about 100 m and 500 m respectively below the level of their dividing water-shed, which is breached in two places by dry channels, (Fig. 2). Two other channels occur through the continuation of the water-shed to the west, ie: between the Burfjell valley and the main trough. The slopes of all the channels are downwards to the main trough.

Channel 1 (Figs. 1 and 2), lying between the eastern apex of Mangholmvatn and a point about 1.5 km from the head of Svartisvatn, is poorly defined. However, the sounding of Svartisvatn indicated the existence of a large fan of debris below the channel and reaching the floor of the lake. This suggests a considerable flow of water over that the part of the water-shed eroding along the line of the Mangholmvatn–Svartisvatn thrust (Fig. 2). The highest point in the floor of channel 2 is accordant with that of channel 1. This second channel, between the north-western corner of Mangholmvatn and the head of Svartisvatn, is very much more pronounced, with a depth of about 30 m and a width of about 60 m, also indicating a large flow of water (Fig. 3). The slope of the floor is downwards to Svartisvatn.

Channel 3 similarly enters the head of Svartisdalen from the eastern end of the Burfjell valley, and is approximately 100 m higher than channel 2. Channel 4 occurs at the western end of the high level valley, and is again higher than channel 3. All follow main lines of weakness in the schist.

For these channels to operate, it was necessary for a reservoir to exist on the southern side of the water-shed. Hence there are two possibilities; the channels were either formed by melt water from an ice mass on Burfjell higher than that on the northern side of the water-shed, or by overflows from a lake which as-

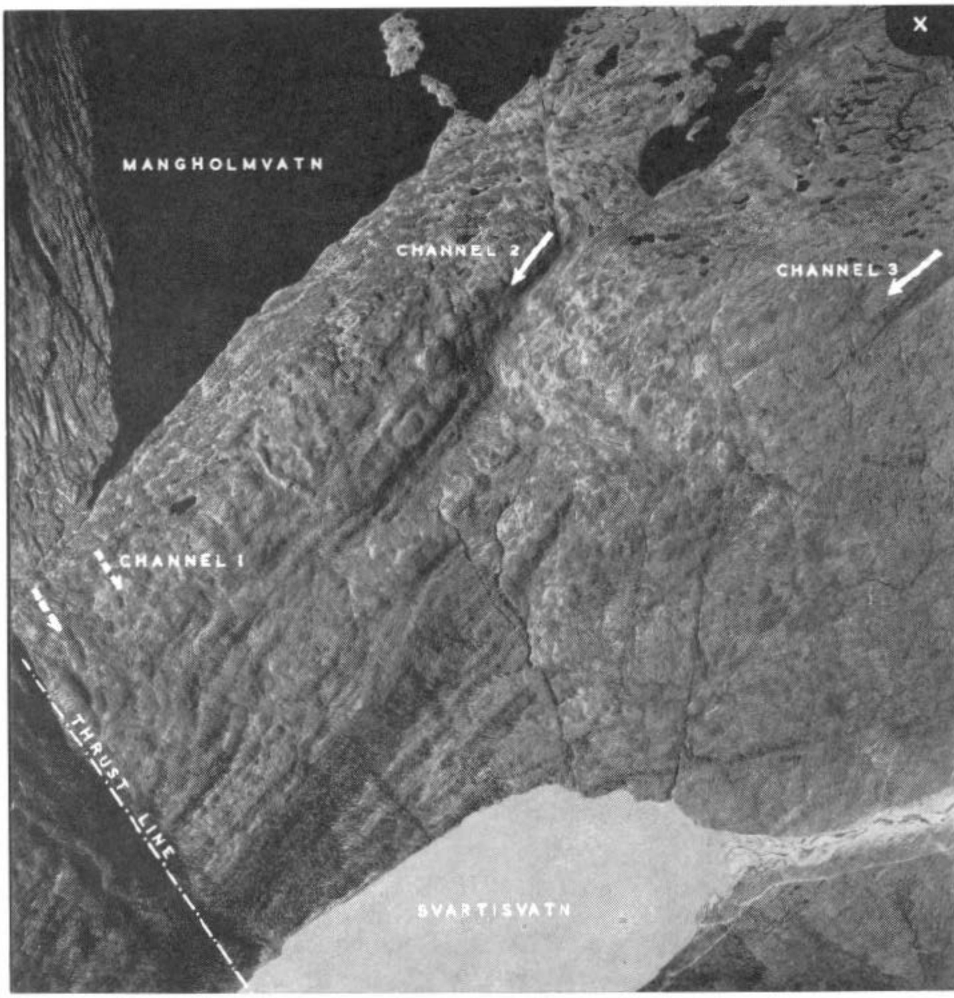

Fig. 2. *Vertical photograph showing channels 1, 2 and 3 (arrows), and the line of the Mangholmvatn–Svartisvatn thrust. (Photograph by permission of Widerøes Flyveselskap.)*

sumed different position and levels on Burfjell during the retreat of the last ice sheet.

It is, in fact, unlikely that a higher ice mass occurred on Burfjell than occurred in the main trough. The striae to the northwest and west of Mangholmvatn indicate that the flow direction of the ice at the end of the Pleistocene was southwards from the centre of Østisen. O. T. GRØNLIE (1940) has also found evidence for this outward movement in the north and east of Svartisen. We may infer, therefore, that the slope of the ice surface was downwards from the centre of the cap to Burfjell. Vertical wasting of the surface would result in the emergence of Burfjell and Rausandfjell, followed by that of the Mangholmvatn–Svartisdalen water-shed. At this point, the ice mass in the main trough would have been, if anything, higher than that remaining on Burfjell. It could be expected, therefore, that melt water might flow across the water-shed from the north to the south; hut the slope of the channels shows that this was not so.

The existence of ice-dammed lakes in the Burfjell valley is more probable.

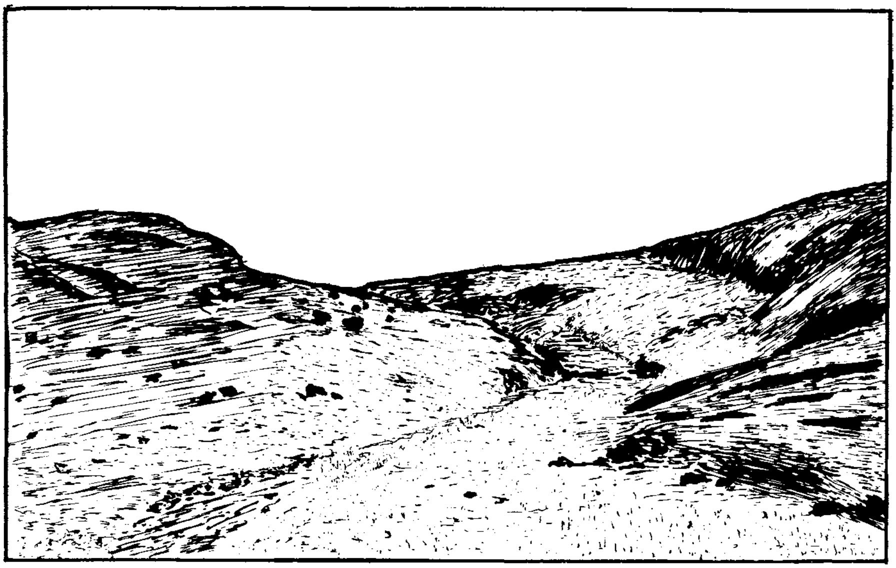

Fig. 3. *Channel 2 seen from the north side of the watershed. (Drawn from a photograph.)*

During the down-wasting of the last ice sheet, the western end of the valley would have emerged first, and any drainage would have been dammed up in the valley head by retreating ice. Channel 4 would undoubtedly have been formed at this time as an outlet from the lake. With further downwastage of the Burfjell ice, the glacier dammed lake would have migrated eastwards, finding outlets wherever structural weaknesses in the water-shed permitted. Finally, the lake is thought to have assumed a position along the north shore of Mangholmvatn between the ice and the water-shed. At this stage, channels 1 and 2 were in operation until the ice dam was lowered sufficiently for drainage to take place down Stillelvdalen to the south.

A higher ice mass on the north side of the water-shed would not necessarily have prohibited the flow of water from the south. Indeed, the debris below channel 1 and the meanders on the lower part of channel 2 suggest very strongly that water disappeared beneath the ice in the main valley.

Bibliography

GRØNLIE, O. T., 1938–39: Some remarks on the land area in Nordland between the glacier Svartisen and the frontier. *Norsk Geogr. Tidsskr.*, **7**, (5–8), Oslo.

— 1940: Traces of the ice age in Nordland, Troms. *Norsk Geol. Tidsskr.* **20**, (1–2), Oslo.

Cambridge Svartisen Expedition: Interim Reports 1959 to 1964. Reports at: *The Royal Geographical Society, The Scott Polar Research Institute* and *Norsk Polarinstitutt.*

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A note on the occurrence of eclogites in Spitsbergen

Abstract. Eclogites have been located in association with hornblendic and feldspathic gneisses, marbles, pelites, psammites and metadolerites, in the area between Raudfjorden and Breibøgen North Haakon VII Land, North Vestspitsbergen. Analyses of a coexisting garnet and clino-pyroxene, are tabulated, along with an estimation of the whole rock composition calculated from the mode.

Eclogities were located during an investigation of the metamorphic Hecla Hoek rocks of North Haakon VII Land, North Spitsbergen, while the author was a member of the Cambridge Spitsbergen Expedition under the direction of W. B. HARLAND.

The eclogites are interbanded with marbles, and hornblendic and feldspathic gneisses. These rocks are contained in a sequence of garnetiferous pelites and psammites, the former containing small amounts of kyanite and staurolite. Quartz lenses carrying andalusite, kyanite and staurolite, occur in the pelites and psammites. Subordinate amounts of amphibolite occur in the lower part of the pelitic sequence. These banded and lenticular masses contain poecilitic garnet and give no fabric evidence of retrogression from eclogite. Metadolerites, with well developed garnet corona textures, occur in the gneissose rocks both concordantly and discordantly to the dominant gneissosity.

The eclogites occur as lenticular masses up to c. 20 m in minimum diameter, and lying with their long axes parallel to the gneissosity in the adjacent rocks. Location of the eclogites in particular horizons within the gneissosity is indicative of greater continuity of the masses prior to boundinage, of which there is abundant evidence in the neighbourhood. All the eclogites show some degree of alteration, with marginal amphibolitisation and an induced foliation concordant with the adjacent gneissosity. Hornblende pods containing relic garnet, clino-pyroxene and diopside-plagioclase symplectite commonly occur in the gneisses.

The primary assemblage of the eclogites is essentially bimineralic, being made up of coarse-medium grained anhedral garnet and pale green clino-pyroxene. Rutile and quartz are typical accessory minerals. Although some semblance of compositional banding has been detected in some of the eclogite masses, no preferred orientation of the mineralogy has been noted.

Table 1. *Estimated composition of the Richardvatnet eclogite, (E952) and analyses of its major constituents.*

	A	B	C
SiO_2	42.0	38.10	51.97
Al_2O_3	14.9	20.89	4.72
Fe_2O_3	3.1	1.77	4.54
FeO	16.5	24.32	5.54
MnO	0.2	0.33	0.02
MgO	6,4	4.27	10.89
CaO	13.7	10.53	19.57
Na_2O	0.8	nil	2.82
K_2O	+	nil	0.04
H_2O	0.1	nil	nil
TiO_2	2.3	0.09	0.44
	100.0	100.30	100.55

A. Estimated whole rock composition of *E952.*
B. Garnet analysis (J. H. SCOON) Alm. 53.4, Py. 16.6, Spess.0.7, Gross. 24.4, And. 4.9.
C. Clino-pyroxene analysis (J. H. SCOON) Di. 55, Hd. 17, Tsch. 8, Jd.+Ac. 20.
Density of garnet 3.97 ± 0.01 and clino-pyroxene 3.389 ± 0.003 (by L. DAVIDSON.)

The garnet and clino-pyroxene from one of the least altered eclogites were analysed by J. H. SCOON (Table 1), and from these, the densities, and the mode (Table 2), an estimate of the whole rock composition was obtained.

Table 2. *Mode (vol. per cent) of the Richardvatnet eclogite (E952).*

Clino-pyroxene	30.1
Garnet	55.3
Hornblende	6.6
Quartz	0.1
Rutile	1.6
Sphene	3.4
Epidote	2.6
Opaque mineral	0.1
Carbonate	0.2
	100.0

3,200 points were counted on three thin sections.

From within the Caledonian of Norway, Great Britain and East Greenland, the only eclogite of comparable composition occurs in Loch Duich, Scotland (YODER and TILLEY 1962). This has been compared with the iron rich olivine tholeiites of Skaegaard and Beaver Bay.

Reference

YODER, H. S. and C. E. TILLEY, 1962: Origin of Basalt Magmas: An Experimental Study of Natural and Synthetic Rock Systems. *J. Petrol.* **3** (3), 342–532. London.

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Remarkable tracks form Vestspitsbergen

The summer of 1964 I spent about 20 days in Ekmanfjorden, Vestspitsbergen, collecting Devonian fossils. During an excursion to one of the sidevalleys to Ekmandalen, between Rättvikfjellet and Leksandfjellet, we came to a small, mostly dry, brook, which was situated about 5 km from Ekmandalen and about 100 m a.s.l. The bottom of the brook, between the stones, was still moist, with expressed current-marks (Fig. 1A) but without sun-cracks.

In one place at the bottom we discovered an abundance of remarkable tracks, spread over a relatively limited area – about 2,500–3,000 cm^2. The tracks covered the bottom mud as a close, irregular plexus. They ran up and down on the uneven bottom in all directions and commonly crossed each other. In some places it seems that the tracks started from minute dimples in the mud.

The shape of the tracks was very remarkable – they composed an unbroken, regular, zig-zag-formed line. On the photographs the shape of the tracks is, unfortunately, not especielly clearly seen, as only one side of the zig-zag line is strongly illuminated by the sun. Therefore it seems that the tracks are composed of regular rows of isolated, short impressions. One can, however, clearly see the real character of the tracks on Fig. 1B to the right of the match. On the same photograph one can get an impression of the real size of the tracks, compared with the size of the match, which is about 55×2 mm,

I have never seen any similar tracks before and am very interested to know if any zoologists know what kind of animal that has made them?

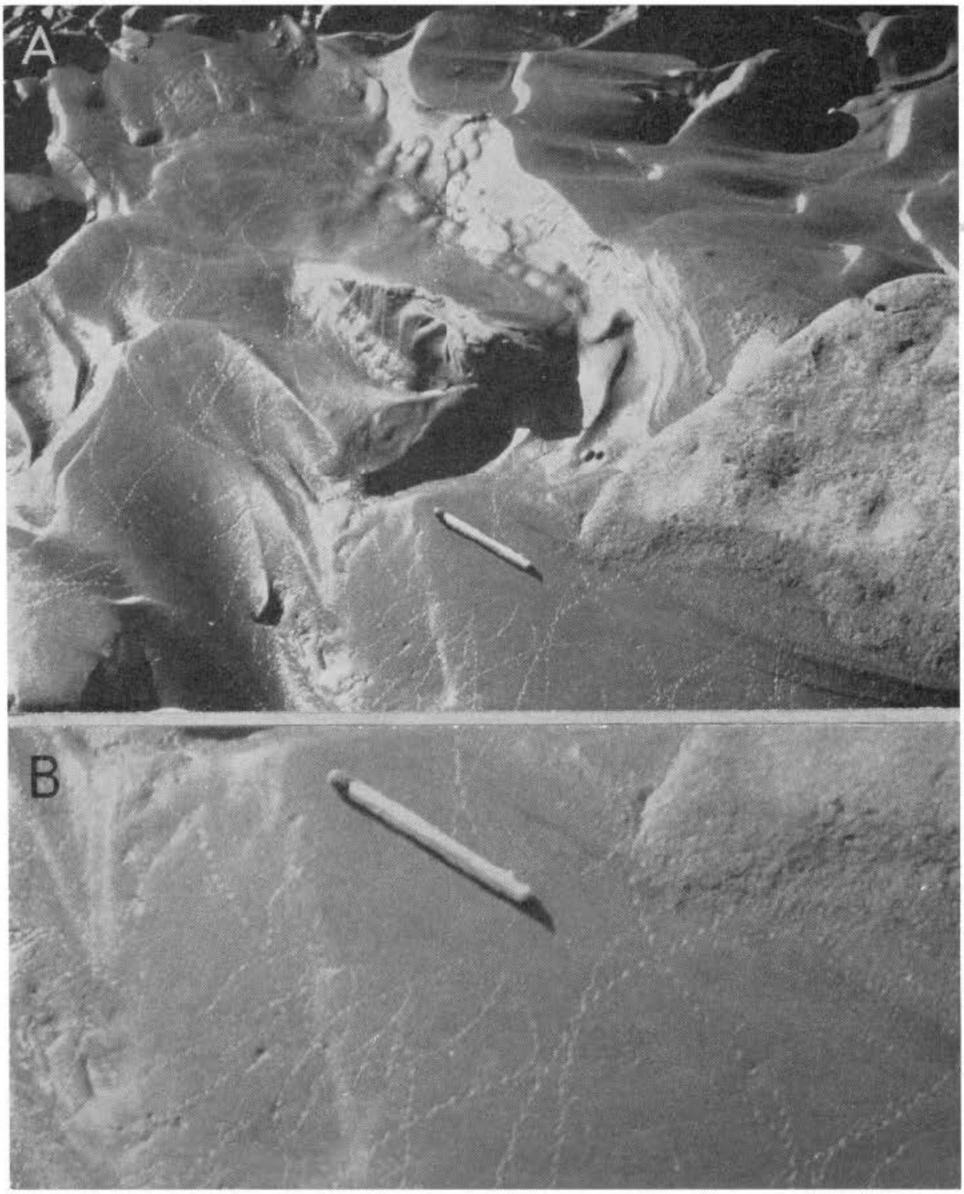

Fig. 1. A. *General view of the brook-bottom with current marks and tracks. The length of the match is about 55 mm.*
B. *Lower part of A anlarged to show more clearly the pattern of the tracks. The breadth of the match is about 2 mm.* Photo: P. SCHELLENBERG.

Theoretically it is very difficult to imagine an animal that *could* make such a single zig-zag track-line. The tracks do not appear in pairs and thus could not be made by feet from the right and left side of the body. They are too regular to be made by a worm. The lines are unbroken and very regular and I can hardly understand how such a remarkable track-pattern can come into existence.

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Paleontologisk Museum, Universitetet i Oslo.

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