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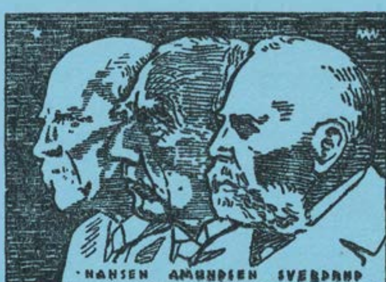

NORSK POLARINSTITUTT
OSLO 1965

DET KONGELIGE DEPARTEMENT FOR INDUSTRI OG HÅNDVERK

NORSK POLARINSTITUTT

Middelthuns gate 27 b, Oslo 3, Norway

Short account of the publications of Norsk Polarinstitutt

The two series, Norsk Polarinstitutt — SKRIFTER and Norsk Polarinstitutt — MEDDELELSER, were taken over from the institution Norges Svalbard- og Ishavs-undersøkelser (NSIU), which was incorporated in Norsk Polarinstitutt when this was founded in 1948. A third series, Norsk Polarinstitutt — ÅRBOK, is published with one volume per year.

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ÅRBØKER

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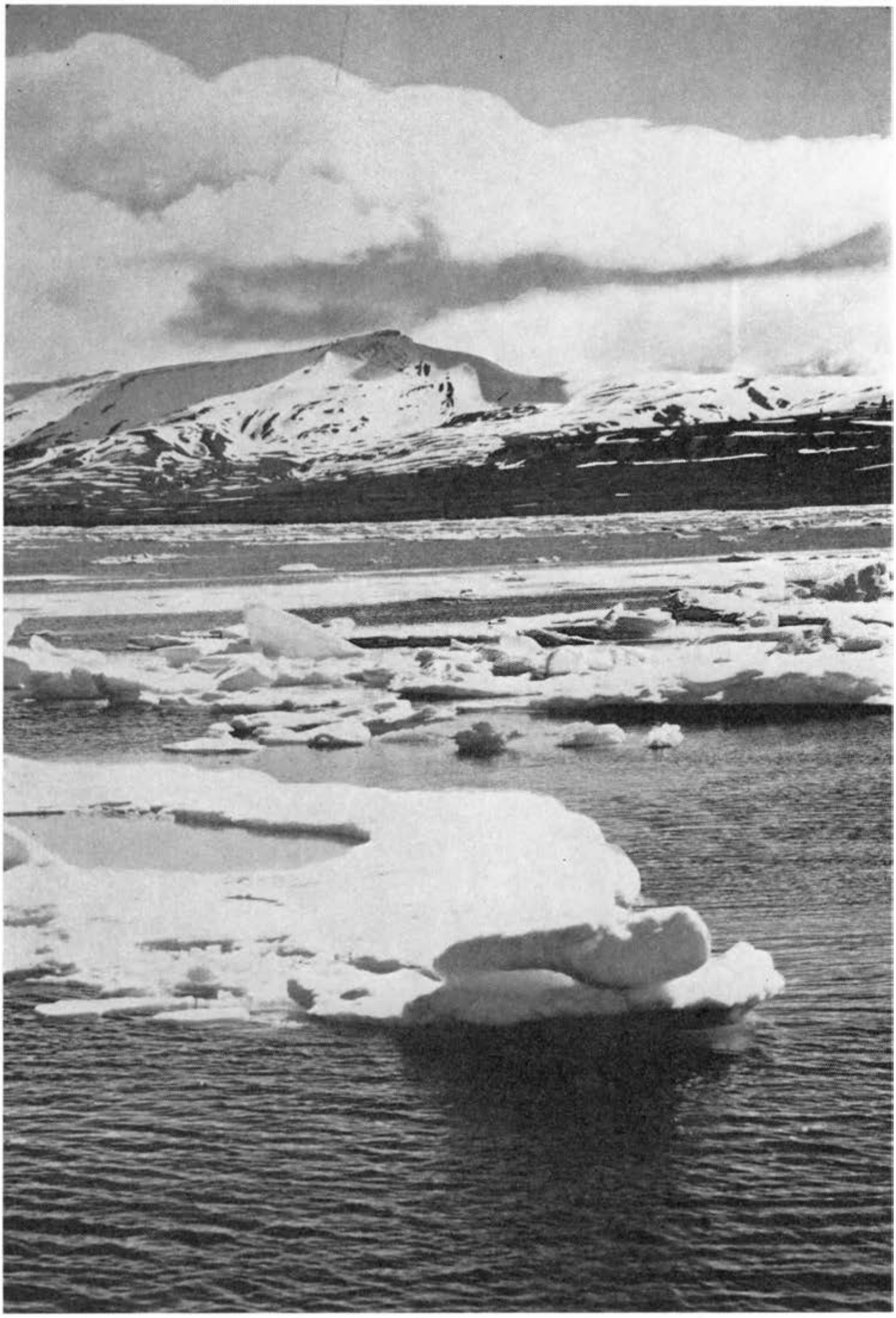

Vardåsen i Grønfjorden er ennå dekket av snø, men fjordisen er i ferd med å gå opp og i lavlandet er det blitt bart. Det er slutten av juni og like før den korte, hektiske Svalbardsommeren er et faktum.
Foto: T. SIGGERUD

Innholdsfortegnelse

DEN NORSKE ANTARKTISEKSPEDISJONEN, 1956–60
SCIENTIFIC RESULTS NO. 7

On the firn temperatures and glacier flow in Dronning Maud Land

BY

TORBJØRN LUNDE[1]

Abstracts

Ice shelf temperatures were measured down to 72 m at Norway Station. In the depth interval from 35 to 50 m the temperature varied from –18.45 to –18.50° C which is thought to be very near the "normal" mean air temperature in this region. Below this the temperature increases gradually to –18.31° C at 72 m depth. This is obviously caused by the heating from the sea underneath the ice shelf which is here a little less than 400 m thick.

During the stay of the expedition in the Antarctica there was a continous increase of the mean temperature in the upper firn layers. From the surface to 10 m depth this increase amounted to 1.06° C on an average.

The relative flow of Fimbulisen is measured in an area of 60 km² (A Fig. 1). There is found a mean compression of $0.6 \cdot 10^{-3}$ m/m · year in direction 127–327^{g}. The flow component normal to this direction (27^{g}) increases by $1.208 \cdot 10^{-3}$ m/m · year in direction 127^{g}.

The final calculation of the absolute flow measurements has not yet been done. Preliminary calculations, however, indicate that the absolute flow is very small, probably less than 20 m/year. From this it is found that the total sum of melting at the bottom of the ice shelf and the material balance must be at least 0.638 m of ice or 0.585 m of water.

The mean surface flow at Bakhallet, Slithallet and Lundebreen in Fimbulheimen, the mountain range south-east of Norway Station, was found to be 16.0, 2.9 and 38.0 m/year respectively (B Fig. 1). Estimating upper and lower values for the mean thickness of these ice streams as well as for the other 9 glaciers draining the inland ice in the same region and upper and lower limits for the flow of the last mentioned 9 glaciers, the northward transport of ice between Terningskarvet (2°45′ E) and Gessnertoppen (6°45′ E) is roughly estimated to equal between 1075 and $480 \cdot 10^{6}$ m³ of water a year.

Estimating upper and lower values for the accumulation south of Fimbulheimen as well, maximum and minimum values for the area of Wegenerisen drained through this part of Fimbulheimen has been calculated to be 9157 and 2753 km² respectively. This clearly shows, what is also seen from the topography (LUNDE 1961, p. 7) that this part of Fimbulheimen acts like a dam to the inland ice forcing the main part of the areas to the south to be drained through the larger ice streams to the west and east.

[1] Mandal, Norge.

Introduction

The glaciological work of Den Norske Antarktisekspedisjonen, 1956–60, consisted of measurements of accumulation and temperature in Fimbulisen and flow of Fimbulisen and three inland ice streams. In an earlier paper the geomorphology and the accumulation in these parts of Dronning Maud Land have been discussed (LUNDE 1961). In the present paper a brief presentation of the other data collected in Antarctica is given.

Comparing aerial photographs from the German Antarctic Expedition 1938–39 (RITSCHER 1942) with those taken by BERNHARD LUNCKE on the Norwegian expedition (LUNCKE 1960), no difference in the position of the snow level can be traced. No further proofs for the balance of the glaciation in Dronning Maud Land will be supplied, as this has been shown by other authors (LIESTØL 1954, SCHYTT 1961).

Temperature measurements in the ice shelf at Norway Station

General remarks

The boring in the ice shelf at Norway Station was done with an electric hot point drill. The energy loss of the power cables was, however, not sufficient to prevent the water above the hot points from freezing, and consequently this had to be hoisted up in a narrow metal cylinder.

One after another of the five hot points were lost either by shortcircuiting, or they froze fast as the meltwater refroze above the hot points. This caused us to start the boring operations twice. The last drill froze fast at a depth of 74 m on the 23rd of June 1958 and put an end to all further attempts to reach greater depths for temperature measurements of the ice shelf.

The calibration of the thermistors was done in the meteorological hut during a period of strong winds and small radiation values. Zero was fixed in a mixture of snow and water.

Firn temperatures were measured in the upper 10 m from April 1957 to December 1959, between 10 and 20 m from April 1957 to December 1958 and between 20 and 72 m from July to December 1958.

After having worked for some time with the temperature observations it was evident that, although the calibrations were made as accurately as possible, the results were not as good as expected. Corrections up to 0.25° C were then made to 10 of the 20 thermistors used, so that the mean temperatures fitted well into a smooth curve.

Temperatures

Using the corrected values, temperature – depth curves were drawn for every month, and the temperatures at fixed depths were found. These values, as well as the mean air temperatures – measured in the meteorological hut some 2 m above the ground – are given in Table 1. The annual temperature variations at 2, 5, 10,

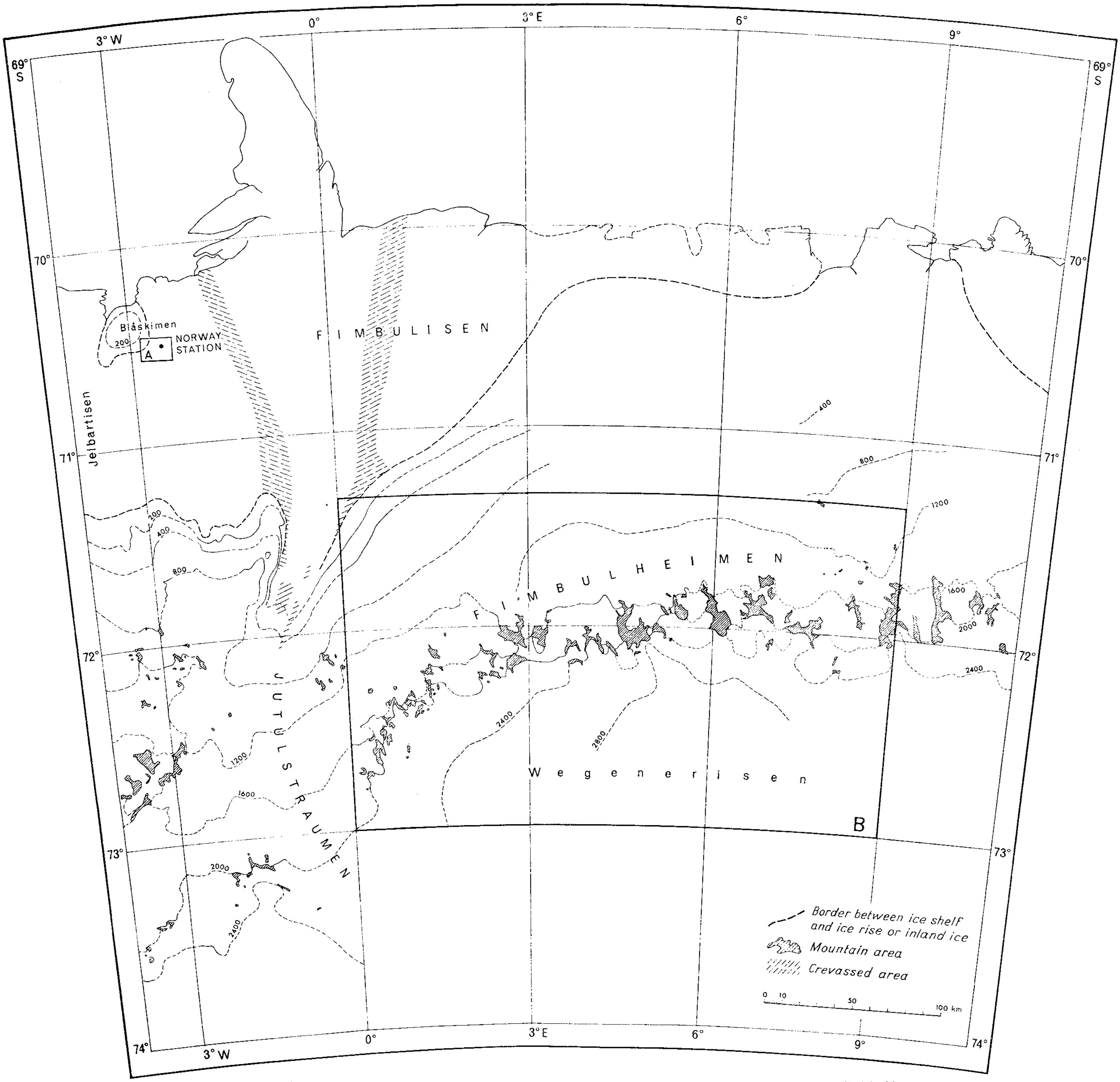

Fig. 1. *The part of Dronning Maud Land visited by Den Norske Antarktisekspedisjonen, 1956–60.*
Inset: A. Area covered by Fig. 6.
B. Area covered by Fig. 11.

Table 1. *Monthly mean temperatures at different depths in the firn at Norway Station*

(Estimated values in brackets.)

Time	Air temp.	1 m	2 m	3 m	4 m	5 m	6 m	8 m	10 m	12 m	15 m	20 m
1957 April	16.25	(14.20)	14.22	14.03	14.56	15.52	16.78	18.20	18.59	18.49	18.30	(18.28)
» May	22.86	(17.39)	16.07	15.37	15.41	15.76	16.43	17.81	18.32	18.39	18.36	(18.30)
» June	17.55	(19.75)	18.06	17.21	16.69	16.57	16.72	17.50	18.05	18.26	18.32	(18.30)
» July	26.71	(20.00)	18.29	17.51	17.39	17.14	17.05	17.37	17.91	18.17	18.34	18.34
» August	26.99	24.94	21.27	19.34	18.38	17.87	17.62	17.42	17.79	18.09	18.32	18.34
» September	28.45	28.08	23.82	20.72	19.48	18.73	18.29	17.50	17.72	17.96	18.26	18.34
» October	19.31	22.95	22.52	21.37	20.40	19.51	18.84	17.66	17.74	17.89	18.12	18.30
» November	12.75	19.57	20.64	20.90	20.24	19.78	19.28	18.00	17.79	17.84	18.09	18.27
» December	5.32	12.80	17.17	19.02	19.37	19.40	19.21	18.18	17.88	17.86	18.01	18.21
1958 January	3.49	6.69	11.71	16.00	17.54	18.36	18.71	18.54	18.15	18.02	18.04	18.18
» February	9.35	7.50	10.17	13.65	15.56	16.92	17.70	18.46	18.33	18.14	18.06	18.16
» March	11.65	10.23	11.06	12.69	14.22	15.67	16.80	18.32	18.32	18.21	18.11	18.14
» April	20.35	15.48	13.76	12.79	13.60	15.04	16.07	17.82	18.14	18.16	18.08	18.14
» May	22.52	19.15	17.31	15.69	15.11	15.51	15.99	17.21	18.00	18.11	18.08	18.13
» June	23.15	20.90	19.24	17.89	16.82	16.40	16.36	16.98	17.80	18.04	18.09	18.14
» July	25.15	21.30	19.92	18.67	17.68	17.16	16.90	16.96	17.69	17.93	18.07	18.14
» August	26.59	23.41	21.50	19.93	18.63	17.88	17.47	17.25	17.63	17.85	18.05	18.15
» September	25.20	24.74	22.84	20.87	19.56	18.66	18.02	17.52	17.64	17.80	18.04	18.14
» October	15.41	20.78	21.84	21.06	20.05	19.23	18.51	17.79	17.76	17.80	18.04	18.12
» November	9.65	15.61	18.63	19.24	19.40	19.10	18.70	17.96	17.84	17.85	17.94	18.12
» December	7.10	13.16	15.60	17.11	17.97	18.26	18.30	18.00	17.94	17.88	17.89	18.08
1959 January	4.61	8.32	12.26	14.54	16.26	17.19	17.72	17.92	(17.95)			
» February	8.05	8.02	10.47	12.44	14.34	15.85	16.77	17.68	(17.85)			
» March	16.08	12.26	11.36	12.17	13.39	14.71	15.79	17.00	(17.52)			
» April	15.80	16.23	14.66	14.08	14.27	14.74	15.44	16.68	(17.25)			
» May	18.02	15.22	14.91	15.05	15.13	15.05	15.37	16.22	(16.85)			
» June	22.30		16.04	15.57	15.47	15.44	15.67	16.14	(16.58)			
» July	21.66		18.13	17.07	16.27	15.86	15.92	16.19	(16.49)			
» August	23.28		18.98	18.01	17.20	16.71	16.43	16.27	(16.48)			
» September	28.50		21.22	19.40	18.25	17.35	16.75	16.40	(16.54)			
» October	17.18		21.28	20.09	19.14	18.10	17.35	16.82	(16.72)			
» November	11.80		18.98	19.14	19.13	18.42	17.78	17.13	16.83			
» December (1–15)	7.10		16.84	17.66	18.39	18.21	17.83	17.28	16.96			

15 and 20 m depth are shown in Fig. 2. The amplitudes in these depths are respectively some 12, 4, 1, 0.2 and 0.0° C.

Under constant climatic conditions the temperature variation-curves are fairly near sinusoidal curves, and their constants can be computed by harmonic analysis (Schytt 1960, pp. 161–163). Table 1 and Fig. 2 show, however, that the temperature in the firn at Norway Station did not vary in this "normal" way as the mean values at a certain depth one month is not repeated at the same month the next year. The 1957 values are usually the lowest and the 1959 values the highest ones.

This is better illustrated in Table 2 where running yearly mean temperatures are given. The values for the air and for 2, 5, 10, 15 and 20 m depth are also given in Fig. 3. Even these mean temperatures of the air and the upper firn layers vary in an irregular way, these variations, however, have almost disappeared at 5 m depth. Increasing temperatures were found at all levels down to 20 m in the time-

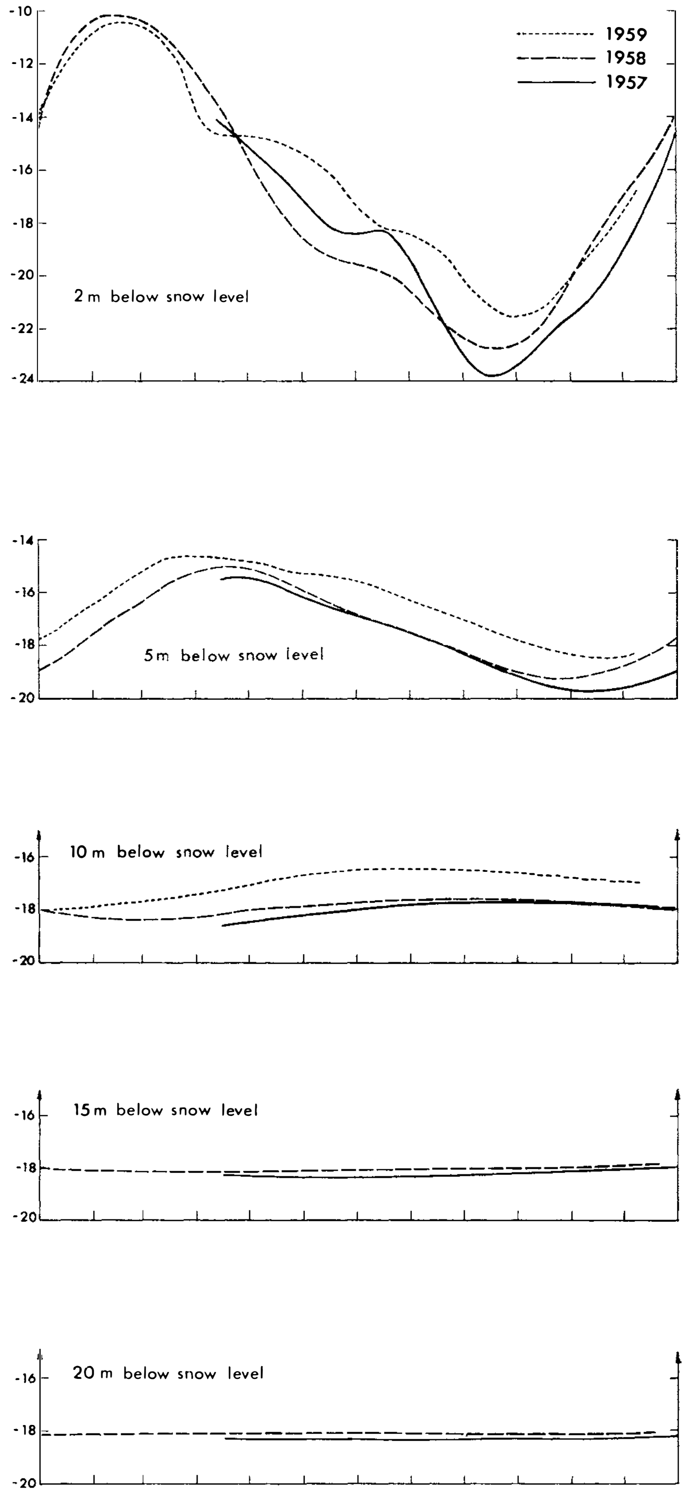

Fig. 2. *Monthly mean temperatures at Norway Station.*

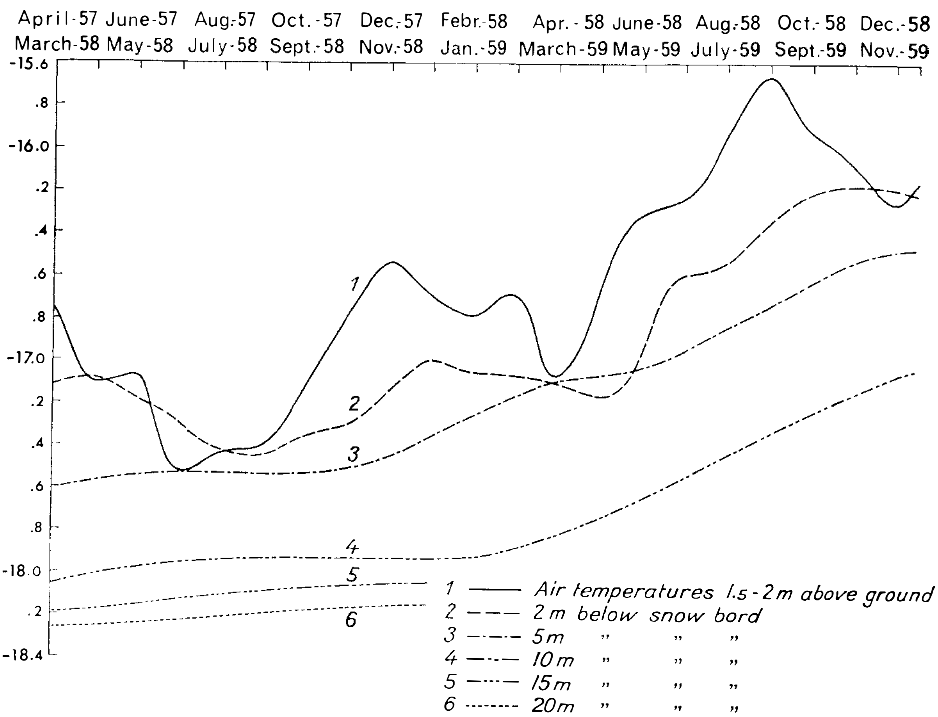

Fig. 3. *Running yearly mean temperatures at Norway Station.*

Table 2. *Running yearly mean temperatures at different depths in the firn at Norway Station*

Time	Air temp.	1 m	2 m	3 m	4 m	5 m	6 m	8 m	10 m	12 m	15 m	20 m
April -57–March -58	16.76	17.02	17.12	17.29	17.45	17.61	17.79	17.91	18.05	18.11	18.19	18.26
May » –April »	17.10	17.13	17.09	17.19	17.37	17.57	17.73	17.88	18.01	18.08	18.18	18.25
June » –May »	17.07	17.28	17.18	17.22	17.35	17.55	17.69	17.83	17.98	18.06	18.15	18.24
July » –June »	17.53	17.37	17.29	17.28	17.36	17.53	17.66	17.79	17.96	18.04	18.13	18.22
Aug. » –July »	17.43	17.48	17.42	17.37	17.38	17.53	17.65	17.75	17.94	18.02	18.11	18.21
Sept. » –Aug. »	17.40	17.38	17.44	17.42	17.40	17.54	17.64	17.74	17.93	18.00	18.09	18.19
Oct. » –Sept. »	17.13	17.10	17.36	17.44	17.41	17.53	17.61	17.74	17.92	17.99	18.07	18.18
Nov. » –Oct. »	16.80	16.92	17.30	17.41	17.38	17.51	17.59	17.75	17.93	17.98	18.06	18.16
Dec. » –Nov. »	16.54	16.59	17.14	17.27	17.31	17.45	17.54	17.75	17.93	17.98	18.05	18.15
Jan. -58–Dec. »	16.69	16.63	17.00	17.11	17.19	17.35	17.46	17.73	17.93	17.98	18.04	18.14
Febr. » –Jan. -59	16.79	16.76	17.05	17.03	17.09	17.25	17.38	17.68	17.92			
March » –Febr. »	16.69	16.80	17.07	16.94	16.99	17.17	17.31	17.62	17.88			
April » –March »	17.07	16.98	17.10	16.89	16.92	17.09	17.22	17.51	17.81			
May » –April »	16.69	17.04	17.17	17.00	16.97	17.07	17.17	17.41	17.74			
June » –May »	16.31	16.71	16.97	16.95	16.97	17.03	17.12	17.33	17.64			
July » –June »	16.24		16.60	16.75	16.86	16.95	17.06	17.26	17.54			
Aug. » –July »	15.94		16.55	16.62	16.74	16.84	16.98	17.19	17.44			
Sept. » –Aug. »	15.66		16.34	16.46	16.62	16.74	16.89	17.11	17.34			
Oct. » –Sept. »	15.93		16.21	16.34	16.51	16.63	16.78	17.02	17.25			
Nov. » –Oct. »	16.08		16.17	16.25	16.44	16.53	16.68	16.94	17.16			
Dec. » –Nov. »	16.26		16.19	16.24	16.41	16.48	16.61	16.87	17.07			
Dec. 18. 58–Dec. 17. 59	16.16		16.21	16.24	16.42	16.47	16.59	16.84	17.04			

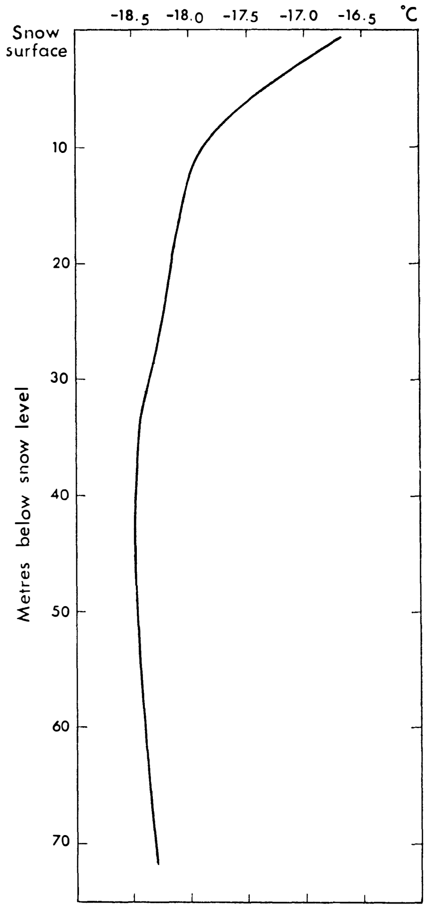

Fig. 4. *Temperature – depth curve 1958 at Norway Station.*

period studied in the present work.[1] Between 2 and 10 m this temperature increase amounted to 1.06° C on an average.

Using the mean temperature for 1958 for the upper 20 m and the mean temperature for the period July–December 1958 at greater depths, the tempera-ture – depth curve is drawn (Fig. 4).

The high temperatures found above the 35 m level are due to a heat wave, the age of which is estimated at about 9 years by the method of SCHYTT (1960, p. 166). We have estimated an accumulation of 7 m of firn during the n/2 years the heat wave has taken to reach a depth of 35 m below the snow surface. The warm period should thus have started in 1949. Neither the measurements, nor the methods of computation are accurate enough to carry out any comparison between the above and the findings of SCHYTT in the Maudheim area (SCHYTT 1960, p. 166, 167).

In the depth interval from 35 to 50 m the temperature is nearly constant, –18.47

[1] Even the thermistor at 29 m depth showed a slight temperature increase of 0.07°C throughout the period it was used, July–December 1958, but at 34 m depth there was no recognizable temperature variation.

to –18.49° C. These values are probably very near the mean air temperatures for this region before the heat wave, described above, started. Another explanation is that, it is the low temperature of the colder regions to the south which is preserved as the ice shelf flows northward. As the flow of ice is very slow in this area this seems, however, very unlikely to be the cause.

Below 50 m the temperature increases gradually to –18.31° C at 72 m depth. This is obviously the effect of heating from the warm sea water (some –1.8° C) underneath the ice shelf which is here a little less than 400 m thick.

Heat balance

On the basis of temperature – depth curves for the first of each month and using the equation for the variation of specific weight with depth: $s = 0.452 + 0.0106\ h$ (LUNDE 1961, p. 14), the heat gain or loss for the upper 10 m of firn for every month from April 1957 to December 1959 is calculated. The values are given in Table 3 and Fig. 5.

The temperatures at 1 m depth are estimated for the last 8 months. The values for 1st January 1960 are extrapolated 14 days (the last measurements of firn temperatures were carried out on the 17th of December 1959).

For the surface layers the air temperatures are used. These, however, are measured 1.5–2.0 m above the ground, and the corrections given by LILJEQUIST (1957, p. 277) are added. As stated before (p. 12) there has been a marked heating of the firn layers for the whole period (the heat gain the first complete year, April 1957–March 1958, is 113 cal/cm²).

The gain or loss of snow by sublimation is found to be very small (LUNDE 1961, pp. 34–36). However small, the liberated heat from a net accumulation of hoar

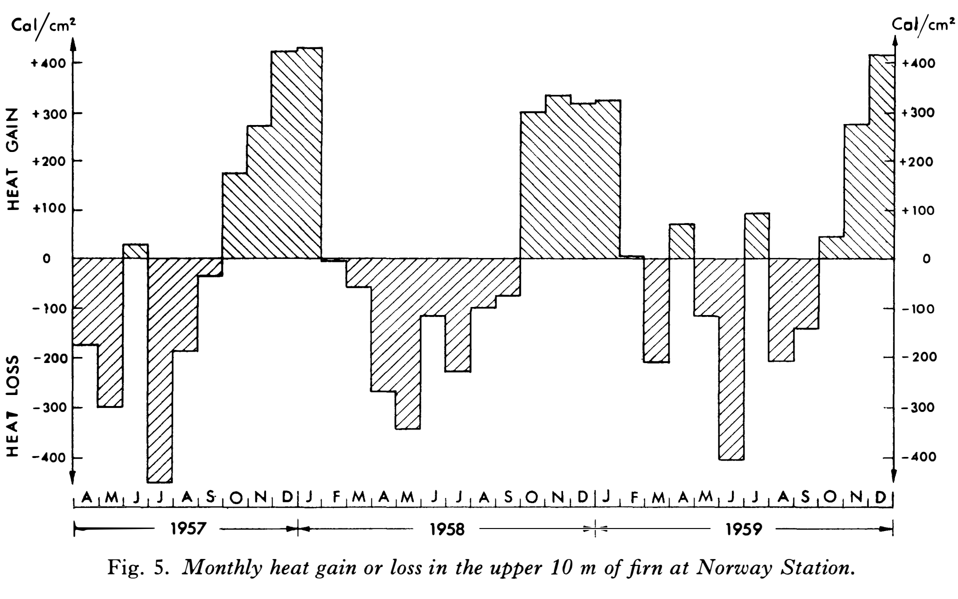

Fig. 5. *Monthly heat gain or loss in the upper 10 m of firn at Norway Station.*

Table 3. *Monthly heat gain or loss per cm² from the upper 10 m of firn at Norway Station*

	1957		1958		1959	
	Heat deficit (cal/cm²)	Heat gain or loss (cal/cm²)	Heat deficit (cal/cm²)	Heat gain or loss (cal/cm²)	Heat deficit (cal/cm²)	Heat gain or loss (cal/cm²)
Jan. 1			4700		4511	
				+429		+324
Febr. 1			4271		4187	
				— 5		+ 4
March 1			4276		4183	
				— 60		—210
April 1	4449		4336		4393	
		—177		—269		+ 71
May 1	4626		4605		4322	
		—299		—344		—115
June 1	4925		4949		4437	
		+ 28		—114		—404
July 1	4897		5063		4841	
		-452		—229		+ 93
Aug. 1	5349		5292		4748	
		-187		— 99		—207
Sept. 1	5536		5391		4955	
		- 36		— 76		—142
Oct. 1	5572		5467		5097	
		+175		+302		+ 45
Nov. 1	5397		5165		5052	
		+275		+335		+278
Dec. 1	5122		4830		4774	
		+422		+319		+413
					Jan. 1 1960 4361	
Heat gain or loss throughout the year:		—251 (9 months)		+189		+150

frost equalling some 5 mm of water would be sufficient for the heat increase measured in the firn layers.

The meteorological factors affecting the heat budget of the firn (the radiation and the turbulent heat transfer) will be discussed by T. VINJE.

The flow of the ice shelf at Norway Station

From March 1957 to January 1959 the relative flow of Fimbulisen, the ice shelf at Norway Station, was measured at 33 stakes in an area of 60 km² (Fig. 6).

A Wild T2 theodolite was used for the mapping of the area. In 1957 a base of 1018.258 m was measured with steel tape north of the station (B_W–B_e in Fig. 6). In 1959 a base of 7774.390 m was measured from Norway Station to a point on Blåskimen, the ice rise WNW of Norway Station (T–F_1 in Fig. 6). The maximum error of the relative stake positions is estimated to be of the order of $\pm$ 0.200 m.

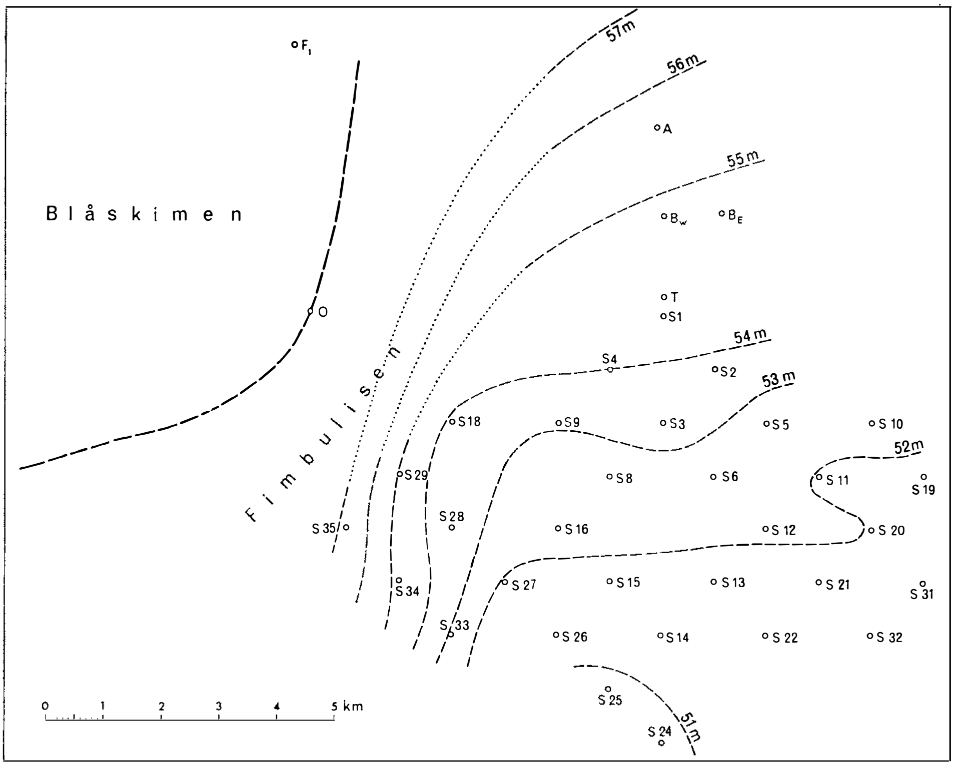

Fig. 6. *The stake area at Norway Station.*

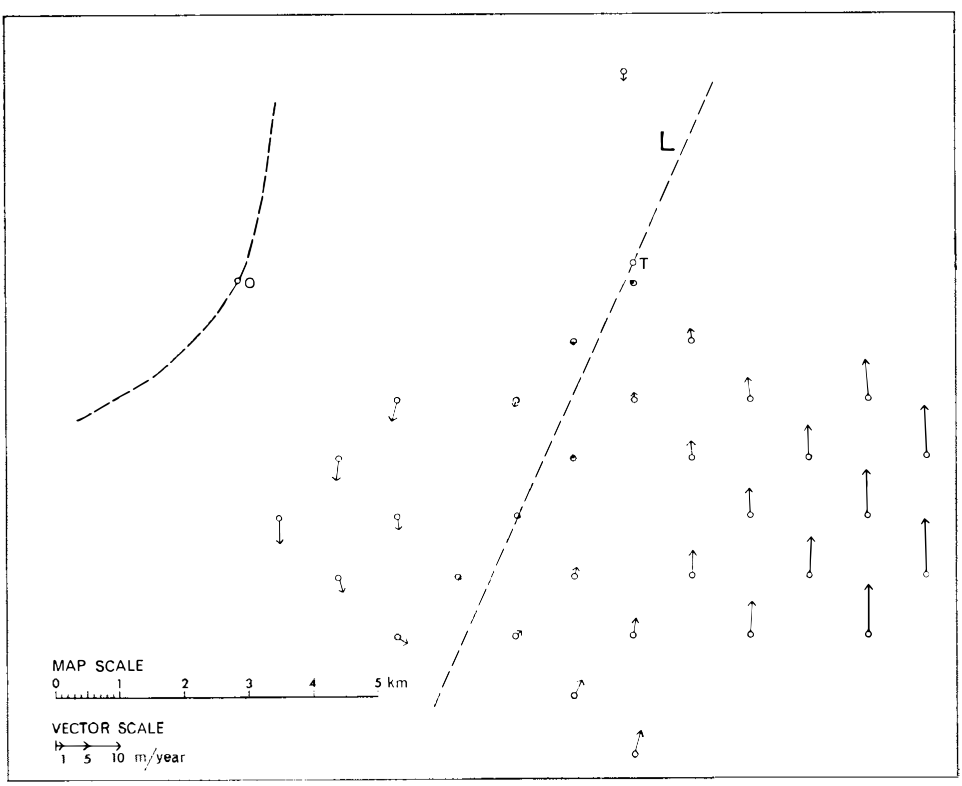

Fig. 7. *The flow of Fimbulisen relative to point T.*

In February/March 1957 and again at the end of October 1959 geodesist S. HELLE measured the absolute position of point T with a Wild T4. The preliminary computation show no variation in the position, there was, however, a counter-clockwise rotation of the azimuth line, T–A, of 0.0417^g. The final computation has not yet been done, and it will consequently not be possible to give the absolute value of the flow.

Fig. 7 and Table 4 give the annual flow relative to T. The maximum error is in accordance with what is found above, estimated to be of the order of $\pm$ 0.250 m/year.

Table 4. *Relative flow per annum of the shelf ice at Norway Station*

Stake	Flow rate	Flow direction	Stake	Flow rate	Flow direction
T	0.00 m	– g	S 18	3.20 m	214.0g
A	1.44	203.6	S 19	7.96	397.1
S 1	0.14	364.4	S 20	7.14	398.2
S 2	1.74	390.3	S 21	6.04	2.7
S 3	1.03	391.8	S 22	5.29	4.7
S 4	0.65	216.4	S 24	3.77	17.2
S 5	3.52	392.4	S 25	2.69	29.5
S 6	2.58	397.4	S 26	1.27	48.5
S 8	0.40	5.0	S 27	0.68	133.9
S 9	1.11	219.4	S 28	2.00	194.4
S 10	6.17	395.1	S 29	3.56	207.5
S 11	5.14	398.1	S 31	8.69	398.2
S 12	4.38	397.9	S 32	7.86	0.0
S 13	3.80	1.9	S 33	1.54	137.8
S 14	2.93	12.0	S 34	2.51	182.0
S 15	1.45	10.8	S 35	4.06	198.9
S 16	0.21	117.1			

As can be expected, the northward flow increases to the east. The spreading out of the ice shelf which is found in several other localities, cannot, however, be traced here. In fact there is a certain compression in the east–west direction.

In order to analyse the values for the relative flow, a straight line is drawn through points of relative flow near zero. The line is running through T in direction 27^g, or roughly parallel to the border between Fimbulisen and Blåskimen. The components of the flow parallel and perpendicular to this line, as well a the distance from line L (positive values mean flow components in direction 27^g and 127^g respectively) are given in Table 5.

Fig. 8 shows the flow parallel to line L, plotted against the distance from this line. The flow increases almost linearly with the distance from L. Calculated by the method of least squares, this linearity is found to be expressed by the equation:

$$S_p = 1.208 \cdot 10^{-3} \cdot d + 0.160 \qquad (1)$$

d is the distance from line L in metres, and S_p is the flow in direction 27^g in m/year. The deviation from this equation is not greater than what may be caused

Table 5. *Flow parallel* (S_p) *and perpendicular* (S_v) *to line L*

Stake	Distance from line L (m)	S_p (m/year)	S_v (m/year)	Stake	Distance from line L (m)	S_p (m/year)	S_v (m/year)
T	0	0.00	0.00	S 18	–2460	–3.14	0.65
A	–1332	–1.34	0.52	S 19	5385	7.09	–3.60
S 1	120	0.08	–0.12	S 20	4935	6.42	–3.12
S 2	1330	1.46	–0.95	S 21	4490	5.61	–2.25
S 3	865	0.88	–0.54	S 22	4030	4.97	–1.82
S 4	–355	–0.64	0.11	S 24	3125	3.72	–0.58
S 5	2515	3.01	–1.82	S 25	1915	2.68	0.11
S 6	2060	2.30	–1.16	S 26	715	1.20	0.42
S 8	415	0.38	–0.14	S 27	–485	0.07	0.68
S 9	–790	–1.11	0.13	S 28	–1715	–1.74	0.98
S 10	4185	5.41	–2.97	S 29	–2910	–3.39	1.07
S 11	3730	4.62	–2.25	S 31	6130	7.81	–3.79
S 12	3280	3.93	–1.93	S 32	5690	7.17	–3.23
S 13	2825	3.50	–1.46	S 33	–960	–0.26	1.52
S 14	2365	2.85	–0.68	S 34	–2165	–1.91	1.63
S 15	1160	1.40	–0.37	S 35	–3375	–3.67	1.73
S 16	–30	0.03	0.20				

by inaccuracy in the triangulation and base measurements and inaccuracy in the direction of the line L.

An extrapolation shows that the point O (the point at the border to Blåskimen which is nearest to L (Fig. 7), located 5500 m WNW of L has a velocity of 6.48 m/year in the direction 227^g.

The flow perpendicular to L, plotted against the distance from L, is shown in Fig. 9. Here there is obviously no simple equation which fits the whole area. As the maximum error of the flow values are as large as 0.25 m/year, we will not try to establish equations for the complicated variation of S_v with different parameters. In addition to the variation with distance from L, S_v also varies along L (increasing values to the SSW). This is seen from Fig. 9, where curves for the same distance from T along L are drawn. The compression is found as the derivative of these curves. It decreases from 0.7–0.8 m/km · year in the eastern part to 0.3–0.4 m/km · year in the western and south-western part of the stake area.

Extrapolating the values for S_v to point o at the border to Blåskimen (Fig. 7), we find the value of S_v to be approximately + 1.0 m/year for this point.

The relative flow of O is thus 6.560 m/year in direction 217.3^g. Fig. 3, p. 4 in the author's paper on snow accumulation (LUNDE 1961) gives a rather remarkable picture of the ice shelf topography with smaller altitudes to the south and south-west (Fig. 6).

The flow values in direction 127–327^g, which were calculated above, clearly explains this. The comparatively inactive shelf ice at Norway Station is simply compressed between the fast-moving ice stream some 36 km to the east, and the ice rise to the NW (Fig. 1). (LUNDE 1961, p. 3).

The flow measurements do not exclude the possibility that the absolute flow is directed to the south-west–south of Blåskimen to Jelbartisen, which is considerably more active than this part of Fimbulisen. This is also indicated by the above-

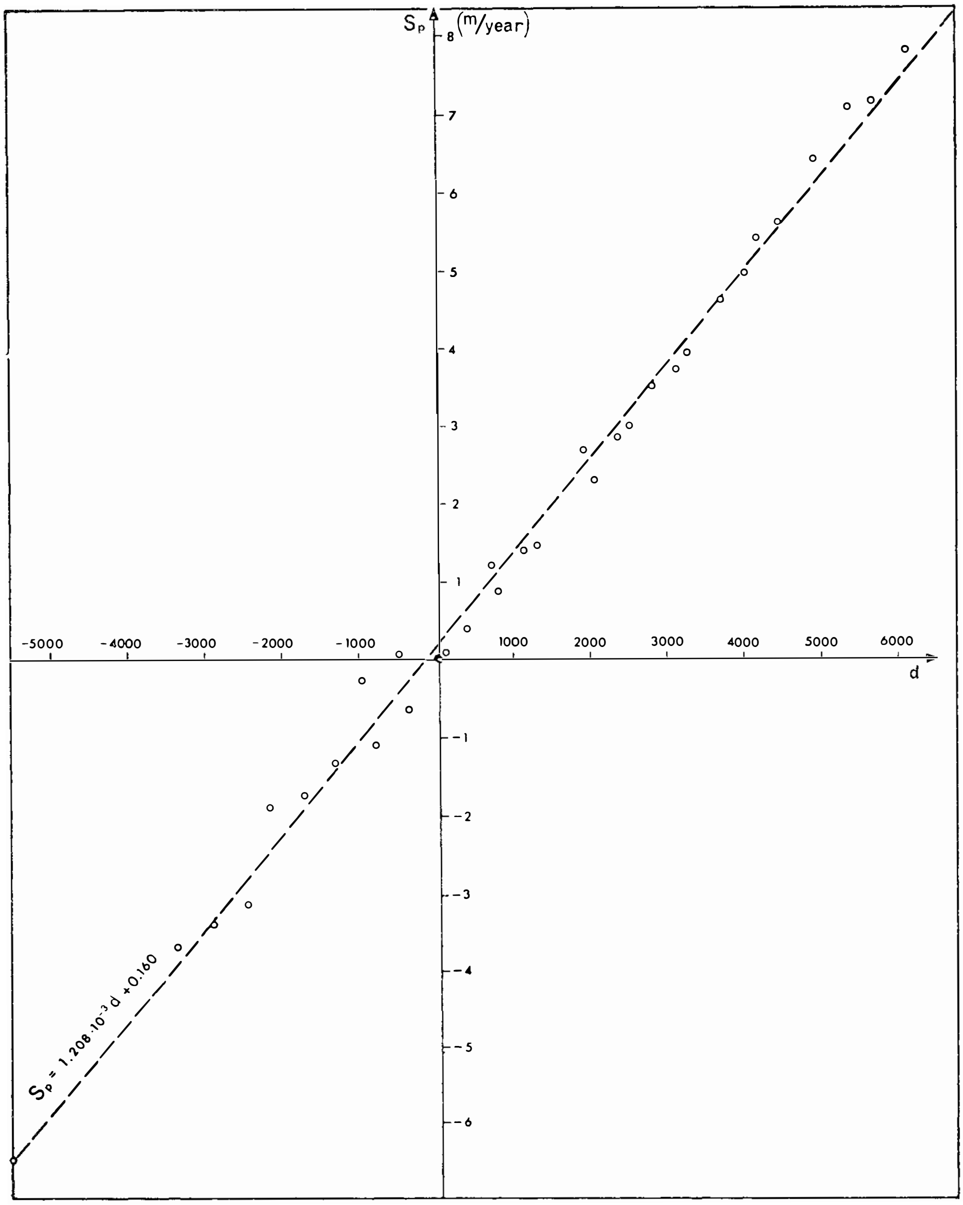

Fig. 8. *Relative flow parallel to line L, plotted against the distance from this line. The broken line gives average values of* S_p.

mentioned topography of the ice shelf. In this case there will be a line of divergence a few kilometres to the east and north of Norway Station. The part of Fimbulisen located west and south of this line is flowing to Jelbartisen, and the part to the east and north is flowing northward to the sea. In the following, however, we will suppose a northward absolute flow of the ice shelf.

The mean compression in direction 127–327^g is 0.6 m/km · year, in direction

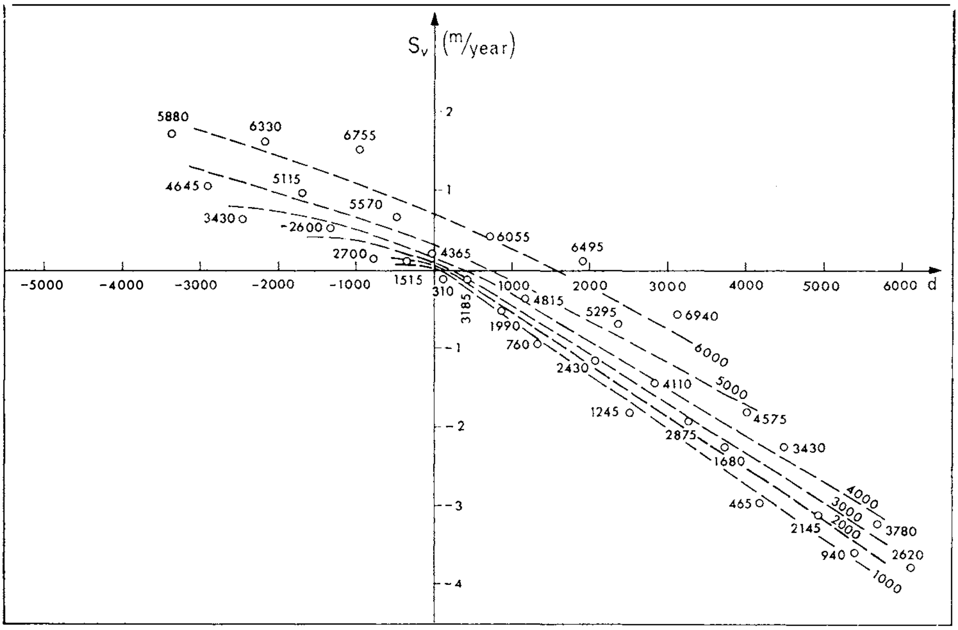

Fig. 9. *Relative flow perpendicular to line L, plotted against the distance from this line. Numbers show distances from T along L. Broken lines give average values of S_V at different distances from T along L.*

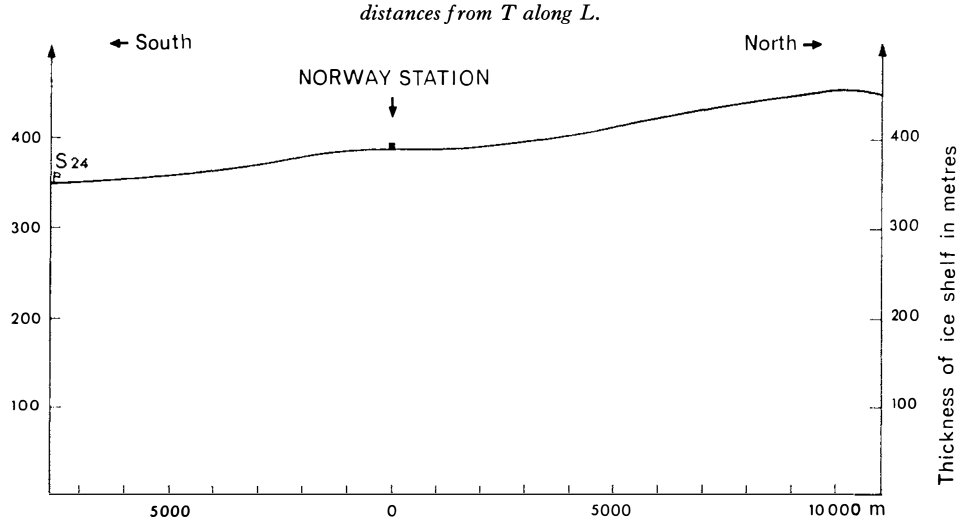

Fig. 10. *Computed ice shelf thickness along a profile from south to north through Norway Station.*

227–27^g, however, no compression can be traced. There is thus an areal decrease of some 0.6 $^0/_{00}$ a year.

Using ROBIN's (ROBIN 1958, Table 38, p. 113) table for the increase of shelf ice thickness with surface elevation and the above mentioned figure (LUNDE 1961, Fig. 3, p. 4) for the surface elevation at Norway Station, the author has computed the shelf ice thickness along a line running from S 24 through T towards the north (Fig. 10). At point T, the ice shelf is 387 m thick (equalling 372.35 m of ice of specific weight 0.917 g/cm³), a compression of 0.6 ‰ a year thus leads to a thickness increase of 0.223 m a year.

The mean annual accumulation of snow at Norway Station equalled 0.495 m of water (LUNDE 1961, p. 12), or 0.540 m of ice of specific weight 0.917 g/cm³. If there were no other influences the ice thickness should thus, in one year increase by: $0.223 + 0.540 = 0.763$ m.

From Fig. 10 we find a thickness increase from south to north of 106 m in 17 km (0.00624 m/m). This gives us the possibility of establishing the equation:

$$M = 0.763 - 0.00624 \cdot S \tag{2}$$

where M is the bottom melting and S the absolute flow. This equation, however, is just valid if the budget of the ice shelf is in balance. If the possibility of the ice shelf not being in balance is taken into account, the equation gets the form:

$$M = 0.763 - 0.00624 \cdot S - \triangle B \tag{3}$$

where $\triangle B$ is the material balance.

Assuming material balance and no movement of point T, the annual bottom melting is 0.763 m of ice or 0.700 m of water. This figure is well above what is found by SWITHINBANK for the Maudheim area (SWITHINBANK 1958, p. 93).

Still assuming material balance, but no bottom melting, the flow to the north is found to be 122.4 m/year.

The preliminary calculations indicate that the absolute flow is less than 20 m/year, this means that the sum of the bottom melting and the material balance is at leats 0.638 m of ice – or 0.585 m of water a year.

The flow of the inland ice

In Fimbulheimen the flow of three ice streams (Bakhallet, Slithallet and Lundebreen) (Fig. 11) was measured from January–February to November–December 1958.

Bamboo stakes (8 at Bakhallet, 12 at Slithallet and 12 at Lundebreen) were triangulated with a Wild T2 theodolite by means of resection from points on the ice. As the coordinates of the control points are rather inexact, only two reference points were used from each ice stream.

The morphology of the ice streams as well as the flow of ice is given in Figs. 12 and 13. The flow is very small at Slithallet, maximum 5.22 m/year, with a mean of some 2.9 m/year. Bakhallet has a maximum flow of 31.55 m/year, and a mean in the measured area of 16.0 m/year. Lundebreen is by far the most active, with a maximum flow of 49.95 m/year and a mean of 38.0 m/year.

By estimating the upper and lower limits for the mean thickness of these three

Fig. 11. *Fimbulheimen – the mountain range south-east of Norway Station. Area surrounded by heavy line shows the maximum area drained through Fimbulheimen between Terningskarvet (2°45′ E) and Gessnertoppen (6°45′ E) (Table 7).*

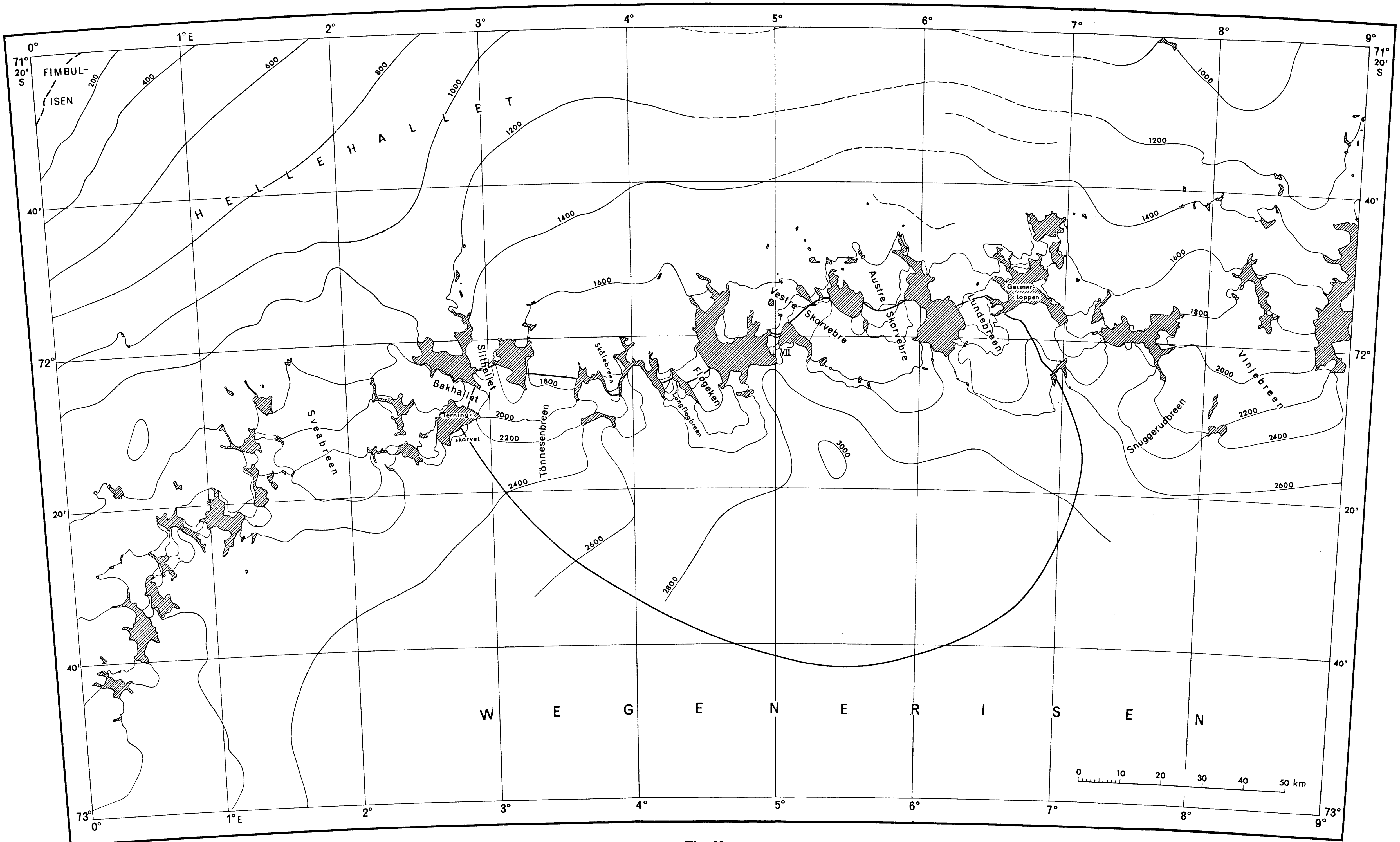
FIMBUL-
ISEN
H E L L E H A L L E T
W E G E N E R I S E N
Sveabreen
Slithallet
Bakhallet
Terning-
skarvet
Tönnesenbreen
Skålebreen
Langflogbreen
Flogeken
Vestre Skorvebre
Austre Skorvebre
Lundebreen
Gessner-
toppen
Vinjebreen
Snuggerudbreen
VII
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
0 10 20 30 40 50 km
0°
1° E
2°
3°
4°
5°
6°
7°
8°
9°
71° 20' S
40'
72°
20'
40'
73°

Fig. 11.

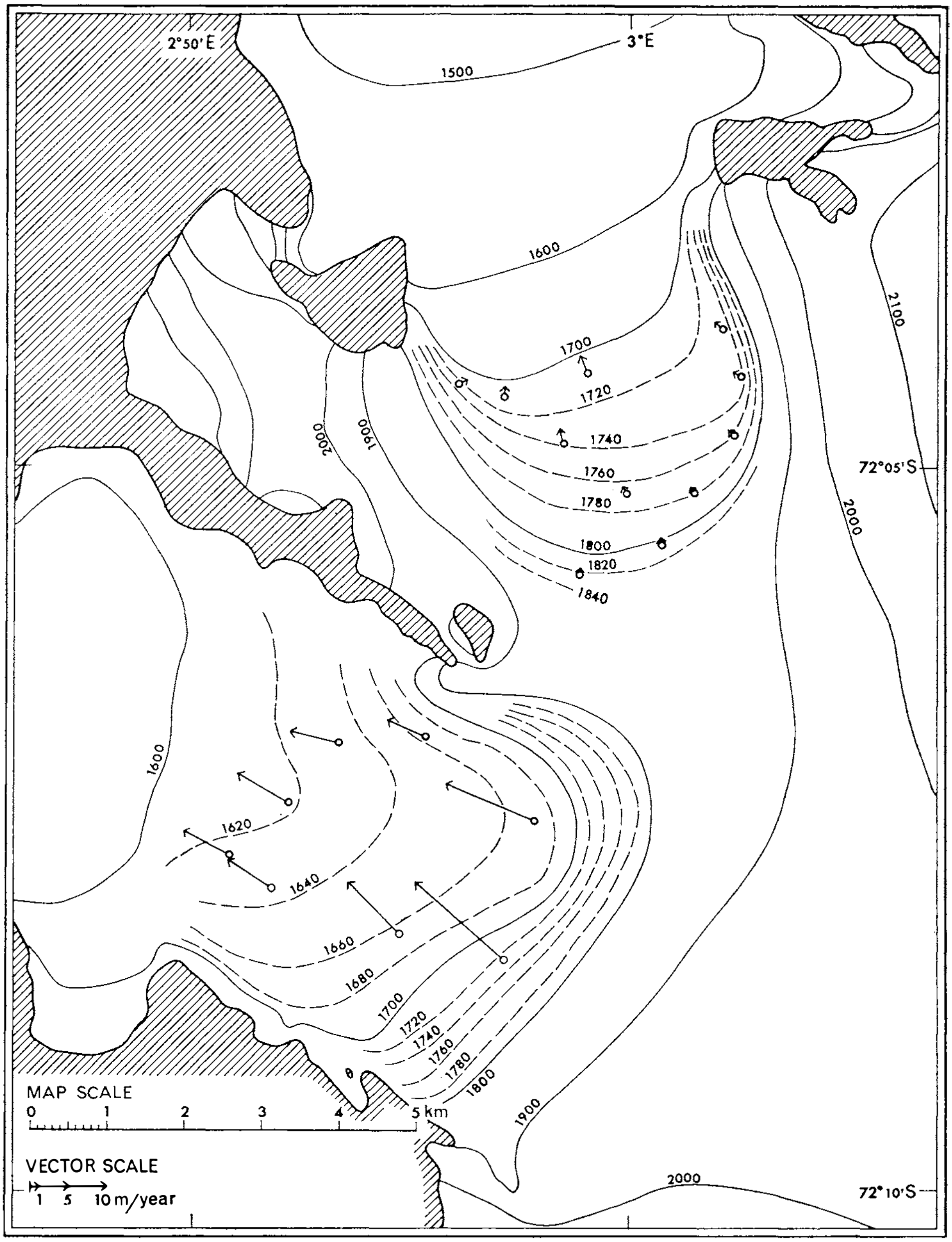

Fig. 12. *Morphology of the ice streams Bakhallet and Slithallet. The flow of the ice streams is shown by vectors.*

ice streams (from the topography of the ice streams and from ROBIN's measurements from similar places farther west (ROBIN 1958)[1]), the upper and lower limits

[1] LAGALLY's formula for the thickness of a glacier gives some 70 m for Slithallet, 200 m for Bakhallet and 500 m for Lundebreen. These values, however, are obviously too low. The viscosity used is $1.0 \cdot 10^{14}$ g $\cdot$ cm^{-1} $\cdot$ sec^{-1} which is the mean for ice near 0° C, while the ice temperature in these regions is –25 to –30° C.

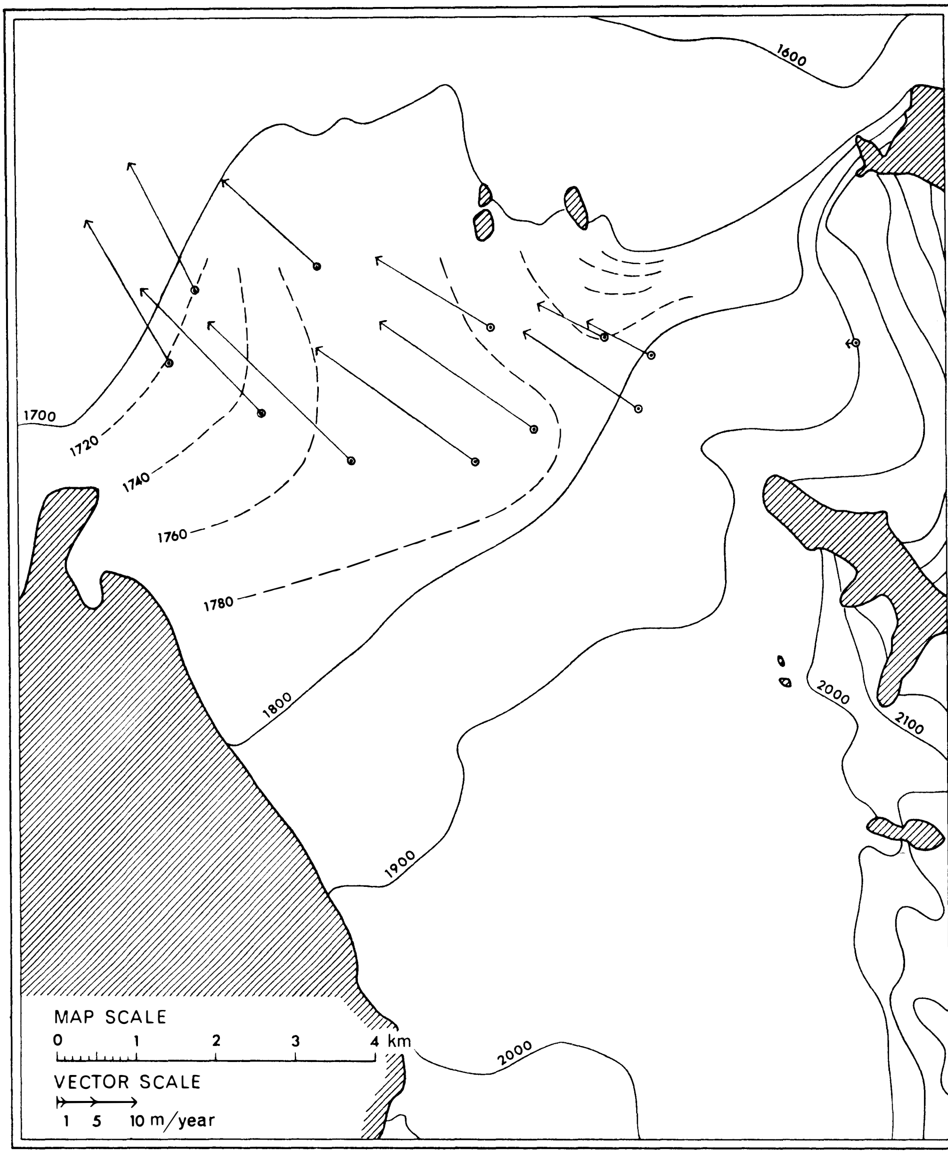

Fig. 13. *Morphology of the ice stream Lundebreen. The flow of the ice stream is shown by vectors.*

for the accumulation on the inland ice sheet (by extrapolation from what is found by SCHYTT for the regions farther west (SCHYTT 1958), and the findings of the present author for the regions to the north of Fimbulheimen (LUNDE 1961)), maximum and minimum values for the transport through these ice streams and the area of the inland ice, which they drain, are found (Table 6).

The figures show that Slithallet only drains a very small area nearby, and is of no importance for the drainage of the inland ice. Bakhallet drains a much larger area, but certainly not an area which corresponds to the fairly long distance of the mountain chain where Bakhallet is the only outlet glacier of any importance from the inland ice. This is true also for Lundebreen, which, drains by far the largest area of the three ice streams investigated.

Table 6. *Ice transport and area drained through three ice streams in Fimbulheimen*

Width of the ice stream (m)		Mean surface flow (m/year)	Thickness (m)		Transport ($\times 10^6$ m^3)[1] (water equival.)		Accumulation (m) (water equival.)		Area drained (km^2)	
			Max.	Min.	Max.	Min.	Min.	Max.	Max.	Min.
Bakhallet	5100	16.0	800	500	52.9	33.0	0.15	0.20	352	165
Slithallet	4000	2.9	500	300	4.7	2.8	0.15	0.20	31	14
Lundebreen	6200	38.0	1000	600	190.8	114.5	0.10	0.15	1908	763

For the other outlet glaciers from the inland ice between Terningskarvet and Gessnertoppen we have estimated values for the flow as well. On this basis the ice transport and area drained, given in Table 7, are calculated.

Table 7. *Ice transport and area drained through Fimbulheimen between Terningskarvet (2° 45′ E) and Gessnertoppen (6° 45′ E)*

	Transport ($\times$ 10^6 m^3 of water)		Area drained (km^2)	
	Maximum	Minimum	Maximum	Minimum
Bakhallet	52.9	33.0	352	165
Slithallet	4.7	2.8	31	14
Tønnesenbreen	415.5	184.7	2770	923
Skålebreen	2.2	0.6	15	3
Langflogbreen	2.2	0.6	15	3
Flogeken	145.8	51.0	1458	255
VII	6.1	2.0	61	10
Vestre Skorvebre I	150.7	60.3	1507	402
» » II	1.0	0.1	10	1
» » III	1.9	0.5	19	3
Austre Skorvebre	101.1	31.6	1011	211
Lundebreen	190.8	114.5	1908	763
Total:	1074.9 (1075)	481.7 (480)	9157	2753

The borders of this maximum area is shown in Fig. 11. If the contours of the map south of Fimbulheimen are to be relied upon, the area drained through these ice streams is probably very near the value listed here as the maximum.

This clearly shows, what is also seen from the topography (LUNDE 1961, p. 7), that this part of Fimbulheimen acts like a dam to the inland ice, forcing the main part of the areas to the south to be drained through the larger ice streams to the west and east (f. inst. Sveabreen and Jutulstraumen to the west, Snuggerudbreen, Vinjebreen and – farther away – Carsten Borchgrevinkisen to the east).

[1] A correction of –10 % for decreasing flow with depth and a mean specific weight of 0.9 g/cm^3 is used.

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The geology of the area around Nordkapp, Jan Mayen

BY

BRINLEY ROBERTS[1] and TERENCE R. W. HAWKINS[2]

Contents

Abstract

The geology of the northeast part of Jan Mayen is described in detail and a geological map is presented. The basis of the stratigraphic subdivision of the volcanic rocks is given and the structure discussed. The petrography of the main types of volcanic rock is described. Conclusions are drawn regarding the types of volcanic activity, the factors controlling the surface features of *aa* lavas, and the relation of *aa* to *pahoehoe* lava. Limited petrological conclusions are drawn, amongst which is the demonstration that the rocks, which show normative olivine and nepheline, belong to the alkali basalt series.

Introduction

Nordkapp is situated at the extreme northeast of Jan Mayen. The island is only the small visible portion of a much larger volcanic edifice, which rises in an isolated position from the Arctic continuation of the Mid-Atlantic Ridge. Nord-Jan is dominated by the volcanic mountain Beerenberg (2 277 m) with its permanent ice field and twenty or so radiating glaciers. The present account is of the

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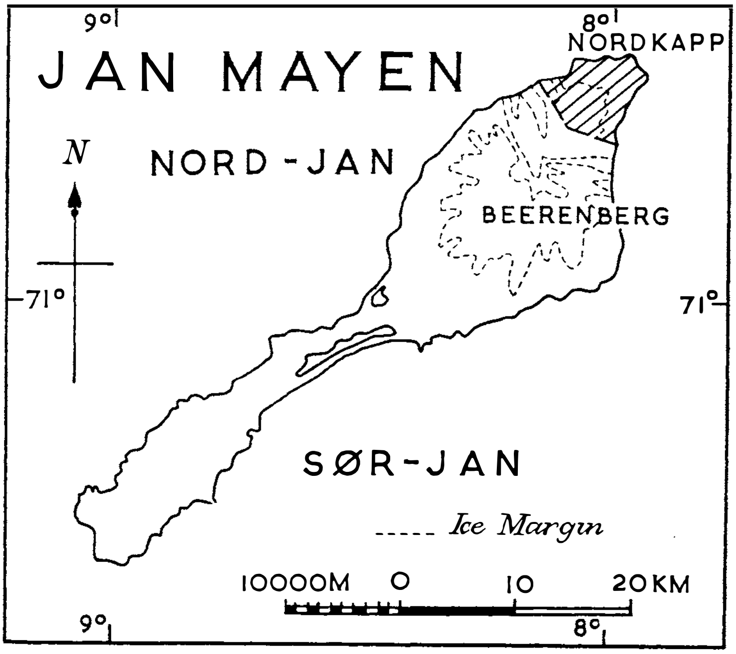

Fig. 1. *Location map with shaded portion showing the area described in the paper.*

area between the Kjerulfbreen and Sigurdbreen and the northeast slopes of Beerenberg to about the 1 000 m contour (see Fig. 1). The field work and geological mapping on the scale 1:10 000 was accomplished on the 1961 University of London Beerenberg Expedition.

The important physical features are best described with the aid of Plate I and Fig. 2. Beerenberg is seen to have the form of a steep sloping imperfect cone sitting on a more gently sloping dome. In the Nordkapp area the slopes of the Nord-Jan dome are for the most part covered by permanent ice forming the ice field and feeding the glaciers Kjerulfbreen, Svend Foynbreen, Smithbreen and Sigurdbreen. A well defined ridge, which is a volcanic rift zone, trends northeast from Beerenberg to terminate just south of Nordkapp. This rift zone carries well displayed fissures, pyroclastic mounds and craters. Two cliff lines with precipitous faces rising to nearly 500 m in parts are the dominant physical features of this area.

The cliff lines, which trend at 80° and 20° respectively, converge to the northeast near Fulmarfloget and reflect important structural directions which are emphasized by dykes running parallel to these cliffs. Below the high cliffs a low coastal platform extends from Krossbukta to Nordkapp and thence to Clandeboyebukta. Cut into this low platform is another cliff of much smaller dimensions than the older 500 m cliffs; it is about 15 m high and shows traces of an 8 m raised beach at its foot. From Nordkapp to Austkapp the 15 m cliffs coincide with the present sea cliffs, and their line is remarkably straight, so straight in fact as to suggest it is structurally controlled. The suggestion is further supported by the occurrence in the 500 m cliffs of a second set of dykes parallel to this line.

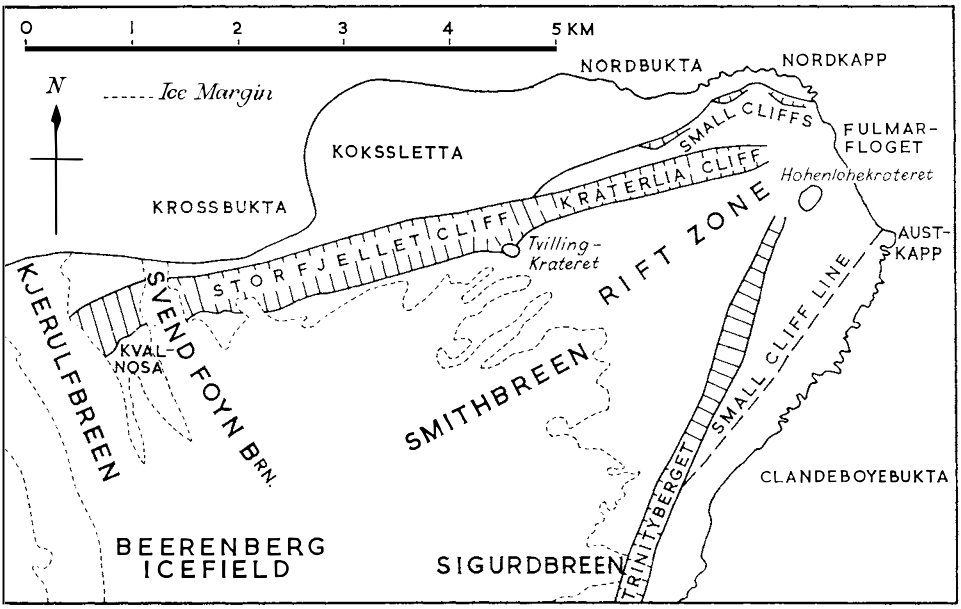

Fig. 2. *Map showing the main physical features of the area.*

Wordie (1926) published the first important work on the geology of Nord-Jan. He thought that Beerenberg was post-Pleistocene because of its extremely fresh topographic appearance, but nevertheless suggested that parts of Sør-Jan were older, and that volcanic activity had moved northeastwards with time. Wordie believed that above the 650 m contour Beerenberg was built of trachybasalt flows, whilst below was a varied succession of lavas, tuffs and sills of anakramite. The most recent activity was from some of the small parasitic cones on the lower flanks of the mountain. Tyrrell (1926) concluded from his petrological study of Wordie's rocks that the parent magma-type of Jan Mayen was trachybasaltic, and that the ankaramitic sills reported by Wordie represented an ultrabasic accumulative magma complementary to the alkali lineage differentiation sequence which could be seen in the lavas. Nicholls (1956) extended Wordie's work and realized that the sills were in fact ankaramitic lavas and made observations concerning the volcanic sequence. He believed he could recognize the following sequence of events in Nord-Jan:

1. The formation of lapilli-tuff by fragmentation of pre-existing rocks not now exposed. 2. Formation of ankaramitic agglomerate. 3. Formation of brown tuffs with trachybasalt bombs.	Kapp Fishburn area only.
4. Formation of ankaramitic agglomerates and tuff-breccias alternating with ankaramitic lavas.	As at Fishburn and Krossbukta.
5. Subaerial ankaramite lava from the Beerenberg vent.	As at Krossbukta, Kapp Fishburn and Jorisbreen.

Cont. next page

6. Trachybasalt from the Beerenberg vent and ankaramite flows from parasitic vents.	Example at Kapp Muyen.
7. Parasitic ankaramite related to radial fissures around the Beerenberg centre.	As at Bylandt Rheidt and Esk craters.
8. Sporadic trachybasalts from recent vents.	At Ternbukta and Sørlaguna.

NICHOLLS further groups his events thus:

1+2+3+4 = First volcanic cycle. No evidence as to the centres of eruption. Fossil soils are intercalated in the sequence.
5+6 = Second volcanic cycle which was centred on the Beerenberg.
7+8 = Third volcanic cycle of parasitic activity on flanks of Beerenberg.

Each cycle is said to begin with ankaramite, either as lava or pyroclastics, and evolves to trachybasalts via intermediates.

FITCH and BANFIELD (in DOLLAR, 1959) recorded tillites interstratified with the lower part of the sequence of volcanics of Nord-Jan – presumably the "fossil soils" of NICHOLLS. They suggested that three broad stratigraphic units were recognizable because they were separated by erosion intervals; the resulting units differed slightly from the threefold divisions of WORDIE and NICHOLLS. The oldest unit, the Red Ankaramitic Series, was thought to form the basement of Nord-Jan and to be largely concealed except in the Nordkapp area. The overlying Beerenberg Series was believed to form the bulk of Nord-Jan and to lie in a broad depression running southeastwards across the island. The youngest unit, the North Cape Series, consisted of the products of the younger flank eruptions.

The programme of the 1961 Expedition was planned to test the hypothesis that recognition of erosion intervals between successive volcanic cycles would enable detailed stratigraphic mapping to be extended over the whole of Nord-Jan. It was recognised that the Nordkapp area was the crux of the problem, and in the event of confirmation of the hypothesis, the key to the elucidation of the structure and stratigraphy. The general results of the 1961 Expedition have been noted by FITCH (1962); the stratigraphic units and the nomenclature used by the members of the expedition in the geological mapping of Nord-Jan are defined by FITCH (1964).

Summary of formations and their structural relationships

The Nordkapp area is built from a series of pyroclastic mounds and lava flows, the former being predominant in bulk. They can be seen in the fine cliff sections of Storfjellet and below Trinityberget. Spectacular sections of the lava dominant part of the pile can be seen at Kvalnosa and along the walls of Kjerulfbreen and to a lesser extent Svend Foynbreen. Whilst the majority of the lavas are ankaramitic basalt *aa* flows the pyroclastics on the other hand, although generally ankaramitic in mineralogy, show varied textural and structural forms. Throughout the volcanic history there is strong evidence of eruption from a system of sinuous and

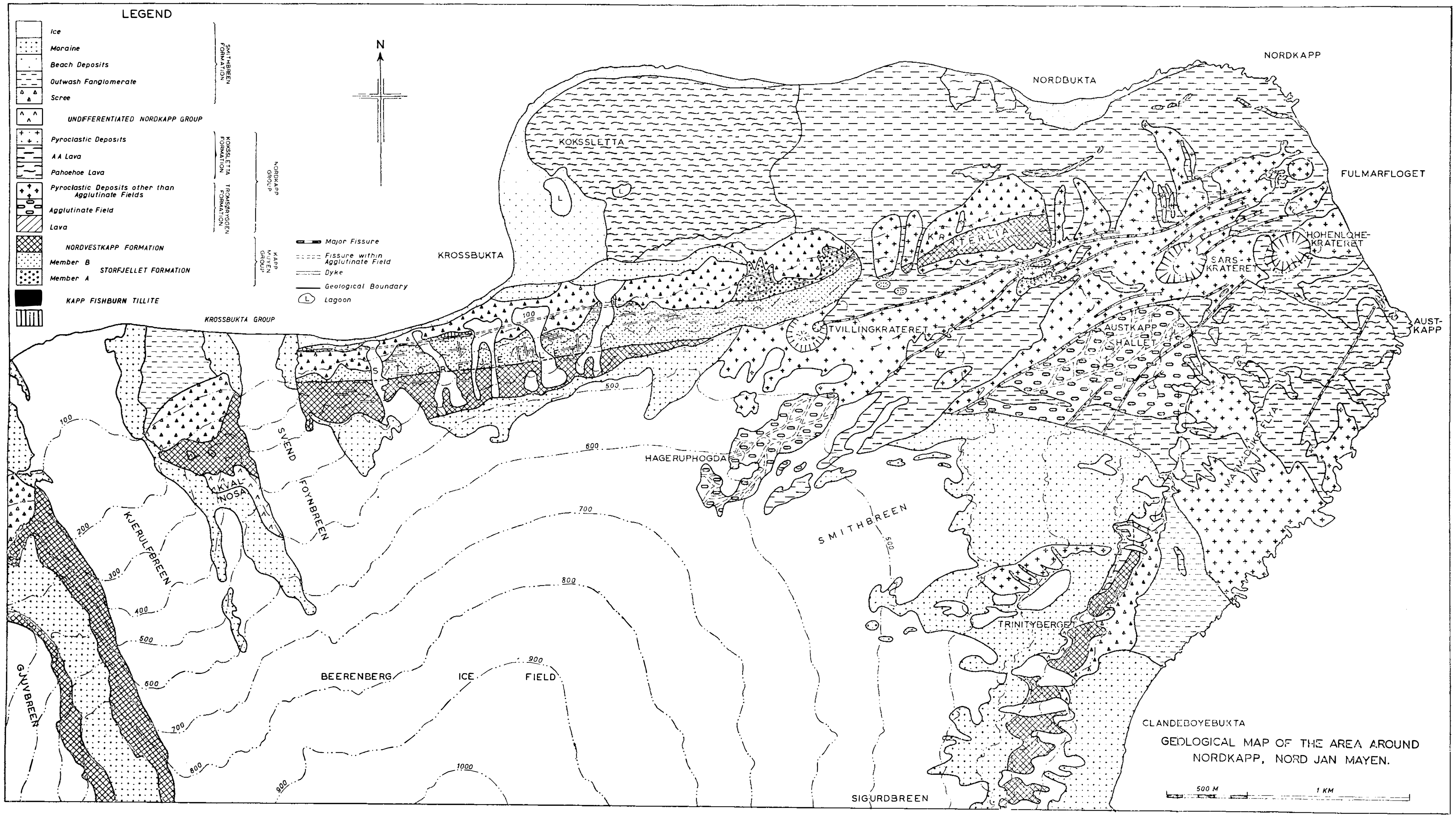

Fig. 3. *Geological map of the area around Nordkapp, Nord Jan Mayen.*

anastomosing fissures, having an overall trend southwest to northeast. Small cinder "whaleback" mounds, and cones aligned along fissures, indicate points at which activity was momentarily concentrated and many lava flows can be traced back to such ephemeral centres. At other times activity has been uniformly distributed along the lengths of fissures as indicated by agglitinate lips and *aa* lavas, which have poured out as "blanket" flows over one or other of the lips. There is no direct evidence in this part of Nord-Jan of eruptions on a large scale from a central vent except during the time of formation of the Nordvestkapp lavas. In other parts of Nord-Jan, however, flows from the central vent (Sentralkrateret) have built the high Beerenberg cone (FITCH, 1962). These flows belong to the Sentralkrateret Formation but no representatives are present in the Nordkapp area.

The stratigraphic table for the Nordkapp area is as follows:

	Smithbreen formation: younger non-volcanic rocks.
Nordkapp Group	Kokssletta Formation: basaltic lavas and pyroclastics. Tromsøryggen Formation: basaltic lavas and pyroclastics.
Kapp Muyen Group	Nordvestkapp Formation: mainly basaltic lavas. Havhestberget Formation: yellow agglomeratic tuff. Storfjellet Formation: pyroclastic mounds with lavas.
	Kapp Fishburn Tillite.
Krossbukta Group:	basaltic lavas and a fossil talus.

The Kapp Fishburn Tillite is regarded as an important horizon. Rocks older than the tillite are placed in the Krossbukta Group, whilst younger volcanic rocks make up the Kapp Muyen and Nordkapp Groups. The two latter groups are separated by an important erosion interval during which the cutting of the 500 m cliffs e. g. Storfjellet, Kraterlia, Trinityberget and similar features elsewhere on Nord-Jan occurred.

The basic structure of Nord-Jan above sea level is threefold, these structural units being the Nord-Jan basalt dome resting on a largely hidden basement, the superimposed high Beerenberg cone, and the northeastward extension of the dome along the Nordkapp Rift Zone ridge. Around Nordkapp we are concerned with only two of these, viz. the northeast sector of the basalt dome and the Nordkapp Rift Zone.

The Storfjellet Formation represents the outcrop in the cliff of a ridge built essentially of pyroclastics and running back southwestwards into the Nord-Jan dome. It is probably the forerunner of the present day Rift Zone. The overlying Nordvestkapp lavas dip away northwest and northeast from the point of emergence of the axis of this ridge, near Tvillingkrateret (see Fig. 4). Elsewhere on Nord-Jan, the bulk of the Nord-Jan dome is built from lavas belonging to this formation and it is evident that most came from the proto-Sentralkrateret, for example the lavas exposed in the walls of Kjerulfbreen. In the case of the northeast of the Nordkapp area however, there is a strong suggestion that many of the Nordvestkapp lavas came from the forerunner of the present Rift Zone.

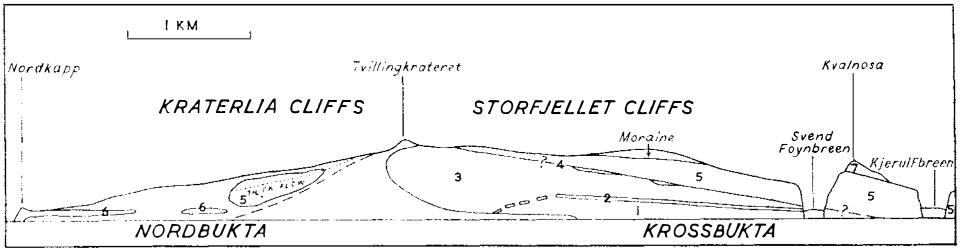

Fig. 4. *Diagrammatic cliff section from Nordkapp to Kjerulfbreen.*

Key: 1 = Krossbukta Formation. 2 = Kapp Fishburn Tillite.
3 = Storfjellet Formation. 4 = Havhestberget Formation.
5 = Nordvestkapp Formation. 6 = Tromsøryggen Formation.
7 = Kokssletta Formation.

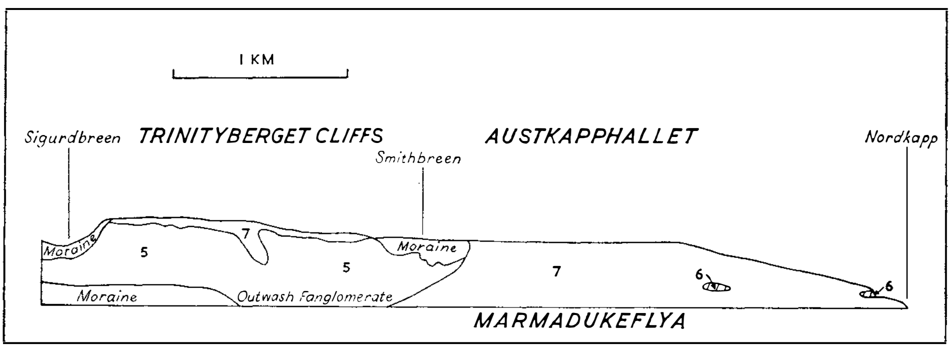

Fig. 5. *Diagrammatic cliff section from Sigurdbreen to Nordkapp.*
Key as for Text Fig. 4.

The Nordkapp volcanics have originated from sinuous fissures on the flanks of the Nord-Jan dome. Products of this volcanic episode rest on Storfjellet or Nordvestkapp rocks and are younger than the 500 m cliffs. They are to be found making these cliffs at Kraterlia, and even drowning them at Marmadukeflya. At Storfjellet, Kvalnosa and Trinityberget only small dribbles of Nordkapp lavas are seen which have run over the cliffs.

The structural pattern of the Nordkapp Rift Zone can be seen on the accompanying geological map. The general trend, southwest to northeast, coincides with the major fissure trend throughout Jan Mayen, the island itself being elongated in this direction. Individual fissures are not perfectly straight but sinuous, and the Rift Zone as a whole converges towards a point off Fulmarfloget. The convergence of fissure lines away from the Beerenberg centre is unique in Nord-Jan, for elsewhere fissures appear to radiate from the Beerenberg centre. The convergent pattern is emphasized by the dyke pattern which shows a similar closure to the northeast. Wordie (1926) believed that in Jan Mayen as a whole, volcanic activity has moved progressively northeastwards with time; Fitch (1964) recognized the general truth of this and suggested that the unusual fissure pattern may represent a magmatic wedging to the northeast, so that future volcanic developments are to be expected northeast of the Beerenberg. A second set of dykes trends

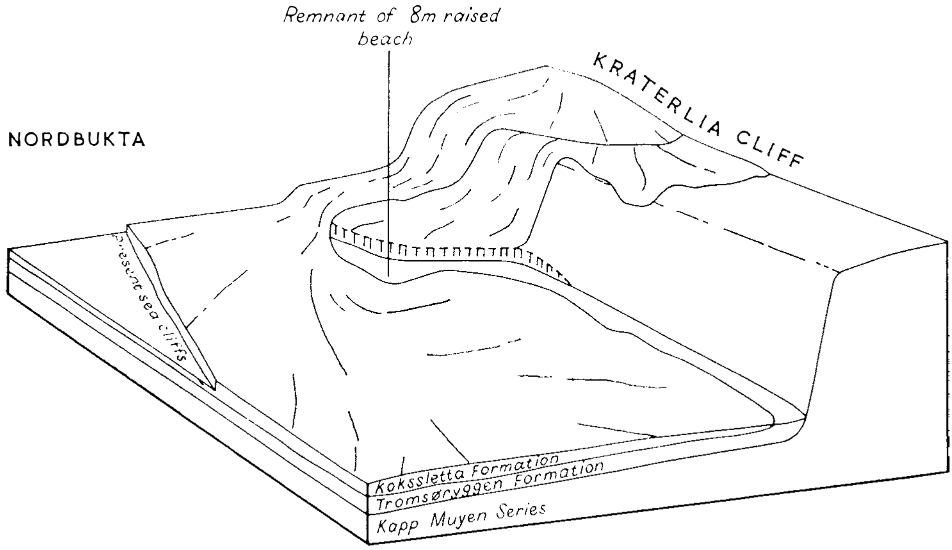

Fig. 6. *Sketch block diagram showing the relationships between the Kapp Muyen Group, Tromsøryggen Formation and the Kokssletta Formation.*

at 330° but no fissures with this trend have been recognized in the Nordkapp area. However the remarkably straight 2 km long coastline from Austkapp to Nordkapp has this trend, and the structural control suggested by the topography may well be a transverse fault.

Krossbukta Group

The group contains the oldest volcanic rocks seen in the area. They are defined as those exposed rocks which can be shown to be older than the Kapp Fishburn Tillite, and, at the type locality just east of Krossbukta low down in the Storfjellet cliff, comprise two basaltic flows and a fossil talus. The talus is recognized as such by its composition of highly angular fragments of porphyritic ankaramitic basalt, ranging from blocks 30 cm in diameter down to the smallest material of the matrix. The talus is now well compacted, and about 3 m thick. The flows of ankaramitic basalt, each about 1.5 m thick, show the well developed blocky and scoriaceous tops and bottoms typical of *aa* flows. The abundant ankaramitic basalt fragments in the talus suggest that many of the now hidden lavas are of this type. The outcrop of the group is further restricted by present day talus and morainic debris.

Kapp Fishburn Tillite

The tillite, separating the Krossbukta Group from the Kapp Muyen Group, outcrops sporadically in the Storfjellet cliff from just east of the second ice couloir east of Krossbukta, to Svend Foynbreen. The deposit shows a maximum thickness of 7 m and has an apparent dip to the west; immediately east of Svend Foynbreen the true dip is 30° to the north. It is correlated with the appreciably thicker tillites found near Kapp Fishburn below the southern slopes of the mountain and is regarded as a satisfactory time and marker horizon.

The tillite is composed predominantly of abraded subangular to subrounded fragments of ankaramitic basalt together with a lesser proportion of non-porphyritic basalt set in a matrix of coarse grained sandy material and much rock flour or mud. Its constitution provides very strong evidence of the wide extent of ankaramitic basalts over the pre-Kapp Fishburn land surface of Nord-Jan. There are no signs of stratification and no obvious preferred orientation of the larger phenoclasts. The abundant rock flour matrix, plus the abraded character of the phenoclasts, are used to differentiate this from the talus deposit.

Passing eastwards along the Storfjellet cliffs the tillite passes beneath modern talus deposits and is not seen again. Considering its dip in the cliff it would be expected to appear in the relatively talus free cliff beneath Tvillingkrateret; that it does not suggests that its dip changes to that prevalent east of Tvillingkrateret (see Fig. 4).

Storfjellet Formation

The formation may be divided conveniently into two members: member A, which consists largely of lavas and is found only at the eastern end of Storfjellet; and member B consisting mainly of pyroclastics. Member B rests on the lavas of member A, and both are cut by numerous dykes, the majority of which trend parallel to the cliff.

The lavas which comprise member A total about 100 m in thickness. They are best exposed in the lower parts of the Storfjellet cliff beneath Tvillingkrateret and thence westwards for about 700 m, at which point they are concealed beneath present day talus accumulations. The lava sequence dips to the north-northeast with the result that they show an apparent dip of rather less than 10° to the east along the cliff face. About 25 flows, each having a thickness of between 3 and 5 m are exposed above the talus at the foot of the cliff and below the cinder cones of member B. The lavas are all of a similar type and in hand specimens are seen to be ankaramitic basalts and occasional ankaramites, with reddened rubbly tops and bottoms.

Member B, which is essentially pyroclastic, consists of a series of cones and whaleback mounds of ash, scoriae and agglutinate, with intercalated thin lava flows of limited areal extent. These subordinate lavas are mostly of ankaramitic basalt, but some are non-porphyritic basalts and a few are true ankaramites. At irregular intervals throughout the pile of pyroclastics thin groups of up to five or six flows sometimes persist over considerable distances, as also do occasional beds of ash, breccia and agglomerate. The ash bands in particular are easily followed on account of their harsh red, yellow and black colours. The maximum thickness of the pyroclastic pile is reached beneath Tvillingkrateret where about 250 m are seen in the cliff section. No individual ash bed or lava flow can be followed throughout the length of the Storfjellet cliff; indeed the majority can be traced for less

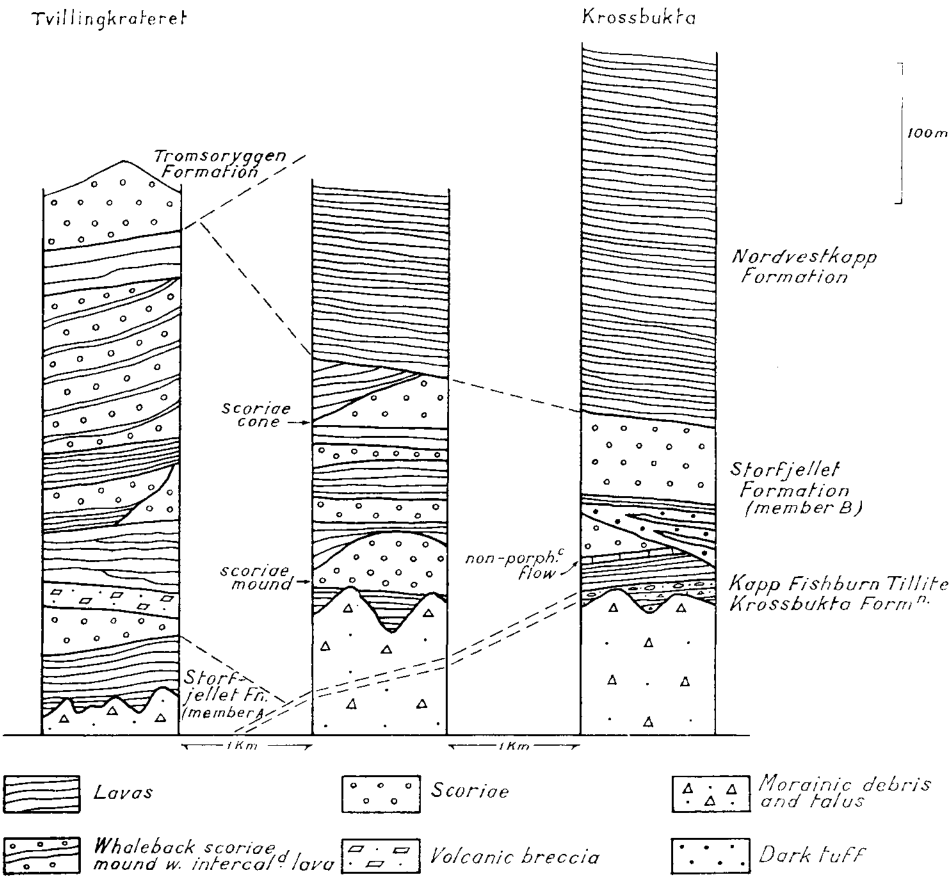

Fig. 7. *Comparative sketch sections in the Storfjellet Formation.*

than 100 m. Fig. 7 illustrates the succession at three different localities in the Storfjellet cliff, and so emphasizes the extreme lateral and vertical variability of the Storfjellet B succession.

Immediately behind Krossbukta and for a short distance eastwards, the following succession can be made out (c. f. Fig. 7):

Storfjellet B.	6. Indistinctly formed, truncated red cinder cones withintercalated lavas	+50 m
	5. Dark grey tuff containing two basalt flows	5–20 m
	Steeply inclined erosion surface.	
	4. Reddened ash and scoriae bed	2–3 m
	3. Massive grey non-porphyritic basalt flow	5 m
	2. Red cinder bed	0.5 m
	1. Seven thin (1–2 m) rubbly ankaramitic basalts	10 m

Kapp Fishburn Tillite.

The thin rubbly ankaramitic basalts at the base of the succession appear closely similar to the lavas of Storfjellet A. Units 1–4 can be traced eastwards from Krossbukta for about 300 m, but to the west they are cut out by the dark grey tuff band (bed 5). Beds 5 and 6 are soon replaced in their turn by two red cinder cones each with a few associated lavas. One of the cones shows almost perfect form because the present cliff coincides with the plane of symmetry of the cone. Many of the cones and whalebacks visible in the cliffs of Nord-Jan present an apparently truncated appearance because the present cliff line does not pass through the plane of symmetry of the cinder pile but rather through a marginal portion. The cone showing perfect form was studied in detail and its intercalated lavas were seen to range in hand specimen from ankaramites through ankaramitic basalts to phenocryst poor basalts.

Havhestberget Formation

Rocks possibly belonging to this formation have been examined in huge fallen blocks at the foot of Storfjellet at a point some 500 m east of Krossbukta. One cannot be certain of the position in the cliff sequence from which the blocks have fallen, but they may well have come from a position below or just within the Nordvestkapp lava succession. A further lens has been reported in the Kraterlia cliff beneath Sarskrateret.

The fallen blocks are composed of a yellowish-brown, hard, sandy looking crystal-lithic tuff. Angular lapilli sized fragments consist of grey porphyritic basalt up to 15 mm across, glomeroporphyritic felspar bearing basalt up to 8 mm in diameter, yellow basaltic pumice up to 20 mm in diameter and broken, dark bottle-green and dark brown pyroxene crystals up to 5 mm across. The matrix is a crystal-lithic tuff with some broken olivine and pyroxene crystals less than 2 mm in diameter. The fragments show no preferred orientation and there is no trace of bedding. The field evidence elsewhere on Nord-Jan suggests that much of the Havhestberget Formation is a sillar rather than an ash fall tuff (FITCH, 1964). In support of this suggestion may be quoted such features as its large areal extent, its chaotic unbedded character – except where the ash flow entered bodies of standing water – and its thickness. There is no evidence forthcoming from the Nordkapp area which lends added support to this view, and it is only possible to state that the characters of the tuff described here do not invalidate the suggestion.

Nordvestkapp Formation

In contrast to the two previously described formations which are largely pyroclastic, the rocks of the Nordvestkapp Formation are predominantly lavas. In Nord-Jan as a whole it is this formation which builds the bulk of the Nord-Jan dome. For a short distance west of Tvillingkrateret and thence eastwards to Kjerulfbreen, a thick sequence (maximum c. 250 m) of thin lava flows can be seen in vertical section in the cliffs where they rest on an erosion surface which truncates Storfjellet cinder cones and intercalated lavas. The Nordvestkapp lavas appear to dip off the Storfjellet ridge, but in fact the true dip is seawards on both sides of this feature. In addition the lavas are magnificently exposed in vertical sections along the walls of Kjerulfbreen, and to a lesser extent Svend Foynbreen, in both of which localities they are seen to be dipping seawards from the Beerenberg centre. Thin red bands of cinders and tuff are occasionally seen within the thick lava sequence; these beds of pyroclastics have been examined in the cliff face beneath Trinityberget where they are more readily accessible than in most other exposures.

Although rocks of this formation can be easily seen, their outcrop in precipitous cliff faces and glacier walls makes it very difficult to carry out field examination at close quarters, and hence to make satisfactory rock collections. The principal difficulty was the intermittent fall of blocks of all sizes loosened by the summer thaw. At the two localities at which collection proved possible an added difficulty was presented by Nordkapp Formation lavas which had dribbled over the cliffs. These, when alternating with talus, or resting on ledges of Nordvestkapp basalts, appear at first to be in sequence within the Nordvestkapp Formation. A detailed collection through the sequence exposed on Kvalnosa showed most of the lavas to be strongly porphyritic ankaramitic basalts with occasional ankaramites and non-porphyritic basalts. All were flows of *aa* type.

To the northeast in the Kraterlia cliffs immediately east of Tvillingkrateret, the succession of Nordvestkapp rocks is partly obscured by talus and Nordkapp volcanics. Above the talus the following general succession can be distinguished:

4.	Series of thin basalt flows each 2–3 m thick................	c. 18 m
3.	Thick, spheroidally weathered ankaramite flow............	15–30 m
2.	Red crystal-lithic tuff	0.75 m
1.	Series of massive basalt flows, each 2–8 m thick............	30 m

The lavas of units 1 and 4 are all *aa* flows. Most are strongly porphyritic ankaramitic basalts, but rare feebly porphyritic lavas are also represented. The red crystal-lithic lapilli tuff, bed 2, can be traced for several hundred metres beneath the thick ankaramite lava flow. Lamination can be distinguished in the outcrop and hand specimen on careful inspection and there is no doubt the tuff is the product of an ash fall. The thick ankaramite, bed 3, which overlies the red tuff is seen at the cliff top just east of Tvillingkrateret, and it extends eastwards to a point just south of Nordbukta where it becomes obscured by the younger Nordkapp lavas and pyroclastics. As seen in the cliff section it has an apparent dip of 10° to the eastnortheast, although this steepens a degree or two near Tvillingkrateret. At the same time the thickness, 30 m near Tvillingkrateret, diminishes until near Nordbukta it is only 15 m. This downdip thinning together with the massive irregular jointing which the rock displays, constitute the main field evidence for assuming the rock to be a lava rather than a sill. Dykes of comparable mineralogy always develop a close perfect columnar jointing.

Lavas belonging to the formation are exposed in cliff sections around Trinityberget. The cliffs are about 150 m high, but the lower section is partly concealed by talus and Nordkapp lavas. In the upper part a series of thin flows, each 2–3 m thick, are seen to be interbedded with occasional tuff and cinder beds. The succession is comparable with that described in the upper part of the Kraterlia cliff, although pyroclastic material is more abundant at Trinityberget.

Tromsøryggen Formation

Rocks belonging to this formation are younger than the 500 m cliffs, such as Storfjellet and Kraterlia, but older than the 15 m cliffs. The relationships are clarified by Fig. 6.

Basaltic lavas occur in the 15 m cliffs which extend from about 400 m south of Nordbukta to just southeast of Nordkapp (see Plate I). From this point to Austkapp the lavas form the lower part of the present sea cliff. Away from the cliffs lavas of undisputed Tromsøryggen age are rarely exposed, but they are very probably seen in the walls of the major Nordkapp fissure striking northeastwards from Sarskrateret, and again in a small window through Kokssletta Formation rocks some 500 m southwest of Hohenlohekrateret.

In the 15 m cliff south of Nordbukta, a series of five thin porphyritic *aa* flows are exposed. They are each 1–2 m thick and spheroidally weathered. A thin band of red bole occurs above the highest flow, which serves to emphasize the time break and unconformity between this formation and the overlying Kokssletta rocks. Lavas of the Kokssletta Formation are seen to have passed over and around these cliffs as shown in Fig. 6. In hand specimen the five Tromsøryggen lavas are porphyritic ankaramitic basalts. The lavas exposed in the walls of the main Nordkapp fissure differ slightly in that they are less weathered and rather more strongly porphyritic. Very similar ankaramitic basalts are seen in the Hohenlohekrateret window where four flows are exposed in a cliff about 15 m high. The base of the feature is talus covered, and Kokssletta flows and pyroclastics obscure the feature to the northeast and southwest.

The lava sequences are overlain by a thick and variable series of pyroclastic rocks which was ejected largely from the fissure system associated with the Nordkapp Rift Zone. The ejected material consisting of scoriae, bombs and agglutinate, built the impressive cones and elongate whaleback mounds which can be seen on the lower slopes of the northeast flanks of Beerenberg. They are overlain in part by the Kokssletta lavas which can be seen to drown the 15 m inland cliffs; and several craters have been breached by later outpourings of these younger flows.

The commonest pyroclastic deposit is an aggregate of scoriae and bombs. The scoriae consists of strongly porphyritic fine grained basalt and basaltic glass; it is highly vesicular and fragments range upwards from lapilli size. Shattered pyroxene and olivine crystals as well as some lithic material fall within the ash grade, but such particles constitute only a small percentage of the total. The largest bombs in the deposits usually show a strongly vesicular centre and a chilled crust of variable thickness; this crust often develops an outwardly directed set of fine columnar joints.

Agglutinate as defined by TYRRELL (1931) is an important pyroclastic deposit. It occurs in three ways: as layers within scoriae mounds; as raised lips along the margins of many of the fissures; and as relatively extensive spreads of agglutinate. These occurrences have been described in detail elsewhere (HAWKINS and ROBERTS, 1963). The agglutinate lips to fissures pass laterally into scoriae with sporadic agglutinated patches, and finally into loose scoriae. Two widespread areas composed entirely of agglutinate were mapped within the Nordkapp Rift Zone. The areas, each covering about 1 sq. km, show a superficial resemblance to an *aa* lava field and the term "agglutinate field" has been proposed for such spreads. The fields are dissected by a large number of anastomosing fissures. Associated features are the occurrence of numerous small ridges 5–10 m high, convex on one side and planar on the other, and small craters or blow holes which have originated wherever a fissure has been temporarily sealed by still plastic agglutinate ejected from an adjacent fissure.

Two varieties of agglutinate can be distinguished: one type occurs adjacent to fissures and vents, and also forms the agglutinate fields; the second type occurs as lenses in cinder cones and whaleback mounds. The former variety consists of dark red vesicular pancakes and bombs, usually 10–20 cm across, with very little intermixed scoriae. The pancakes are comparable with the "bombes en bouse de vache" of LACROIX (1930), and the undersides usually show Pele's hair structures. The second variety is composed of driblets of pale red basaltic material. These are smaller than pancakes and sub-tabular in form. They are generally less scoriaceous and less vesicular than the former variety and tend to be richer in phenocrysts.

Koksletta Formation

The formation consists principally of basalts formed from the most recent outpourings of lava in Nord-Jan. They form large areas of the present land surface and are strikingly fresh, showing all the minor structures and features associated with *aa* and *pahoehoe* types. At only a few localities can pyroclastic deposits be dated later than these lavas, and so certainly of Koksletta age. It is noteworthy that the most recent volcanic activity recorded in Nord-Jan was of a pyroclastic nature in the vicinity of Dagnyhaugen.

In the area roughly bounded by Hageruphøgda, Austkapphallet and Trinityberget, Koksletta lava flows are found only sporadically and have a small areal spread. The vast majority of the small flows can be traced to the source fissure, and only flows of *aa* type are found. In contrast with this area, the Koksletta–Nordkapp platform and much of the surface of Marmadukeflya are covered with Koksletta basalts which include both *aa* and *pahoehoe* types. There is some reason to believe that this contrast may be due to the initial gradient of the ground over which the lava was flowing.

Aa flows are usually less than 2 m thick, and evidently possessed very high mobility. Striking evidence of this is supplied by the manner in which *aa* flows have spread out thinly over the Koksletta platform at the foot of the Storfjellet–Kraterlia cliffs. In other places where the slope over which the lava has flowed had an appreciable gradient, e. g. the talus and scoriae covered cliffs south of Nordbukta, the flows are concentrated in conduits leading down the slope, and the flow is now represented as a thin, vitreous skin lining the conduit. The surface presented by a fresh *aa* flow bears a direct relation to the gradient down which it flowed, and therefore to its velocity. On appreciable slopes, which were nevertheless insufficient to cause streaming in conduits, the surface is both scoriaceous and blocky, but features such as spiracles are never developed; these features occasionally occur where the gradient is very gentle, but they become common, and often several metres high on flats where the lava has been able to accumulate as a standing pool. There is a parallel increase in the general blocky and uneven nature of the surface on the more level ground. The formation of spiracles must therefore be related to the prolonged release of volatiles from the standing, or very slow moving, body of crystallising lava, and presumably the blocky nature of the *aa* surface is similarly related.

Pahoehoe flows occur less commonly than *aa* flows. Indeed they occur only on flats and shallow gradients. A flow of considerable areal extent covers much of the low platform of Koksslettta, but some of the features it shows are atypical, being due to the fact that the flow was emplaced on wet beach material. The flow is between 0.5 and 1 m thick and the surface is either relatively smooth or shows well developed ropy structures. Pressure ridges are prominent near the snout of the flow, and are parallel to this front margin, i. e. at right angles to the direction of movement. Sinuous lava tunnels, and blisters up to 10 m across and 3 m high are also common features. The blisters are usually cracked irregularly but the pieces can be fitted perfectly on either side of the cracks so that there can be little doubt that the domes are due to relatively gentle distension by steam generated as the flow advanced over wet beach material. Occasionally blisters have been elongated normal to the direction of lava movement and the resulting structure resembles a pressure ridge. Indeed it may be that there are no true pressure ridges developed in this particular flow.

Another extensive *pahoehoe* flow occurs west of Austkapp in the northern part of Marmadukeflya. It occurs on a slope of about 1 in 12 or rather less, and shows significant differences from the Koksletta flow. Blisters and tunnels are developed in this flow but they are smaller, lower in proportion, and although often cracked, are never completely disrupted as they sometimes are on Koksletta. Low ridges occur, not normal to the direction of flow as on the Koksletta platform but downslope. Many of these are arched up lava tunnels and as such are genetically different from the ridges on the Koksletta platform. There appears to have been a mass forward movement at Koksletta, whereas stream flow predominated at Marmadukeflya, the difference no doubt being due to the gradients involved.

The relationship between the two lava types appears straightforward on the Koksletta platform, with the great spread of *aa* lava overlying the *pahoehoe* flow. Detailed mapping of the lava types from Marmadukeflya to Nordkapp however, brought out a superficially more complex relationship between the two types. Although *aa* lavas clearly rest on *pahoehoe* surfaces at most localities, in several places *pahoehoe* lava appeared to rest on the *aa* flow. This apparent anomaly occurred only when the younger *aa* flow had followed lava tunnels in the older *pahoehoe* lava and emerged and spread out at the snout of the pre-existing flow. In the Nordkapp area therefore, during extrusion of Koksletta basalts, *pahoehoe* preceded *aa* flows.

Two thin *aa* basalt flows between Tvillingkrateret and Sarskrateret on the

Nordkapp Rift Zone are overlain by a thin and discontinuous deposit of ash and scoriae containing sporadic but beautifully fresh bombs. The deposit is traceable to the big un-named cone standing between Tvillingkrateret and Sarskrateret. The authors place this deposit within the Kokssletta Formation, although it may well be as young as some members of the Smithbreen Formation.

Smithbreen Formation

The formation includes all those non-volcanic deposits which are younger than the Kokssletta rocks.

The most abundant of these deposits is morainic detritus. All such material – whether forming ground, lateral or terminal moraines – appears very much the same lithologically, consisting largely of fragments of basaltic rocks ranging from boulder size downwards, and set in a matrix of rock flour and fine sand. The fragments are mainly of ankaramitic basalt although in the lateral moraines of Kjerulfbreen a high proportion of glomeroporphyritic plagioclase bearing basalt occurs. These boulders of comparatively uncommon rock types have probably been derived from the Sentralkrateret Formation.

The succession of ice advance and retreat, and the associated moraines, have been discussed and described in a series of recent publications (FITCH, 1962; KINSMAN, SHEARD and FITCH, 1962; FITCH, KINSMAN, SHEARD and THOMAS, 1962; KINSMAN and SHEARD, 1963). However, one interesting morainic feature occurs as an irregular bench at the foot of the Storfjellet cliff. The detritus represents ground moraine which has been pushed bodily over the edge of the cliff by an advance of the Beerenberg ice field. Present day avalanche cones are being built upon this bench.

Talus presents a striking appearance along the major cliff faces. The accumulation takes place during the summer thaw when there is a nearly continuous fall of rock debris loosened as ice melts in crevices. The main constituents of the talus deposits are basalt blocks which may, on rare occasions, exceed 20 m across, the lighter pyroclastic material having been carried away by melt water to form outwash fans extending away from the talus at the foot of the cliff. The fans occur sporadically where summer melt water streams emerge from the talus. The rock fragments are usually less than 10 cm in diameter, being mainly red and black scoriae with lesser amounts of smaller basalt fragments. At Marmadukeflya the extensive outwash fans consist almost entirely of scoriae and other pyroclastic materials which have been carried by melt water from the nearby pyroclastic mounds and agglutinate fields on Austkapphallet. A little further south however, in front of the lavas and talus of Trinityberget, basalt fragments are the dominant material in the outwash fan.

Two small lagoons, Dopen and Svarttjørna, are situated on the Kokssletta platform flanking Krossbukta. Here silt and mud rich in organic matter covers a total area of about 0.3 sq. km, and reaches a maximum thickness of 1 m. Winter snow and ice is trapped between the boulders pushed up by winter sea ice and the

Kokssletta *pahoehoe* lava front, the melt water remaining in summer to form the lagoons.

Present day beach material is of two types: pebbles and boulders of basalt which have been pushed up by winter sea ice to fringe the Kokssletta–Nordkapp coastal platform; and dark green to black sand consisting of basalt fragments together with abundant fragments of olivine and pyroxene crystals.

Intrusive rocks

Three types of intrusions are met with in Nord-Jan: dykes, sills and irregularly shaped intrusions. In the Nordkapp area however, the intrusions, with a single exception, are dykes. The exception is a sill about 2 m thick, seen in the cliff immediately northeast of the snout of Svend Foynbreen. The sill, which is inaccessible, contrasts strongly with the Nordvestkapp Formation lavas into which it is intruded on account of the strong development of a perfect, close, columnar jointing. Not a single example of good columnar jointing has been observed in a lava flow, and for this reason the rock is regarded as a sill.

Dykes are abundant, particularly in the Storfjellet Formation and to a lesser extent in the Nordvestkapp Formation. They vary in thickness from a few cm to 4 m, though the majority are about 0.75 m. The thinner dykes tend to follow a slightly sinuous course about horizontal as well as vertical axes. The thicker dykes on the other hand show very little variation in attitude and remain constant in thickness over distances exceeding 1 km. Dykes thicker than a few cm show excellent development of columnar jointing, the frequency of which appears related to the thickness of the dyke, the thickest dykes showing the lowest joint frequency.

The close coincidence between the dyke and fissure pattern has already been mentioned. It is evident that many are infilled former fissures, especially some of those which run parallel to the major cliff lines of Storfjellet–Kraterlia and Trinityberget. However, no fissures are known in the area having the trend of the second set of dykes, viz. 330°, and it seems likely that these dykes fill tensional cracks transverse to the principal rift system, and its associated parallel fissures and dykes.

It is not possible to be precise about the ages of the intrusions. Many of the abundant dykes cutting the Storfjellet Formation fail to penetrate the overlying Nordvestkapp rocks so they are at least pre-Nordvestkapp. There is a strong possibility that some at least represent the fissures through which much of the Storfjellet Formation itself was ejected. An examination of the deep open fissures of the present main Rift Zone convinces the authors of this possibility. On the other hand, they may represent feeders to Nordvestkapp lavas, but this the authors doubt, for the field relations of the Nordvestkapp lavas point to derivation from a proto-Sentralkrateret pit or sink rather than from flank eruptions. No dykes were seen cutting Tromsøryggen or Kokssletta rocks, yet several seen cutting the older strongly weathered formations were remarkably fresh. These must be Nordkapp in age. It is likely therefore that dyke formation has been concentrated in, though not confined to, periods of fissure eruption viz. Storfjellet and Nordkapp, and was largely lacking during the period of intense central activity during which the Nordvestkapp Formation accumulated.

In hand specimen two types of intrusive rock can be recognized: those without ferro-magnesian phenocrysts, and those in which these phases are conspicuous or abundant. The non-porphyritic types are relatively rare, but both types occur in each of the dyke systems, i. e. in those associated with the Rift Zone, and in those transverse to this direction. The non-porphyritic types are black to dark grey compact rocks which contrast strongly with the purplish or brownish porphyritic types. The latter are often moderately vesicular and frequently carry up to 40 % ferro-magnesian phenocrysts, two properties which seem to accelerate the weathering process.

Petrographic review

A classification of rock types based on modal analysis is of limited value, for the very fine grain and the strongly porphyritic character of most of the rocks does not allow accurate determination. Despite the difficulties a number of modal analyses were undertaken, but the discrepancies expected between the mode and the norm were found, and it is apparent that a classification on lines similar to those adopted by LeMaitre for the Gough Island material (LeMaitre, 1962) would be one way of solving the problem. Nevertheless at this stage of the enquiry the authors believe the modes determined can be used to name the rocks.

The consistent appearance of olivine and nepheline in the norms indicates the rocks are of the alkali basalt series, whilst high normative orthoclase implies they are members of the alkali olivine basalt, trachybasalt, trachyandesite, trachyte lineage. Alkali felspar is present interstitially in all the rocks, even the most mafic, but it has not been observed as a phenocryst phase. The rocks are named according to colour index and the modal plagioclase: ankaramites, in which clinopyroxene is dominant and the colour index exceeds 70 (Williams et al., 1954, p. 73–74); trachybasalts, in which the colour index is less than 70, the plagioclase is labradorite and alkali felspar exceeds 10 % of the rock (Williams, op. cit., p. 57–58); and trachyandesite in which the plagioclase is andesine, alkali felspar exceeds 10 % of the rock, and which is generally closely similar to trachybasalt. With the exception of the Koksletta Formation, in which only trachybasalts and trachyandesites have been found, each formation contains all three rock types.

A typical ankaramitite is rich in strongly resorbed xenocrysts of diopsidic augite rimmed with titanaugite. Olivine xenocrysts are less plentiful but again strongly resorbed. Xenocrysts of plagioclase are very rare; when present they are intensely resorbed and twinning tends to be obscure, perhaps as a result of re-heating. The groundmass consists of sparse labradorite or calcic andesine laths rather less than 0.3 mm long. Pinkish brown titanaugite grains are very abundant and often form plates over 0.3 mm across which subophitically enclose plagioclase laths. Olivine occurs regularly as subhedral grains. Interstitial patches are occupied by alkali felspar rarely accompanied by analcite. A distinctive feature is the occurrence of magnetite, not only as abundant equant grains, but also as interstitial patches and smears which penetrate along crystal boundaries and cleavages. Ilmenite occurs as rods, often in parallel swarms. Apatite needles are plentifully disseminated throughout the groundmass.

Ankaramites grade into trachybasalts (the category includes the "ankaramitic basalts" of the above pages) by a reduction in the xenocrysts of diopsidic augite and olivine. Plagioclase glomerocrysts, which are not xenocrysts, may be common and always show normal, and rarely oscillatory, zoning. There is a complementary change in the groundmass: plagioclase (labradorite) becomes more abundant and titanaugite decreases. Subophitic texture is less common and the intergranular texture tends to develop. Olivine remains common as subhedral grains. Magnetite occurs more as equant grains and less as interstitial masses. Interstitial alkali felspar is invariably present; analcite rarely so.

Trachyandesites, in which the plagioclase is calcic andesine, strongly resemble some of the trachybasalts. They may be just as rich as the latter in the ferromagnesian xenocrysts they contain, but they are often richer in plagioclase glomerocrysts. The groundmass develops either an intergranular texture or even a trachytic texture. The titanaugite tends to occur as subhedral grains and prisms, and magnetite is present only as equant grains. Interstitial alkali felspar is common and analcite is sometimes present.

Olivine phenocrysts may be met with in any of the rock types. The larger crystals are presumably xenocrysts, unlike the smaller and microphenocrysts which are a product of the crystallisation of the melt now represented by the surrounding groundmass. They are unzoned and show no reaction relation – a feature characteristic of the olivines of alkali basalts. Many olivines are partially altered to iddingsite. Others show exsolution of iron ores, sometimes hematite, occasionally magnetite. GAY and LEMAITRE (1961) attribute this to re-heating in an oxidising environment, and the evidence from Nord-Jan fully supports this conclusion. Olivines showing such exsolution ores are particularly common in agglutinates where evidence of prolonged fire fountaining is very strong. Many of the larger crystals show strained extinction and the development of translation gliding lamellae subparallel to (100) (TURNER, 1942). They are probably xenocrysts which crystallised at depth in a magma reservoir and were introduced into the melt, represented by the groundmass of the rock in which they are now found, during its ascent to the surface.

The large clinopyroxenes, dark bottle-green in hand specimen, are pale yellow-green to colourless in thin section. They are diopsidic augites and like the large olivines may be found in any of the rock types and show strong resorbtion. They are zoned, possessing a thin rim of lilac or pinkish-brown titanaugite. They too are probably xenocrysts, only the rim representing crystallisation from the enclosing melt. Furthermore they are frequently strained. Resorbtion cavities in the diopsidic augites occasionally carry prisms of kaersutite – in the sense of WILKINSON (1961) – and the cavity wall is altered to a depth up to 0.01 mm to this amphibole.

In a few rocks a second clinopyroxene may be seen forming phenocrysts rarely over 3 mm across. They are pinkish to lilac-brown titanaugites, closely zoned and obviously true phenocrysts. More frequently they occur as glomerocrysts, e. g. in many of the Tromsøryggen rocks, where individual crystals are less than 0.5 mm across, closely zoned, and develop hourglass structure.

Plagioclase occurs both as phenocrysts and xenocrysts. Rare crystals may occur which show intense resorbtion and in which the multiple twinning is obscure; they are probably xenocrysts and are usually bytownite; normal zoning is only feebly developed or even absent. On the other hand many rocks carry abundant phenocrysts and glomerocrysts which show strong normal zoning from a labradorite core to an andesine rim; rarely the zoning is oscillatory. They may also show slight resorbtion, but such crystals are obviously true phenocrysts. They are common in Nordvestkapp and Nordkapp rocks, but this is not diagnostic, for rocks rich in plagioclase glomerocrysts may occur in any of the formations.

Little more need be added at this stage concerning the remaining minerals, except to state biotite occurs as ragged plates and mossy aggregates in the groundmass of a couple of trachybasalts and several trachyandesites.

Finally the rarity of a glass mesostasis is worthy of comment, again a feature typical of alkali basalts (YODER and TILLEY, 1962, p. 355). Glass is present in only the tuffs, agglutinates, and the rapidly chilled skins of some flows.

Analyses of Nordkapp rocks are listed in Table 1 together with the norms. When total alkalis are plotted against silica on a Tilley diagram (TILLEY, 1950, p. 42) the trachybasalts and trachyandesites are seen to fall within and near

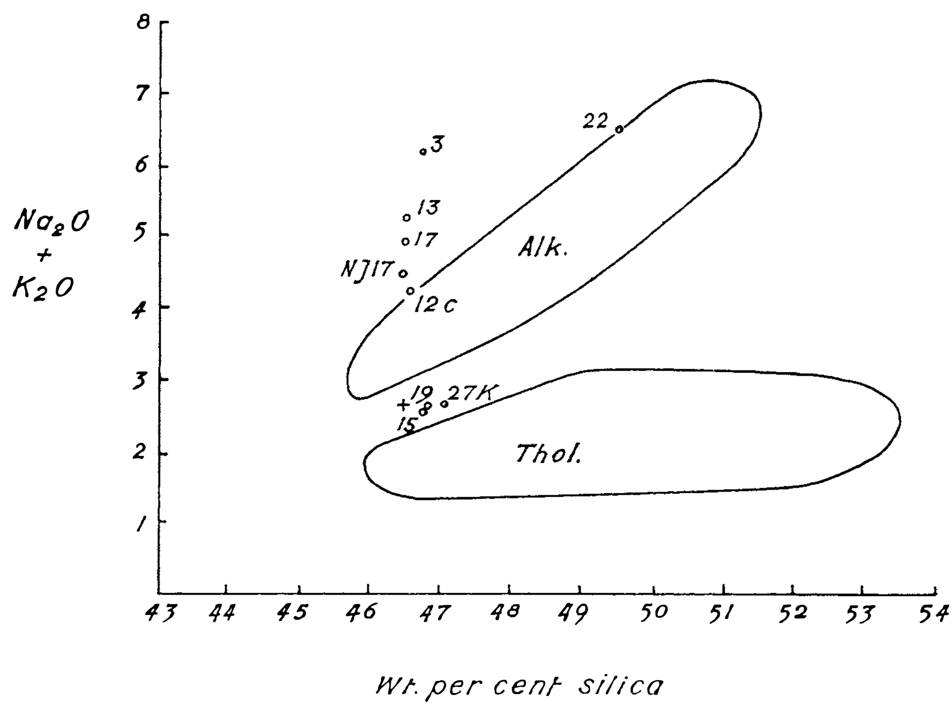

Fig. 8. *Plot of total alkali/silica for analysed Nordkapp rocks.*
Alk. = area of Hawaiian alkali rocks.
Thol. = area of Hawaiian tholeiitic rocks.
\+ = picrite basalt of Gough Island. (From LEMAITRE, 1962.)

the field of the Hualalai and Mauna Kea olivine basalts and mugearites (see Fig. 8). The ankaramites however fall nearer the field of the tholeiitic series of the Mauna Loa and Kilauea rocks, but accumulative rocks would normally fall outside the area of the alkali basalts. Indeed they occupy much the same position as the picrite basalt of Gough Island (LeMaitre, 1962, p. 1327). There is therefore no evidence of any tholeiitic tendencies; all are members of the alkali basalt series.

Conclusions

1. Volcanic activity in Nord-Jan has been of two types: fissure eruptions and central vent eruptions. The proto-Nordkapp Rift Zone was in existence during the accumulation of the Storfjellet pile of lavas and pyroclastics, the rocks having been ejected from fissures associated with this rift system. The Nordvestkapp lava phase followed the formation of a central vent, the proto-Sentralkrateret, and the consequent building of the Nord-Jan dome. However, fissure activity did not cease entirely, and it is probable that some of the Nordvestkapp lavas between Nordbukta and Krossbukta have been derived from the proto-Nordkapp Rift Zone. The sillar constituting the Havhestberget tuff marks the initial eruptions from the proto-Sentralkrateret before activity settled to a steady and rapid outpouring of basaltic lavas. The Nordkapp Group rocks are solely products of fissure eruptions from the Nordkapp Rift Zone.

2. The abundance of agglutinate among the pyroclastic deposits from the Nordkapp Rift Zone fissures indicates that fire fountaining has been a dominant volcanic mechanism. Agglutinate fields result from simultaneous eruption of bomb size plastic ejecta from an anastomosing network of minor fissures within a major fissure zone. As a result the fields are elongate parallel to the major fissure zone.

3. The most recent fissure eruptions which produced series of basaltic flows, began in each case with mild explosive activity and fire fountaining followed by the outpouring of *pahoehoe* lava and, in turn, by *aa* flows. One may assume that fire fountaining and explosive activity caused the magma high in the fissure to become impoverished in volatiles with a consequent increase in viscosity, and that this material produced *pahoehoe* lava on eruption; magma lower in the fissure would remain richer in volatiles and on eruption produced *aa* flows. These suggestions agree with those of Washington (1923) and Rittmann (1962, p. 66–68) who state that *pahoehoe* results from a magma relatively impoverished in volatiles whereas *aa* lavas are the result of solidification of melts rich in volatiles.

4. The gradient, down which an *aa* lava produced by fissure eruption flows, largely controls the development of surface features and structures. On slopes steeper than about 20° the lava is channelled into conduits; on lesser slopes the lava moves as a blanket flow; and on the gentlest gradients the surface develops the blocky and scoriaceous surface characteristically associated with *aa* flows. The greatest development of blocky surface, spiracles etc. is seen in standing pools and on the slowest moving portions of flows.

Table 1. *Analyses, norms and localities of some Nordkapp rocks*

Analyst: W. H. HERDSMAN

Weight %	NC. 3.	NC. 12C.	NC.13.	NC.15.	NC.17.	NC.19.	NC.22.	NC. 27K.	NJ.17.
SiO_2	46.78	46.59	46.49	46.81	46.53	46.84	49.39	47.05	46.42
TiO_2	2.82	2.41	2.20	1.87	2.56	2.21	2.72	1.88	2.41
Al_2O_3	16.77	14.41	15.21	8.02	13.77	6.54	14.13	13.38	16.04
Fe_2O_3	4.04	4.93	3.03	4.42	4.77	4.76	3.17	3.68	5.32
Cr_2O_3	Nil	0.05	0.04	0.25	0.06	0.19	0.07	0.08	Nil
FeO	8.33	6.61	9.58	5.51	7.33	7.37	8.07	7.18	8.77
MgO	4.33	8.22	6.01	15.18	8.01	14.09	5.43	9.18	4.86
MnO	0.22	0.21	0.22	0.17	0.22	0.18	0.22	0.18	0.23
CaO	9.08	11.43	11.08	14.48	10.96	14.59	9.26	13.69	10.17
BaO	0.12	0.06	0.16	0.06	0.06	0.10	0.16	0.06	0.06
Na_2O	3.14	2.47	2.68	1.41	2.47	1.48	3.48	1.62	2.08
K_2O	3.02	1.76	2.54	1.21	2.46	1.21	3.18	1.12	2.46
H_2O+	0.36	0.42	0.36	0.45	0.36	0.38	0.25	0.52	0.58
H_2O-	0.34	0.07	0.05	0.08	0.13	0.03	0.05	0.22	0.17
P_2O_5	0.68	0.43	0.53	0.29	0.46	0.29	0.56	0.28	0.58
CO_2	0.15	0.08	Nil	Nil	0.03	Nil	Nil	0.04	Nil
	100.18	100.15	100.18	100.21	100.18	100.26	100.14	100.16	100.15
Or.	17.79	10.56	15.01	7.23	14.46	7.23	18.90	6.67	14.46
Ab.	18.86	17.29	11.53	6.81	13.62	7.86	20.17	13.62	17.82
An.	22.52	22.80	21.96	11.68	19.18	7.51	13.62	25.85	26.97
Ne.	4.26	1.99	5.96	2.84	3.98	2.56	4.97		
Di.	14.78	24.70	24.39	45.81	25.94	50.11	23.48	32.00	16.32
Ol.	8.29	9.40	10.64	14.31	9.52	12.62	7.54	8.82	5.81
Hy.								2.46	4.45
Ilm.	5.32	4.56	4.26	3.50	4.86	4.26	5.17	3.65	4.56
Mt.	5.80	7.19	4.41	6.50	6.96	6.96	4.41	5.34	7.66
Ap.	1.68	1.01	1.34	0.67	1.01	0.67	1.34	0.67	1.34
Rest	0.85	0.68	0.61	0.84	0.64	0.60	0.37	0.92	0.81
	100.15	100.18	100.11	100.19	100.17	100.38	99.97	100.00	100.20

Spec. no.	Rock type	Formation	Locality
NC. 3.	Trachybasalt	Storfjellet	Lava. Storfjellet cliff near Krossbukta.
NC. 12C.	Trachybasalt	Tromsøryggen	Lava. 15 m inland cliff south of Nordbukta
NC. 13.	Trachybasalt	Nordvestkapp	Lava. Kraterlia cliff south of Nordbukta
NC. 15.	Ankaramite	Nordvestkapp	Lava. Kraterlia cliff south of Nordbukta
NC. 17.	Trachybasalt	Storfjellet	Lava. Storfjellet cliff below Tvillingkrateret
NC. 19.	Ankaramite	Storfjellet	Lava. Storfjellet cliff below Tvillingkrateret
NC. 22.	Trachyandesite	Storfjellet	Lava. Storfjellet cliff below Tvillingkrateret
NC. 27K.	Trachybasalt	Nordvestkapp	Lava. Kvalnosa buttress.
NJ. 17.	Trachybasalt	Koksslettta	Lava. Koksslettta platform

5. WORDIE's brief observations (1926) on Nord-Jan are generally supported, although the belief that above the 650 m contour Beerenberg is built solely of trachybasalt flows is erroneous. His suggestion that volcanic activity has tended to move northeastwards throughout Jan Mayen as a whole receives support. TYRRELL's petrological observations are also generally supported.

6. NICHOLLS' work, in as much as it applies to the Nordkapp area, is difficult to interpret. It is probably an over-simplification to state that each volcanic cycle begins with ankaramite and evolves to trachybasalt via intermediates.

7. The suggestion of FITCH and BANFIELD (in DOLLAR, 1959) that three broad stratigraphical units were recognizable because they were separated by erosion intervals, is supported with small modofication. Their suggestions on the structure of Nord-Jan have been considerably modified (FITCH, 1964) now that the importance of the Nord-Jan dome is appreciated.

8. Most petrological conclusions are beyond the scope of the present paper, but the following points may be mentioned:

a. The rocks clearly belong to the alkali basalt series of TILLEY (1950). They are undersaturated, showing normative olivine usually accompanied by nepheline, normative hypersthene appearing only in two of the analysed rocks. The very high potash content was noted by TYRRELL (1926) and is an outstanding character of the rocks; this feature apart, the rocks appear generally comparable with those of certain other islands on the Mid-Atlantic Ridge including Gough Island (LEMAITRE, 1962), Tristan da Cunha (DUNNE, 1941), the Azores (ESENWEIN, 1929; TORRE DE ASSUNCAO, 1959).

b. Many of the rocks are accumulative, and on first inspection the proportion of ankaramites is unusually high. However most turn out to be strongly porphyritic basalts, and the Nordkapp evidence favours the interpretation of TYRRELL viz. that trachybasalt (alkali olivine basalt) is the parent.

c. The almost constant occurrence of large xenocrysts of diopsidic augite and olivines (often showing glide lamellae) in the volcanics implies the existence of a magma reservoir rather than direct tapping of a fundamental source.

Acknowledgements

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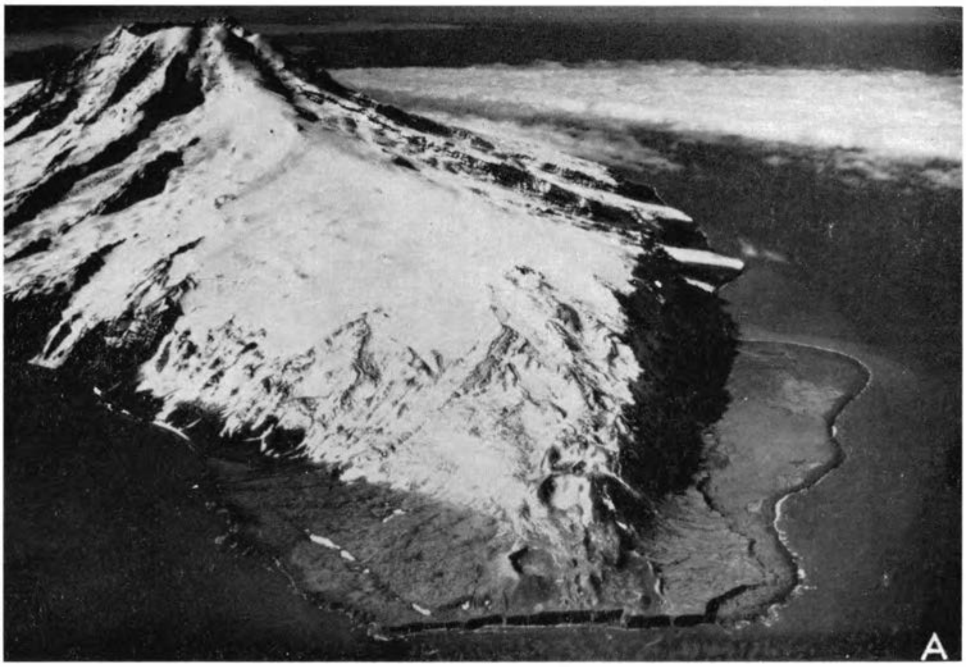
PLATE I

A. Beerenberg from the northeast showing the area described. The high level Beerenberg cone (Sentralkrateret) sits on the Nord-Jan dome (essentially Nordvestkapp Formation). The dome is elongated in a northeast direction by the ridge of the main Rift Zone, from the fissures of which the Nordkapp Group was erupted. The Kokssletta Formation, seen on the Kokssletta coastal platform, is backed by the low inland cliff cut in the Tromsøryggen Formation. Photo: B. LUNCKE. (Courtesy of Norsk Polarinstitutt.)

B. Storfjellet cliff immediately east of Krossbukta (height 500 metres). The base camp is sited on the 8 metre raised beach and is backed by a shelf of morainic debris which has been dumped over the cliff from the Beerenberg ice field. Present day avalanche cones debouch onto this shelf. The vertical face of the cliff terminating in pinnacles consists of pyroclastics and intercalated lavas of the Storfjellet Formation, member B; two sets of dykes, one set parallel to the cliff face, the second trending at 330°, are prominent. Above the pinnacles is the lava sequence of the overlying Nordvestkapp Formation. Photo: J. F. COLE.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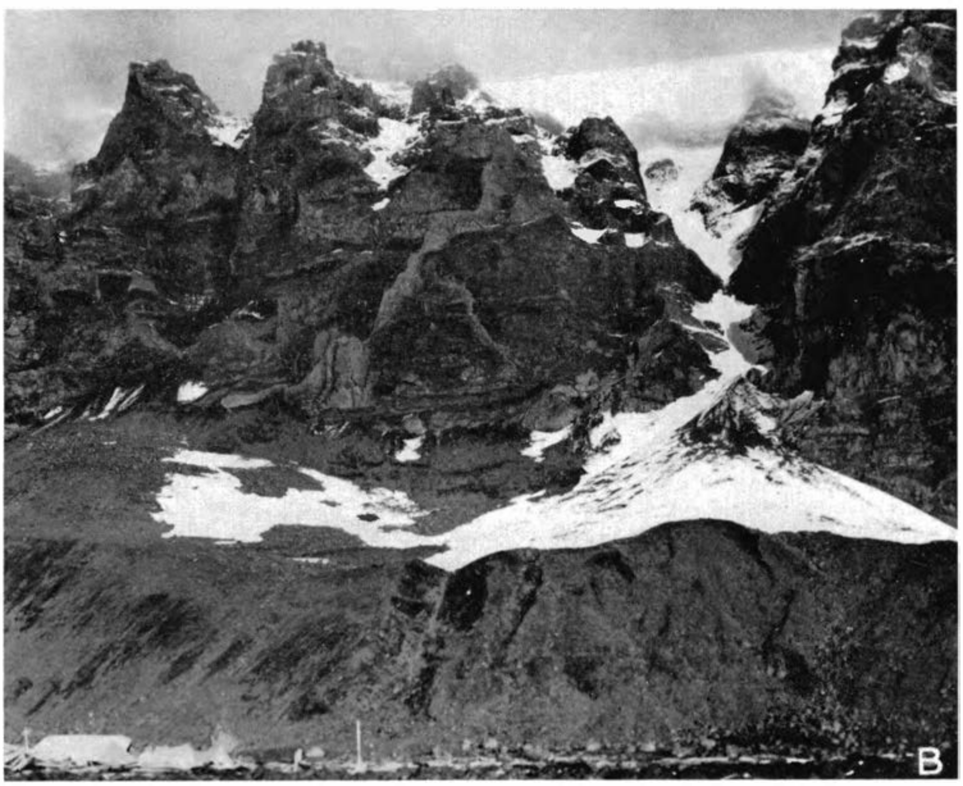
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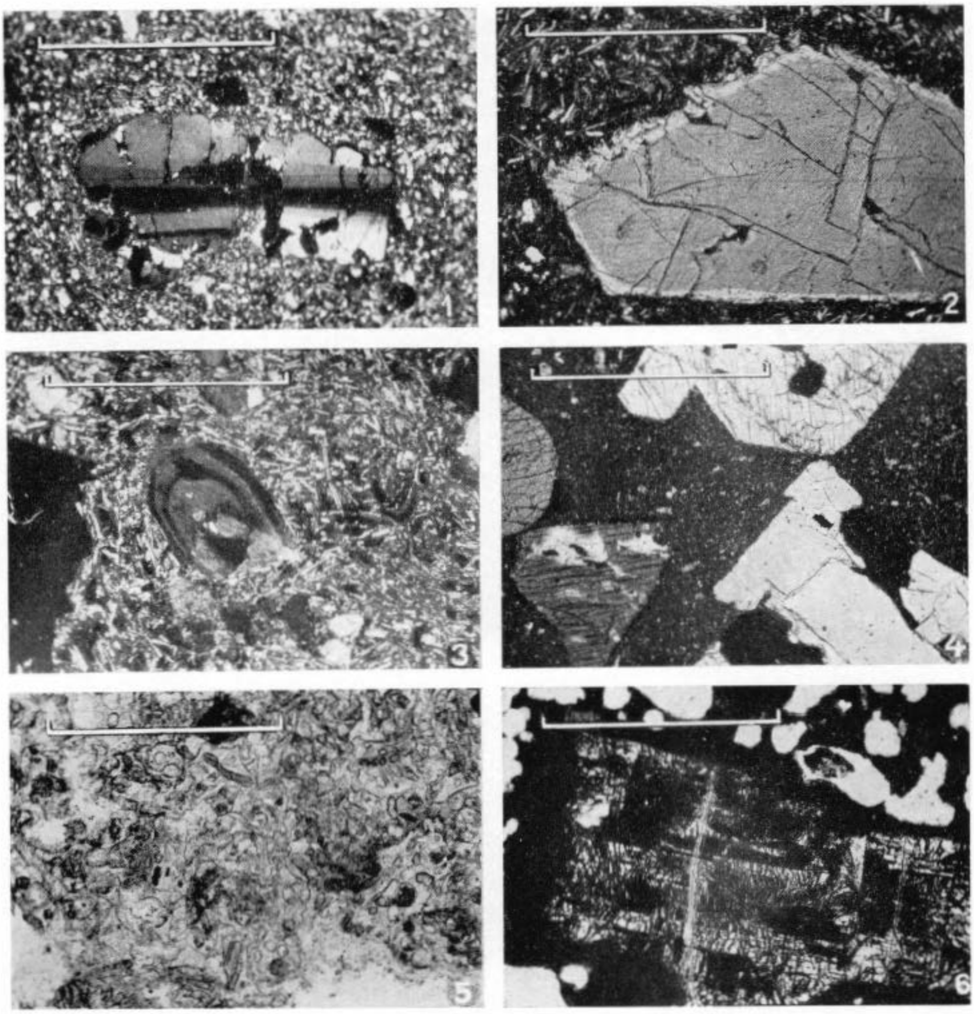

PLATE II

1. Olivine xenocryst showing glide lamellae and slight iddingsitisation in trachybasalt. NC. 42 F. Storfjellet Formation, member A. Crossed polarisers.

2. Diopsidic augite xenocryst with titan-augite rim. The ragged nature of the rim is probably a growth feature and not due to resorbtion. Trachybasalt showing intergranular texture. NC. 41 A. Storfjellet Formation, member A. Crossed polarisers.

3. Titanaugite phenocryst showing fine zoning and hourglass structure. Trachybasalt with good intergranular texture. NC. 12 A. Tromsøryggen Formation. Crossed polarisers.

4. Very fine grained ankaramite carrying resorbed xenocrysts of olivine and diopsidic augite. NC. 15. Nordvestkapp Formation. Crossed polarisers.

5. Havhestberget tuff showing the ash grade matrix of yellow glass shards, fragments of vesicular pumice and glass dust. Plane polarised light.

6. Xenocryst of olivine copiously exsolving magnetite due to re-heating and oxidation set in dark red vesicular basaltic glass. Agglutinate, Tromsøryggen Formation. Plane polarised light. Inscribed line represents 1 mm.

Palaeomagnetic studies on rocks from North Jan Mayen

BY

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Contents

Abstract

Magnetic studies on ten specimens of basaltic rocks from the Arctic island of Jan Mayen are described and commented upon. The specimens were collected by a new technique as part of the scientific programme of the 1961 University of London Beerenberg Expedition. A brief review of the geology of Nord-Jan is given, and descriptions of the analysed rocks are included with the field collecting data.

Introduction

Palaeomagnetic studies on rocks from Jan Mayen rank amongst the earliest of such investigations, for rocks were collected from the island by CHEVALLIER and MERCANTON (MERCANTON 1922, 1926; CHEVALLIER, 1930). The number of samples collected by these early workers was small: in addition both obtained much of their material from the same locality, a lava flow near Jamesonbukta, on

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Table 1. *Summary of the geological history of Beerenberg*

Rock-stratigraphic units: Nord-Jan		Brief description and main criteria of recognition	Geological estimate of age of volcanic member in years B. P.
Nordkapp group. Includes all the products of Post-Sentralkrateret fissure and parasitic volcanic activity and the present day glacial and other sedimentary deposits	Smithbreen formation	All rocks younger than the Kokssletta volcanics, including the recent explosive volcanic accumulations of Dagnyhaugen, the moraines of the present icefield, outwash and torrent gravels, beach and lagoon deposits, present day scree and avalanche fans	small parasitic eruptions up to historical times
	Kokssletta formation	Volcanic rocks of the latest major eruption cycle, which build topographically fresh fissure/cone systems, fissure-fed lava fields and coastal lava platforms. Ankaramitic and glomeroporphyritic plagioclase-basalts in the north, only glomeroporphyritic plagioclase basalts in the south. Older than the Smithbreen moraines, younger than the "10-metre raised beach" and related features	2,500–3,500
	Tromsøryggen formation	Ankaramitic basalt lavas and pyroclastics which build great fissure line ridges, cones and lava fields. Rests on an old land surface, is younger than the main "Post-Sentralkrateret and Post-Nordvestkapp" cliff feature, older than the "10-metre raised beach" cliff. No longer displays completely fresh volcanic accumulation surfaces and is cut into by both cliff and torrent erosion	4,000–5,000
Builds the high level cone of Beerenberg	Sentralkrateret formation	A distinctive glomeroporphyritic plagioclase-basalt rock-type. Builds the central high-level cone of Beerenberg. Rests unconformably on Nordvestkapp rocks in Sørhallet: is older than the main "Post-Sentralkrateret and Post-Nordvestkapp" cliff feature and other pre-Tromsøryggen erosion surfaces	Atlantic 6,000–7,000
Kapp Muyen group. Builds the basalt lava-dome of Beerenberg	Nordvestkapp formation	A distinctive lithological unit composed of numerous fluent centrally-erupted basalt flows building the main lava dome of Beerenberg. Ankaramitic basalts predominate. Local centres were active at Kapp Muyen, Libergsletta and in the Søraustkapp Rift Zone. Overlies Havhestberget rocks in all sectors and is beneath Sentralkrateret and younger rocks	Atlantic 7,000–8,000
	Havhestberget formation	Very distinctive rock-type and lithological unit, composed of basaltic pumice-tuff. Mostly agglomeratic or block-bearing basalt sillar or non-welded ignimbrite deposited by an ash-flow mechanism, but some subaerial and water-lain bedded tuffs and tuff-breccias also seen. Subordinate lava flows and fissure ridges. Overlain by Nordvestkapp lavas: rests unconformably on Storfjellet or Kapp Fishburn Tillite	
	Storfjellet formation	A distinctive lithological unit of ankaramitic basalt lavas and voluminous cinder accumulations. Only seen in the Storfjellet cliff sections, where it is overlain by the pumice-tuffs of the Havhestberget Formation and by the Nordvestkapp lavas, and itself overlies the Kapp Fishburn Tillite	Boreal c. 9,000
	Kapp Fishburn Tillite	A distinctive basaltic tillite occuring low down in the volcanic succession. Associated with fossil scree. The majority of the phenoclasts are of ankaramitic basalt, some exhibiting glacial striae. Rests on Krossbukta lavas with local unconformity. Buried by Storfjellet rocks in the north, overlain unconformably by Havhestberget pumice-tuffs in the south	greater than 10,000
	Krossbukta formation	The oldest volcanic rocks to outcrop in Nord-Jan. Overlain by Kapp Fishburn Tillite. Junction where seen is an eroded surface in the volcanics buried beneath tillite. Ankaramitic basalt lavas interbedded with fossil scree material	
	Hidden volcanic formations	Rocks of the submerged and hidden volcanic formations are not exposed in Nord Jan. Their presence can be inferred from the form of the structural contours on the later formations and from the form of the submarine contours around Jan Mayen. Blocks and lapilli in the explosion debris of such vents as Eggøya, and in the Kapp Fishburn Tillite, together with accidental xenoliths present in some lavas, give a good indication of the character of these early formations. They must include a full sequence of basaltic rocks and their differentiates through to trachytes and quartz-trachytes	
Submarine foundation of Jan Mayen	Submerged volcanic formations		

the southern shore of the large volcano, Beerenberg. The suitability of the iron-rich basic volcanic rocks of Jan Mayen for further palaeomagnetic study was suggested to the authors by DOLLAR in 1960, and preliminary exploratory measurements were made on three samples which he provided from Sør-Jan. Plans were made for extensive collecting during the 1961 University of London Beerenberg Expedition to Jan Mayen, but the expedition programme was severely curtailed as a result of a fatal accident, and it was only possible to obtain a restricted suite of samples (collected by TALBOT). The purpose of this note is to summarise the palaeomagnetic work carried out to date on rocks from Beerenberg, and to indicate possible fields for further research.

Brief review of the geology of Nord-Jan

Jan Mayen rises from the Arctic continuation of the North Atlantic Ridge some 600 kms north of Iceland. The foundation of the island is a submerged volcanic pile presumed to be of Tertiary age. A large basalt volcano, Beerenberg (71° 05′ N, 8° 10′ W), dominates the northern half of the island. Beerenberg is 2277 m high and 50 kms in circumference. It consists of a broad basalt lava-dome or -shield carrying a single large summit lava-cone on its crest. The volcano is built on a major south-west/north-east rift structure, and fissure eruptions have been very important on its flanks. The oldest visible Beerenberg lavas are late-Pleistocene in age; the major part of the volcano has been built by a series of eruption cycles during post-Pleistocene times. All of the rock-stratigraphic units listed in Table 1, which summarizes the geological history of Beerenberg, include extrusive and intrusive volcanic members. Full description of the geological evolution of Beerenberg and its icefield will appear elsewhere (FITCH 1964; KINSMANN and SHEARD 1963; see also FITCH 1961, 1962; FITCH, KINSMAN, SHEARD and THOMAS 1962; KINSMAN, SHEARD and FITCH 1962; HAWKINS and ROBERTS 1963; ROBERTS and HAWKINS 1964 in press). The volcanic units mapped by CARSTENS in 1959 in the far south of Jan Mayen (CARSTENS 1963) are thought to correlate with the nomenclature used here as follows:

Table 2. Correlation between rocks of Nord- and Sør-Jan

FITCH 1962, 1963	CARSTENS 1963
Koksslettta Formation	Kraterflyia basalts
Tromsøryggen Formation	Upper Volcanic Series
Sentralkrateret Formation	Middle Volcanic Series
Kapp Muyen Group	Lower Volcanic Series

The collecting technique

Specimens for palaeomagnetic study must be marked and classified in such a way that the spatial orientation in the field can be recreated in the laboratory. It is usually sufficient to indicate on the specimen a horizontal plane and the direction of apparent Magnetic North. From previous work on Jan Mayen it was known, however, that the magnetic field distortion due to some of the basic lava rock-types present renders this method inadequate (e. g. differences of up to 180° in the apparent Magnetic North have been noticed at points only hundreds of yards apart on Røysflya). Fortunately the detail on the 1:50,000 topographic map

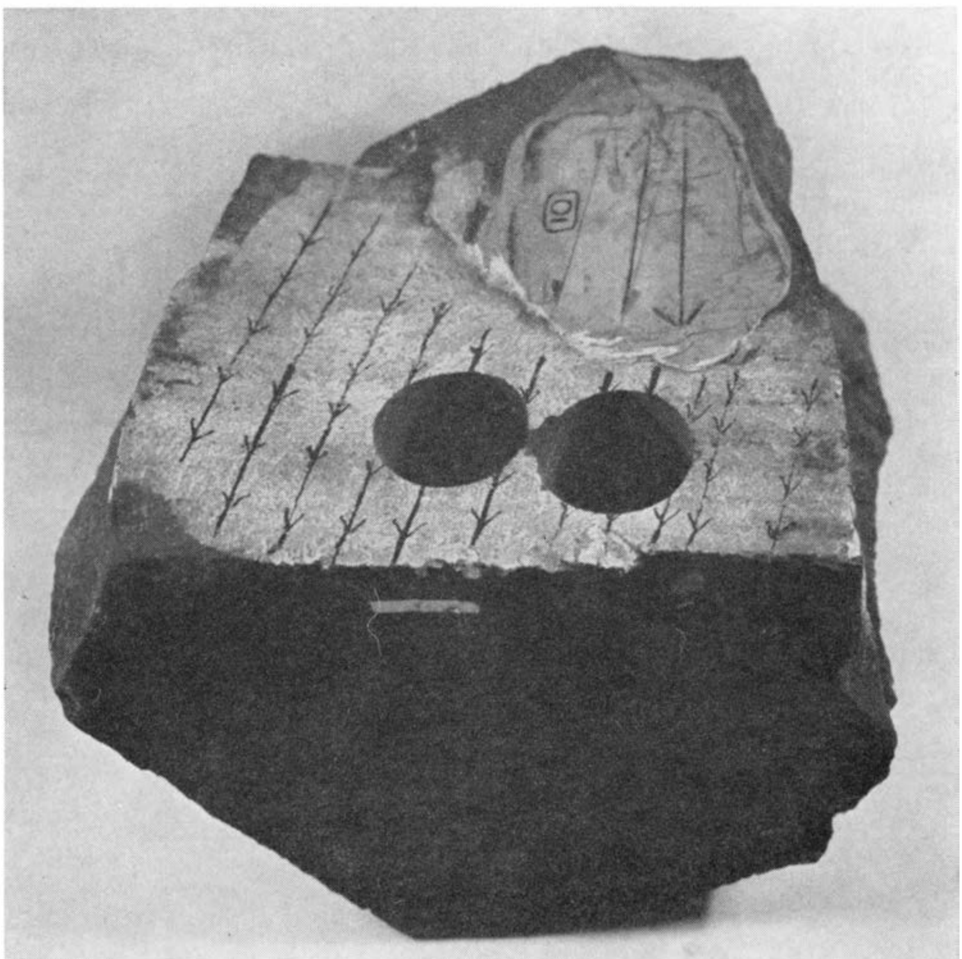

Fig. 1. *Specimen Jm 10. An east-west Koksletta dyke cutting Tromsøryggen tuffs in the upper part of Valberget. The large arrow on the right hand side of the plastic wood platform is a sight on apparent magnetic North. The left hand arrow is the sight line from which geographical North was determined by resection. The fine lines drawn in the geographical meridian were extended as a parallel grid on the white painted top of the specimen in the laboratory.*
The rock is a vesicular microphyric basanitic trachybasalt.

published in 1959 by Norsk Polarinstitutt enables an optical orientation of $\pm$ 2° to be obtained by use of simple surveying methods.

In the method used on Jan Mayen in 1961, a level sighting platform of plastic wood was built onto a suitable rock outcrop, the horizontal upper surface being produced with the flat back of a spirit level clinometer. Using a light alidade, lines of sight were then marked on this surface. The location of the sampling station was determined by resection, the angle between True North and one of the lines of sight measured on the map, and this information transferred to the specimen. It was found to be advantageous if both True and Apparent Magnetic North were marked on the specimen in the field to provide a measure of the local magnetic field distortion.

Ideally, the plastic wood platform should be allowed to harden completely before the lines of sight are taken and scored on it, but in many situations in the field this lengthy process is impractical. It was found that, with care, clean specimens could be dislodged and replaced before the readings were taken, and that if reasonably well protected, the still incompletely hardened plastic wood platforms returned to Base Camp intact. Coloured inks were used at Base Camp to emphasize the scored sighting lines and after a day or two the plastic wood became rock-hard and then survived without damage transport to the laboratory.

If similar work is to be undertaken where conditions do not allow any time for the sighting surface to harden, it is suggested that a thin rigid, non-magnetic surface be set in the plastic medium or, if the rock surface is suitable, attached with a very quick drying cement similar to that used successfully by SIGURGEIRSSON in Iceland. The greatest limitation of the optical orientation method is the need for reasonable visibility conditions. On Jan Mayen, where thick mists are common, this caused considerable delays on occasion.

Field relationships and description of the rocks collected

Ten oriented specimens were collected for palaeomagnetic analysis. The data obtained is presented in Table 3 and in Figs. 3 and 4, and its significance is discussed in a later section. Field and petrographic information on each of the rocks analysed is given below. The grid reference system used to identify the sampling localities is based on a 2 km square grid. This grid is present (or its intersections are marked), on the 1:20,000 topographic map of Jan Mayen available at Norsk Polarinstitutt. Fig. 2 illustrates the alphabetical key which was used in conjunction with the 2 km square grid to designate individual geological field mapping slips. Map references are given in each alphabetically designated square by reference to co-ordinates that have their origin in the south-west corner.

Kokssletta rocks

Five of the specimens collected for palaeomagnetic study were basalts from the Kokssletta formation, thought to have been erupted between 2,500 and 3,500 years ago. Three (Jm 1, Jm 2, Jm 5) are from lava flows and two (Jm 4, Jm 10)

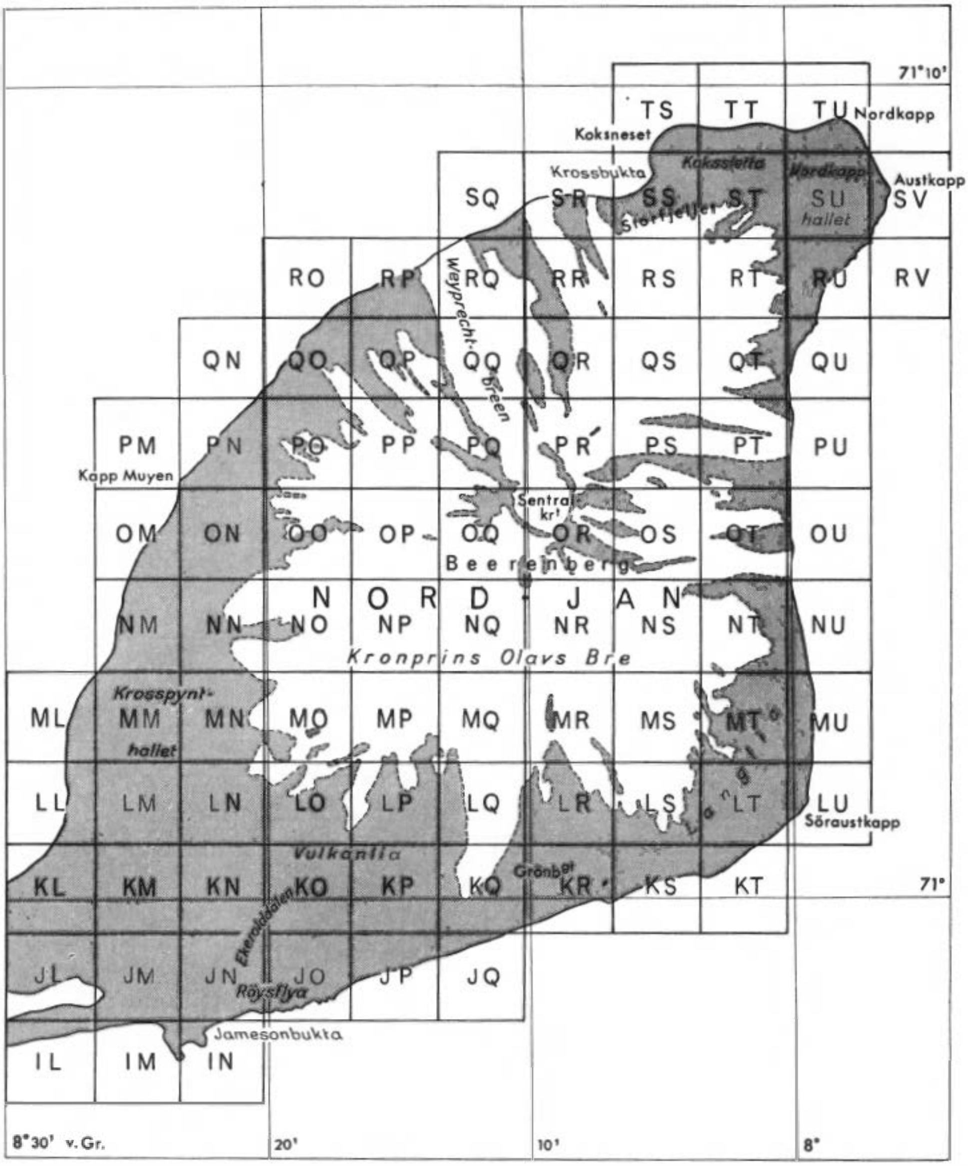

Fig. 2. *Alphabetical key to 2 km square field mapping slips used by the Berenberg Expedition. Rock samples are located using a grid reference having its origin in the south-west corner of each slip.*

near surface dykes. The Koksletta eruptions of all parts of Nord-Jan are of a very similar fissure controlled type, and the basalts emitted during this cycle build extensive lava fields and coastal lava platforms on the lower flanks of Beerenberg. The well-preserved lava-structures of the Koksletta formation show these eruptions to be directly comparable in form with the 1959/60 flank fissure eruption of Kilauea.

Specimen Jm 1 (grid reference JN 9523) was collected from the vesicular top of a thick aa-flow of Koksletta basalt forming the present day sea-cliffs at the east-north-east end of Jamesonbukta. This is part of Røysflya, a wide coastal lava platform resting on the "10-metre" pre-Kokssletta wave-cut beach in front of the old sea cliffs of Havhestberget. It was built by lava streams fed from various small vents along the lower parts of the Vulkanlia parallel fissure system.

Specimen Jm 2 (grid reference KNO 120) is from the vesicular top of a pahoehoe flow of Kokssletta basalt that emerges from the fissures in the upper part of Schmelckdalen, 50 metres upstream from the opening into a large caved-in lava tunnel. Below the lava tunnel exposure this flow passes over the Valberget cliff to spread out on the "10-metre" coastal abrasion platform 1 km to the west of Røysflya.

Specimen Jm 5 (grid reference JP 1580) is from the small Kokssletta flow that sweeps around Bernakrateret, a Tromsøryggen cinder cone, and out onto the "10-metre" platform 1 km to the east of Røysflya.

Specimen Jm 4 (grid reference KR 0945) is from a vesicular north–south dyke belonging to the Kapp Fishburn fissure system, intruded into the Tromsøryggen cinder whaleback of Grønberget.

Specimen Jm 10 (grid reference JN 1595) was collected from a vesicular east-west dyke which is intruded into tuffs of Tromsøryggen age in the upper part of Valberget.

The three lava flows sampled are closely related in time and are thought to be representative of eruptions from the lower levels of the south-west fissure systems of Beerenberg during Kokssletta times. The vesicular character and field relationships of the two dyke rocks suggests that they were near surface intrusions, most probably sections of the feeding fissures of lava eruptions of Kokssletta age. It is not possible to demonstrate the time-sequence of events within the Kokssletta cycle of eruptions with any certainty, but indirect evidence (such as degree of surface weathering, relative exposure by erosion and the fact that in the Nordkapp area, at the other end of the main fissure system, voluminous pahoehoe flows preceded the aa-eruptions in the Kokssletta cycle), suggests that it might be reasonable to suppose that the Schmelckdalen flow is early Kokssletta and the Røysflya eruptions a later event.

Megascopically and microscopically, the five specimens of Kokssletta basalt from the lower southern flank of Beerenberg appear to represent effusions of the same alkali-basalt magma-type. They are all of a dark grey microlitic basalt, characteristically speckled by an even distribution of small white glomero-porphyritic aggregates of felspar between 1 and 3 mm in diameter. Each contains small variable amounts of fresh bottle-green pyroxene and orange-yellow to lime-green olivine phenocrysts between 2 and 12 mm in diameter. All are vesicular, the vesicles in the lavas up to 15 mm across. Flow-structures are present, either as distortion of the vesicles, alignment of the microlites of the groundmass or as a banding of more and less vesicular layers. The very fine-grained groundmass of the rocks is characterized by its richness in pyroxene and iron ores and by the presence of an alkali-felspar residuum. Microphenocrysts of augite and olivine are present amongst abundant labradorite microlites enclosed within the groundmass. The larger phenocrysts never amount to more than 15 % of the rock. Analcite is suspected in some slides and the rocks can be classified therefore as basanitic trachybasalts.

Tromsøryggen rocks

Three of the palaeomagnetic specimens were collected from basalts of the Tromsøryggen formation, thought to have been erupted between 4 and 5,000 years ago. This was a period of extensive fissure eruption, building large composite lava and tuff ridges across the lower flanks of Beerenberg.

Specimen Jm 6 (grid reference JO 9581) was collected from a Tromsøryggen ankaramite lava flow near Veslegryta; erupted from the Vulkanlia fissure system, and seen to have flowed over a land surface cut in Kapp Muyen tuffs and lavas. The rock is strongly porphyritic with over 30 % of bottle-green pyroxene and lime-yellow olivine phenocrysts up to 1 cm across, enclosed in a fine-grained vesicular matrix. The matrix consists of augite and olivine microphenocrysts with rare labradorite laths set in a dark iron-rich cryptocrystalline base. Felspar amounts to not more than 10–15 % of the rock.

Specimen Jm 8 (grid reference KL 1060) is from a near surface vent intrusion or lava flow that forms part of dissected Tromsøryggen cone seen in the sea-cliffs north-west of Fugleberget. This rock is a pale grey vesicular trachybasalt with numerous small phenocrysts of olivine, augite and labradorite set in a fine-grained crystalline matrix of augite, olivine, iron-ore, plagioclase and alkali-felspar. A notable feature of this rock is a xenolith of peridotite with a spinellid (possibly approaching hercynite in composition) as a common accessory.

Specimen Jm 9 (grid reference JN 1090) is from a north-south dyke of Tromsøryggen age cutting an inlier of Havhestberget sillar in the lower part of Valberget. The rock is a very fine-grained vesicular and porphyritic dark-grey trachybasalt. The numerous fresh euhedral phenocrysts of pyroxene and olivine, amounting to some 40 % of the rock, with pyroxene slightly subordinate to olivine, range between 1 and 10 mm in diameter. Vesicularity is developed in bands and streaks revealing the flow within the dyke fissure. The largest vesicles are up to 5 mm across whilst against the walls of the fissure the rock is almost free of vesicles. The matrix consists of many euhedral augite grains with less numerous labradorite laths and microlites set in a cryptocrystalline to glassy groundmass rich in minute iron-ore grains.

Sentralkrateret rocks

Sentralkrateret is the large composite lava-cone, 6 to 7,000 years old, that forms the summit of Beerenberg. From its crater, lavas flowed radially down shallow valleys on the flanks of the mountain away from the central cone.

Specimen Jm 3 (grid reference KR 3465) is a trachybasalt collected from the base of one of these flows lying on an old erosion surface cut in Nordvestkapp lavas, and exposed to-day as the capping of a Nordkapp north-west/south-east erosion ridge east of Grønberget. The Sentralkrateret trachybasalts are exceptionally rich in small glomerophyric aggregates of plagioclase and correspondingly poor in ferromagnesian phenocrysts, but in all other respects they are similar to the basanitic trachybasalts of the Kokssletta formation already described.

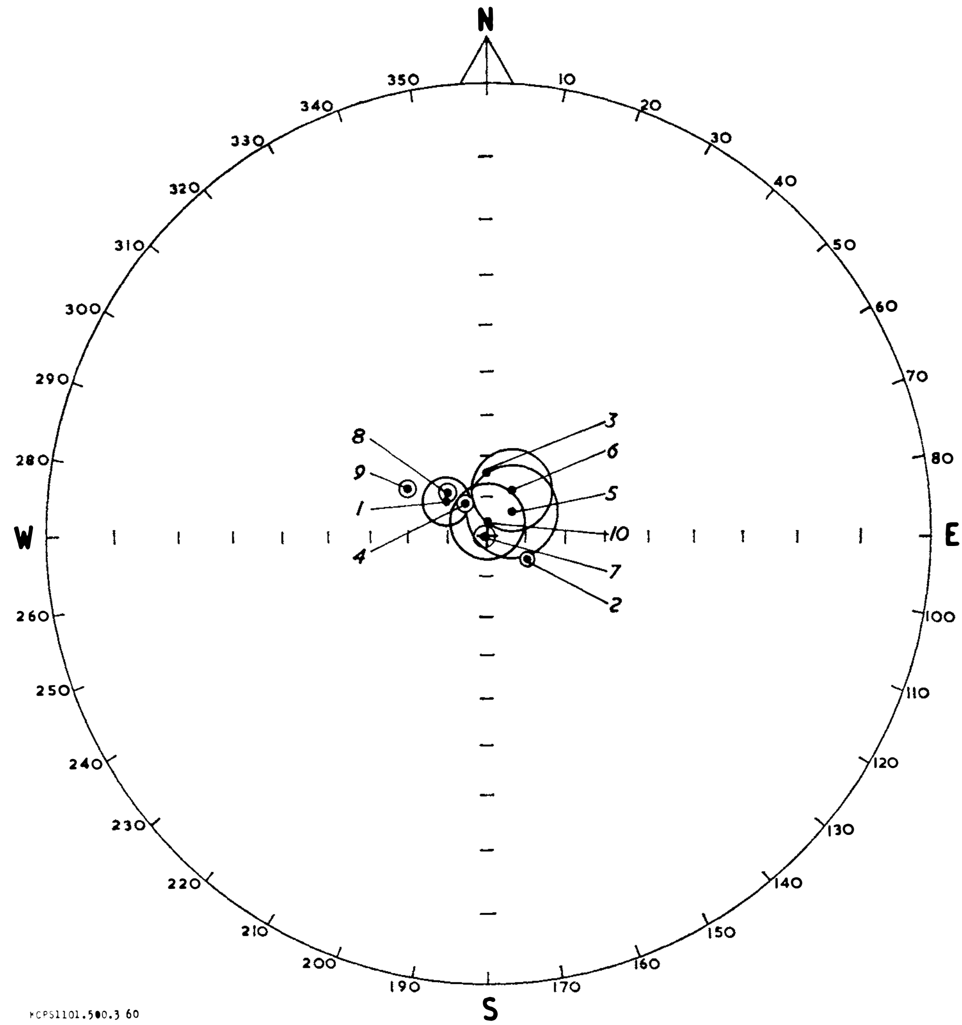

Fig. 3. *Stereogram of sample mean directions of magnetization of Jan Mayen basalts.*

Kapp Muyen rocks

The older core of the Beerenberg volcano is a basalt lava-shield predominantly built of ankaramite and ankaramitic trachybasalt lavas and pyroclastics. Specimen Jm 7 (grid reference KO 4043) was collected from a small inlier of Nordvestkapp or Havhestberget lava seen beneath a Nordkapp lava fall north of Dagnyhaugen in the Ekerolddalen. The rock is an even more typical example of Beerenberg ankaramite than Jm 6. Over 40 % of the rock consists of large augite and olivine phenocrysts set in a fine crystalline granular matrix of augite, iron-ore and very rare plagioclase microlites. Numerous small microphenocrysts of olivine and augite are scattered throughout the matrix. Felspar makes less than 10 % of the rock.

The rocks of Beerenberg are closely related petrologically. The bulk of the lavas range from very basic ankaramites through trachybasalts to basanitic trachy-

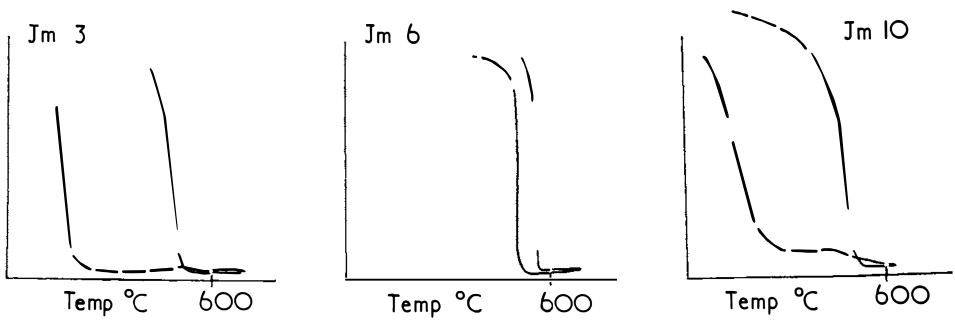

Fig. 4. *Thermo-magnetic curves for Jan Mayen basalts.*

basalts. The common alkali-basalt-trachyte differentiation sequence of Sør-Jan (CARSTENS 1961; 1963), although derived from a member of this magma-lineage, is but poorly represented in Nord-Jan. One of the most striking features of Jan Mayen rocks is their absolutely fresh condition, and the almost total absence of zeolites or other vesicule fillings.

Palaeomagnetic studies

Methods

Two or more 1″ cores were drilled from each sample using a phosphor-bronze, diamond impregnated, trepanning tool. Up to four 1″ cylinders were then machined from each rock sample, with a phosphor-bronze diamond saw. Orientation marks were carefully retained at each stage.

The direction of natural remanent magnetization (N.R.M.) of each cylinder was obtained using a short period astatic magnetometer. As a standard technique the stability of N.R.M. was tested by demagnetization about three axes in alterating magnetic fields of progressively greater intensity, the direction of magnetization being measured after each stage. This technique has also been used successfully to remove secondary magnetization found in some igneous rocks. However, in the present case at no stage did the directions change significantly in fields of up to 350 oe peak field.

Treatment of results

A sample mean direction of magnetization for the four cores was obtained at each demagnetization stage, using the statistic developed by FISHER (1953). As the best result, the stage at which the estimate of precision k is the largest, is adopted. This stage varies from sample to sample, but it is found that fields in excess of 250 oe are not required. The relevant data is given in Table 3.

A number of samples were thermally demagnetized using an automatically recording Chevallier balance. The Curie points in general lay in the region of 500–530° C, somewhat below the Curie point of pure magnetite, suggesting a certain amount of titanium in solid solution (Fig. 4). There was no indication of more than one magnetic phase, with the possible exception of Jm 4.

Table 3. *Palaeomagnetic data on Jan Mayen Samples*

Sample Number	Sample Description	Mean Decli- nation	Mean Incli- nation	Circle of Confidence	Demagne- tization Stage	Curie Point Temperature	Pole Position	
Jm 1	Kokssletta aa flow	310.5	+76.5	5°.4	original	500° C	70.7N	74.2W
Jm 2	Kokssletta pahoehoe flow	120.5	+79.1	1°.0	original	—	55.4N	44.0W
Jm 3	Sentralkrateret flow	0.1	+74.6	6°.5	170 oe	530° C	80.1N	169.3W
Jm 4	Kokssletta dyke	323.6	+79.6	1°.4	original	500° C	77.9N	67.0W
Jm 5	Kokssletta aa flow	46.9	+81.3	12°.0	250 oe	530° C	75.7N	71.2E
Jm 6	Tromsøryggen flow	29.8	+76.7	9°.9	250 oe	570° C	77.3N	115.9E
Jm 7	Kapp Muyen inlier	244.9	+88.2	2°.3	170 oe	530° C	69.2N	1.8E
Jm 8	Tromsøryggen basalt	316.3	+75.0	2°.2	original	—	70.8N	85.3W
Jm 9	Tromsøryggen dyke	299.9	+66.5	1°.5	original	—	55.1N	85.4W
Jm 10	Kokssletta dyke	2.1	+86.9	8°,7	170 oe	520° C	77.2N	12.0E
	Mean direction of all samples	339.5	+82.5	6°.7	k=52.3*			
	Position of ancient pole	82.7N	34.0W					

* k – a measure of dispersion (FISHER 1953).

The direction of magnetization of each sample is shown on the stereogram, Fig. 3. From the mean of the ten samples a pole position was computed that does not differ significantly from the present pole position, and this small difference may be due to incomplete sampling of secular variation. The results are consistent with the geological estimate of the age of Beerenberg.

Future work

Insufficient is known of the fine detail of direction changes to know whether small differences in mean directions of magnetization of different groups of rocks closely similar in age may be of any importance. As the results of this pilot investigation indicate, detailed flow by flow collecting within the successive lava groups on Jan Mayen may well reveal the extent of secular variation to be expected within the rocks of a volcanic cycle. One outcome of such an investigation of secular variation could be the provision of a key to the correlation of lava sequences in different regions in the way that KAHN (1960) has shown. Furthermore, detailed collecting from the older formations on Jan Mayen may reveal the zone of reversed magnetization known to occur in basal Villafranchian, thereby providing a valuable marker horizon near the Plio-Pleistocene boundary. Correlation of groups of flows within the Tertiary on the basis of the alternation of zones of normal and reversed magnetization must await the establishment of a standard sequence of zones elsewhere.

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Ice conditions at Svalbard 1946-1963

BY

TORBJØRN LUNDE[1]

Abstract

Maps showing the mean ice limits in the Svalbard region for each month, February–September, from 1946 to 1963 are given. The maximum and minimum ice-covered areas are also shown.

The thickness of the winter ice, the monthly wind drift of ice and the transport of ice through the strait between Hopen and Edgeøya are calculated and correlated with curves showing the variation in ice conditions from year to year.

For the years studied, the alternation between bad and good ice conditions has followed a three to four year cyclic pattern. The same cycle is also found for the calculated ice thickness and can even be traced for the wind drift of ice.

Introduction

Earlier works

The distribution of sea ice in the Svalbard area has occupied several authors since Spitsbergen was discovered by WILLEM BARENTS in 1596. This interest in the distribution of sea ice has been mostly a purely practical interest. Sea ice has been the barrier which has closed the shores for the small sailing vessels. Consequently sea ice observations have generally occupied a rather minor place in these long, descriptive, early publications; usually only a few lines in the section dealing with difficulties encountered by the ship.

J. LAING and later F. R. KJELLMAN have given useful summaries of what they knew of the ice conditions in former years (LAING 1815, 1818), (KJELLMAN 1875). Unfortunately the information given by these early observes is, with a few exceptions, very inexact, normally neither the exact date nor the position is given (the position was of course very difficult to find in those days). To find the amount of ice or the ice character from the information given is a nearly impossible task.

The first person to collect data on sea ice in a more systematic way was KARL PETTERSEN – a customs officer in Tromsø, northern Norway. From 1864 to 1889 he collected ice observations from the Norwegian vessels travelling in the Svalbard region. This contribution to our knowledge of sea ice is an outstanding example of how much one man of limited expert knowledge can accomplish within this subject.

[1] Mandal, Norge.

Det Danske Meteorologiske Institut started their publication, "Isforholdene i de Arktiske Have", in 1893. Very valuable information has been collected in this publication throughout the period it has been published (1893–1956, with the exception of the years from 1940 to 1945). The scale of the maps (1 : 27,000,000) is, however, too small to give any details.

The data given by Det Danske Meteorologiske Institut have been used by other research workers who have tried to establish mean values for the distribution of sea ice in these areas in different months. Mention should be made of: Reichs Marine Amt (1916 and 1926), MARIA FROMMEYER (1928), FRIEDRICH KISSLER (1934) and FRANZ NUSSER (1958).

ADOLF HOEL collected data on sea ice for many years. Some of these observations were published (HOEL 1917), and some were sent to Det Danske Meteorologiske Institut.

Ice atlases

On three occasions Det Danske Meteorologiske Institut has published mean values for the ice distribution. The first one (Det Danske Meteorologiske Institut 1917) contains the mean ice limits, 1898–1913, as well as maximum and minimum ice distribution for the months April–August. The mean for the period 1898–1922 is published in the yearbook of 1925 (Det Danske Meteorologiske Institut 1926). The last ice limits published are the means from 1919 to 1943 in the yearbook of 1953 (Det Danske Meteorologiske Institut 1956).

In 1946 The Hydrographic Office United States Navy published a large ice atlas (Hydrographic Office 1946). The atlas gives mean ice limits for all months as well as the distribution of different types of ice for the period 1898–1938. All data available were used in order to give information as reliable as possible. A further effort was made with the publication of The Oceanographic Atlas of the Polar Seas, by the same office (Hydrographic Office 1958).

A German ice atlas gives the percentage chance of meeting sea ice in different regions for the period 1919 to 1942/43 (BÜDEL 1950). This atlas, however, is rather difficult to use as it is nearly impossible to decide where one frequency interval is replaced by another.

These atlases are of a too small scale to give any details (the scale varies from 1 : 20,000,000, to 1 : 27,000,000). The last three atlases mentioned give the ice distribution and the mean percentage of ice for the winter months too. Not all the sources for these publications are known. However, it is believed that there is not sufficient knowledge about sea ice in the Svalbard region – especially during the winter months – to give reliable information of this kind.

Ice limits 1946–1963

General remarks

In the following the available information at Norsk Polarinstitutt for the sea ice around Svalbard from 1946 to 1963 has been summarized. The sources have been observations from ships, airplanes and shore stations, some of this informa-

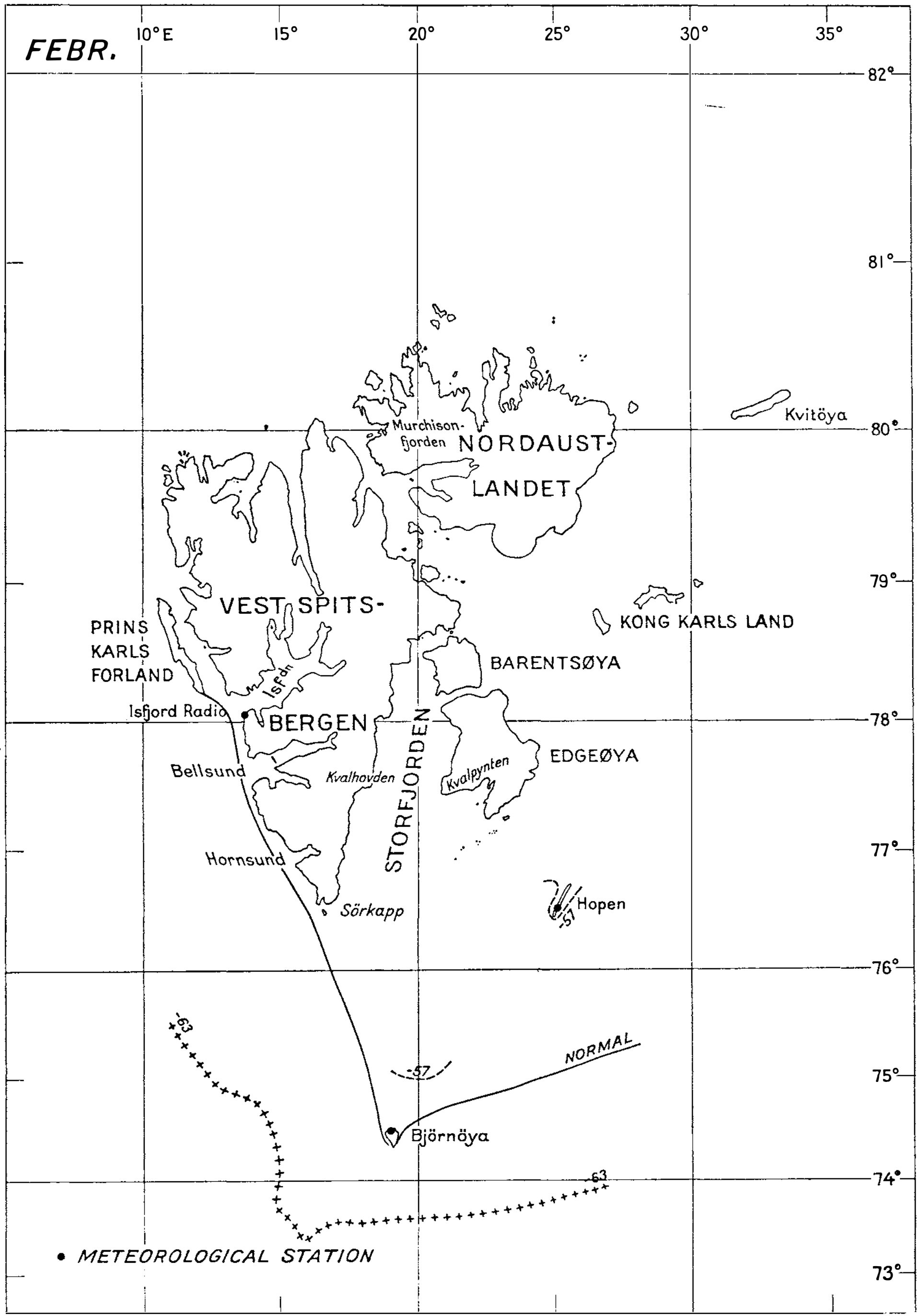

Fig. 1. *Mean ice limit 1946–1963 for February. Extreme positions of the ice edge and the year it occurred is also shown. Scale: 1:5 · 10^6 at 78° N.*

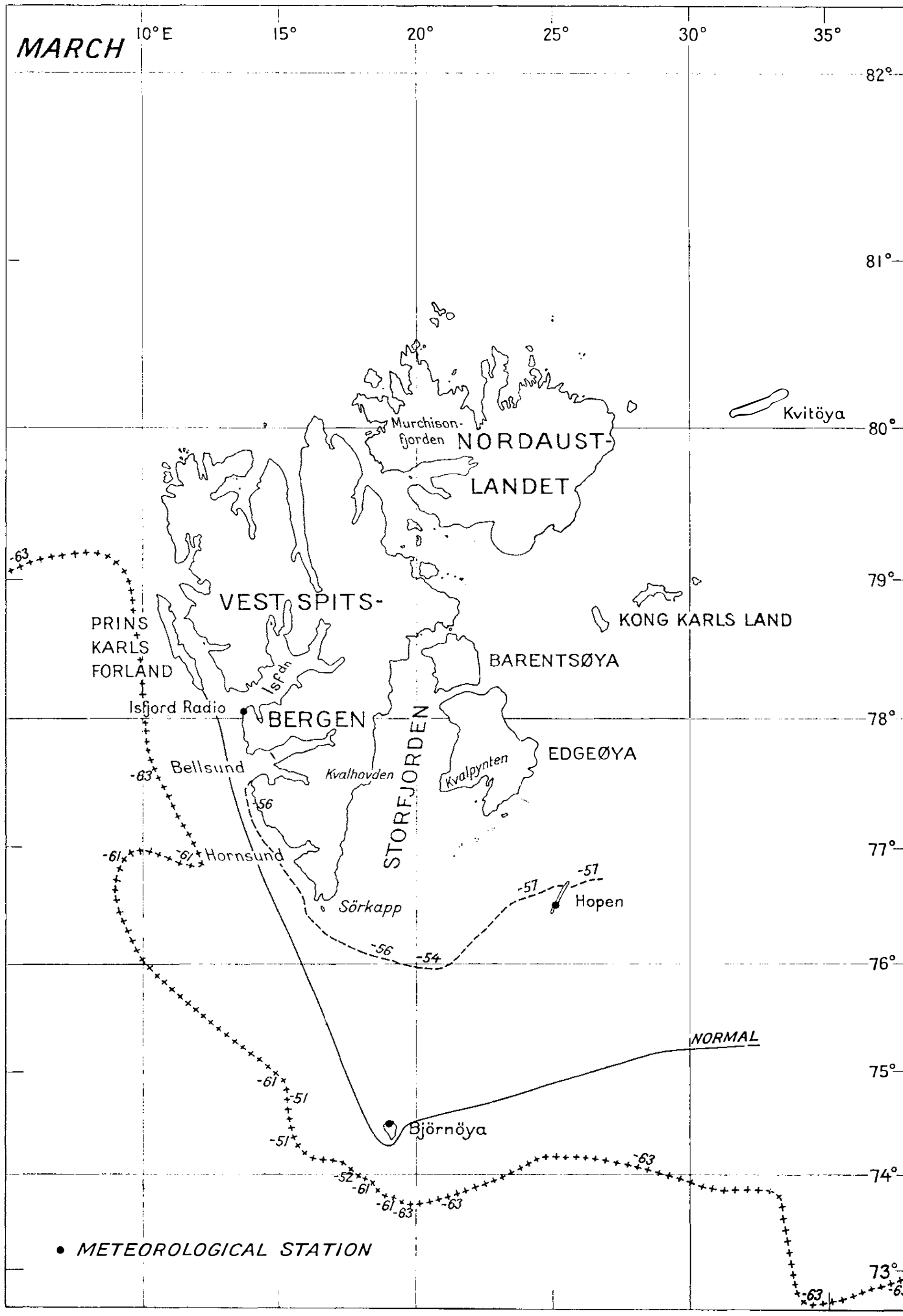

Fig. 2. *Mean ice limit 1946–1963 for March. Extreme positions of the ice edge and the year it occurred is also shown. Scale: 1:5 · 10^6 at 78° N.*

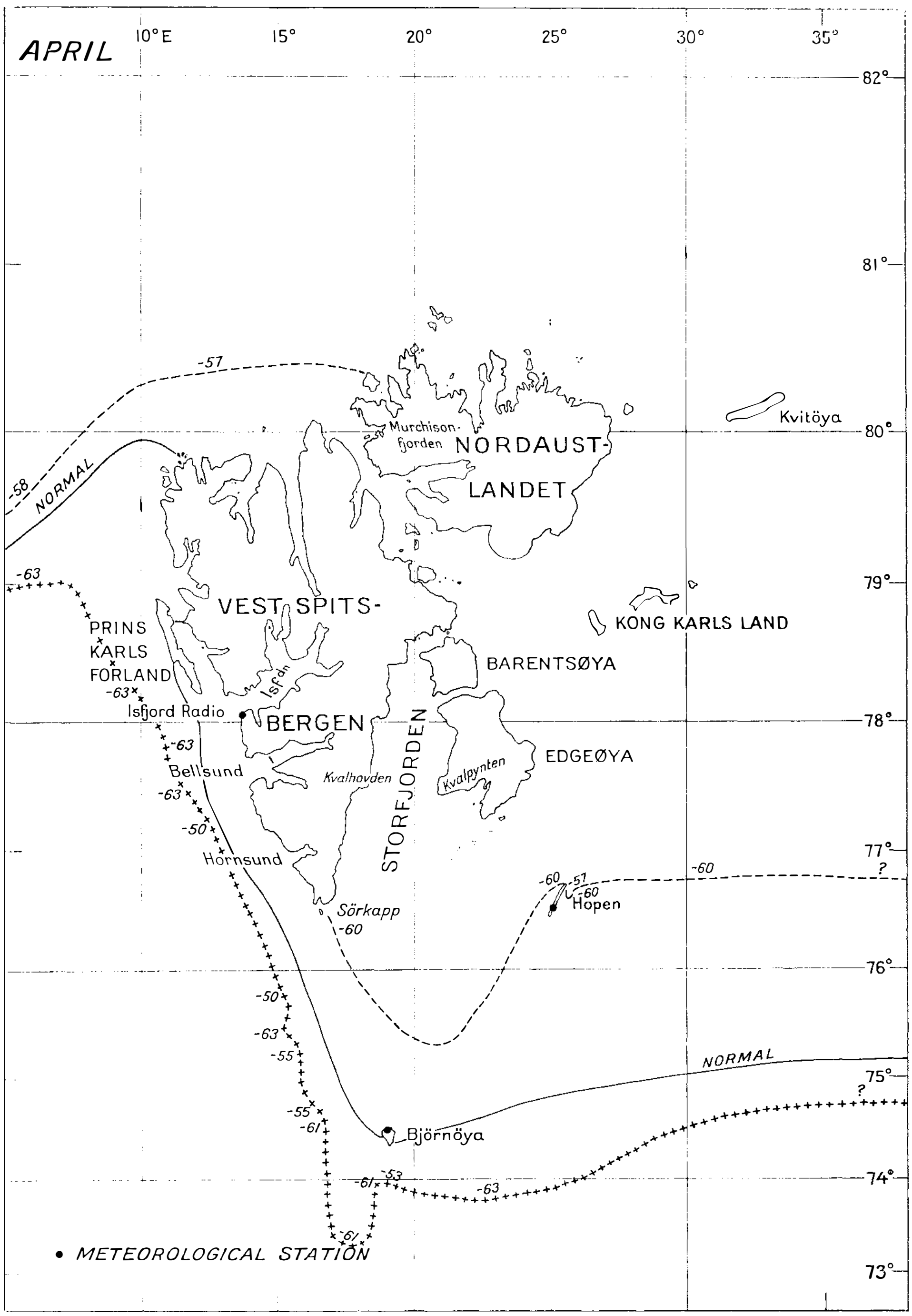

Fig. 3. *Mean ice limit 1946–1963 for April. Extreme positions of the ice edge and the year it occurred is also shown. Scale: 1:5 · 10^6 at 78° N.*

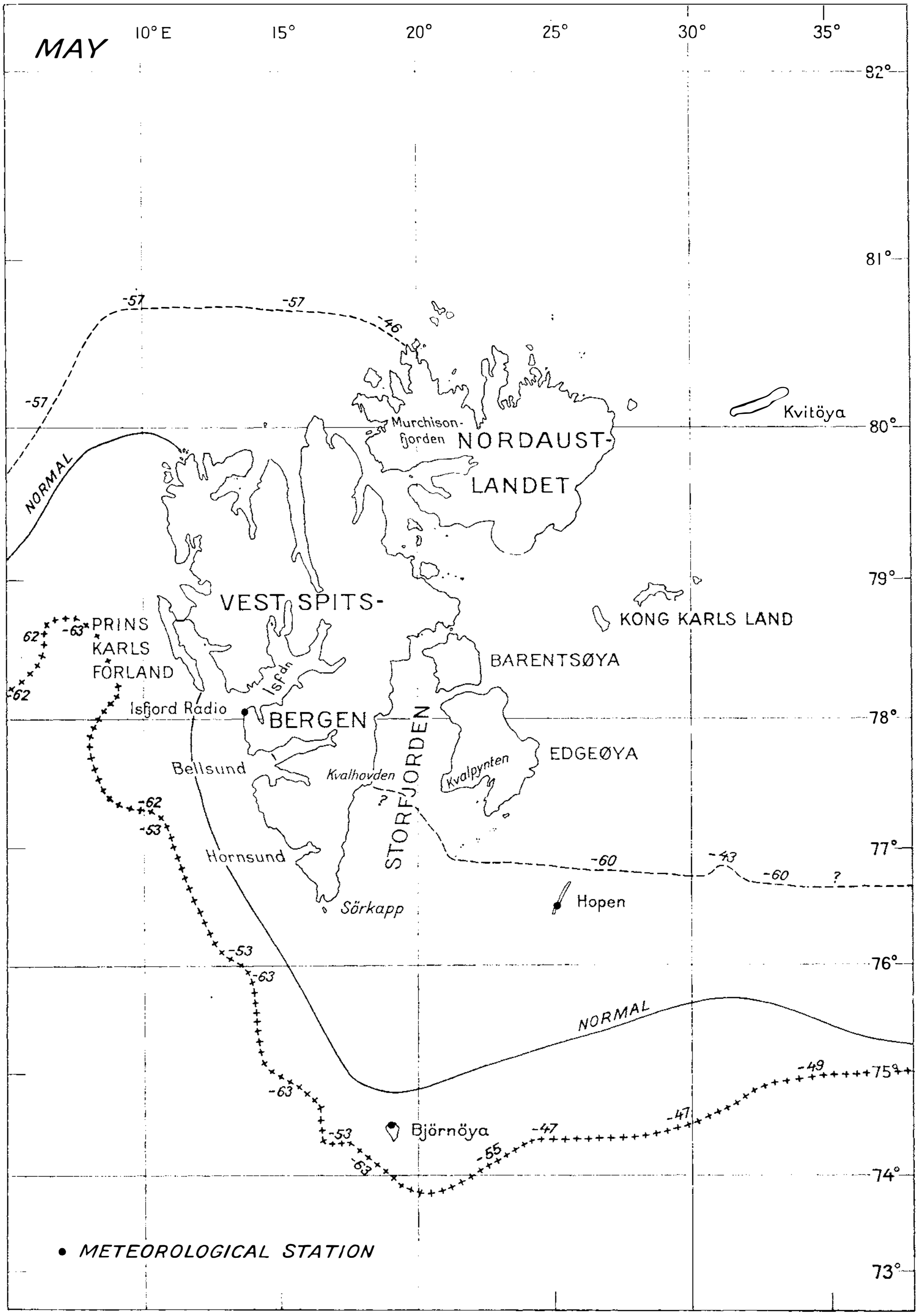

Fig. 4. *Mean ice limit 1946–1963 for May. Extreme positions of the ice edge and the year it occurred is also shown. Scale: 1:5 · 10⁶ at 78° N.*

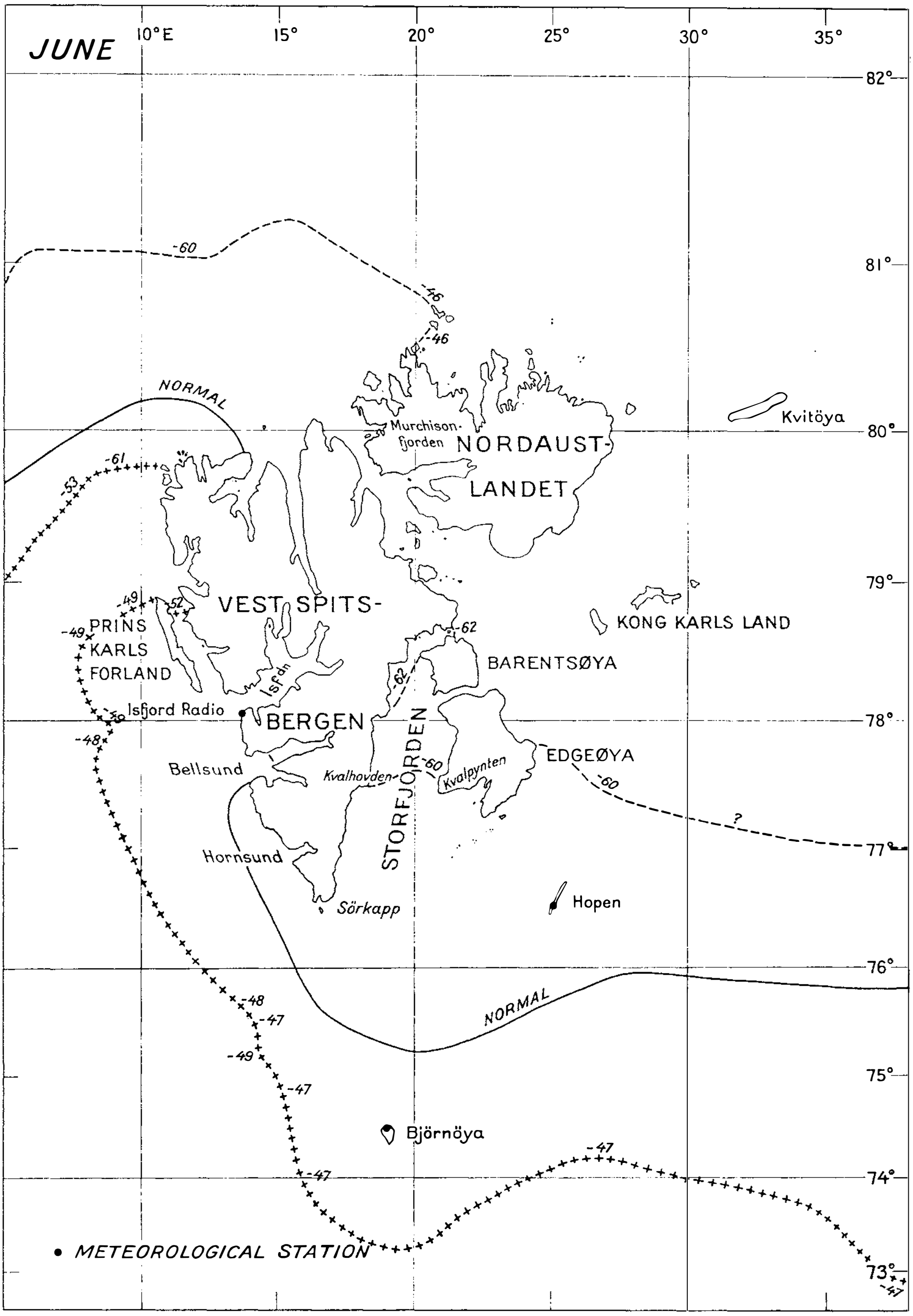

Fig. 5. *Mean ice limit 1946–1963 for June. Extreme positions of the ice edge and the year it occurred is also shown. Scale: 1:5 · 10^6 at 78° N.*

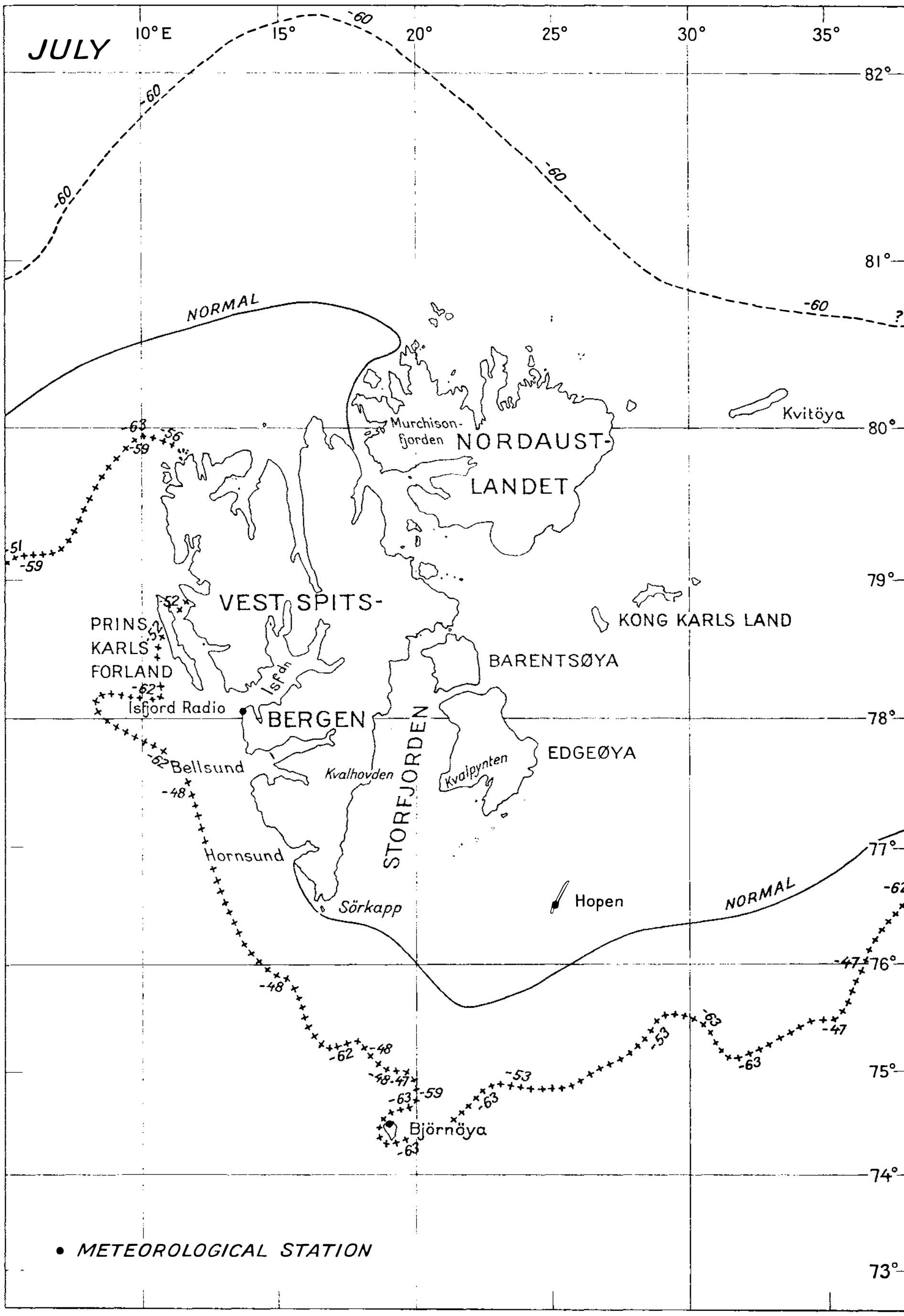

Fig. 6. *Mean ice limit 1946–1963 for July. Extreme positions of the ice edge and the year it occurred is also shown. Scale: 1:5 · 10⁶ at 78° N.*

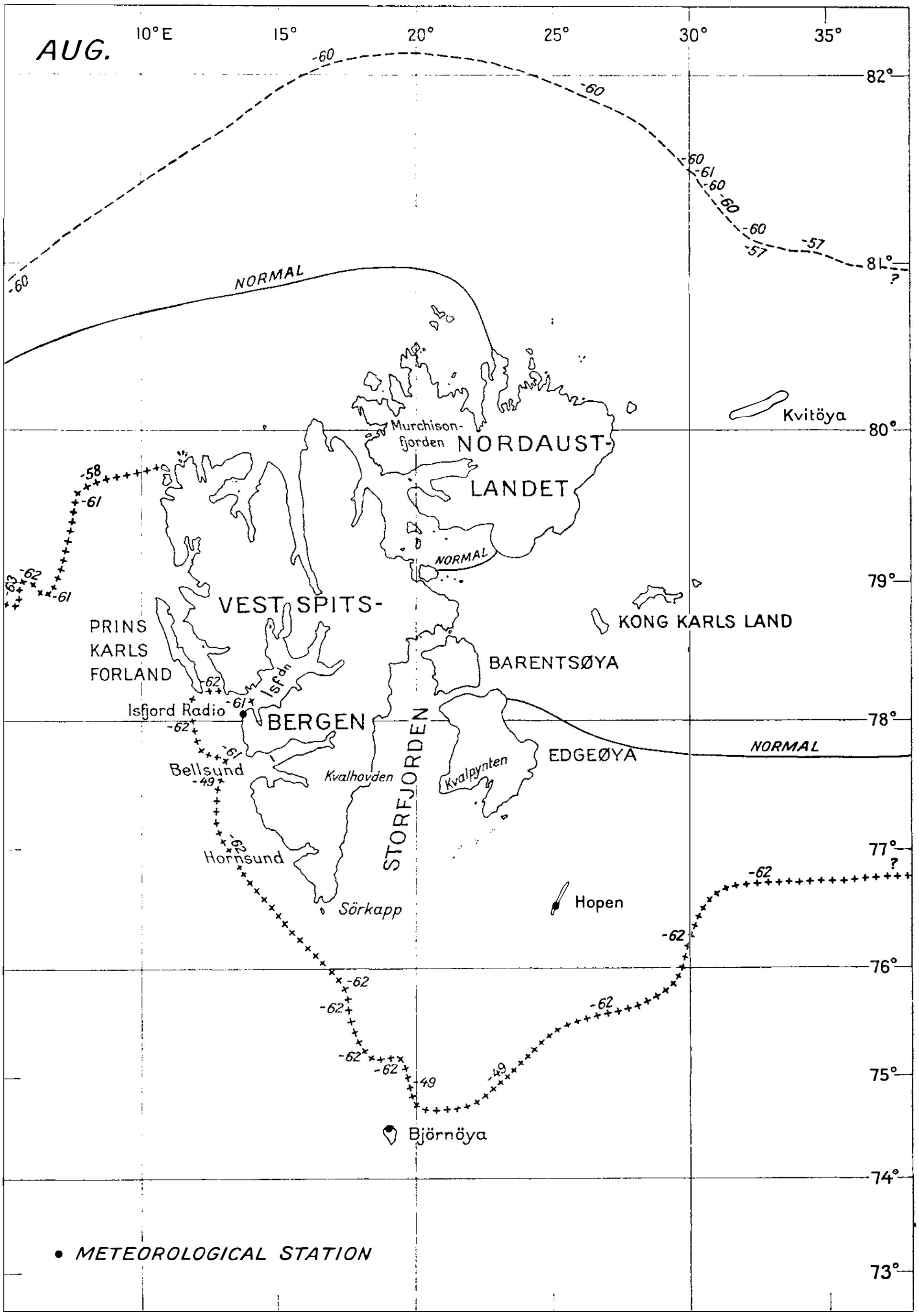

Fig. 7. *Mean ice limit 1946–1963 for August. Extreme positions of the ice edge and the year it occurred is also shown. Scale: 1:5 · 10⁶ at 78° N.*

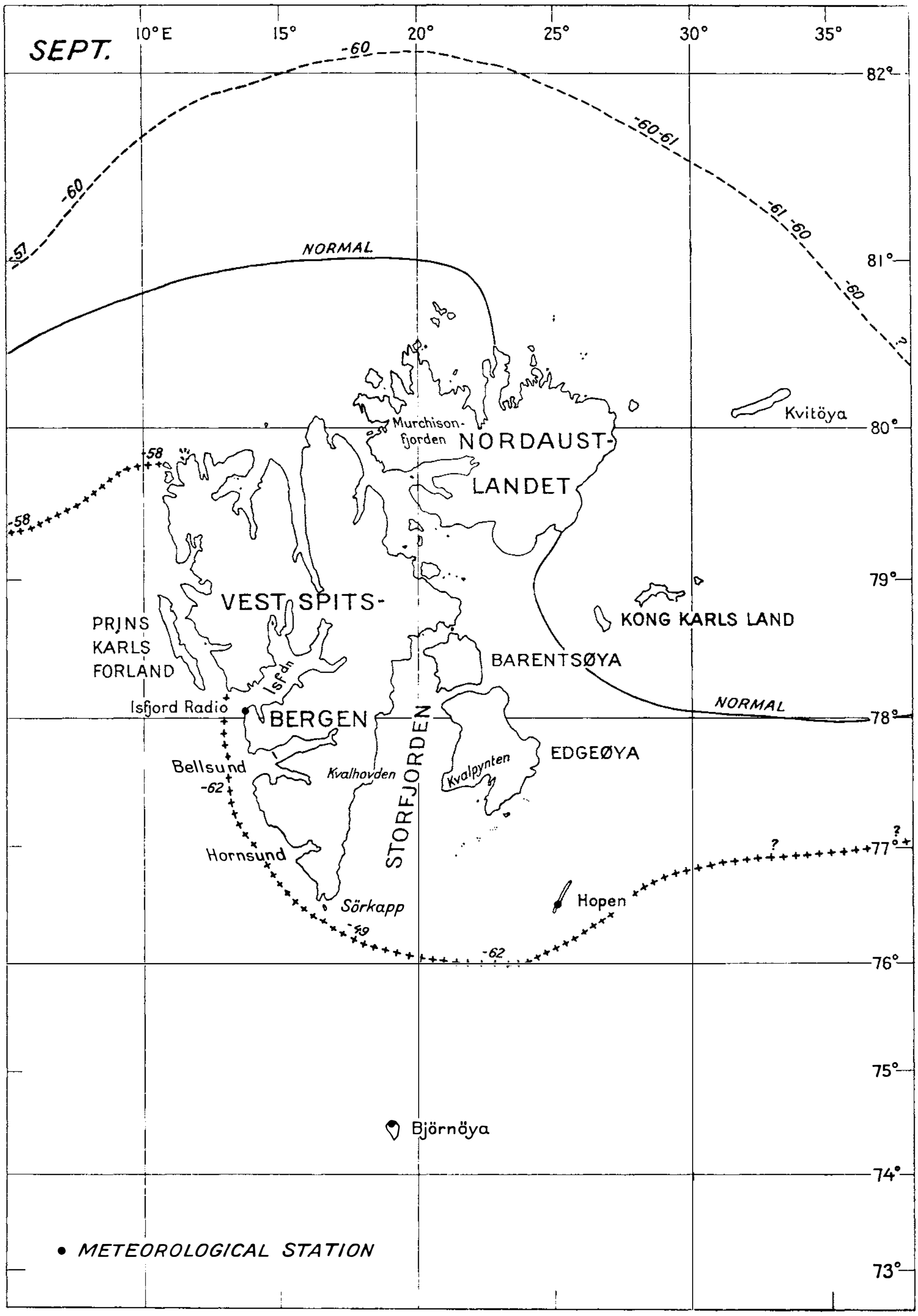

Fig. 8. *Mean ice limit 1946–1963 for September. Extreme positions of the ice edge and the year it occurred is also shown. Scale: 1:5 · 10^6 at 78° N.*

tion is "second hand" and is taken from "Det Danske Meteorologiske Institut's Yearbook 1946–1956". The mean ice limits found for the 8 months February–September are given in Figs. 1–8. These limits to a certain degree can obviously be erroneous. It is, however, believed that on the west coast of Vestspitsbergen they are correct to within some 5 nautic miles. On the northern and eastern side of Spitsbergen the probable errors are far greater, and greatest in the north-easternmost part where the number of observations are small. The ice limits are most reliable in the summer (June–July), but however, in February – and also in March and September – these limits should only be taken as a rough guide to where ice may be found.

The maximum and minimum limits given are more uncertain. Strong winds may unobserved have carried the ice edge to extreme positions, or, what is still very usual, the observations have never reached us. The years when the extremes were reached are written along these ice limits.

The available information is insufficient to give ice limits for the 4 months October–January. Nor do we know enough about ice character and concentration to give any picture of this. Normally a ship will meet close as well as heavy pack ice fairly near the ice edge on the north and east coast (more broken ice is sometimes observed at the end of the summer). On the south, and especially on the west coast, the ice is normally more broken or even scattered, and most of it is only one year old.

The ice limits for February are based on information from the 8 years: 1950 and 1957–1963. Most of the observations are from the bank areas near Bjørnøya. East of 28° E, south of Spitsbergen, and north of the Isfjorden area nothing is known about the ice conditions in February.

The ice limits for March are based on information from the 15 years: 1947 and 1950–1963. For this month too most of the observations are from the bank areas near Bjørnøya. East of 28° E we only have information on the ice edge in 1953 and 1963 and north of the Isfjorden area we have only information on the ice edge in 1963.

The ice limits for April are based on fairly good information for the 15 years: 1947 and 1950–1963. The maximum and minimum ice-covered areas in the easternmost part and the minimum ice-covered area north of Spitsbergen are, however, not very reliable. This is the month in which the ice normally reaches its greatest extension near Bjørnøya and the area to the east. West and north-west of Spitsbergen the normal maximum extension is reached in April and May.

The ice limits for May are well known from information from the 18 years in question. Maximum and minimum extension may be somewhat inexact in the south-easternmost part (east of 28° E). North of Svalbard one single airplane observation from 1958 gives an ice edge even farther north than the minimum ice extension shown in the map. This does not agree, however, with other observations that year. The observed ice edge is probably an "inner ice edge" or an edge of close, heavy pack ice, and this observation has consequently been neglected. On the west coast of Vestspitsbergen, and southward to some 75° N, 17° E the ice reaches its greatest mean extension in May. In the last half of the month the decay of the ice starts in the marginal zones, especially on the west coast.

The ice limits for June are better known than in any other month. Information from the years 1946–1963 has been obtained. The mean – as well as the minimum ice limit has receded quite a bit since the month before, while the maximum ice-covered area (with the exception of the regions farthest to the north-west) is almost the same as in May. This shows the typical transition to the summer months in which the difference between the maximum and the minimum ice-covered areas is much greater than during the winter and spring (Fig. 5). Normally there is fast ice in Storfjorden north of the line Kvalhovden–Kvalpynten in June. In contradiction to what is shown in the map, there has been in all likelihood some ice in this area even in 1960.

The ice limits for July, too, are well known. Some information on the 18 years in question has been gathered. The easternmost part of the minimum ice limit is somewhat uncertain as it very likely has been situated even farther to the north. The difference between the maximum and the minimum ice-covered area is still greater than in June. Normally the fast ice in the fjords of Vestspitsbergen breaks up in the beginning of July or at the end of June. The normal break up date for the fast ice in Storfjorden is probably near the middle of July.

The ice limits for August are fairly well known. Of the years dealt with here information is not available for 1953 and 1956. The difference between the maximum and the minimum ice-covered area is still very large. It probably has been even greater as the minimum ice limit most likely has been situated farther to the north than the map shows. Generally speaking we know less about the years with good ice conditions than about the others for this month, a fact that well may have brought in a systematic error and thus shifted our "mean ice limit" to a too southerly position for August.

The ice limits for September are not known so well. Exact information is only available for the last 7 years. Here too there is probably a systematic error as most of what we know is from the first half of the month. The smallest extension of drift ice in this area occurs in the last half of August and first half of September.

Ice conditions October–January. From the end of September the ice limit moves southward again as the melting of ice does not keep pace with the southward transport of ice. In October formation of new ice will normally start, first in the calm fjords and near shore regions farthest to the north-east, later on ice is formed in the open sea and in the areas farther south and west. At the end of November ice is frequently an obstacle to navigation in the fjords of Vestspitsbergen. Isfjorden may break up and be open to navigation at any time of the year. With the exception of fjords and bays the northern part of the west coast is icefree in a normal winter.

Calculated data for the sea ice 1946–1963

Ice thickness is calculated by using the formula established by LEBEDEV (LEBEDEV 1938, LUNDE 1963).

$$i = 1.245 \cdot \sum \Theta^{0.62} \cdot s^{-0.15}$$

i is the ice thickness in centimeters, $\sum\Theta$ is the accumulated degree days of frost[1], and s is the thickness of the snow layer in centimeters.[1] The values for the period 1946–1963 are given in Table 1.

Table 1. *Thickness of the ice formed during the winter in the Hopen area*

Period	Duration	Accumulated degree days of frost	Thickness of snow layer	Thickness of ice
-45 – -46		No observations	–	–
9/10-46 – 29/5-47	233 days	1609	31 cm	72 cm
16/10-47 – 10/6-48	237 »	2204	42 »	85 »
22/10-48 – 17/6-49	239 »	1907	46 »	76 »
21/9 -49 – 11/6-50	264 »	926	63 »	46 »
22/11-50 – 28/5-51	188 »	1801	68 »	69 »
17/10-51 – 18/5-52	215 »	2388	46 »	87 »
22/10-52 – 31/5-53	222 »	1822	42 »	74 »
26/12-53 – 8/5-54	134 »	877	32 »	49 »
14/10-54 – 19/5-55	218 »	1123	43 »	55 »
12/10-55 – 24/5-56	226 »	1776	55 »	71 »
30/10-56 – 24/5-57	207 »	894	39 »	49 »
12/11-57 – 24/5-58	194 »	1498	50 »	64 »
11/10-58 – 28/4-59	200 »	2034	85 »	72 »
18/11-59 – 23/5-60	188 »	1254	62 »	56 »
2/10-60 – 28/5-61	239 »	2137	51 »	80 »
13/11-61 – 7/6-62	207 »	2413	39 »	90 »
10/10-62 – 18/5-63	211 »	2730	47 »	94 »
Mean: 16/10 – 26/5	213 days	1729	49 cm	70 cm

Wind drift of ice is calculated by using the formula established by Zubov (Zubov 1947).

$$c = 13000 \frac{dp}{dx}$$

c is the average displacement of ice given in kilometers a month and $\frac{dp}{dx}$ is the pressure gradient in millibars a kilometer.[2] The drift speed (c) and the drift direction (φ) given in Table 2, are calculated from this formula, using values from "Amtsblatt des Deutschen Wetterdienstes" 1948–1963 for calculating the pressure gradient (Lunde 1963).

Ice transport. As is shown in my earlier paper (Lunde 1963), it is possible to calculate the transport of ice by wind to the south-west through the 81 km wide strait between Hopen and Edgeøya by the following formula.

$$T = 81 \cdot 10^{-5} \cdot i \cdot c \cdot \sin(\varphi - 150^{g})$$

[1] Degree days of frost (below –1.8° C) and thickness of snow layer (specific weight 0.4 g/cm^3) are calculated from the measured values of temperatures and precipitation at Hopen meteorological station.

[2] This pressure gradient is the mean gradient in the area: 80° N 20° E – 80° N 40° E – 75°N 40° E – 75° N 20° E, the centre of which is at 77° 30′ N 30° E.

Table 2. *Monthly wind drift of ice at 77°30'N, 30°E*

	Jan.		Febr.		March		April		May		June	
	c	φ	c	φ	c	φ	c	φ	c	φ	c	φ
1946												
1947												
1948	(55	265)	(61	25)	(87	217)	(82	335)	(0	–)	(49	281)
1949	(143	287)	(156	361)	(84	27)	(65	306)	(113	288)	(10	167)
1950	55	135	143	329	112	325	86	330	116	198	36	234
1951	70	275	87	395	126	311	88	274	74	244	31	200
1952	177	322	136	310	84	328	125	311	65	239	116	359
1953	135	301	75	27	82	262	103	313	32	248	79	47
1954	92	253	91	38	109	298	49	322	35	360	65	336
1955	181	251	181	337	211	346	42	286	88	324	86	234
1956	143	342	129	28	56	166	140	327	58	330	47	169
1957	98	348	218	319	178	335	25	364	68	241	69	266
1958	116	348	167	335	90	290	45	336	81	346	16	186
1959	185	286	36	59	58	214	92	343	55	250	42	107
1960	117	299	168	299	105	357	142	350	43	22	15	289
1961	86	350	38	334	147	292	99	270	24	333	32	379
1962	88	290	136	291	189	253	43	236	71	248	73	313
1963	118	254	119	229	38	309	31	205	56	392	2	150

	July		Aug.		Sept.		Oct.		Nov.		Dec.	
	c	φ	c	φ	c	φ	c	φ	c	φ	c	φ
1946												
1947												
1948	(47	300)	(36	156)	(73	356)	(88	175)	(142	136)	(83	189)
1949	96	172	23	370	34	157	133	248	103	379	256	355
1950	32	174	21	70	88	337	27	397	36	307	133	292
1951	34	255	32	113	60	180	62	143	133	248	136	275
1952	22	185	40	181	91	304	6	100	79	2	133	323
1953	44	206	66	31	57	172	112	386	139	384	70	88
1954	36	89	36	266	64	321	77	288	66	20	128	359
1955	83	68	55	98	112	363	139	260	136	268	166	324
1956	39	59	73	298	84	275	94	339	107	374	75	263
1957	19	78	52	14	73	339	250	376	180	338	174	300
1958	87	312	88	178	18	395	48	339	18	181	20	332
1959	34	67	19	237	109	288	69	387	67	30	85	14
1960	39	398	29	306	55	15	130	215	18	344	15	170
1961	56	342	81	346	20	217	35	360	121	344	98	272
1962	26	37	43	278	19	387	188	329	58	372	117	290
1963	59	189	73	372	78	357	84	329	73	268	113	271

Figures in brackets are based on the air pressure gradient in the triangle: Hopen, Bjørnøya, Isfjord Radio, and can consequently not be compared directly with the other values.

We get the ice transport in km³ when i, c and φ are taken from Tables 1 and 2. Positive values mean transport to the south-west. The transport is only given for the months from March to June as the calculated ice thicknesses (Table 1) are just valid for the spring months (strictly speaking they are valid for the last-mentioned date in column 1, Table 1 only).

Table 3. *Monthly ice transport through the strait between Hopen and Edgeøya*

Year	March	April	May	June	Total
1948	(+ 5.2) km³	(+1.3) km³	(0.0) km³	(+3.0) km³	(+ 9.5) km³
1949	(— 1.7) »	(−4.8) »	(+2.6) »	(+5.8) »	(+ 1.9) »
1950	+ 1.6 »	+1.0 »	+3.2 »	+1.3 »	+ 7.1 »
1951	+ 4.0 »	+4.6 »	+4.1 »	+1.2 »	+13.9 »
1952	+ 2.0 »	+5.1 »	+4.5 »	−1.2 »	+10.4 »
1953	+ 4.8 »	+3.4 »	+1.9 »	—4.7 »	+ 5.4 »
1954	+ 3.2 »	+0.8 »	−0.2 »	+0.6 »	+ 4.4 »
1955	+ 0.6 »	+1.6 »	+1.6 »	+3.7 »	+ 7.5 »
1956	+ 0.8 »	+2.8 »	+1.0 »	+0.8 »	+ 5.4 »
1957	+ 1.7 »	−0.2 »	+2.7 »	+2.7 »	+ 6.9 »
1958	+ 3.9 »	+0.5 »	+0.3 »	+0.5 »	+ 5.2 »
1959	+ 2.9 »	+0.6 »	+3.2 »	—1.5 »	+ 5.2 »
1960	— 0.5 »	0.0 »	−1.8 »	+0.4 »	— 1.9 »
1961	+ 7.5 »	+6.1 »	+0.4 »	−0.9 »	+13.1 »
1962	+13.8 »	+3.1 »	+5.2 »	+2.9 »	+25.0 »
1963	+ 2.2 »	+1.8 »	−2.6 »	0.0 »	+ 1.4 »
Mean 1950-1963	+3.5 km³	+2.2 km³	+1.7 km³	+0.4 km³	+7.8 km³

Figures in brackets are based on the air pressure gradient in the triangle: Hopen, Bjørnøya, Isfjord Radio, and can consequently not be compared with the other values.

Variations in the calculated and the observed data on sea ice 1946—1963

The area covered by ice east, south and west of Spitsbergen for each month from February to September are given values from +3 (extremely large ice-covered areas) to −3 (extremely small ice-covered areas). The sum of these numbers for each year gives a measure of the mean ice conditions from February io September that year (full drawn curve in Fig. 9 a – the broken curve gives the ice conditions in spring (Febr.–May), the dotted curve gives the ice conditions in summer (June–September)). The calculated ice thickness and ice drift (the component towards south-west) are also given (Fig. 9, b and c).[1] There is a distinct correlation between ice thickness and drift of ice on the one hand and actual ice conditions on the other hand.

The separate curves for spring and summer give additional information on the relative importance for the ice conditions of the two factors, ice thickness and

[1] As the variation in the position of the ice edge is delayed in relation to the drift of ice, this computed drift is given for the period January–August (Spring: January–April, Summer: May–August).

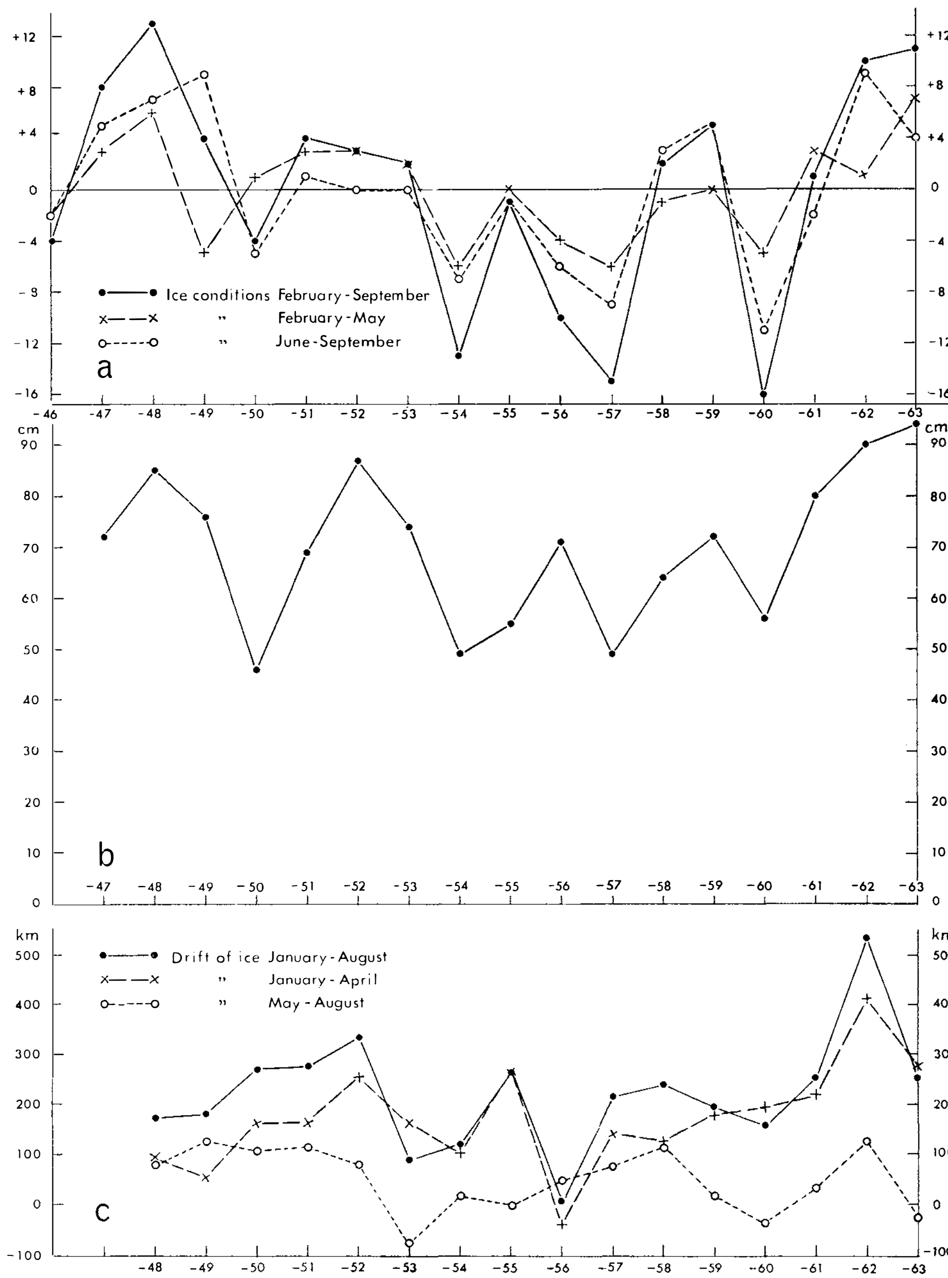

Fig. 9 a. *Ice conditions for the years 1946–1963 (positive numbers mean more ice than normal, negative numbers mean less ice than normal).*

b. *Calculated thickness of the winter ice at Hopen for the years 1947–1963.*

c. *Calculated south-west component of the wind drift of sea ice for the years 1948–1963 (the wind drift for 1948 and 1949 is not directly comparable with that for the other years).*

wind drift of ice, which mainly are due to air temperature and air pressure gradient. There is a good correlation between the ice thickness and the ice conditions in spring, and when this is not the case (e. g. 1955 and 1956) this is explained by special values for the drift of ice. The importance of the wind drift of ice is more marked in summer than in spring.

The difference between maximum and minimum ice-covered areas is much greater in summer than in spring (Figs. 4–7, 9, a). This is occasioned by the bottom topography and the current in these areas. From Sørkapp to Bjørnøya and east thereof the sea is very shallow and the turbulence consequently small (NANSEN 1919, pp. 9, 10, LUNDE 1963, p. 24). In these areas the combined effect of freezing and the preponderance of north-easterly winds during the winter will usually be sufficient to bring the ice edge to the normal position for the winter and spring months (Figs. 1–4).

South and west of Bjørnøya the waters are much deeper, and the importance of turbulence and warm Atlantic current is far more distinct. This is normally enough to prevent the progress of ice in these areas. When the ice occasionally moves some tens of kilometers south and west of Bjørnøya, the oceanographic factors mentioned will normally destroy these ice masses fairly soon (the most severe ice conditions known were in 1881 when the ice edge was observed at 71° 30′ N 9° E as late as 17th of May (PETTERSEN 1881)).

In cold summers with frequent and strong north-easterly winds the melting is not sufficient to remove the ice from the shallow bank areas north-east of Bjørnøya. However, when the ice is melted in these regions, the decay of ice goes faster in the deeper part of Barentshavet north-east of Hopen, and the waters may be ice-free far north of Kvitøya (the best ice conditions known were in 1960 when the ice edge was observed at 82° 20′ N 16° E in the end of July).[1]

The variations in ice conditions are of a cyclic nature and are of three or four years duration. (Fig. 9, a).[2] The same periods are found in the curve showing ice thickness (Fig. 9, b), and some traces of them are even found in the curve for the drift of ice (Fig. 9, c). The 18-year period studied here, is, however, too short to decide whether this periodicity is merely accidental or not.[3]

There are, however, other authors who have found similar periodical variations. J. CHAVENNE found corresponding periodicity in ice conditions and air temperature (CHAVENNE 1875). F. KISSLER found a mean period in ice conditions of 4.7 years for Barentshavet from 1898 to 1931 and periods of 4.4, 4.6 and 4.5 years for other parts of the Arctic (KISSLER 1934). For the Northern Sea Route A. BURKE makes use of a three year cycle in ice conditions (in addition to a period of 60 years) for giving ice prognoses (NAZAROV 1938).

[1] The main factors determining the melting of sea ice are thought to be solar radiation and turbulent heat transfer from the atmosphere. In marginal zones of the ice-covered areas (like Svalbard) conduction of heat from the sea is also of great importance. However, it is at present not possible to evaluate the melting of sea ice, nor the relative importance of the above mentioned agents.

[2] There are some indications of a longer cycle also, but as to the length of this, however, no estimate based on the few years studied here is possible.

[3] If this periodicity continues, we will get far better ice conditions east, south and west of Svalbard in 1964 than in the three preceding years.

The causes for this periodicity in ice conditions are difficult to find. Oceanographic factors may be of great importance. N. S. URALOV's curves for current speed on the Thompson Threshold and water temperatures on the Kola Meridian show similar variations (URALOV 1959). The causes for these variations as well as the variations in air temperature described above has, however, not yet been explained.

I. V. MAKSIMOV (1958) describes "the polar tide" in air pressure whose cycle is 14 months. The amplitude of this tide varies with latitude, and has its maximum (some 1 mb, as a mean) at 70° N. According to MAKSIMOV it will cause great climatic fluctuations: "The magnitudes of the seasonal fluctuations of atmospheric pressure, of air temperature and of precipitation, as well as the magnitudes of the seasonal fluctuations in the speed of heat transfer by the major oceanic currents and the magnitudes of seasonal fluctuations of ice accumulation in the arctic seas are all subject to these irregular seven-yearly pulsations. Here, therefore, the polar tide phenomenon appears as the principal governing agent in the long-term variability of all the seasonal phenomena not only in the atmosphere but also in the seas of the high latitudes" (p. 119). This climatic period is, however, 7 years, and can therefore hardly explain the above-stated ca. 4-year periodic variations in ice conditions. If this had been the case, it would also have explained that a *large* ice-covered area in European/Asiatic Arctic seems to be contemporaneous with a *small* ice-covered area in Canadian Arctic, and vice versa.

The ice conditions in 1963

Expected ice condition. The winter 1962/63 was the coldest one since the meteorological measurements started at Hopen in 1946 (Table 1). After this it was expected that the ice conditions in the spring of 1963 would be worse than in any other year since 1946. This was made even more probable by the large ice masses that were found on the south and west coast of Vestspitsbergen in the late summer and autumn 1962 (LUNDE 1963 p. 33).

The wind drift of ice in December 1962 and January and February 1963 was fairly fast to the south-west (Table 2). This too would cause much ice south and west of Spitsbergen during the first months of the year. From March on, however, the mean wind drift of ice was very slow and only small amounts of ice were transported from the north-east (Table 3).[1] A fairly rapid improvement of ice conditions could thus be expected as soon as the melting of ice started in May–June.

Actual ice conditions for 1963 are in exact accordance with those described above (Fig. 10):

1. During the winter and spring there was more ice south and west of Spitsbergen than in any other year since 1946.
2. From May the ice conditions improved very fast and during June the drift ice disappeared almost completely from the west coast (some remnants in Isfjorden and Hornsund were seen as late as mid July).

[1] The transport of ice by current is not taken into account.

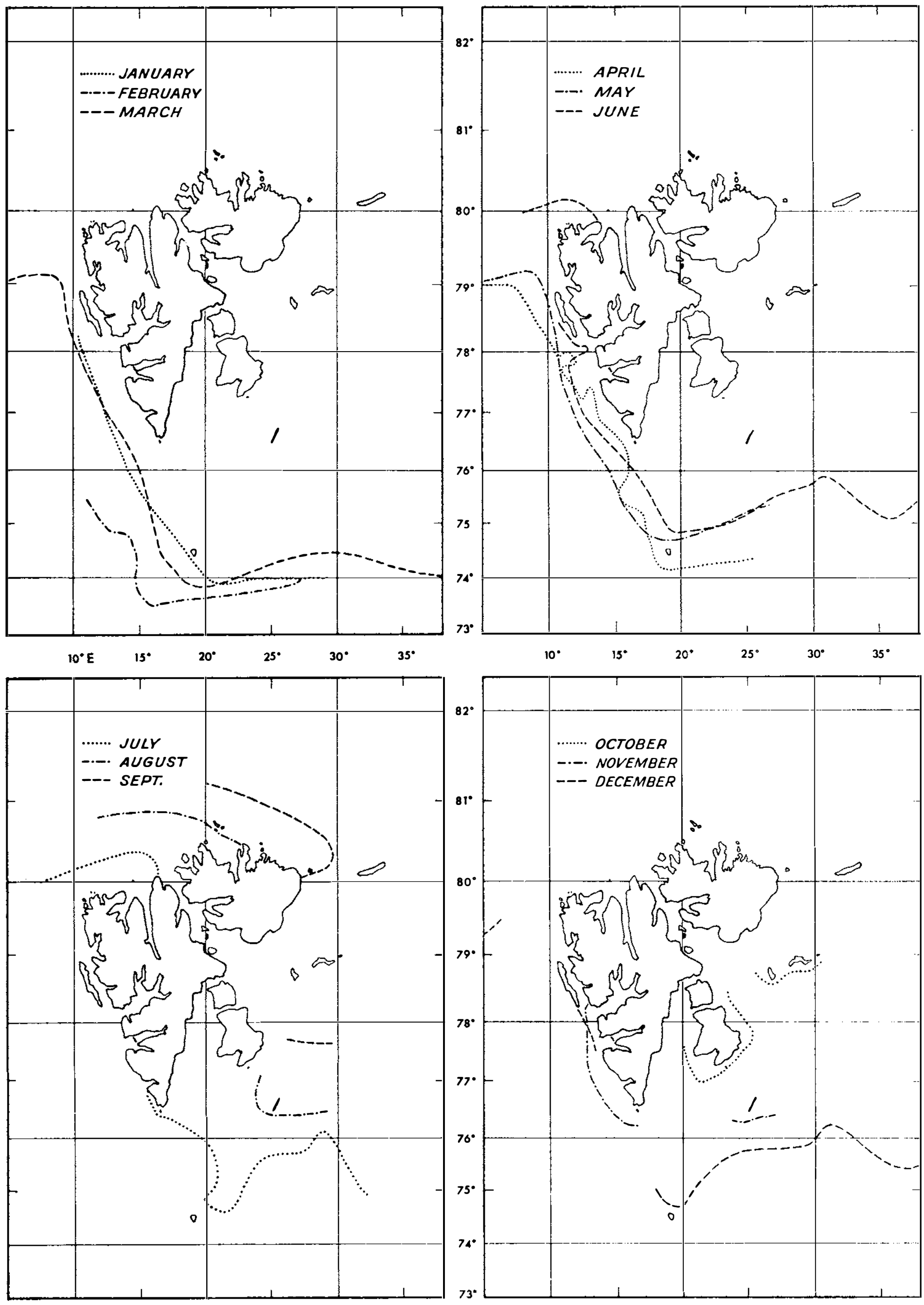

Fig. 10. *The mean monthly position of the ice edge for 1963. Scale: 1:12,5 · 10⁶ at 78° N.*

3. From July the ice conditions improved much on the south and east coast too, and were near the normal in September (at the end of the melting season). On the north coast too the ice conditions improved fast during the summer and were even better than normal in September.

As an example of the fast melting of ice east of Spitsbergen it can be mentioned that from the 3rd June to the 2nd July, when the transport of ice was negligible (Table 3), the mean ice concentration in an area of 38000 km² between Hopen and the ice edge had decreased from 58 % to 31 %. The corresponding figures for an area of 58000 km² north-east of Hopen were 79 % and 68 %. The decrease in ice volume, however, is unknown as the decrease in ice thickness was not measured.

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On the geology of the upper Grusdievbreen area, Olav V Land, Vestspitsbergen

BY

AUDUN HJELLE

Abstract

Stratigraphical and structural observations from the upper Grusdievbreen area, Central Vestspitsbergen, are presented, together with a map. The rocks concerned belong to the lower Middle Hecla Hoek Formation; and the stratigraphy is compared with that in central Ny Friesland, further north.

Introduction

General geology. During Norsk Polarinstitutt's regional geological work in Olav V Land and Ny Friesland in the summer of 1963, some time was also spent studying the stratigraphy and structure of a small area near the geological base camp at Blånuten. Except for minor intrusions, the rocks concerned are all of sedimentary origin, the prevailing types being quartzites, sandstones, somewhat sandy greywackes, and limestones. The beds are in general dipping 50–70° [1] towards ENE, with the younger beds to the east. According to WILSON (1958) this sequence belongs mainly to the lower Middle Hecla Hoek (Precambrian) formation underlying the Enpiggen beds of upper Middle Hecla Hoek age in the eastern Japetusryggen.

Stratigraphy

The oldest beds occur in SW Blånuten and the youngest in easternmost Japetusryggen. The sections were taped and total stratigraphic thickness obtained was 1620 m. Fig. 2 shows the main lithological units in the different localities, and also the suggested local correlations. In the eastern part of Rheanuten, the beds are inverted and repeated, and the figure shows only those in the SW. A more detailed description of the beds is given in the table 1 below, and interpretations of the data is shown in Fig. 3.

[1] Centesimal degrees are used in N.P.'s geological work.

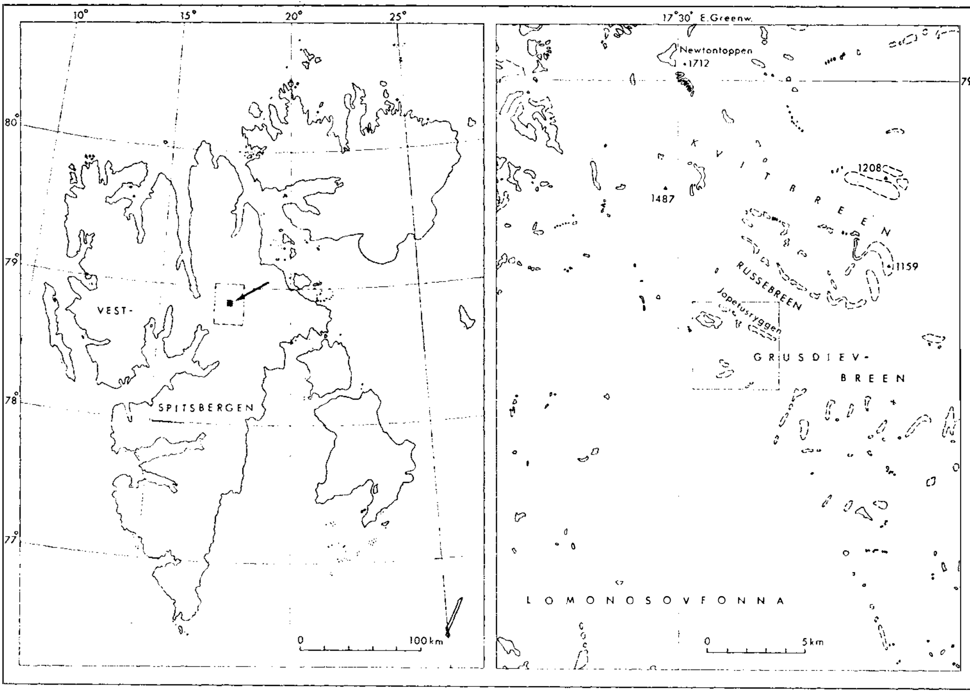

Fig. 1. *Key maps, showing the location of the upper Grusdievbreen area.*

Structural features

Fig. 4 shows the displacements of the beds exposed in SW Rheanuten. The fault is accompanied by folding, which, however, has affected only the greywackes. The trace of the fault is apparent to a limited extent in the area under consideration, but similar structures can be seen further SE in outcrops 2.5 km SSE of easternmost Japetusryggen and at Stonga, SE of Japetusryggen.

The reason for the pronounced asymmetrical maximum in the joint diagram in Fig. 5 A, is uncertain, the strike of the joints coincides, however, fairly well with the strike of the supposed faults between W and E Japetusryggen and along Grusdievbreen (Fig. 3). These faults correspond probably to the regional fault system with main strike WNW or ENE described from Ny Friesland (HARLAND 1959), but faults and fissures with WNW strike and steep dip to SSW may also have developed by upward pressure during intrusion of the nearby large body of younger "Chydenius-granite" (2.5 km NE of Japetusryggen).

In the quartzites and quartzitic sandstones, ripple marks are common. The orientation of a number of them has been measured, and, assuming a gently plunging regional fold axis, converted to their suggested prefolding orientation by tilting the bedding planes to a horizontal position on a stereographic net. The results are shown in Fig. 5 B and suggest that the main direction of current flow viz. approximately normal to the most pronounced ripple mark orientation, has been from WNW to ENE, which direction is approximately perpendicular to the Ny Friesland geosyncline. The other maximum which is thus parallel to the

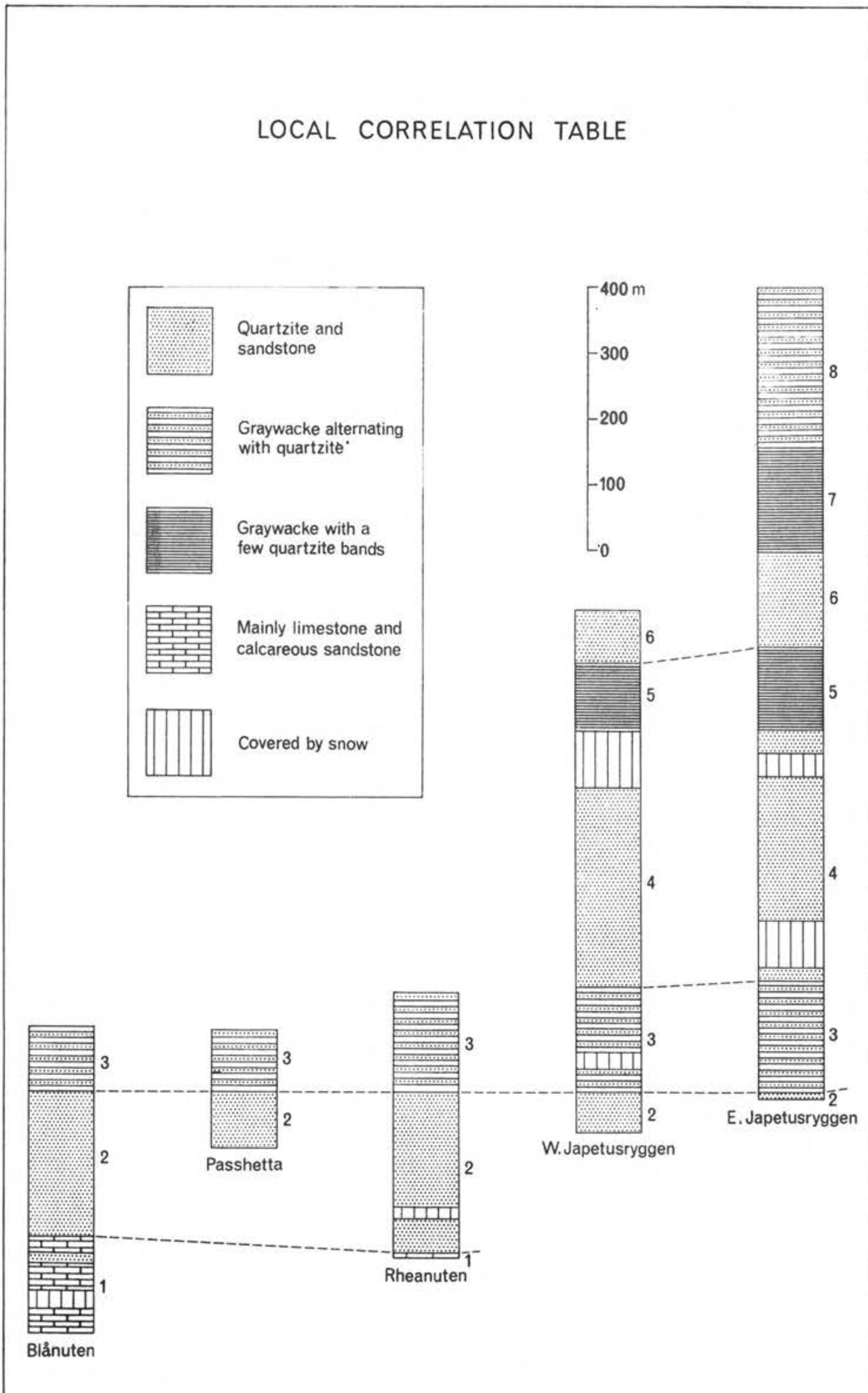

Fig. 2. *Local correlation table concerning the different localities in the upper Grusdievbreen area. The numbers correspond to those in the geological map. Fig. 3.*

Stratigraphic observations, upper Grusdievbreen area

The numbers to the right correspond to those in Fig. 3

BLÅNUTEN	PASSHETTA	RHEANUTEN	W JAPETUSRYGGEN	E JAPETUSRYGGEN	
				26 m Greywacke alternating with quartzite and calcareous beds. 48 m Quartzite with greywacke and subordinate shale bands. 8 m Greywacke. 20 m Quartzite of mixed colour. 16 m Greywacke with quartzite bands. Near the top also sandy limestone bands. 73 m Quartzite with bands of greywacke and sandy limestone. 5 m Greywacke. 9 m Quartzite mainly light grey. 25 m Greywacke with quartzite bands. 7.5 m Quartzite, light pure.	**8**
				160 m Greywacke of dark colour.	**7**
			82 m Quartzite, mainly light grey, pure, with dark quartzite and shale bands near the top.	145 m Quartzite, grey and light reddish. Greywacke bands 2.5 and 13 m begin 61 and 80 m above base.	**6**
			103 m Greywacke, with some quartzite bands towards the top. 90 m Obscured by snow.	130 m Greywacke with a few quartzite bands.	**5**
			317 m Quartzite, pure, mainly light reddish.	37 m Quartzite, light grey. 37 m Obscured by snow. 230 m Quartzite, mainly light reddish. 60 m Obscured by snow.	**4**
40 m Greywacke with bands of shale and quartzite. 66 m Greywacke alternating with quartzite. 5 m light quartzite begins 46 m above base.	42 m Greywacke and shale with minor quartzite bands. 62 m Greywacke alternating with quartzite. 4.8 m pure light quartzite begins 42 m above base.	24 m Quartzite alternating with greywacke and siliceous shale. 24 m Quartzites of mixed colour. The upper 4.5 m is a pure white quartzite. 59 m Greywacke and shale with minor quartzite bands. 63 m Greywacke alternating with quartzite. Light quartzite bands 6.7 and 3.7 m begin 4.5 and 42 m above base.	105 m Greywacke, partly migmatized, alternating with quartzite, mainly dark grey. 28 m Obscured by snow. 36 m Quartzite, dark grey, alternating with partly migmatized greywacke.	45 m Quartzite with greywacke bands. 65 m Greywacke with subordinate quartzite bands. 65 m Greywacke alternating with quartzite. On the top 4.5 m light quartzite.	**3**
136 m Quartzitic sandstone, light reddish. 14 m Quartzite, pure white. 59 m Quartzite, mainly pure, light grey. 26 m Quartzite, grey-green, partly impure.	91 m Quartzite, grey, and quartzitic sandstones mainly light reddish.	160 m Quartzite, mainly grey, impure towards top. 29 m Quartzite. The upper 16 m is pure white. 20 m Obscured by snow. 49 m Quartzite, grey, partly calcareous.	65 m Quartzite, greywith dark migmatitic bands.	11 m Quartzite, light, pure.	**2**
19 m Limestone and calcareous sandstone. 22 m Quartzite, partly impure. Some siliceous shale in upper part. 52 m Limestone, calcareous sandstone and a few thin quartzite bands. 30 m Obscured by snow. 27 m Limestone, mainly dark, with white calcite veining and bands of calcareous sandstone.		10 m Limestone, calcareous sandstone and quartzite.			**1**

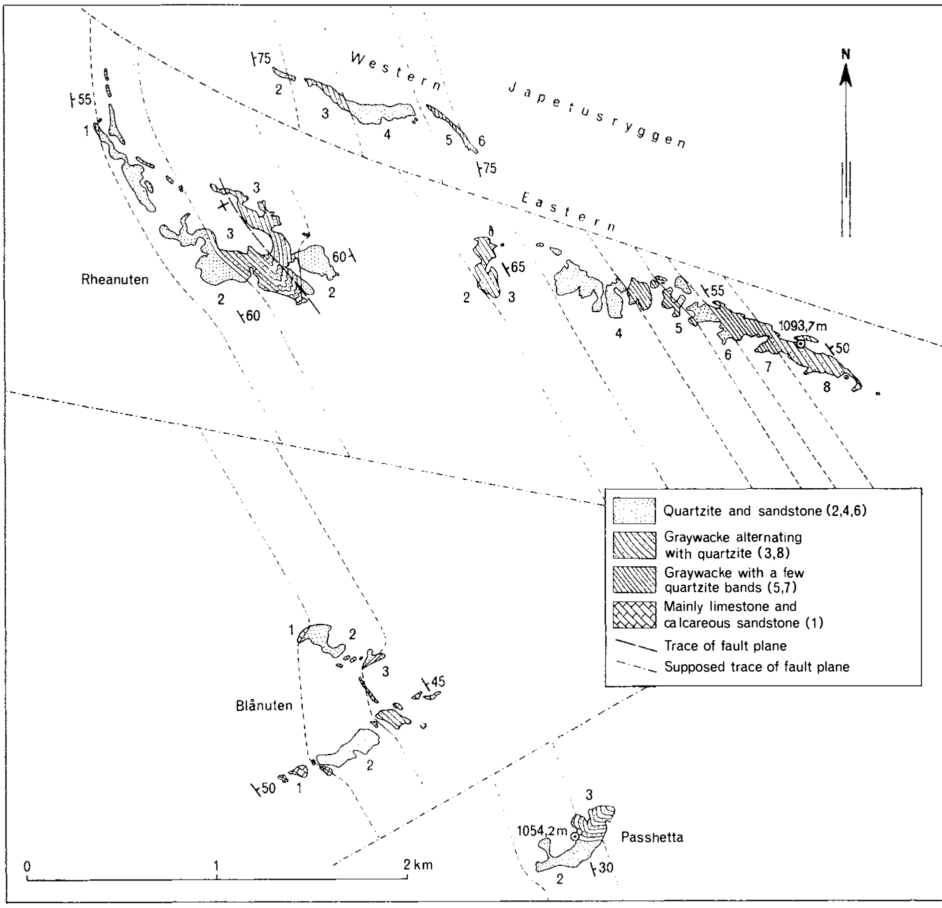

Fig. 3. *Geological map, upper Grusdievbreen area. Contours compiled from Norwegian vertical air photographs 1961. The altitudes in E Japetusryggen and Passhetta from Norsk Polarinstitutt's surveying 1963.*

direction of flow may be related to shoreline trends or to secondary streams normal to the main sedimentation direction.

At Blånuten and Passhetta the siliceous beds seem to be less quartzitic than farther north, and sandstones occur. These quartzitic sandstones are of light red and reddish brown colour with some darker material in the form of three-dimensional structures (Fig. 6 B, p. 88). The dark material consists mainly of iron-oxides and the structures are often concordant with small joints and cracks (Fig. 6 A). A possible explanation is that iron-rich solutions penetrated into the rock by adsorption and were precipitated according to the conditions in the settled sandstone. The iron content of the solution could be primary or the solution could have been enrichened in iron during penetration.

Hydrothermal mineralization and a small number of dykes both probably connected with the granite intrusion mentioned can be seen, especially in Japetusryggen and Rheanuten. The mineralization occurs as thin pathing aggregates of muscovite on joint surfaces, the three dykes observed range in composition from biotite amphibolite (E Japetusryggen) to biotite-diorite (W Japetusryggen). Those

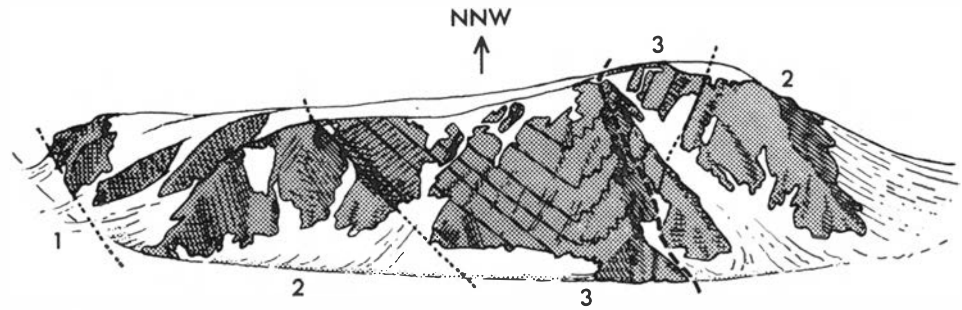

Fig. 4. *Faulting and folding exposed in S Rheanuten. The numbers correspond to those in the geological map. Fig. 3. Drawn from photograph taken from the summit of Blånuten.*

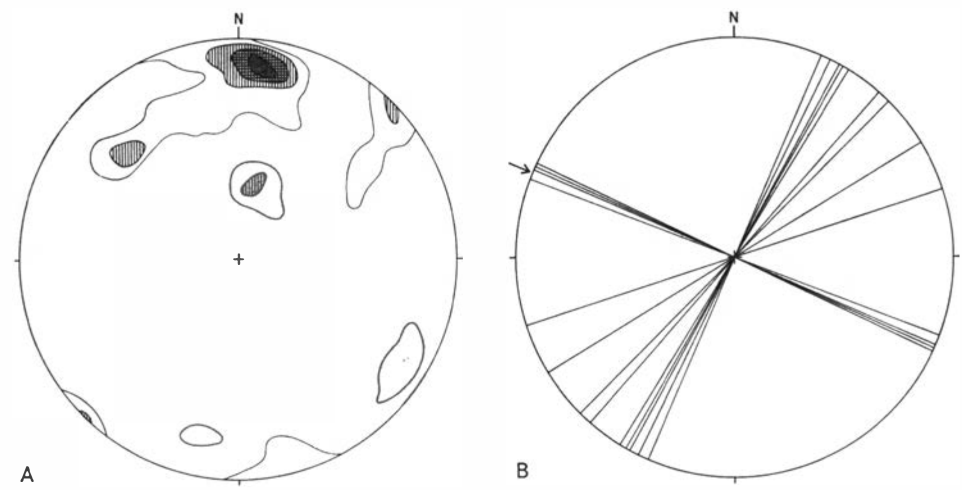

Fig. 5. *A: Joint diagram, 78 observations. Contours 2.5, 5, 7.5 and 10 %. Equal area projection, lower hemisphere.*
B: Suggested prefolding directions of crestal elongation of ripple marks. 14 observations. Arrow shows direction of flow of current as indicated by cross-bedding.

in W Japetusryggen are transitional through migmatitic types into the surrounding rocks.

Regional correlations

As mentioned WILSON suggested that the eastern part of Japetusryggen belongs to the Enpiggen beds of the upper Middle Hecla Hoek. Our investigations farther west show that no calcareous beds of any importance appear before reaching western Rheanuten and southwestern Blånuten, and the beds in those latter localities are therefore considered to equal the upper part of the Cavendishryggen Limestones in the Middle Veteranen series described from central Ny Friesland. The extensive beds (380 m) essentially of pure light quartzite exposed in the western and eastern Japetusryggen might then correspond to the Lower Glasgowbreen quartzite. These and other suggested correlations are shown in Fig. 7 (p. 88).

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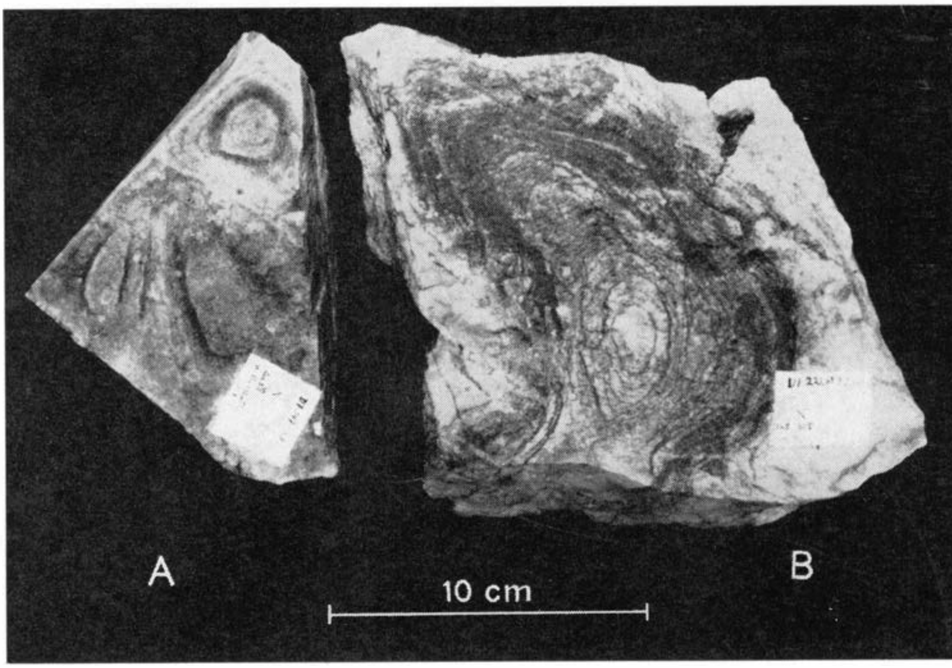

Fig. 6. *Structures in quartzitic sandstone, Blånuten.*

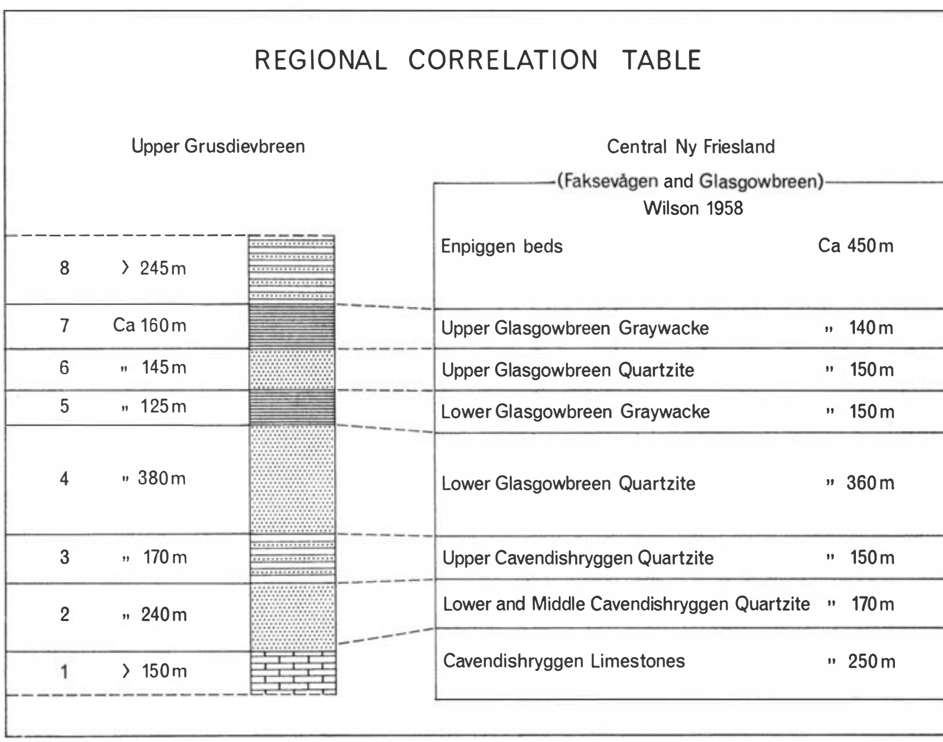

Fig. 7. *Regional stratigraphical correlations.*
The numbers to the left correspond to those in the geological map. Fig. 3.

Relief of the marginal zone of Werenskioldbreen

BY

JAN SZUPRYCZYŃSKI[1]

Contents

Abstract

The author has investigated the marginal zone of Werenskioldbreen. The characteristic features of all the forms met in the zone are described, and special attention has been devoted to the ice-moraine ridges and the eskers.

Situation of the glacier

Werenskioldbreen is situated in the southern part of Wedel Jarlsberg Land. Its position is defined by the geographic coordinates: 77° 05′ N lat., 15° 20′ W long. It is a valley glacier of Alpine type (1) with well developed firn field and tongue. This glacier moves in an equatorial direction from east to west. The glacier tongue is surrounded by the following mountain massifs: from the south by the Angellfjellet (591 m a. s. l.) and Eimfjellet (641 m a. s. l.), from the north by Erikfjellet (547 m a. s. l.) and Wernerknatten (634 m a. s. l.). At present the length of the glacier is, at the most 7.5 km, it reaches up to 3 km in width at the glacier front and up to 2 km in its middle part (Fig. 1).

In 1957 to 1960 research work on Werenskioldbreen was carried out by a glaciological group with prof. A. KOSIBA as leader. Parts of the results of this research were published in 1958 and 1959 (19, 20). The glacier front lies at present at 30 m a. s. l. A photogrammetric survey made on Werenskioldbreen by C. LIPERT (21) disclosed the recession of this glacier. From 1936 to 1959 the

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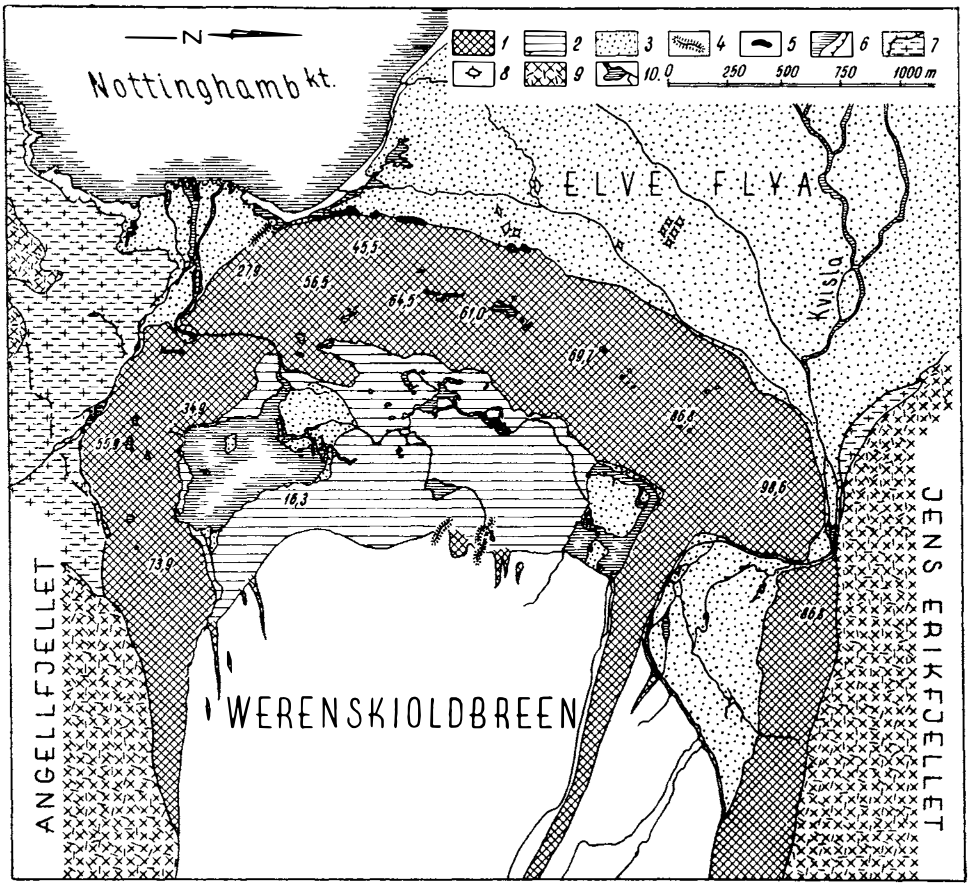

Fig. 1. *Relief map of marginal zone of Werenskioldbreen.*
1. area of frontal, lateral and middle ice-moraine; 2. ridges ablation and ground moraine; 3. outwash plains; 4. eskers; 5. pseudomorainic forms; 6. edges of marine terraces; 7. marine terraces; 8. terrace monadnocks; 9. mountain massifs; 10. lakes and rivers.

glacier front retreated 850 m eastwards. Thus the recession has been very rapid, amounting to some 40 m annually (19). According to KOSIBA's (20) estimate, the thickness of the glacier in its frontal section was reduced some 75 m during the recession, equalling close to 2 m annually.

Ice-moraine ridges and hillocks

On the basis of a detailed topographical map of Werenskioldbreen and its forefield I undertook in 1960 the geomorphological survey of the marginal zone. In the marginal zone of Werenskioldbreen two zones could be distinguished:

1. the zone of ice-moraine ridges
2. the zone of the ablation moraine and marginal outwashes.

In the forefield of the ridges there extends the surface of an extramarginal outwash.

Ice-moraine ridges surround the glacier in a compact group. The exterior base of these ridges lies at a distance of 1200–1500 m from the edge of the glacier. From this edge the complex of the ice-moraine ridges is at present separated by the area occupied by an ablation moraine. The ridge complex extends, from south to north, over a stretch of some 3 km. The maximum width of the belt of these ice-moraine ridges is 650 m. Their relative heights, as regards the extramarginal outwash spread over the forefield, are from 25 m in the southern to 68 m in the northern part. The Culm part of the ridges is in the northern part of the complex, and reaches 98.6 m a. s. l. The southern part of the complex of ice-moraine ridges is lower than the northern part. While in the southern part the highest culminations are 56.5 m, 64.5 m, 67.6 m, and 61.0 m a. s. l., they are in the northern part: 80.8 m, 86.8 m, 76.5 m, 81.7 m, and 98.6 m a. s. l. In a transverse section across the ridge complex an asymmetry in the development of its slopes is distinctly visible. The distal scarps are steep along nearly their total length, whereas the proximal slopes are gentle. The inclination of the distal scarps always exceeds 30° and their maximum slant is as much as 52°. On the other hand, the inclination of the proximal slopes is usually 8° to 24°.

The surface of the ridge complex is mostly built of fine material with diameters of less than 0.1 m (Fig. 3). In certain parts of the ridges, however, coarser material up to 1.0 m diameter may be observed. Large blocks occur but very rarely. The largest block, of almost 3.0 m, was found on the northern ridge scarps of Kvisla river. The rock material of the ice-moraine ridges is derived from the mountain

Fig. 2. *Complex of ice-moraine ridges of Werenskioldbreen on background of the Jens Erikfjellet (576 m a. s. l.) and Tonefjellet (933 m a. s. l.) mountain massifs. July 1960.*
Photo: J. Szupryczyński.

Fig. 3. *Morainic material of surface ice-moraine ridges of Werenskioldbreen. July 1960.*
Photo: J. Szupryczyński.

massifs surrounding the glacier. These massifs are built of Precambrian rocks of the Hecla-Hoek formation (2). Among the material found in the ice-moraine ridges quartzites and amphibolites were identified in the southern part, and conglomerates, quartzites, shales, limestones and dolomites in the northern part. All larger blocks lying on top of the ridges are angular. The material of the moraines rests on relic ice. In 1958 a 150 m long stretch of relic ice was found uncovered on the surface of the distal scarps (20). In this section the entire scarp was devoid of a moraine cover from an altitude of 8 m a. s. l. to almost the summit of the ridge. The highest culminations, especially those of the southern part, are developed in the shape of acute pyramids. The pyramid form is due to the relic ice in its core. On sharp peaks the cover of moraine material shows a thickness of barely some centimeters. The author also established the occurrence of relic ice at many points of the proximal ridge slopes. The moraine material covering the relic ice varies in thickness, from several centimeters to a score of meters. In the entire ridge complex there is a lack of larger exposures; even so, on the basis of various fragments of exposures I ascertained the moraine cover to be of boulder-clay character.

The relief of the complex of ice-moraine ridges is fairly variegated. On the crest of the complex numerous hillocks and elevations appear separated by corresponding depressions. Within this ridge complex the differences in height attain 30 m. Here two courses of ridges and hillocks may distinctly be observed; in the depressions separating the elevated structures numerous pools occur.

The ridge area is devoid of a vegetation cover; plants occur in sporadic clusters. In some parts the ice-moraine ridges suffer marked alterations, while in other parts no changes of relief were observed. This difference in the degree of modern re-sculpturing of the ridges was already pointed out by KOSIBA (20). The alterations of the relief are greatest in the middle part of the complex of ice-moraine ridges. The relic ice, uncovered on the distal scarps, undergoes intensive ablation. Melting ice is the cause of solifluxion of the moraine material over the entire width of the scarp. Visible on the distal scarp of the ridge complex is a large system of scars of landslides and of large solifluxion lobes. In the large lobe forms, of 3–8 m length, a sorting of the material may distinctly be seen; the coarser material forms a fringe for the finer material, which – in the shape of muck – fills the inner part of the lobe. Alongside of the fresh forms of solifluxion lobes and slide scars old forms are also observed. A particularly vivid landscape appears on the scarps of the distal ridges. On July 16, 1960, I watched on these scarps a large slide moving over a width of some 50 m. Due to this slide a pseudomorainic ridge of 0.5–1.0 m height was formed at the base of the scarp. These kind of pseudomorainic ridges occur quite frequently on Spitsbergen. Of periglacial forms relic forms of pavement belts and debris circles occur within the ridge area (8). On larger rock blocks it is easy seen the effect of mechanical weathering. Debris pebbles often surround larger blocks (17), and next to blocks resting on inclined surfaces rubble tails up to 1.5 m length are often seen.

Similarly as on Gåsbreen (24) the ice-moraine ridges of Werenskioldbreen developed in front of a vanishing glacier, as shown by the fact that relic ice forms the base of the ridge complex. According to KOSIBA (19), the ice-moraine ridges of Werenskioldbreen indicate the range of this glacier in the 1915–1920 period. This age estimate of the ice-moraine complex is based on the comparison of photogrammetric pictures taken by the 1918 Norwegian Expedition with the later development of the glacier, and on glaciological arguments based on glaciological research carried out in 1957–1959 (20). KOSIBA (20) considers it possible that, in the Holocene, Werenskioldbreen reached further, extending even beyond the present-day range of the ridges. The front of the glacier debouched into the sea. Similar conditions may have prevailed here as with Gåsbreen; even so, no conclusive morphological evidence is on hand confirming this assumption.

Lateral moraines

At the sides of the glacier the ice-moraine ridges discussed pass directly into the ice-moraine ridges of lateral moraines. On the southern glacier edge the latter ridges are weakly developed, whereas at the northern edge they accompany the glacier tongue along its entire length. This assymmetrical development of the lateral moraines has been brought about mainly by the structure of the rocks surrounding the glacier and by differences in the exposition of the rock walls to the sun. As a rule, the southern mountain slopes are shaded, whereas during the noon hours the rock slopes north of the glacier are subject to intense insolation. Consequently, mechanical weathering is advanced on the northern scarps more than on the southern slopes, and it is this process that is decisive for both the size and the length of the lateral moraines. The southern flank of the lateral ice-moraine ridges accompanies the scarps of the Angellfjellet massif for a distance of about 1 km. In its northern part this is a distinct ridge of about 450 m width and with a relative height of up to 50 m. Upwards along the glacier this ridge narrows and finally passes into a cover lying on the mountain slope (Figs. 1 and 6). The crest of the lateral ice-moraine ridge is mostly narrow; often it does not exceed half a meter's width. Usually the inclination of the distal and proximal scarps exceeds 30°. On the surface of this ridge fine material dominates, alongside of which blocks up to 3.0 m diameter occur (quartzites, amphibolites). These blocks are angular, deposited chaotically. Most probable they are derived from fairly recent rock falls. The interior of the ridge is filled by relic ice. The thickness of the moraine cover does not exceed 3.0 m; it is particularly thin on the slopes of the proximal ridges. In July 1960 the proximal slope was entirely devoid of a cover of moraine material on a length of some 150 m. The inclination of the ice scarp reaches here 42°. The proximal slopes of the ridge are undergoing marked alterations, as indicated by numerous landslides observed on their surfaces. Frequently such slides occur suddenly. I watched a large landslide of 20 m diameter developing within a score of seconds. At the face of the scar left by this slide, large solifluxion lobes developed.

At the northern end of the glacier the lateral moraine extends over a length of more than 3 km. It starts at approximately 350 m a. s. l. next to the scarps of the Wernerknatten massif. Generally this moraine shows the shape of a ridge, but locally it forms merely a cover on the mountain scarp. In the upper section of the glacier the height of the lateral moraine reaches up to 5.0 m, with a width up to 10 m at the base and 1.0 m at the crest. The maximum scarp inclination is 30°. In the lower glacier section the lateral moraine ridge widens to 300 m at its base and becomes a typical ice-moraine ridge. Sometimes the crest of the ridge attains a width up to 80 m, but, on the whole, the ridge shows a rugged relief and the width of the crest is no more than 3.0 m. The relative height of the lateral moraine ridge gradually increases from 5.0 m to some 50 m at its lower end (an ice-moraine ridge).

On the surface of the upper part of the ridge the material building the lateral moraine are shales (2). In the lower part usually finer material dominates, among which now and then an accumulation of larger rocks are found. Among these blocks dolomites, quartzites and conglomerates were identified. The largest block specimens attain diameters of 3.0 m (for instance, at the altitude of 100 m a. s. l.). The moraine material rests on relic ice. The thickness of the moraine cover varies from several centimeters to several meters.

The terminal section of the lateral ice-moraine ridge presents a remarkably vivid landscape. The proximal slopes show numerous landslides and solifluxion lobes. Some parts of the ridge are absolutely inaccessible due to morainic muck flowing down from the slope surface. Generally speaking, the proximal slope is gentle, with an inclination of 10° to 20°, whereas the distal scarps are, as a rule steeply inclined, with 38° maximum. I failed to notice solifluxion features on the distal scarps.

Medial moraines

Medial moraines are of varied origin. Most frequently they are formed by the junction of lateral moraines when two glaciers join (7). Medial moraines also stretch away from nunataks projecting from the firn field or from part of the glacier proper. At the contact with the terminal moraine the cover of the moraine material is relatively thin, of the order of some centimeters to some meters. The relief of the medial moraine ridge depends mainly on the relic ice which is deposited under the thin moraine cover. Characteristic is the sorting of the material forming the medial moraine; this sorting is connected with the glacier's movement. The ice contained in the medial moraine is an integral part of the glacier.

Along the morphological axis of the medial moraine, a narrow crest ridge extends of 0.30 to 1.50 m width. Its height varies from 0.10 to 0.50 m, with slope inclinations of 26° to 42°. All along this crest ridge practically all boulders are arranged with the long axis parallel with the morphological axis. This arrangement confirms the results of investigations made by G. LUNDQUIST (22), who ascertained that any material deposited on a moving body is oriented in a particular pattern, i. e., that the long axis of all blocks and boulders coincide with the direction of movement. It also should be emphasized that all rock blocks, even those up to 1.5 m diameter, lying in the track of the medial crest ridge, have the same position as the smaller boulders, and their long axis are parallel with the glacier's flow.

Zone of ablation moraine and of marginal outwashes

Between the area occupied by the terminal moraine and the edge of the glacier a distinctly noticeable depression appears with a level or slightly undulating surface. On the basis of the present detailed survey of this, the author distinguished here areas containing an ablation moraine and marginal outwashes (Fig. 1).

The ablation moraine zone extends in front of the southern edge of the glacier, between the lateral ice-moraine ridges and the medial moraine. This area was produced by rapid surface deglaciation. The moraine material lying on the ice sank downwards, forming the cover of an ablation moraine. This manner of producing an ablation moraine has been determined for the first time in 1947 by R. F. FLINT (10). The structure of this type of ablation moraine is undirected. In this type of ablation moraine the material is deposited on top of the ground moraine, or directly on bedrock. In the area south of the terminal moraine, the ablation moraine cover reaches a thickness of 3 m. From under this cover rocks of the substratum frequently protude, mostly shales cutting out vertically. The rock substratum lies at two levels, at 20–25 m a. s. l. and 40–42 m a. s. l. respectively. These rocks represent exhumed surfaces of 20 and 40 meter terraces into which the glacier encroached during its transgression. A detailed distribution of the exposures of the terraces appearing from under the ablation moraine is given in the map of the marginal zone of Werenskioldbreen.

The author thoroughly studied the cross-sections of the moraine material de-

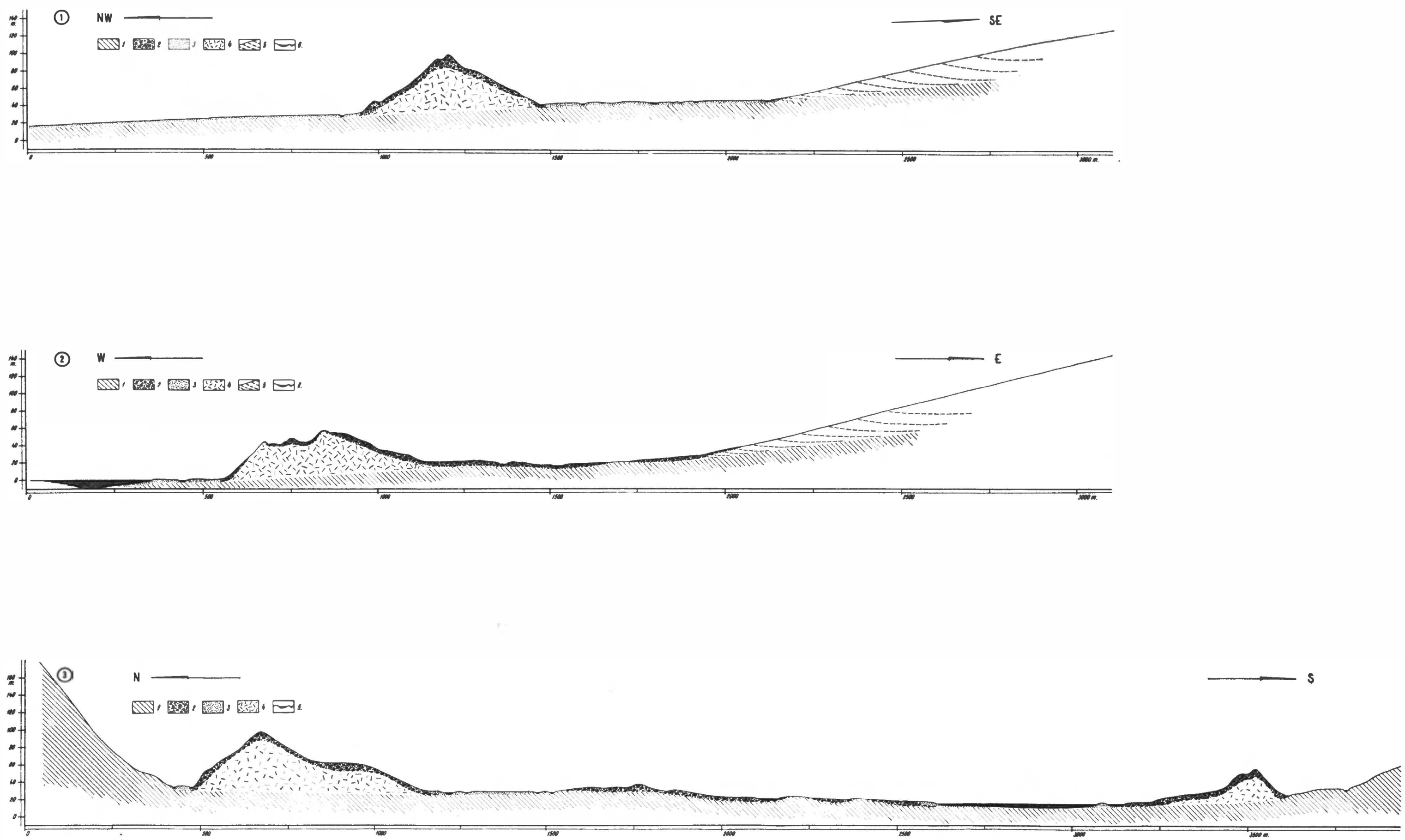

Fig. 4. I. *Transversal section of the marginal zone of Werenskioldbreen.*
1. substratum; 2. morainic material; 3. outwash plains; 4. relic ice; 5. glacier; 6. lakes and streams.
II. Transversal section of the marginal zone of Werenskioldbreen.
1. substratum: 2. morainic material; 3. outwash plains; 4. relic ice; 5. glacier; 6. lakes and streams.
III. Longitudinal section of the marginal zone of Werenskioldbreen. 1. substratum; 2. morainic material; 3. outwash plains; 4. relic ice; 5. lakes and streams.

posited on the rock substratum. In a normal tillite profile of glacier areas two horizons should show (18): at the bottom there should be a clayey material, often of gneissic texture corresponding to the ground moraine, while at the top should appear uncompacted material of the ablation moraine. In all the sections the author examined here (400–200 m from the glacier edge) was nowhere determined a bipartition of the tillite. Everywhere chaotically deposited material was mostly encountered. On this basis the author is of the opinion that nowhere in front of the glacier, at least nowhere within a zone of 400 m to 200 m from its edge, a ground moraine has been laid down. The material of the ablation moraine has been deposited directly on top of the rock substratum.

Directly adjoining the glacier edge an ablation moraine is being formed at present, however, it originates in a manner different from the ablation moraine described above. From the glacier snout a surface moraine descends, strongly watersoaked which directly in front of the glacier produces a zone of morainic muck. This morainic muck coalesces at the glacier edge, or it is displaced further into the forefield of the glacier. In an ablation moraine of this type, fine material dominates, but frequently larger boulders are found sliding down the glacier snout and afterwards submerged in the morainic muck. The author has investigated sections of an ablation moraine of this type, lying at a distance of some 80 m from the glacier edge, where the material had hardened completely. The section examined of an ablation moraine of this type shows a bipartition. Larger rock blocks lie at the bottom, directly on the substratum; at the top the material is of finer grain – a typical boulder clay. The sections examined were of small size, of 0.20 to 0.80 m thickness. The coarser material at the bottom is angular, proving that it is derived from a surface moraine. Towards the end of this research, in September, the author had intended to undertake detailed measurements of the position of boulders in a moraine of this type; unfortunately, atmospheric conditions prevented the completing the observations initiated.

It was M. Klimaszewski (18) who, for the first time in the Spitsbergen area, identified an ablations moraine of this type in the forefield of Comfortlessbreen, Elisebreen and Vestgötabreen. The present author is of the opinion that zones of a freshly emerged ground moraine and a zone of a muck moraine lying in front of Grønfjordbreane and described by K. Gripp (12) also represent the type of ablation moraine discussed above. The gradual formation of an ablation moraine flowing down from a glacier surface has been investigated very thoroughly by W. H. Ward (27) at the edge of the Barnes glacier on Baffin Land.

In the southern part of the zone containing the ablation moraine, between the glacier edge and the shore of a small marginal lake, another moraine appears showing a structure again differing from the two types discussed previously. On a slightly slanting plane (up to a gradient of 6 %) small ridges occur, parallel to each other and perpendicular to the glacier edge. They are built of heterogeneous moraine material; between these ridges small furrows are distinctly visible. The width of each small ridge at the base reaches 1.0–1.5 m, with 3.0 m as maximum. The width of the furrows is up to 1.0 m, their height does not exceed 0.3 m. The material occurring on the surface of these small ridges, along their crest lines, is

Fig. 5. *Marginal outwash in front of Werenskioldbreen. August 1960.*
Photo: J. SZUPRYCZYŃSKI.

distinctly sorted. Larger and smaller boulders, lying in the crest lines of the ridges, are arranged parallel with the morphological axis of the form and are distinctly rounded. This type of moraine has been identified by V. SCHYTT (23) in the forefield of the Isfjells glacier in the Kebne-Kaise mountain massif of North Sweden. Cross-sections made in 1949 and 1952 across the interior of the snout of the Isfjells glacier revealed that the small ridges extending at the glacier edge are continued as ridges underneath the glacier. This therefore is a "fluted moraine" of particular structure (23), produced by the flow of moraine material underneath the glacier.

Connected with the marginal pools is the formation of outwash cones. The meltwater streams penetrate the lake Gullsjøen and form a clearly visible outwash cone on the northern shore of this lake (Fig. 7). The dimensions of this cone are: in the N–S axis some 350 m, from E to W some 300 m. This outwash cone is built of gravel, with a 5 cm fraction dominating. At the bottom of this outwash banks of coarse gravel up to 15 cm diameter also occur. The superposition of several successive outwash cones can easily be observed. In the western part of the outwash lobe there extends an abandoned old channel of an outwash stream; along this channel it proved an easy matter to study the structure and the thickness of the outwash cone. In the northern part its maximum thickness reaches 4.5 m. In the bottom strata of the outwash numerous large boulders occur; this is due to the destruction of a ground or ablation moraine. The inclination of the strata in the outwash cone is up to 16°; these strata are spread out fan-wise in a southern direction. The structure of the bottom strata reveals that during a certain period this outwash was built up by streams flooding from the east, probably directly from the glacier edge. The dip of the bottom strata is 4°–14° southwards.

A distinct cone of a marginal outwash was also discovered in front of the glacier edge, on the southern slopes of the medial moraine. As to its grading, the material of the marginal outwash is differentiated. In the northern part coarser material predominates, distinctly stratified showing diameters of 0.05 to 0.1 m. On the other hand, the modern cone is built of fine-grained material. On the small islands protruding above the water level of the marginal lake besetting the outwash, an extremely fine silty and clayey material, was found.

In front of the northern glacier edge a large lobe of marginal outwash extends, of some 550 m width and a maximum length of 1000 m. On the whole this outwash is built of gravel. The surface of this outwash is much diversified; it contains numerous terrace-levels that proved difficult to correlate. In its western part this outwash is pitted by many depressions – part of them old stream channels. Other depressions, oval-shaped, were probably produced by melting blocks of relic ice. However, the author was unable to study the structure of the outwash found here.

The marginal outwash adjoining the northern glacier edge is dissected by melt-water streams issuing from the front of the glacier. All these streams join Kvisla river, which escapes from the marginal zone through a gap between the slopes of the ice-moraine ridges and the slope of the Jens Erikfjellet massif.

Eskers

In the marginal zone of Werenskioldbreen there exist four esker forms. The distribution of these forms is shown in the map of the marginal zone of Werenskioldbreen (Fig. 1). One of these eskers is situated at the base of the slopes of the distal ice-moraine ridges, the remaining eskers extend at the glacier edge.

Of particular interest, in view of its situation, is the esker found next to the slopes of the ice-moraine ridges. This esker is relatively small: its total length is 128 m, its maximum relative height 4.4 m. In this esker three successive sections may be observed, slightly differentiated by the course of their morphological axes and by their exterior shapes. The morphometric data for the three sections are as follows:

1st section: length – 34 m
trend of morphological axis of form – N 310°
height of form measured in the south – 3.40 m,
height of form measured in the north – up to 2.0 m
width at base – up to 10.0 m
width of crest – » » 0.5 »
inclination of slopes: southern slope – 38°
northern » – up to 30°

2nd section: length – 60 m
trend of morphological axis of form – N 318°
height of form measured in the south – from 440 m (E) to 2.0 m (W)

height of form measured in the north – up to 0.5 m
width at base – up to 10.0 m
width of crest – » » 2.0 »
inclination of slopes: southern slope – up to 38°,
in the north – up to 38°

3rd section: length – 34 m
trend of morphological axis of form – N 325°
height of form from 1.0 m (E) to 0.5 m (W), at end of eskers – 0.3 m
width at base – up to 5.0 m
width of crest – » » 1.5 »
inclination of slopes: southern slope – 16° to 30°,
northern slope – 16° to 32°

This esker is developed in the shape of a ridge (Fig. 8). Its surface gradually subsides westwards. From the north the esker is in contact with the slopes of the ice-moraine ridges; from the south it borders on the outwash. The esker consists of stratified fluvioglacial deposits of arenaceous silts, sands and gravels. At the base of the esker the dip of the strata is from 6° to 16° westwards, the strike of the bedding varies between N 10° and N 55°. Thus the structural axis is at right angles or slightly oblique to the morphological axis of this form. The deposits occurring at the top of the esker are slightly disturbed, as indicated by the wide angles of their dip. The top strata of the esker subside northwards and it seems certain that they do not represent the original pattern of deposition. The northern slope of the eastern section of the esker shows a cover of boulder clay, with large boulders up to 0.3 m diameter. In this eastern part the author failed to excavate the esker to its base. Already at 1 m depth below the surface of the esker permafrost has been found. On and off, the surface of the esker is covered by vegetation. This vegetation cover presents a sharp contrast with the perfectly bare slopes of the complex of ice-moraine ridges.

Both its geological features and its interior structure indicate that this esker has been formed supraglacially, i. e. in an open ice crevasse (7). The esker contains fluvioglacial material, distinctly sorted, from the bottom of the form up to its top. Structural measurements prove the water flow in the crevasse to have been linear, from SE to NW.

I believe that the esker was produced at the same time as the ice-moraine ridges, i. e. in the period from 1915 to 1920 (19, 20). It also seems probable that, in the case of Werenskioldbreen, similar conditions existed as during deglaciation of Gåsbreen (24, 25). If we assume this theory to be correct, the ice-moraine ridges of Werenskioldbreen do not represent the maximum range of the glacier attained during the Holocene, and its real range is marked by the crevasse forms. Additional esker and kame forms may have existed in the glacier's forefield, but they were presumably destroyed by outwash streams and by the abrasive action of the sea. And the only form preserved was probably this esker situated directly at the ridge slopes, although even this form may have been considerably longer; the northwestern section of the esker was probably destroyed by waves during

Fig. 6. *Esker at southern margin of ice-moraine ridges of Werenskioldbreen. In background Nottingbukta. July 1960.* Photo: J. Szupryczyński.

storms. In stormy weather the sea waves reached the slopes of the ridges as shown by driftwood deposited in close proximity to the ridge slopes (at the distance of some 50 m north of the esker). Nor does Kosiba (20) dispute a probable wider range of Werenskioldbreen during the Holocene. The highest esker form within the marginal zone of Werenskioldbreen has been found at the glacier edge. This esker lies south of elevation 46.0 m a. s. l. (Fig. 1). The length of this esker, determined on July 20, 1960, by means of a geodetic tape along its morphological axis, was exactly 125 m, whereas on September 1st this length was only 107 m. In the map of the marginal zone the length determined in 1958 has been shown. The author will come back to the problem of changes in the length of this esker after first discussing its morphometric characteristics.

These morphometric data are as follows:

length – 125 m, 107 m
trend of morphological axis of form – clearly visible at successive sections showing (starting from the east): N 285°, N 270°, N 240°, N 295°
height of form – 1.6 m to 8.4 m (at 37.2 m a. s. l.)
width at base – 1.3 m to 25.0 m
width of crest – 0.1 m to 2.2 m
inclination of slopes – everywhere exceeding 30°.

The entire form consists of four sections separated by depressions in the crest line. The crest line is undulating; in its longitudinal profile numerous depressions occur. The highest part of the esker appears in the middle of its length. Generally speaking the esker shows rugged features; upon a considerable length the crest width does not exceed 0.5 m (Fig. 9). Only the eastern part of the esker has a perfectly flat crest. In the top of this form a stratified fluvioglacial material is clearly visible. This material rests on ice representing here the base of the form. The thickness of the fluvioglacial material is from 0.60 to 4.20 m. In it, silts, sands and gravel occur. On the whole, finer material predominates as indicated in Table 1.

Table 1

Fraction	Weight in grams	Per cent
More than 10 mm	17.200	4.2
10 – 5 »	19.700	5.0
5 – 2 »	36.600	9.2
2 – 1 »	70.000	17.5
1 – 0.5 »	77.700	19.4
0.5 – 0.2 »	100.600	25.1
0.2 – 0.1 »	57.100	14.3
0.1 – 0.06 »	10.600	2.7
less than 0.06 »	10.500	2.6
Total:	400.000	100.0

The fluvioglacial material is angular, the grains show no rounding whatsoever, thus indicating an extremely short transport. In the western part a much coarser material occurs than in the eastern part. In its major part the esker rests on the glacier; only its extreme western part is laid down beyond the glacier. This esker lies on ice, the slopes of which are undercut by meltwater and, therefore, are subject to fairly intensive ablation. Melting ice caused considerable disturbances in the original accumulation as shown, i. a. by the change in the dip of the strata. In those parts of the esker where its crest subsides, the direction is eastwards – contrary to the course of this form. The relief of the form reveals it to have originated englacially, in a tunnel within the glacier. The interior of the form clearly shows the stratification of the material, whereas the surface is covered by a thin sheet of an ablation moraine. The structure of the bedding indicates a linear westward water flow in the tunnel. The dip of this bedding varies between 4° and 22°.

This esker originated in an englacial tunnel and emerged gradually from the glacier with the gradual progress of ablation at the snout of the glacier. The ice which at present lies at the bottom of the form was once the floor of the ice tunnel, and this ice is protected by its fluvioglacial cover against melting. After the ice has melted the entire form is bound to collapse and to be flushed away by meltwater during further periods of glacier recessions. With each year this esker is undergoing marked alterations. During the seasons of my research work in 1960, meltwater destroyed within 40 days a section 18 m long of the eastern part of this

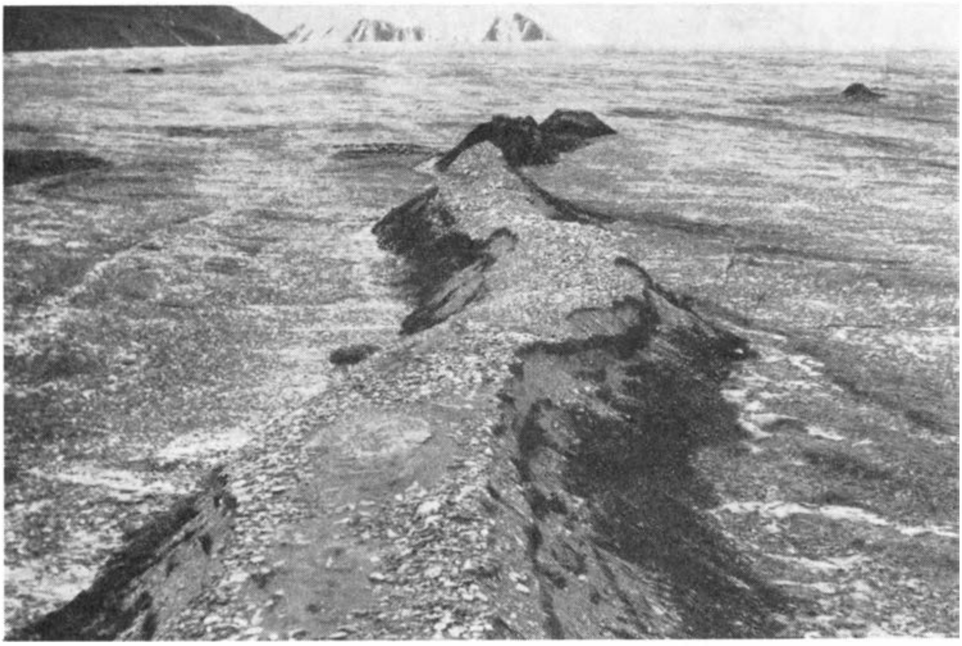

Fig. 7. *Esker on surface of Werenskioldbreen. July 1960.*
Photo: J. SZUPRYCZYŃSKI.

esker. The dimensions of this part of the esker were relatively small: up to 1.60 m height and 2.80 m width at base. Only 50 % of the height of the esker consisted of fluvioglacial material deposited on the ice.

North of elevation 46.0 two eskers exist. The larger esker shows the following morphometric data:

length along morphological axis – 213 m
morphological axis of form: it changes from N 225° to N 340°
height – up to 1.8 m
width at base – 3.0 to 7.5 m
width of crest – 0.4 to 4.0 m
inclination of slopes – 30° to 34°; at points of undercutting by meltwater – up to 60°

This esker lies at the tunnel mouth of an englacial stream. The eastern side of this form is markedly destroyed by meltwater streams issuing from the glacier. During several days of powerful ablation a 7.0 section of this esker was carried away in its eastern part. Meltwater disrupted it for a length of 3.5 m and flushed away all fresh material from this part of the esker. The esker surface is inclined 4° to 6° westwards. From bottom to top, clearly visible, is the stratification of the fluvioglacial material, consisting of silts, sand and gravels. It is possible here to trace the continuity of the strata over the entire length of the esker.

The material found in this esker shows no rounding, proof of its short distance of transport. Structural measurements carried out in the interior of the form indicate a linear westward flow of the water, concordant with the trend of the morphological axis of the form. The dip angles of the strata are from 8° to 12°. This esker developed supraglacially at the glacier snout in a very shallow crevasse and was deposited directly on the substratum. This is but a small form, still it shows well-defined morphological features and a clearly visible structure. Unless meltwater destroys it, this esker is likely to survive for a long period of time.

South of the form discussed is situated a short esker ridge of 46 m length. This is a form bent sickle-wise. The eastern part, 21 m long, shows a morphological axis with a trend of approximately N 260°. The remaining part of 25 m length has a N 310° trend of its morphological axis. The height of this form is from 1.2 to 1.4 m. Its base width is 4.4 m, while the width of its crest is up to 2.0 m. The crest is flat over the entire length of the esker and shows a 5° westward slant. The structure of this esker is identical with its neighbour. The slopes inclined up to 30°, are in many places undercut by meltwater running off the glacier. The origin of this esker must have been the same as that of the form described above.

J. K. CHARLESWORTH (7) states that very rarely esker forms are discovered in polar regions. In Spitsbergen their occurrence has been determined in few localities only. E. J. GARWOOD and J. W. GREGORY (11) mention in their paper the occurrence of gravel ridges in northern Spitsbergen. These, however, some authors believe to be of erosive origin, presumably sculptured in a gravel patch (an outwash ?). In 1938 M. KLIMASZEWSKI (18) discovered in the region between Kongsfjorden and Eidembukta, in the north-western part of Spitsbergen, two short esker forms of subaquatic origin. One of them, an esker ridge lying at the edge of Comfortlessbreen, was built up of sand and silt and reached a height of 3.0 m; its angles of slope inclination was approximately 35°. The other esker, situated at the edge of Aavatsmarkbreen, was built up of fine gravel, and was only 1.5 m high. KLIMASZEWSKI does not give any details as to the forms of these eskers nor of their interior structure. As far as their heights are concerned, these forms resemble the eskers occurring in the marginal zone of Werenskioldbreen. A. KORNERUP (7) saw in 1879 in Western Greenland a ridge running parallel with a glacier, built of sand gravel of 6.0 m height and some 80 m length. On the eastern shores of Greenland M. VAHL (7) observed a similar ridge of a relative height of 5.0 m and a length up to 30 km. It seems probable that in both instances these were esker forms.

In Iceland, north of Vatnajökull glacier, P. WOLDSTEDT (28) discovered esker forms in 1937. The area in which eskers occur, in the forefield of Vatnajökull glacier, north of its section called Bruarjökull, is, in E. M. TODTMANN's opinion (26), the most extensive among modern glaciated areas. Such a large accumulation of eskers as occur in Iceland cannot be found anywhere else in the polar regions. Here esker ridges reach up to 1.5 km in length (26) and 5.0 m in height (26). The esker forms occurring north of the Bruarjökull glacier were the object of research carried out by G. HOPPE (14), who ascertained them to be of subglacial origin.

In Alaska eskers were discovered in the forefield of the Vakuta and the Woodworth glaciers. Excellent pictures of an esker occurring in the forefield of the

Woodworth glacier, taken by B. Washburn, are shown in a handbook published by R. F. Flint (10). The formation of esker forms has also been observed in the forefield of the Malaspina glacier (7). The above literature review indicates that, in polar regions, eskers reach very moderate dimensions compared with the eskers found in areas of Pleistocene glaciation in Europe and North America.

Extramarginal outwashes

In the forefield of the terminal moraine there is spread out the cone of an extramarginal outwash (Fig. 1). The dimensions of this cone are, in its W–E axis, 3.5 m and some 3.0 km in its N–S axis. The surface of this outwash cone slants at a small angle westwards. The outwash surface is dissected by numerous channels carrying meltwater streams. This outwash is built up of fluvioglacial material, i. e. sands and gravels. At consolidated parts of its surface clusters of rock plants grow. The outwash is separated from the open sea by a storm ridge up to 2.0 m high. Inside this storm ridge numerous pools are situated, receiving the flow of various smaller outwash creeks. The largest creeks dissect the storm ridge and issue directly into the sea.

The interior structure of this outwash is fairly complicated. The entire outwash cone is built of a number of smaller cones superimposed on each other. The dip of the outwash strata is from 6° to 18° westwards within the section extending from S 220° to N 330°. In the proximal part of the outwash erosion may be observed, caused by larger streams such as Kvisla river. The channel of this river is incised into the outwash to a depth of 3.0 m, while the depth of the water is no more than 1.2 m. On the other hand, accumulation of the outwash cone takes place mainly in its distal part and, partly also, along banks of the creeks. The contact between the outwash and the open sea is extremely variable. During storms, waves penetrate deeply into the shore and destroy the extreme distal parts of the outwash, while during calm weather the outwash cone is supplemented on the seaward side.

Monadnocks of marine terraces – here the 8-meter terrace – jut out above the surface of the outwash. The relative height of these terrace monadnocks with regard to the outwash surface does not exceed 3 m. The top of the monadnocks is covered by a dense vegetation. This is in strong contrast to the outwash surfaces showing a sparse vegetation.

A small cone of an extramarginal outwash is situated south of the complex of ice-moraine ridges. Its dimensions are 500 × 600 m (in a NS direction). In its proximal part, this cone is built of coarse material while the distal side contains fine material. This outwash has been built by the stream issuing from Gullsjøen, situated in front of the glacier edge, and by its tributaries entering from Bratteggdalen.

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Foraminifera in some bottom samples from shallow waters in Vestspitsbergen

BY
JENÖ NAGY

Contents

Abstract

The Foraminifera have been examined in 45 dried bottom samples collected from nine areas in the southern part of Vestspitsbergen. 39 of the samples were taken from shallow waters near glacier termini, while 6 samples were taken near the beach. Altogether 59 benthonic and one planktonic species were found. The quantitative distribution of the species for each of the investigated areas is given. Three main types of faunas have been recognized.

Introduction

The faunas in the waters surrounding the Spitsbergen archipelago have been studied by several workers over the last century. The only comprehensive foraminiferal work, however, is the paper by GOËS from 1894, for which he studied bottom samples from the waters surrounding Vestspitsbergen and from some of the fjords. FEYLING-HANSSEN (1964) has given a brief account of the Foraminifera in a few samples from Isfjorden and Van Keulenfjorden in Vestspitsbergen.

The material studied for the present investigation are bottom samples collected from the waters of Hornsund, Storfjorden, and Van Keulenfjorden. The samples were taken from 45 stations at depths between zero and 51 metres. Most of the stations are located in the proximity of the calving termini of glaciers. The collections were made during the summers of 1962 and 1963, on the expeditions organized by Norsk Polarinstitutt.

Methods

The collection of bottom samples was not included in the programme of the expeditions, therefore a simplified field technique was employed.

The bottom sampler is shown in Fig. 1. By the sampling it was pulled along the bottom, usually for 4 to 7 metres, and then weighed. A rowboat was used during the sampling, and the depths were obtained by means of a measuring line. One sample was taken at each station.

Since the sampler has no cover, the sediment in the upper part of the container may be more or less affected by turbulence while it is weighed. This may have some effect on the composition of the fauna contained in the sediment. Therefore, the upper 2 or 3 cm of the content of the sampler was always discarded. As soon as possible after the collecting, the samples were dried and subsequently preserved in plastic bags.

In the laboratory, the samples were freed of fine sediments by washing through two successive sieves with mesh diameter of 1,0 mm and 0,10 mm respectively. The residues were dried before examination. The Foraminifera in the sandy samples were concentrated by means of carbon tetrachloride (CCl_4).

The investigated areas and their faunas

The postition of the areas from which the samples have been taken are shown in Fig. 2; the individual stations are indicated in Fig. 3.

The distribution of the Foraminifera species in terms of percentages of the

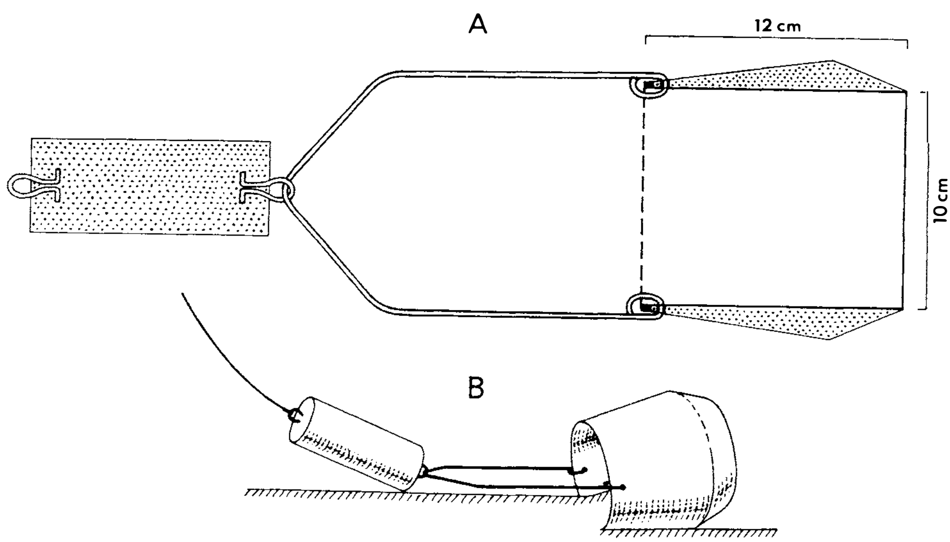


Fig. 1. *The bottom sampler: A – median section (parts of lead dotted); B – diagrammatic sketch of sampler in operation.*

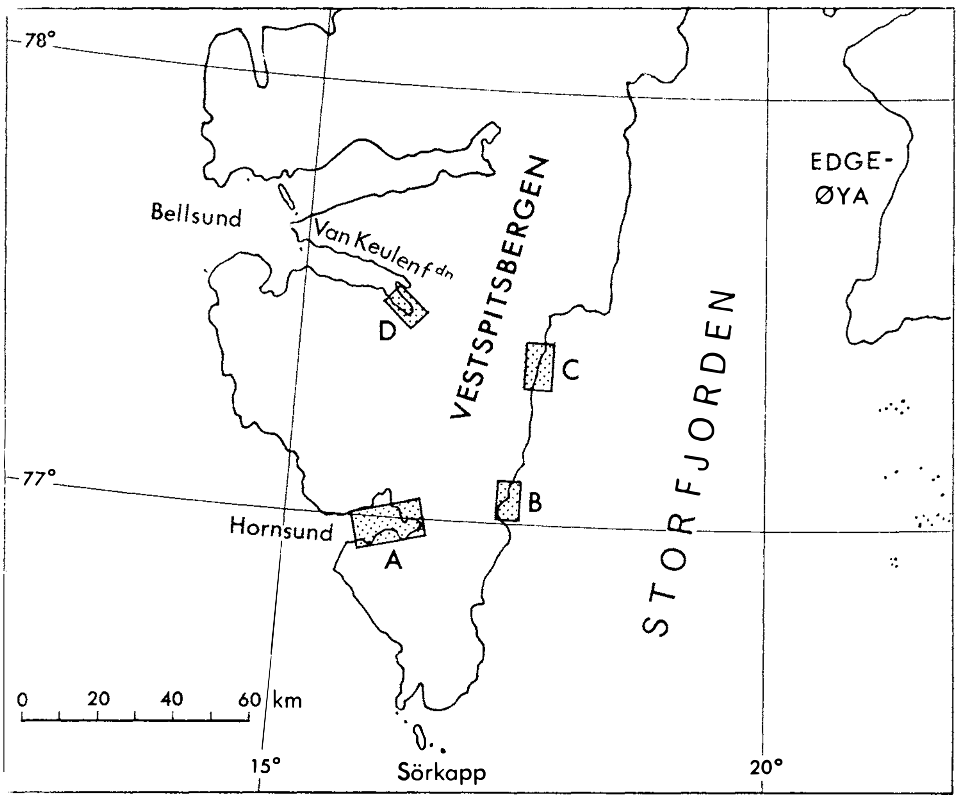


Fig. 2. *Southern part of Vestspitsbergen. The sampling stations are located within the dotted areas A to D (cf. Fig. 3).*

total population at the individual stations is given in Table 1. In this table 32 species are listed individually in the order of decreasing abundance, while the remaining 28 species which occur only at scattered stations at very low percentages are united under "rare species". Particulars concerning the latter species and their occurrence are given on pp. 115–125. An account of the investigated areas with a brief description of their faunas is given in the following.

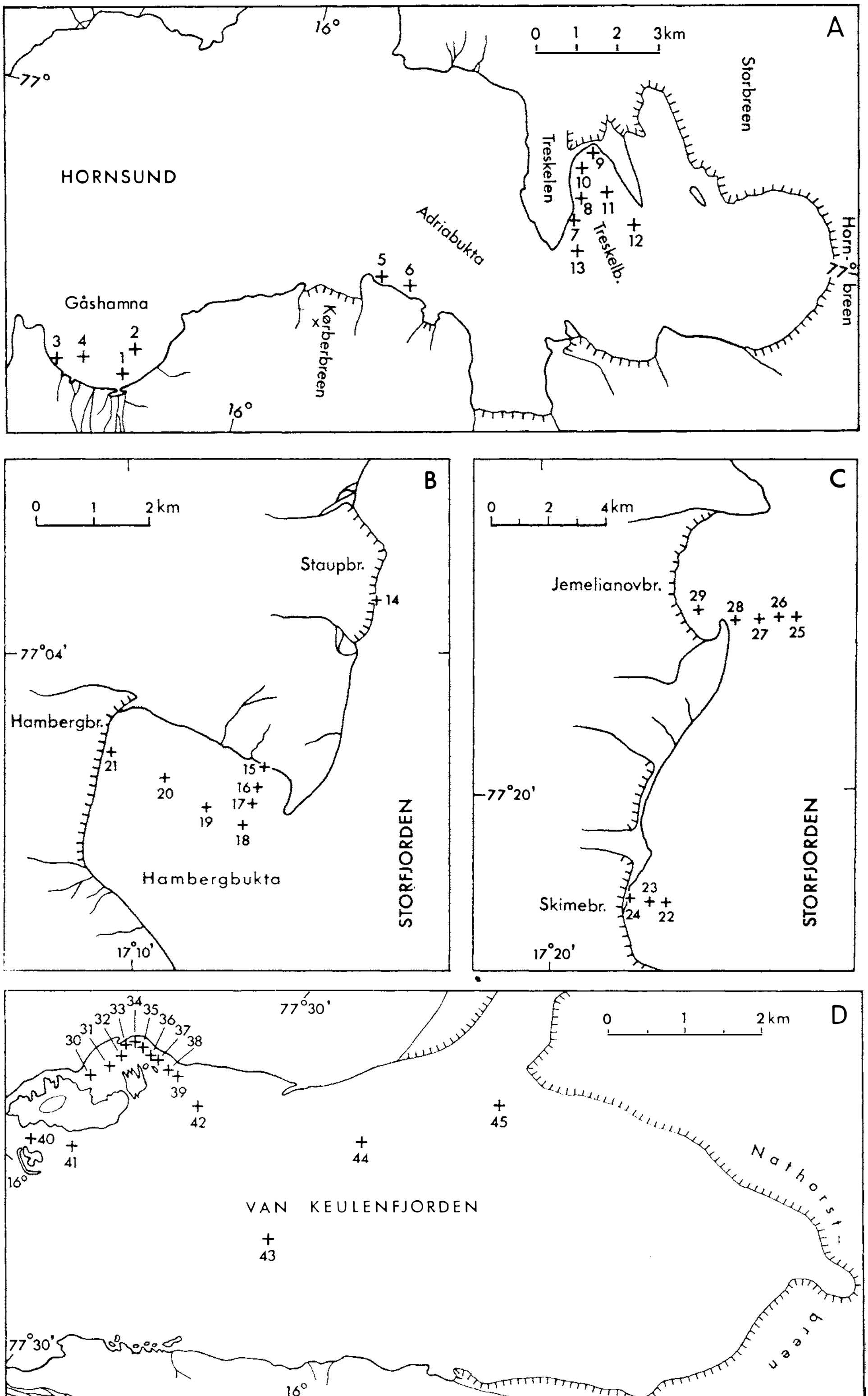
HORNSUND (Fig. 3 A)

Stations 1–4: Gåshamna

Depths 4–15 m; distances offshore 0,1–0,7 km.

Meltwater from a glacier terminus 2 km south of the beach runs into the bay where the stations are located. During the sampling seaweeds were also brought up from the bottom.

The dominant species is *Elphidium clavatum*. The following species occur with fairly high frequencies: *Buccella frigida, Cibicides lobatulus, Elphidium bartletti, Elphidium frigidum, Elphidium orbiculare, Elphidium subarcticum, Elphidium* sp. Three species show increasing frequencies with increasing depth; *Astrononion gallowayi, Cassidulina crassa, Nonion labradoricum.*


A
0 1 2 3km
16°
77°
HORNSUND
Storbreen
Treskelen
Treskelb.
Adriabukta
Gåshamna
Kerberbreen
1 2 3 4 5 6 7 8 9 10 11 12 13
B
0 1 2 km
Staupbr.
14
77°04'
Hambergbr.
15 16 17 18 19 20 21
Hambergbukta
STORFJORDEN
17°10'
C
0 2 4km
Jemelianovbr.
25 26 27 28 29
77°20'
Skimebr.
22 23 24
STORFJORDEN
17°20'
D
77°30'
0 1 2km
30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45
16°
VAN KEULENFJORDEN
Nathorst-breen
77°30'
16°

Stations 5, 6: Adriabukta

Depths 11 and 37 m; distances offshore 0,2 and 0,3 km.

In addition to the Foraminifera the samples contained a rich mollusk fauna. A bottom vegetation of seaweeds was observed.

The foraminiferal faunas at the two stations consist of 39 and 42 species respectively. Most of the species occur with a few specimens, however. Frequent species at both stations are: *Cassidulina crassa, Cibicides lobatulus, Elphidium clavatum.* The following species are frequent at the shallower station but rare at the deeper one: *Elphidium bartletti, Elphidium orbiculare, Elphidium* sp. The following species are frequent at the deeper station and rare at the shallower: *Astrononion gallowayi, Nonion labradoricum, Spiroplectammina biformis.*

Stations 7–13: Treskelbukta

Depths 10–50 m; distances from the calving terminus of Storbreen and Hornbreen 3–6 km. Some of the samples contained *Portlandia arctica* and other small taxodont pelecypods.

The number of species observed in the samples varied from 6 to 13. The fauna is dominated by *Astrononion gallowayi, Cibicides lobatulus,* and *Elphidium clavatum.* Species which are frequent at some of the stations but rare or absent at others, are as follows: *Cassidulina crassa, Lagena gracillima, Nonion labradoricum, Psammosphaera fusca, Triloculina oblonga.*

STORFJORDEN, SOUTHERN AREA (Fig. 3 B)

Station 14: E of Staupbreen

Depth 6 m; distance from the terminal cliff of the glacier about 10 m.

The fauna consists of 11 species. Of the total population *Cibicides lobatulus* constitutes 70 per cent, *Elphidium orbiculare* 12 per cent, and *Elphidium clavatum* 6 per cent.

Stations 15–21: Hambergbukta

Depths 1,5–51 m; distances from the calving terminus 0,1–2,8 km.

The terminal cliff of the glacier now lies about 2 km behind the position indicated on the official map from 1936. Some of the samples contained *Portlandia arctica.*

The number of species at the stations varied from 4 to 10. The dominant species is *Cibicides lobatulus* occurring at frequencies between 30 to 72 per cent. *Astrononion gallowayi, Cassidulina crassa, Elphidium clavatum,* and *Elphidium* sp. are common at most, and absent at a few of the stations.

Fig. 3. *Detail maps showing the position of the sampling stations: A – Hornsund; B – Storfjorden, southern area; C – Storfjorden, northern area; D – Van Keulenfjorden.*

LOCATION	HORNSUND													STORFJORDEN															VAN KEULENFJORDEN															
	Gåshamna				Adria-bukta		Treskelbukta							E. of Staupbr.	Hambergbukta							E. of Skime-breen		East of Jemelianovbr.																				
STATION NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	23	22	25	26	27	28	29	33	34	37	36	35	31	38	41	42	40	39	30	32	44	45	43
DEPTH IN METERS	4	5	9	15	11	37	10	12	20	23	32	35	50	6	1,5	4	13	51	48	16	49	5	10	27	16	14	16	44	0	0,2	1	1,5	2	2	2	2,5	3	3	4	4,5	5	13	22	30
PERCENTAGE DISTRIBUTION OF COMMON SPECIES																																												
Elphidum clavatum	46	16	14	10	14	13	19	24	10		32	38	6	6	16	5	17			6	4			73				8	70	80	81	60	80	94	51	53	81	62	43	50	78		50	100
Elphidum sp.	6	7	7	1	12	0,5	2				1			2	8	10	9			8	8	13	76	20	57	50	30	7	12	17	19	39	18	6	34	47	9	16	19					
Cassidulina crassa	1	3	9	13	14	19	2		9	13	7	8		2		17	12	10	19	3					8	20	12	25	10	1					3			19				33	50	
Nonion labradoricum	1	1	2	7	2	8	7	13			13		6			4	3			8					7			1	4	0,5					3			3				33		
Lagena gracillima					0,2	0,4		2	18	20	3	8																2	1	1		1	2	0,3	3		6		38	50	22			
Angulogerina fluens					0,2	0,2	1						3	1	8																				3									
Elphidium subarcticum	10	5	12	6	3	1	1		5					2					8	6		6			7		24	21							3							33		
Astrononion gallowayi	1	2	3	23	1	14	12	8		20	7	15	8	2		11	25	10	14	24	14						4	2	1															
Cibicides lobatulus	4	2	7	1	11	21	48	28	5	20	24	15	71	70	44	45	30	72	55	40	47	6						1	1															
Elphidium orbiculare	2	5	2	8	9	0,5		7	5		1			12	24	5	2					75		4	21	30	27	5																
Islandiella norcrossi	1		1	1	0,5	1	1	2			2	8	3	1															1															
Spiroplectammina biformis		1	3	1	3	10	1		5															3				24																
Buccella tenerrima	5	7		1	1	1		2			4		3	1		1	1																											
Elphidium frigidum	4	1	4	4	1	0,4														5																								
Reophax arctica					0,6	0,5																	9					2																
Oolina melo			1		0,4	0,2	1									1																												
Triloculina oblonga		2			1				5	20	5	8																																
Psammosphaera fusca		0,4	1	1	0,6	0,4	3	10	38																																			
Elphidium bartletti	11	2	12	5	9	1	2	4																																				
Tholosina sp.		14	1	1	1	0,1																																						
Pateoris hauerinoides		2	1	1	0,4	0,4																																						
Eggerella advena		1	1	2	0,5	0,3																																						
Quinqueloculina stalkeri			2	2	2	1																																						
Ammotium cassis		2		1	2	0,1																																						
Virgulina schreibersiana		0,4			2	1																																						
Quinqueloculina agglutinata				0,3	0,3	0,2																																						
Proteonina fusiformis		1	1	2		0,3																																						
Gordiospira arctica		1	3	1	4																																							
Quinqueloculina seminulum		1	1	2	1																																							
Cyclogyra involvens		0,2		0,4	0,3																																							
Cyclogyra foliacea				0,3	0,2																																							
Buccella frigida	8	19	12																																									
RARE SPECIES — NUMBER OF SPECIES		3		9	9	16				1	1			1		1	1	1	1				1				2	2									1							
RARE SPECIES — PERCENTAGE		4		5	3	5				7	1			1		1	1	8	4				15				3	2									4							
TOTAL POPULATION — NUMBER OF SPECIMENS	323	482	473	508	1388	1277	131	44	21	15	210	13	108	163	25	283	170	11	27	37	28	39	44	30	14	10	33	163	138	565	334	692	192	1178	35	163	53	32	21	2	18	3	2	1
TOTAL POPULATION — NUMBER OF SPECIES	13	27	22	34	39	42	13	10	9	6	12	7	7	11	5	10	9	4	5	8	4	4	3	4	5	3	7	14	8	5	2	3	3	3	7	2	4	4	3	2	2	3	2	1

Table 1. *Distribution chart of foraminifera species. Total population refers to the total number of specimens and of species obtained from 150 grams of dried sediment from each station.*

STORFJORDEN, NORTHERN AREA (Fig. 3 C)

Stations 22–24: E of Skimebreen

Depths 4–10 m; distances from the glacier terminus 0,1–1,5 km. West of the stations the terminal cliff of the glacier lies on the land, in some places only a few meters from the shore. South of the stations it extends out into the fjord.

Two of the samples contained 3 and 4 species respectively. The dominant species is *Elphidium* sp. The third sample which was taken nearest to the glacier contained no Foraminifera.

Stations 25–29: E of Jemelianovbreen

Depths 14–44 m; distances from the calving terminus 0,5–4 km.

The number of species varies from 3 to 7, except at the station nearest the glacier where it is 14. The fauna is dominated by *Cassidulina crassa, Elphidium orbiculare,* and *Elphidium* sp. The following species occur with high frequencies at some of the stations: *Elphidium clavatum, Elphidium subarcticum.*

VAN KEULENFJORDEN (Fig. 3 D)

Stations 30–42

Depths 0–5 m; distances from the calving terminus of Nathorstbreen 6–9 km.

The number of species varied from 2 to 8 at the stations. The fauna is dominated by *Elphidium clavatum* occurring with frequencies of 43 to 94 per cent. Less frequent but still common is *Elphidium* sp. At most of the stations *Lagena gracillima* occurs with a few specimens. Occasional specimens of other species were observed at a few stations.

Stations 43–45

Depths 13–30 m; distances from the calving terminus of Nathorstbreen 0,6–3 km.

150 g of bottom material examined from each of the three stations contained altogether two specimens each of *Elphidium clavatum* and *Cassidulina crassa,* further one specimen each of *Nonion labradoricum* and *Elphidium subarcticum.*

The species and their distribution

The following account includes 59 benthonic and one planktonic species observed in the material. Families and genera are arranged according to POKORNÝ (1958), while the species are arranged alphabetically.

Fam. Saccaminidae

Psammosphaera bowmanni HERON-ALLEN and EARLAND
Pl. 1, figs. 1, 2

Psammosphaera bowmanni HERON-ALLEN and EARLAND; HÖGLUND, 1947, p. 49, pl. 4, figs. 1–8.

Length 0,40–0,50 mm, breadth 0,25–0,28 mm.

Occurs with 15 per cent at station 22 and 1 per cent at stations 2 and 42.

Psammosphaera fusca SCHULZE

Psammosphaera fusca SCHULZE; HÖGLUND, 1947, p. 46, pl. 4, figs. 9–14.

Diameter 0,30–0,70 mm.

Occurs in Gåshamna and Adriabukta usually with 1 per cent or less. In Treskelbukta it occurs at 3 stations wiih frequencies up to 38 per cent.

Tholosina sp.

Pl. 1, figs. 3, 4

Description. Test circular in outline as seen from above, hemispherical as seen from the side, attached to a small rock fragment; base conforming to the surface to which it is attached; chamber single undivided; wall finely arenaceous, surface smooth; aperture consisting of a few simple pores near the base; colour greyish-white to reddish-brown.

Diameter 0,15–0,25 mm, height 0,10–0,20 mm.

Occurs in Gåshamna and Adriabukta with usually 1 per cent, but one single station had 14 per cent.

Proteonina fusiformis WILLIAMSON

Pl. 1, figs. 5, 6

Proteonina fusiformis WILLIAMSON; HÖGLUND, 1947, p. 52, pl. 4, fig. 21; text figs. 20, 21.

Length 0,25–0,50 mm, greatest breadth 0,20–0,26 mm.

Occurs with frequencies about 1 per cent in Gåshamna and Adriabukta.

Armorella sphaerica HERON-ALLEN and EARLAND

Pl. 1, fig. 7

Armorella sphaerica HERON-ALLEN and EARLAND; HÖGLUND, 1947, p. 55, pl. 5, figs. 1–9.

Greatest diameter 1,0 mm excluding the tubes.

One specimen was found at station 4.

Fam. Rhizamminidae

Hippocrepinella hirudinea HERON-ALLEN and EARLAND

Pl. 1, fig. 8

Hippocrepinella hirudinea HERON-ALLEN and EARLAND; HÖGLUND, 1947, p. 43, pl. 1, figs. 8–10; text figs. 18, 19.

Length up to 0,70 mm, breadth 0,20 mm.

Frequencies about 1 per cent at the stations 4 and 6.

Fam. Reophacidae

Reophax arctica BRADY

Reophax arctica BRADY; LOEBLICH and TAPPAN, 1953, p. 21, pl. 1, figs. 19, 20.

Length 0,25–0,65 mm, greatest breadth 0,10–0,20 mm.

Frequencies less than 1 per cent in Gåshamna and Adriabukta. Occurs in Storfjorden at the stations 22 and 29 with 9 and 2 per cent respectively.

Fam. Ammodiscidae

Ammodiscus gullmarensis HÖGLUND
Pl. 1, fig. 9

Ammodiscus planus HÖGLUND, 1947, p. 123, pl. 8, figs. 2, 3, 8; pl. 28, figs. 17, 18; text figs. 85–89, 105, 106, 109.
Ammodiscus gullmarensis HÖGLUND, 1948, p. 46.

Diameter 0,15–0,30 mm.

A few specimens were found at station 5.

Fam. Lituolidae

Alveolophragmium crassimargo (NORMAN)

Alveolophragmium crassimargo (NORMAN); FEYLING-HANSSEN, 1964, p. 228, pl. 2, figs. 5–8.

Greatest diameter 0,63 mm, thickness 0,35 mm.

One specimen was found at station 5.

Recurvoides turbinatus (BRADY)

Recurvoides turbinatus (BRADY); LOEBLICH and TAPPAN, 1953, p. 27, pl. 2, fig. 11.

Diameter 0,20–0,40 mm.

Frequencies about 1 per cent at the stations 4, 5 and 11.

Ammotium cassis (PARKER)
Pl. 1, fig. 10

Ammotium cassis (PARKER); LOEBLICH and TAPPAN, 1953, p. 33, pl. 2, figs. 12–18.

Length 0,40–1,80 mm, greatest breadth 0,20–1,10 mm.

Occurs at two stations both in Gåshamna and Adriabukta with 2 per cent or less.

Fam. Textulariidae

Textularia torquata F. PARKER
Pl. 1, figs. 11, 12

Textularia torquata F. PARKER; LOEBLICH and TAPPAN, 1953, p. 35, pl. 2, figs. 12–21.

Length of the figured specimens: 0,21 and 0,25 mm, breadth 0,13 and 0,14 mm.

Occurs with frequencies about 1 per cent at the stations 5 and 21.

Spiroplectammina biformis (PARKER and JONES)
Pl. 1, figs. 13, 14

Spiroplectammina biformis (PARKER and JONES); HÖGLUND, 1947, p. 163, pl. 12, fig. 1; text figs. 140, 141.

Length 0,15–0,65 mm, breadth of biserial portion 0,11–0,19 mm, breadth of coil 0,04–0,15 mm.

Occurs at 3 stations in Gåshamna and 2 stations in Adriabukta, with a maximum frequency 3 and 10 per cent respectively. Both in Treskelbukta and E of Jemelianovbreen occurs at two stations; frequencies up to 5 and 24 per cent respectively.

Of about 80 per cent of the specimens, the sides of the biserial portion are approximately parallel and the planispiral portion is comparatively large (Pl. 1, figs. 13 and 14). About 10 per cent have a biserial portion tapering towards the spiral portion which is comparatively small. Between these two forms it seems to occur transitional specimens, and they are therefore included here in one specimen.

Fam. Trochamminidae

Trochammina rotaliformis WRIGHT
Pl. 1, fig. 16 a, b

Trochammina rotaliformis WRIGHT; CUSHMAN, 1948, p. 42, pl. 4, fig. 16.

Greatest diameter of figured specimen 0,56 mm, height of spire 0,28 mm. One specimen was found at station 28.

Fam. Verneuilinidae

Eggerella advena (CUSHMAN)
Pl. 1, fig. 15

Eggerella advena (CUSHMAN); CUSHMAN, 1948, p. 32, pl. 3, fig. 12.
– LOEBLICH and TAPPAN, 1953, p. 36, pl. 3, figs. 8–10.

Length 0,35–0,60 mm, greatest breadth 0,17–0,20 mm.

Occurs with 2 per cent or less in Gåshamna and Adriabukta. The observed specimens fit very well the description and figures given by LOEBLICH and TAPPAN (l. c.).

Fam. Nubeculariidae

Cyclogyra foliacea (PHILIPPI)
Pl. 1, fig. 17

Cyclogyra foliacea (PHILIPPI); FEYLING-HANSSEN, 1964, p. 245, pl. 4, fig. 8.

Greatest diameter up to 1,35 mm, thickness 0,20 mm.

A few specimens were found at one station both in Gåshamna and Adriabukta.

Cyclogyra involvens (REUSS)
Pl. 1, fig. 18

Cyclogyra involvens (REUSS); FEYLING-HANSSEN, 1964, p. 246, pl. 4, fig. 9.

Greatest 0,20–1,95 mm, thickness 0,06–0,60 mm.

A few specimens were found at two stations in Gåshamna and at one in Adriabukta.

Gordiospira arctica CUSHMAN
Pl. 1, fig. 19

Gordiospira arctica CUSHMAN; LOEBLICH and TAPPAN, 1953, p. 49, pl. 7, figs. 1–3.

Greatest diameter 0,23–0,90 mm, greatest thickness 0,13–0,42 mm.

Occurs in Gåshamna and Adriabukta. Maximum frequency 4 per cent.

Fam. Miliolidae

Quinqueloculina agglutinata CUSHMAN
Pl. 1, fig. 21

Quinqueloculina agglutinata CUSHMAN; CUSHMAN 1948, p. 33, pl. 3, fig. 13.

Length 0,72–0,85 mm, breadth 0,47–0,55 mm.

A few specimens occur at two stations in Adriabukta and at one station in Gåshamna.

Quinqueloculina arctica CUSHMAN
Pl. 1, fig. 20

Quinqueloculina arctica CUSHMAN; LOEBLICH and TAPPAN, 1953, p. 40, pl. 5, figs. 11, 12.

Length 0,55–0,85 mm, breadth 0,40–0,57 mm.

A few specimens were found at the stations in Adriabukta.

Quinqueloculina seminulum (LINNÉ)

Quinqueloculina seminulum (LINNÉ); CUSHMAN, 1929, Bull. 104, pt. 6, p. 24, pl. 2, figs. 1, 2.

Length up to 2,20 mm, breadth up to 1,30 mm.

Occurs at three stations in Gåshamna and at one in Adriabukta. Frequencies 2 per cent or less.

Quinqueloculina stalkeri LOEBLICH and TAPPAN
Pl. 1, fig. 22

Quinqueloculina stalkeri LOEBLICH and TAPPAN, 1953, p. 40, pl. 5, figs. 5–9.

Length 0,22–0,52 mm, breadth 0,14–0,30 mm.

Occurs in Gåshamna and Adriabukta. Frequencies 2 per cent or less.

Pateoris hauerinoides (RHUMBLER)
Pl. 1, fig. 25

Pateoris hauerinoides (RHUMBLER); LOEBLICH and TAPPAN, 1953, p. 42, pl. 6, figs. 8–12; text figs. 1 a, b on p. 44.

Greatest diameter 0,23–0,60 mm.

Frequencies up to 2 per cent in Gåshamna and less than 1 per cent in Adriabukta.

Triloculina oblonga (MONTAGU)
Pl. 1, fig. 23

Triloculina oblonga (MONTAGU); FEYLING-HANSSEN, 1964, p. 257, pl. 6, figs. 9, 10.

Length 0,37–0,70 mm, breadth 0,18–0,33 mm.

Occurs at one station both in Gåshamna and Adriabukta; frequencies 1 to 2 per cent. In Treskelbukta observed at 4 stations; maximum frequency 20 per cent.

Pyrgo williamsoni (SILVESTRI)
Pl. 1, fig. 24

Pyrgo williamsoni (SILVESTRI); LOEBLICH and TAPPAN, 1953, p. 48, pl. 6, figs. 1–4.

Length of figured specimen 0,48 mm, breadth 0,35 mm, thickness 0,30 mm.

A few specimens were found at station 4.

Fam. Nodosariidae

Dentalina forbisherensis LOEBLICH and TAPPAN
Pl. 1, fig. 26

Dentalina forbisherensis LOEBLICH and TAPPAN, 1953, p. 55, pl. 10, figs. 1–9.

Length of figured specimen 1,18 mm, breadth 0,25 mm.
Two specimens were found at station 6.

Dentalina ittai LOEBLICH and TAPPAN
Pl. 1, fig. 27

Dentalina ittai LOEBLICH and TAPPAN, 1953, p. 56, pl. 10, figs. 10–12.

Length of figured specimen 0,73 mm, greatest breadth 0,17 mm.
Occurs at the stations 28 and 29; frequencies about 1 per cent.

Lagena apiopleura LOEBLICH and TAPPAN
Pl. 1, fig. 29

Lagena apiopleura LOEBLICH and TAPPAN, 1953, p. 59, pl. 10, figs. 14, 15.

Length about 0,38 mm, breadth about 0,25 mm.
A few specimens were found at the stations 2, 4, 6, and 16.

Lagena gracillima SEGUENZA
Pl. 1, fig. 28

Lagena gracillima SEGUENZA; LOEBLICH and TAPPAN, 1953, p. 60, pl. 11, figs. 1–4.

Length 0,50–0,81 mm, breadth 0,12–0,18 mm.
Common in Treskelbukta and Van Keulenfjorden with maximum frequencies 20 and 50 per cent respectively. In Adriabukta and E. of Jemelianovbreen only a few specimens were found.

Lagena laevis (MONTAGU)

Lagena laevis (MONTAGU); LOEBLICH and TAPPAN, 1953, p. 61, pl. 11, figs. 5–8.

Length 0,5 mm, breadth 0,2 mm.
One specimen found at station 6.

Fam. Buliminidae

Globobulimina auriculata arctica HÖGLUND

Globobulimina auriculata arctica HÖGLUND; FEYLING-HANSSEN, 1964, p. 305, pl. 14, fig. 6.

Length 1,0 mm, thickness 0,65 mm.
One specimen was found at station 6.

Virgulina schreibersiana CZJZEK
Pl. 1, fig. 30

Virgulina schreibersiana CZJZEK; CUSHMAN, 1937, p. 13, pl. 2, figs. 11–20 (with extensive synonymy). – FEYLING-HANSSEN, 1964, p. 309, pl. 14, figs. 19–21.

Length 0,27–0,50 mm, breadth 0,10–0,17 mm.

Occurs at two stations in Adriabukta and one in Gåshamna with frequencies 2 per cent or less.

Oolina caudigera (WIESNER)

Oolina caudigera (WIESNER); LOEBLICH and TAPPAN, 1953, p. 67, pl. 13, figs. 1–3.

Length about 0,25 mm, breadth about 0,17 mm.

A few specimens were found at the stations 2 and 6.

Oolina lineata (WILLIAMSON)

Pl. 1, fig. 31

Oolina lineata (WILLIAMSON); LOEBLICH and TAPPAN, 1953, p. 70, pl. 13, figs. 11–13.

Length of figured specimen 0,28 mm, breadth 0,24 mm.

A few specimens were found at station 6.

Oolina melo D'ORBIGNY

Oolina melo D'ORBIGNY; LOEBLICH and TAPPAN, 1953, p. 71, pl. 12, figs. 8–15.

Length 0,25–0,38 mm, breadth 0,22–0,28 mm.

Occurs at two stations in Adriabukta and at one station in Gåshamna, Treskelbukta and Hambergbukta. Frequencies about 1 per cent.

Oolina squamosa (MONTAGU)

Oolina squamosa (MONTAGU); LOEBLICH and TAPPAN, 1953, p. 73, pl. 13, figs. 9, 10.

Length 0,28 mm, breadth 0,22 mm.

One specimen was found at station 6. It corresponds well to the description and figures given by LOEBLICH and TAPPAN (l. c.).

Fissurina cucurbitasema LOEBLICH and TAPPAN

Pl. 1, fig. 32

Fissurina cucurbitasema LOEBLICH and TAPPAN, 1953, p. 76, pl. 14, figs. 10, 11.

Length of figured specimen 0,24 mm, breadth 0,15 mm.

A few specimens were found at station 6.

Fissurina marginata (MONTAGU)

Pl. 1, fig. 33

Fissurina marginata (MONTAGU); LOEBLICH and TAPPAN, 1953, p. 77, pl. 14, figs. 6–9.

Length 0,19–0,33 mm, breadth 0,16–0,30 mm.

Occurs at the stations 5, 6, 16, and 17. Frequencies about 1 per cent.

Angulogerina fluens TODD

Pl. 2, figs. 2, 3

Angulogerina fluens TODD, in CUSHMAN and TODD, 1947, p. 67, pl. 16, figs. 6, 7.

Length 0,25–0,50 mm, greatest breadth 0,17–0,24 mm.

Occurs at a few occasional stations. Frequencies 0,2 to 3 per cent, but one single station had 8 per cent.

Bolivina pseudopunctata HÖGLUND
Pl. 2, fig. 1

Bolivina pseudopunctata HÖGLUND, 1947, p. 273, pl. 24, fig. 5; pl. 32, figs. 23, 24; text figs. 280, 281, 287.

Length 0,30–0,48 mm, breadth 0,12–0,27 mm, thickness about 0,09 mm.

A few specimens were found at the stations 5 and 6.

Fam. Cassidulinidae

Cassidulina crassa D'ORBIGNY

Cassidulina crassa D'ORBIGNY; NØRVANG, 1958, p. 36, pl. 8, figs. 20–22; pl. 9, figs. 24, 25.

Greatest diameter 0,18–0,37 mm, thickness 0,13–0,18 mm.

Common in Hornsund and Storfjorden with maximum frequency 19 and 25 per cent respectively. In Van Keulenfjorden it occurs only at 6 stations, with frequencies 1 to 50 per cent.

Islandiella norcrossi (CUSHMAN)
Pl. 2, fig. 4 a, b

Islandiella norcrossi (CUSHMAN); NØRVANG, 1958, p. 32, pl. 7, figs. 8–13; pl. 8, fig. 14.

Greatest diameter 0,25–0,53 mm, thickness 0,14–0,25 mm.

Occurs regulary in Hornsund, usually with 1 to 2 per cent. Very rare in Van Keulenfjorden and E. of Staupbreen.

Islandiella teretis (TAPPAN)
Pl. 2, fig. 5

Islandiella teretis (TAPPAN); FEYLING-HANSSEN, 1964, p. 326, pl. 16, fig. 17.

Greatest diameter up to 0,74 mm, thickness up to 0,33 mm.

A few specimens were found at the stations 3 and 6.

Fam. Nonionidae

Nonion labradoricum (DAWSON)
Pl. 2, fig. 7

Nonion labradoricum (DAWSON); CUSHMAN, 1939, p. 23, pl. 6, figs. 13–16.

Greatest diameter up to 0,75 mm, thickness up to 0,37 mm.

Common in Hornsund; maximum frequency 13 per cent. Present also at 5 stations both in Storfjorden and Van Keulenfjorden; maximum frequency 8 and 33 per cent respectively.

Astrononion gallowayi LOEBLICH and TAPPAN
Pl. 2, fig. 8

Astrononion gallowayi LOEBLICH and TAPPAN, 1953, p. 90, pl. 17, figs. 4–7.

Greatest diameter 0,23–0,55 mm, thickness 0,10–0,18 mm.

Abundant at most of the stations in Hornsund and Hambergbukta; frequencies usually between 10 and 20 per cent. It is very rare elsewhere; a few specimens were found at two stations E. of Jemelianovbreen and at one station in Van Keulenfjorden.

Fam. Spirillinidae

Patellina corrugata Williamson
Pl. 2, fig. 6

Patellina corrugata Williamson; Cushman, 1948, p. 67, pl. 7, fig. 11.

Greatest diameter of figured specimen 0,2 mm.

A few specimens were found at the stations 5 and 6.

Fam. Discorbidae

Buccella frigida (Cushman)
Pl. 2, fig. 10 a, b

Buccella frigida (Cushman); Andersen, 1952, p. 144, figs. 4–6.

Greatest diameter 0,28–0,58 mm, thickness 0,11–0,25 mm.

Occurs at three stations in Gåshamna. Maximum frequency 19 per cent.

Buccella tenerrima (Bandy)
Pl. 2, fig. 11 a, b

Buccella inusitata Andersen; Loeblich and Tappan, 1953, p. 116, pl. 22, fig. 1.

Greatest diameter 0,22–0,50 mm, thickness 0,14–0,26 mm.

Occurs in Hornsund with frequencies 1 to 7 per cent. In Hambergbukta and E. of Staupbreen a few specimens were observed.

Epistominella exigua (Brady)
Pl. 2, fig. 9

Pulvinulina exigua Brady, 1884, p. 696, pl. 103, figs. 13–14.

Greatest diameter 0,17–0,24 mm, thickness 0,08–0,13 mm.

Occurs at one station in Gåshamna and two stations in Adriabukta; frequencies 1 per cent or less. In Treskelbukta it occurs at one station with 7 per cent.

Cibicides lobatulus (Walker and Jacob)
Pl. 2, fig. 12 a, b

Cibicides lobatulus (Walker and Jacob); Nyholm, 1961, p. 157–196, pl. 1–5, text figs. 1–21.

Greatest diameter 0,24–0,70 mm, thickness 0,11–0,27 mm.

Common in Gåshamna and Adriabukta with frequencies up to 7 and 21 per cent respectively. Abundant in Treskelbukta, E. of Staupbreen, and in Hambergbukta with frequencies up to 70 per cent. Very rare in the other areas.

Trichohyalus pustulata Loeblich and Tappan

Trichohyalus pustulata Loeblich and Tappan, 1953, p. 118, pl. 23, figs. 8–9.

Greatest diameter 0,65 mm, thickness 0,34 mm.

One specimen was found at station 4.

Fam. Robertinidae

Robertina arctica D'ORBIGNY

Robertina arctica D'ORBIGNY; CUSHMAN, 1948, p. 61, pl. 6. figs. 16–18.

Length 0,35–0,52 mm, breadth 0,21–0,27 mm.

A few specimens were found at station 5.

Fam. Orbulinidae

Globigerina bulloides D'ORBIGNY

Globigerina bulloides D'ORBIGNY; BRADY, 1884, p. 593, pl. 79, figs. 3–7.

Greatest diameter 0,18–0,28 mm.

A few specimens were found at the stations 5, 6, and 29.

Fam. Elphidiidae

Elphidium bartletti CUSHMAN

Pl. 2, figs. 13, 14

Elphidium bartletti CUSHMAN, 1933, p. 4, pl. 1, fig. 9.

Greatest diameter 0,25–1,20 mm, thickness 0,15–0,51 mm.

Occurs at all of the stations in Gåshamna and Adriabukta; maximum frequency 12 per cent. Rare in Treskelbukta.

Elphidium clavatum CUSHMAN

Pl. 2, figs. 21, 22

Elphidium clavatum CUSHMAN; LOEBLICH and TAPPAN, 1953, p. 98, pl. 19, figs. 8–10.

Greatest diameter 0,18–0,80 mm, thickness 0,08–0,35 mm.

Widely distributed in most of the areas. It generally constitutes 60 to 80 per cent of the fauna at the stations in Van Keulenfjorden and 10 to 20 per cent in Hornsund. In Storfjorden it occurs at 8 stations usually with more than 5 per cent.

Elphidium frigidum CUSHMAN

Pl. 2, figs. 19, 20

Elphidium frigidum CUSHMAN, 1933, p. 5, pl. 1, figs. 8.

Greatest diameter 0,30–0,95 mm, thickness 0,11–0,38 mm.

Occurs in Gåshamna and Adriabukta with frequencies 4 per cent or less.

Elphidium orbiculare (BRADY)

Pl. 2, fig. 15 a, b

Nonion orbiculare (BRADY); CUSHMAN, 1948, p. 53, pl. 6, fig. 3.

Greatest diameter 0,26–0,73 mm, thickness 0,14–0,36 mm.

Common at most of the stations in Hornsund and Storfjorden; maximum frequencies 9 and 75 per cent respectively.

Elphidium subarcticum CUSHMAN

Pl. 2, fig. 16 a, b

Elphidium subarcticum CUSHMAN, 1944, p. 27, pl. 3, figs. 34, 35.

Greatest diameter 0,27–0,66 mm, thickness 0,12–0,28 mm.

Common in Gåshamna with maximum frequency 12 per cent, rare in the other areas.

Elphidium sp.

Pl. 2, figs. 17 a, b, 18

Description. Test free, discoidal, planispiral and involute, periphery rounded; chambers from 7 to 10, usually 9 in the final whorl; sutures slightly depressed, gently curved, with few, rather indistinct retrale processes; wall calcareous perforate; aperture a row of pores at the base of the apertural face of the final chamber, often covered with granular shellmaterial.

Greatest diameter 0,25–0,73 mm, thickness 0,13–0,30 mm.

Common at most of the stations in the investigated areas; maximum frequencies 12 per cent in Hornsund, 76 per cent in Storfjorden and 47 per cent in Van Keulenfjorden.

Elphidiella arctica (PARKER and JONES)

Pl. 2, fig. 23

Elphidiella arctica (PARKER and JONES); CUSHMAN, 1939, p. 65, pl. 18, figs. 11–14.

Greatest diameter of figured specimen 1,10 mm, thickness 0,40 mm.

A few specimens were found at the stations 6 and 19.

Conclusions

A single planktonic species was observed in the material, namely *Globigerina bulloides*, which occurs very rarely at a few stations. On the basis of the distribution of the benthonic species it is possible to distinguish three main types of fauna:

Fauna I. In near-shore waters in Gåshamna and Adriabukta.

The numbers of both specimens and species are large in comparison with the stations located near glacier termini. A depth zonation is indicated in these waters.

The fauna is dominated by *Elphidium clavatum*. The following species are common and constitute an important element of the fauna at most of the stations:

Astrononion gallowayi	*Elphidium bartletti*
Cassidulina crassa	*Elphidium orbiculare*
Cibicides lobatulus	*Elphidium subarcticum*
	Elphidium sp.

Fauna II. In waters near glacier termini in Treskelbukta, E. of Staupbreen and in Hambergbukta.

The number of specimens in 150 g of dried sediment is usually less than 200 and the number of species generally between 5 and 10. No depth zonation could be recognized in these waters.

The fauna is dominated by *Cibicides lobatulus* at most of the stations. The following species are common:

Astrononion gallowayi
Cassidulina crassa
Elphidium clavatum

Fauna III. In waters near glacier termini in Van Keulenfjorden and E. of Jemelianovbreen.

The number of specimens in 150 g dried sediment is usually less than 200 and the number of species generally between 2 and 5. No depth zonation could be recognized.

The fauna is dominated by *Elphidium clavatum* and *Elphidium* sp.

Acknowledgments

My thanks are due to Dr. R. W. Feyling-Hanssen, Curator at the Paleontological Museum of the University of Oslo, and to cand. real. D. Risdal, Institute of Geology, University of Oslo, for helpful advice and assistance with literature. I wish to express my thanks to Mr. M. Galåen for the drafting of the text-figures and Miss Signe Øverland for typing of the manuscript. I am greatly indepted to Dr. S. Manum, who corrected the English of the manuscript.

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Explanation to the plates

Some of the photographs have been slightly retouched. The figured specimens are kept in the collections of the Paleontological Museum of the University in Oslo.

PLATE 1

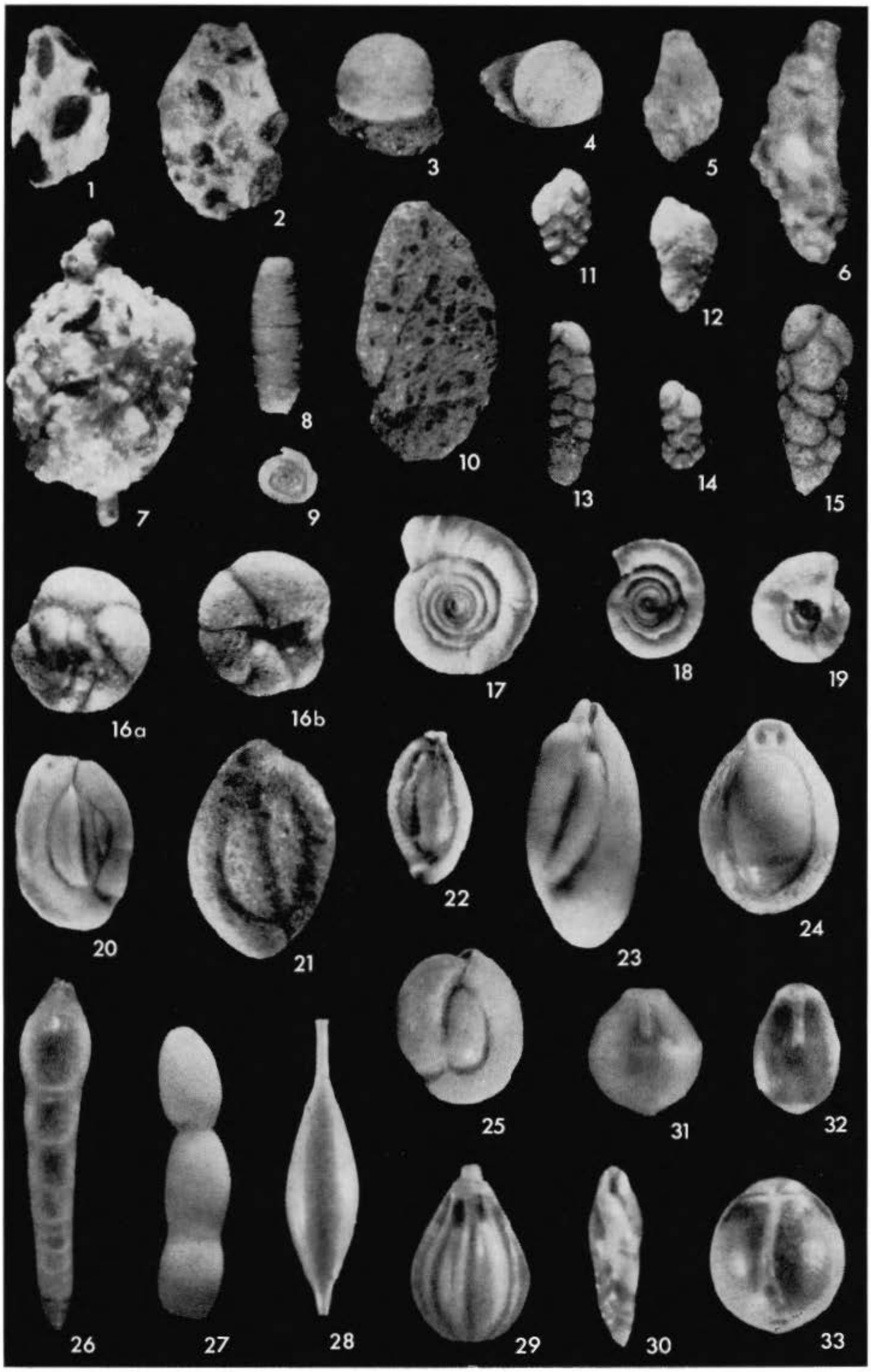
Figs.

1, 2. *Psammosphaera bowmanni* HERON-ALLEN and EARLAND. 1, × 54, Sta. 2; 2, × 67, Sta. 42.
3, 4. *Tholosina* sp. × 63; Sta. 2.
5, 6. *Proteonina fusiformis* WILLIAMSON. × 67, Sta. 4.
7. *Armorella sphaerica* HERON-ALLEN and EARLAND. × 34, Sta. 4.
8. *Hippocrepinella hirudinea* HERON-ALLEN and EARLAND. × 42, Sta. 4.
9. *Ammodiscus gullmarensis* HÖGLUND. × 32, Sta. 5.
10. *Ammotium cassis* (PARKER). × 22, Sta. 5.
11, 12. *Textularia torquata* F. PARKER. × 68, 11, Sta. 29; 12, Sta. 5.
13, 14. *Spiroplectammina biformis* (PARKER and JONES). × 40, Sta. 29.
15. *Eggerella advena* (CUSHMAN). × 53, Sta. 4.
16 a, b. *Trochammina rotaliformis* WRIGHT. × 38, Sta. 28.
17. *Cyclogyra foliacea* (PHILIPPI). × 20, Sta. 4.
18. *Cyclogyra involvens* (REUSS). × 18, Sta. 2.
19. *Gordiospira arctica* CUSHMAN. × 18, Sta. 3.
20. *Quinqueloculina arctica* CUSHMAN. × 30, Sta. 5.
21. *Quinqueloculina agglutinata* CUSHMAN. × 45, Sta. 4.
22. *Quinqueloculina stalkeri* LOEBLICH and TAPPAN. × 45, Sta. 5.
23. *Triloculina oblonga* (MONTAGU). × 53, Sta. 11.
24. *Pyrgo williamsoni* (SILVESTRI). × 60, Sta. 4.
25. *Pateoris hauerinoides* (RHUMBLER). × 47, Sta. 5.
26. *Dentalina forbisherensis* LOEBLICH and TAPPAN. × 44, Sta. 6.
27. *Dentalina ittai* LOEBLICH and TAPPAN. × 59, Sta. 28.
28. *Lagena gracillima* SEGUENZA. ×65, Sta. 11.
29. *Lagena apiopleura* LOEBLICH and TAPPAN. × 70, Sta. 4.
30. *Virgulina schreibersiana* CZJZEK. × 58, Sta. 5.
31. *Oolina lineata* (WILLIAMSON). × 70, Sta. 6.
32. *Fissurina cucurbitasema* LOEBLICH and TAPPAN. × 84, Sta. 6.
33. *Fissurina marginata* (MONTAGU). × 84, Sta. 6.

PLATE 2

Figs.

1. *Bolivina pseudopunctata* HÖGLUND. × 78, Sta. 5.
2, 3. *Angulogerina fluens* TODD. × 72, 2, Sta. 13; 3, Sta. 7.
4 a, b. *Islandiella norcrossi* (CUSHMAN). × 52, Sta. 4.
5. *Islandiella teretis* (TAPPAN). × 39, Sta. 4.
6. *Patellina corrugata* WILLIAMSON. × 70, Sta. 6.
7. *Nonion labradoricum* (DAWSON). × 44, Sta. 4.
8. *Astrononion gallowayi* LOEBLICH and TAPPAN. × 60, Sta. 4.
9. *Epistominella exigua* (BRADY). × 74, Sta. 6.
10 a, b. *Buccella frigida* (CUSHMAN). × 40, Sta. 2.
11 a, b. *Buccella tenerrima* (BANDY). × 40, Sta. 2.
12 a, b. *Cibicides lobatulus* (WALKER and JACOB). × 54, Sta. 5.
13, 14. *Elphidium bartletti* CUSHMAN. × 42, Sta. 5.
15 a, b. *Elphidium orbiculare* (BRADY). × 37, Sta. 5.
16 a, b. *Elphidium subarcticum* CUSHMAN. × 53, Sta. 3.
17a,b,18. *Elphidium* sp. × 45, 17, Sta. 36; 18, Sta. 5.
19, 20. *Elphidium frigidum* CUSHMAN. × 37, Sta. 3.
21, 22. *Elphidium clavatum* CUSHMAN, × 47, Sta. 36.
23. *Elphidiella arctica* (PARKER and JONES). × 34, Sta. 19.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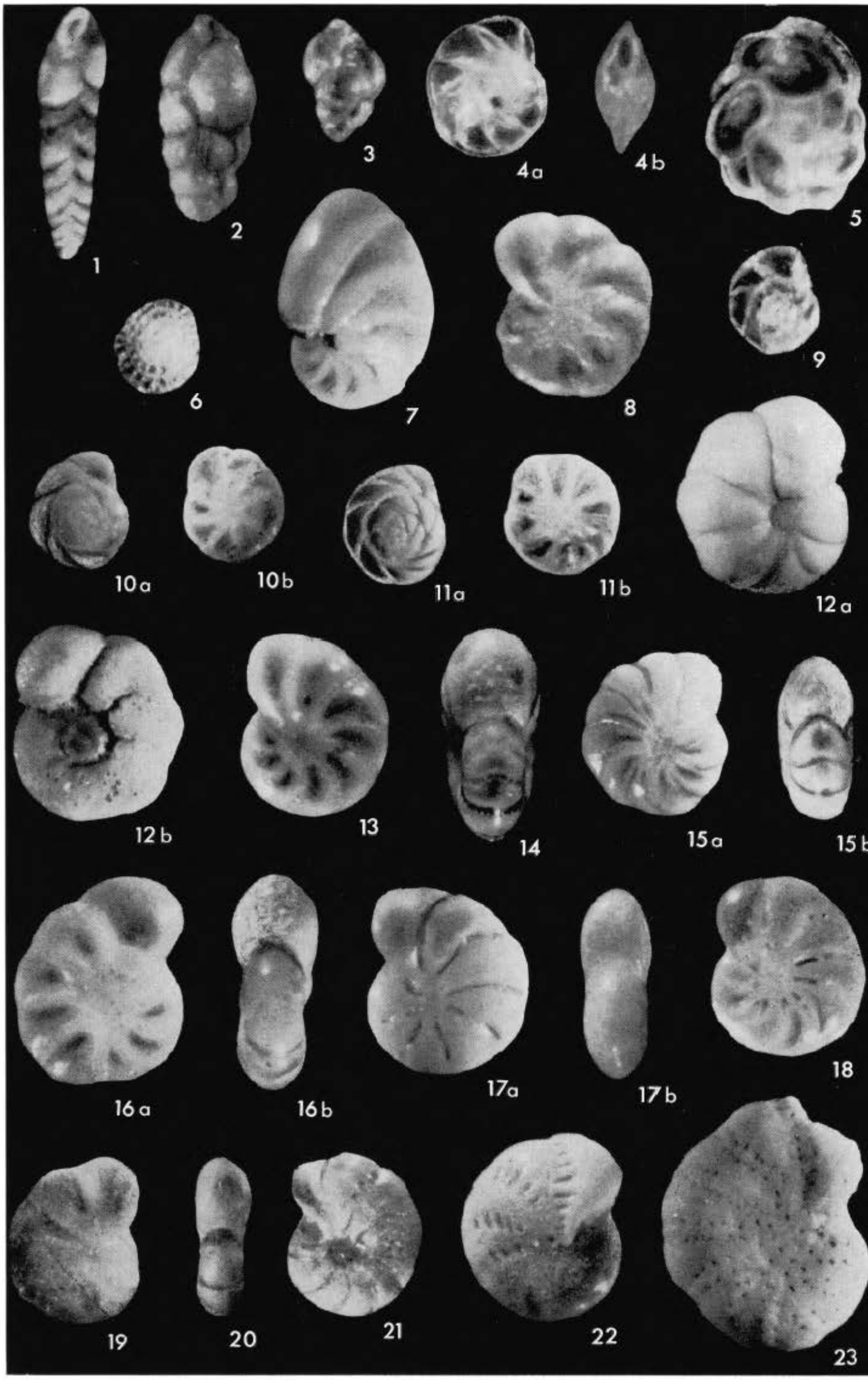
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The determination of the thickness of Finsterwalderbreen, Spitsbergen, from gravity measurements

BY

EYSTEIN S. HUSEBYE[1], ANDERS SØRNES[2] and LARS S. WILHELMSEN[3]

Abstract

An account is given of a detailed and accurate gravity survey carried out on Finsterwalderbreen and the nearby area. Using the appropriate ice-rock density differential, cross sectional shapes of the glacier are computed to fit observed variations in the residual anomaly on traverses across the glacier. Results are presented on cross section diagrams and as an isopach map, and the accuracy of the computed depths is discussed. It is concluded that gravity measurements alone can give a very good indication of the shape of a valley glacier and also of its depth with relative little expenditure of time both in the field and the office.

Introduction

A geophysical expedition to Finsterwalderbreen and adjoining area was organized in 1962 as part of a co-operative venture between Norsk Polarinstitutt and Jordskjelvstasjonen, Universitetet i Bergen. In charge of the expedition was ANDERS SØRNES, while EYSTEIN S. HUSEBYE was leader of the gravity survey.

Gravity measurements were made on Finsterwalderbreen and the nearby area. Earlier, other glaciers have been investigated by the gravity method (BULL et al. 1956, RUSSEL et al. 1960, and THIEL et al. 1957) and accurate results were also obtained here. Refraction profiles for the determination of geological structures were made in the area surrounding the glacier (Fig. 1), (KLOSTER 1963). Seismic measurements on the glacier were considered practically impossible, since Jordskjelvstasjonen at this time had only refraction equipment and the wave velocity of ice and rock in this area is practically identical.

The gravity field work was mainly performed by E. S. HUSEBYE and LARS S. WILHELMSEN. The reduction work was mainly done by E. S. HUSEBYE, while the interpretation of the anomalies was done by E. S. HUSEBYE and A. SØRNES.

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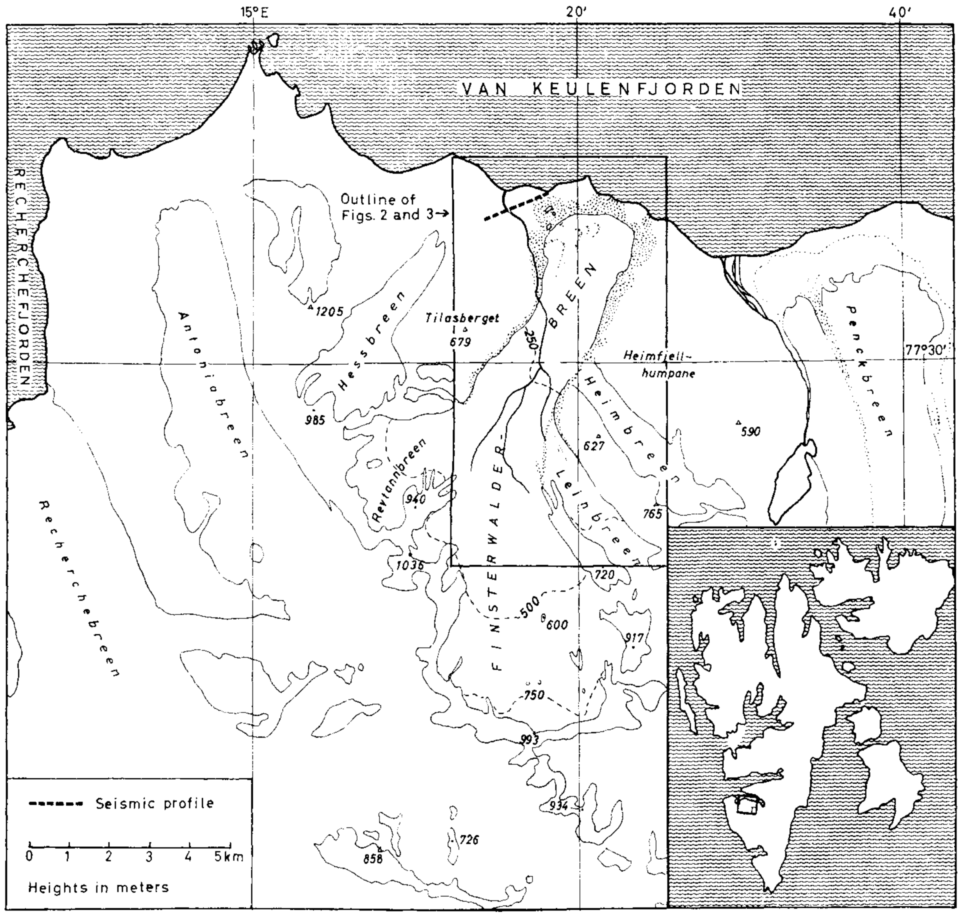

Fig. 1. *Sketch map of the area.*

Description of the area

Finsterwalderbreen lies on the south side of Van Keulenfjorden, Spitsbergen. The glacier is ca. 10 km long and 1,5–3 km wide (Fig. 1). The topography is here rather rough. The sides of the valley often dip 20° and more while the area along the coast is level except for a part covered by moraines. In some places the exact course of the glacier's boundary is a bit uncertain since the ice there is covered by moraines. This is especially true for the northeastern part of the glacier.

A map with a scale of 1:25,000 covers the glacier and the nearby area, while the whole region is mapped to a scale of 1:100,000.

A glaciological description of the Van Keulenfjorden area has been given by LIESTØL (1956). A geological map covering the glacier and the surrounding area has been worked out by S. Z. RÓZYCKI (1959). The map shows that the northern and eastern part of the glacier and the nearby area, consist of sedimentary rocks, shales, sandstones and limestones of quite different ages. The southwestern part consists of older Paleozoic and Precambrian rocks. The rough terrain and permafrost made it very difficult to obtain representative stone samples, which meant that the geological data could not be incorporated in the interpretation of the gravity measurements. The density determination is mainly based upon 36 samples taken from both ends of the B-, C- and D-profiles and a few other places, and gave a mean value of 2,66 with a standard deviation of 0.04.

Field procedure

The instrument used for the gravity measurements was a Worden Gravity Meter No. 135, which was rented from Norges Geologiske Undersøkelse, Trondheim. For practical reasons it was not possible to tie the main gravity base, "Slettebu", to the International Gravity Network, and therefore the observed gravity values are only on a relative base.

The stations were located on the glacier by running line-of-sight traverses between stakes at and besides the points A00, B00, – – –. At the same time the distances between the stations on the traverses, were chained. Fig. 2 shows the station network which comprised 232 observation points. The elevations of the stations were determined by levelling, and this work was combined with the gravity measurements. The positions and elevations of most of the stations outside the glacier were obtained from a theodolite survey. The accurate determination of the coordinates of the stakes and cairns (necessary for the theodolite survey) was conducted by O. LIESTØL, who also provided data for an ablation correction. The inaccuracies in the elevation determinations are with few exceptions smaller than $\pm$ 0.5 meter and in the case of the gravity measurements, 0.15 mgal.

The field work was carried out by two men during six weeks of reasonable weather in the summer 1962. In this connection it is worth mentioning that the circumstances for carrying out field work during July–August, was rather unfavourable. During this period the surface of the glacier was far from smooth and it was difficult to cross the many glacier streams. This made traversing the glacier difficult and limited the possibility for using a snow scooter.

Reduction of the observations

The relative detailed gravity coverage of the area and the precise determinations of the station coordinates provided data for a fairly accurate study of the geometry of the ice masses. The BOUGUER anomalies were calculated as would normally have been done for any gravity survey carried out as a geophysical prospecting venture. Of the special operations included in this procedure, only the terrain correction is worth mentioning. HAMMER's method, together with the accurate maps of the area, gave relatively precise values for the terrain corrections. The work involved, was considerably reduced by combining HAMMER's method with SANDBERG's (1958) and by applying the interpolation principles described in the papers of WINKLER (1962) and NEUMANN (1964).

The BOUGUER anomaly (Fig. 2) represents the mass deficiency due to the substitution of less dense ice for the heavier country rock. Also the effect of the

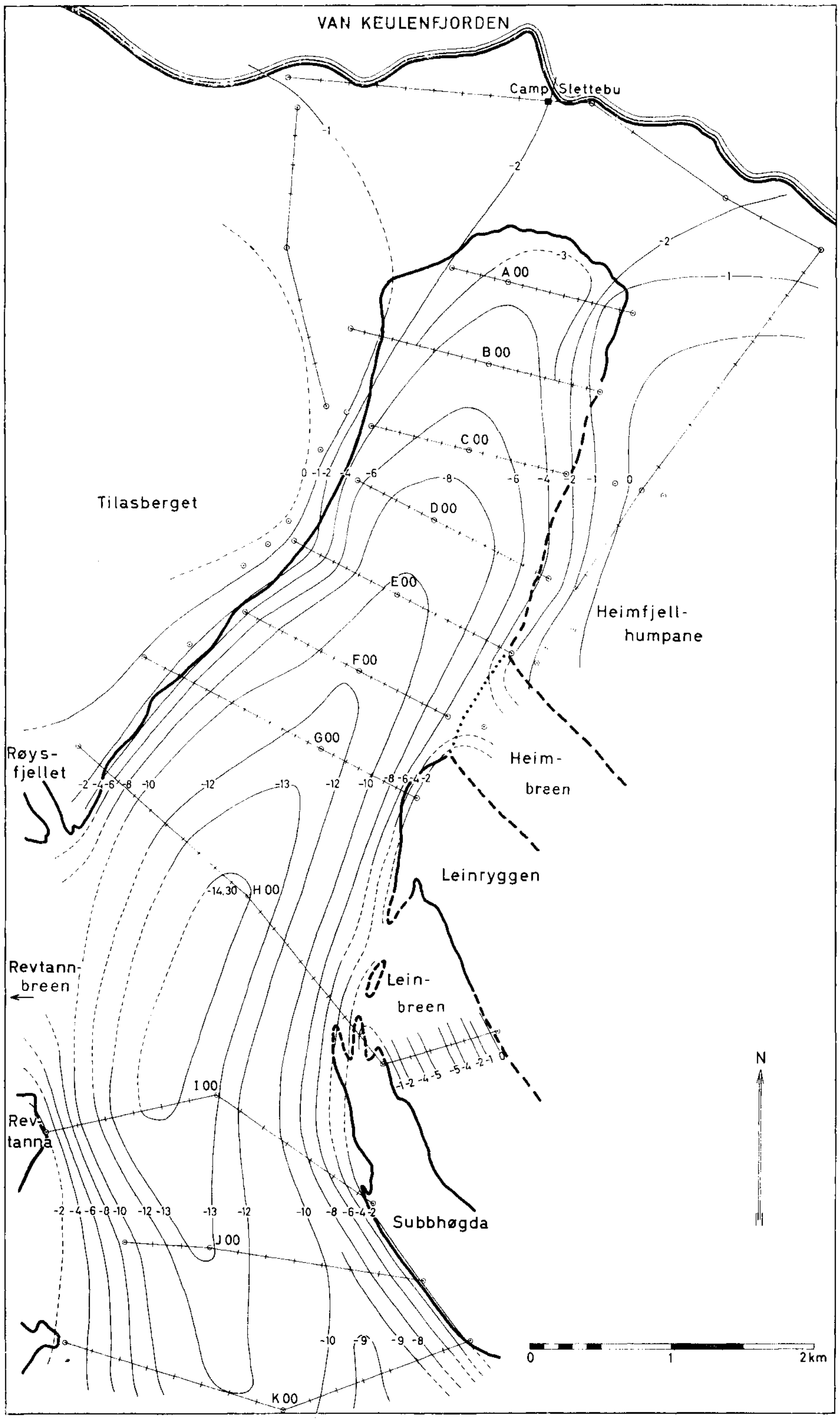

Fig. 2. *Map showing station network and Bouguer anomalies in milligals.*

regional trend is included in the BOUGUER anomaly, but in this case it was not possible to detect any important influence from such an origin. This was found by utilizing the anomaly values of the stations outside the glacier combined with approximate computations of the glaciers gravity effect in these points (HUSEBYE 1962). Therefore the residual anomalies were determined as the differences between a relative zero value and the BOUGUER anomalies for the respective stations (In Fig. 2 the zero-line is lacking for the southern profiles). Exceptions were H-, I-, J- and K-profiles where the value + 0,5 partly was applied instead of zero. Here the observations indicate a small gradient of the regional trend, falling westward for the H-profile and eastward for the J- and K-profiles, constant for the I-profile, but 0.5 mgal higher than normal. The variation in the BOUGUER anomaly at the front of the glacier is most likely due to the existence of a valley filled with sediments (KLOSTER 1963).

It follows from the above that the BOUGUER and residual anomalies are identical for most of the profiles. The possible inaccuracies in the residual anomalies will be discussed later.

Results obtained and their accuracy

Glaciers are suitable objects for gravity investigations since the surface of the anomaly usually is known in detail and the configuration will have a relatively regular shape. The interpretation was based on the residual anomaly and the assumption that the glacier is two-dimensional under each traverse. For the A- and K-profile a more three-dimensional configuration was choosen. The first rough determinations of the ice thickness were made from the residual anomaly curve by applying the formula for the BOUGUER correction. In the present survey the density differential was 2.66 (rock) minus 0.90 (ice) equals 1.76, or 13.5 meters of ice thickness per mgal. With the appropriate glacier cross section determined in this manner, a more refined method was applied (TALWANI et al. 1960) to eliminate the assumption of infinite extent inherent in the BOUGUER correction formula. This method is constructed for arbitrary three-dimensional bodies, and is especially favourable to apply on two-dimensional structures. It is more time consuming than the common "two-dimensional" methods, but gives more precise results. The results of this survey are presented in Fig. 3 while Fig. 4 shows cross sections of the glacier under two profiles in more detail.

Some years ago a drilling was made by O. LIESTÖL at A00 where a minimum ice thickness of 35 meters (related to the present surface of the glacier) was found, while our result is 48 meters.

In the mentioned paper by O. LIESTÖL it is stated that the moraines most likely contain considerable masses of ice. A few scattered observations taken on the moraines do not agree with this statement.

The possible inaccuracies in the depth determinations of Finsterwalderbreen, are mainly caused by the choice of the relative zero value for the evaluation of the residual anomalies and of 2.66 as the mean rock density. If the latter assumption is wrong, it will give an error in the interpretation which is proportional to the

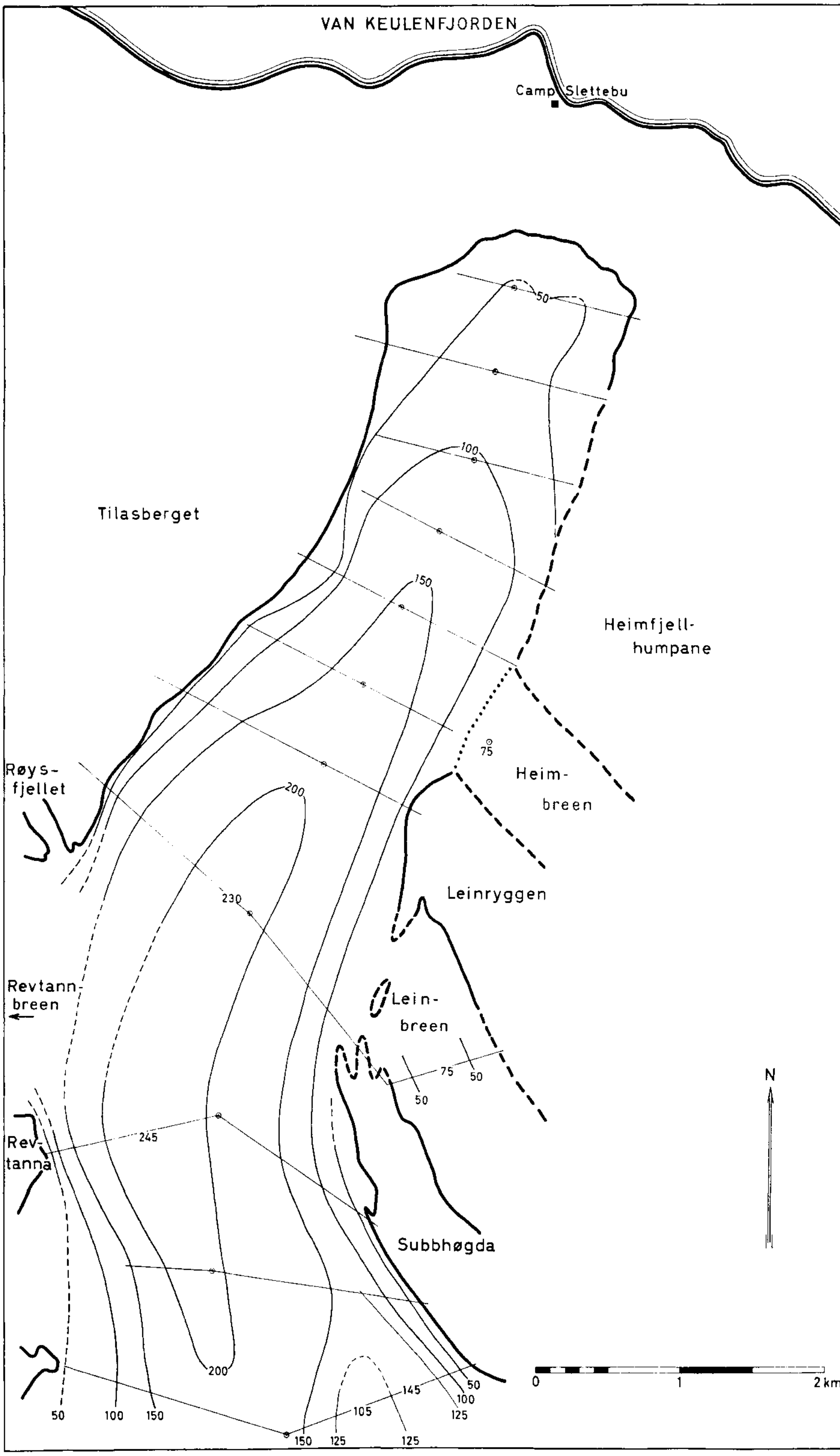

Fig. 3. *The ice-thickness in meters shown as an isopach map.*

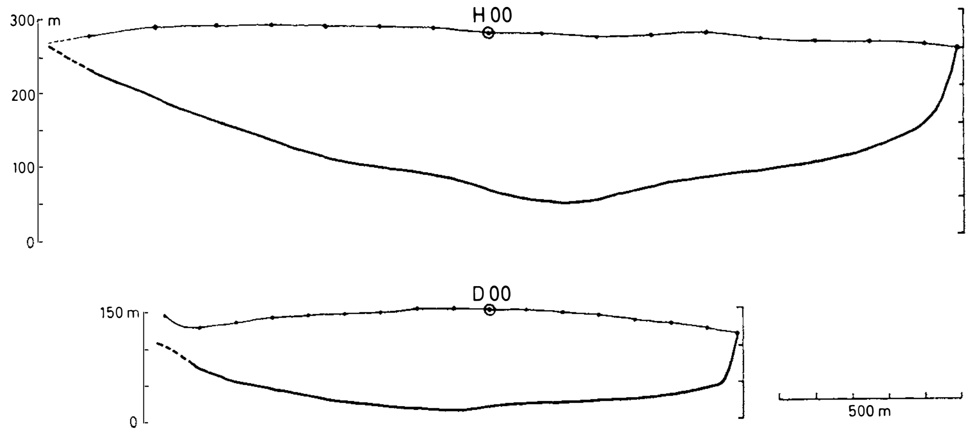

Fig. 4. *D and H cross section diagrams shown in detail.*

thickness of the glacier, but this does not influence the residual anomalies since the elevation variation across each profile were small and these anomalies are based on the BOUGUER anomalies of points at both ends of each profile. If the rock density is wrong by say 0.10, this error equals about 1 mgal for the deepest points (240 meter) of the glacier. Any inaccuracy in the zero value which will be greatest for the southern profiles where few stations were located outside the glacier, are believed to be smaller than 1 mgal.

The mentioned uncertainties in the location of the boundary of the glacier, influence the depth determination only in these parts and only where the ice thickness is relatively small.

Our conclusion with regard to these considerations is that the inaccuracy in the computed ice thickness will be smaller than about 15 % of the total thicknesses, except for the most southern and northern profiles, where errors of 20–25 % can be expected. The cross sectional shapes of the glacier will be more accurate than the depths of the glacier.

Conclusions

Seismic measurements for the determination of the depths of a valley glacier is preferable, but this method is slower in the field and more costly than gravity measurements. Without much loss of accuracy the mentioned methods can be combined, and the field work will be simplified. Even gravity measurements alone as described here, can give precise results, with relative little expenditure of time both in the field and office, when the area is properly mapped and the terrain surrounding the glacier is not too rough.

Acknowledgements

We are very grateful to the glaciologist O. LIESTØL, Norsk Polarinstitutt, who is making special studies of Finsterwalderbreen, for his valuable advice and assistance with the field work and for making the map to the scale of 1:25,000. It is also a pleasure to thank the other people who have helped, especially Miss E. IRGENS for drawing the figures. Norsk Polarinstitutt, Oslo, initiated and gave financial support for this expedition, while Jordskjelvstasjonen, Universitetet i Bergen, put at our disposal the necessary instruments. We are very grateful to the mentioned institutions which made this investigation possible.

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Some sedimentological observations in the Old Red Sandstone at Lykta, Vestspitsbergen

BY

KRZYSZTOF BIRKENMAJER[1]

Abstract

The present author made some sedimentological observations in the Old Red Sandstone (Keltiefjellet Division, Wood Bay Series: Lower Devonian) at Lykta, Dicksonfjorden, during the excursion to Svalbard in connection with the XXI International Geological Congress in 1960. The most characteristic sedimentary structures are described and illustrated, and their directional significance in reconstructing the sedimentary basin is indicated.

Introduction

On August, 1960, the present author as a member of the excursion to Svalbard in connection with the XXI International Geological Congress (N. HEINTZ 1962) had the opportunity to carry out some sedimentological observations in the Old Red Sandstone at Lykta, Dicksonfjorden, central Vestspitsbergen. As the duration of the visit was very restricted, more detailed investigations were not possible. However, even these brief examinations have shown the richness and variability of directional structures in the sandstones, which have not been described so far from the spot. To obtain a clear picture of the sedimentary environment it is necessary to extend similar observations throughout the main areas of the Old Red Sandstone formation in Svalbard (i. e. between Isfjorden and Woodfjorden). It is beyond doubt that they could result in establishing the palaeogeographic position of source areas of clastic material, and mode of transportation. It seems very fortunate that such investigations are in progress, as announced by P. F. FRIEND (1961) and W. B. HARLAND (1963).

There are very few sedimentary structures described and illustrated so far from the Old Red Sandstone formation of Svalbard. Of special interest is the paper by D. L. DINELEY (1960) who examined the area east of Ekmanfjorden, and mentioned the presence of desiccation cracks, oscillation ripple-marks, groove casts, flute casts, load casts, convolute and slump bedding, probable spring pits etc., and illustrated some sole markings. The conditions of sedimentation

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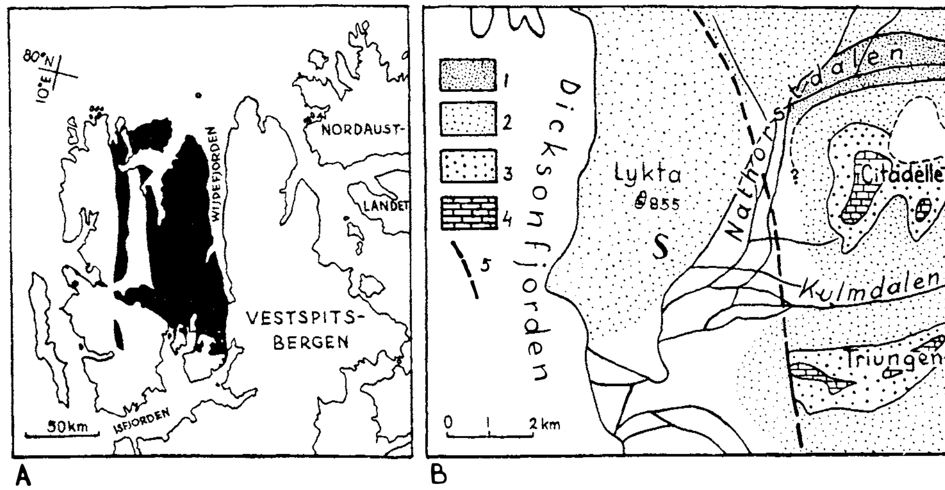


Fig. 1.

A – Position of Lykta within the Devonian basin of central-north Vestspitsbergen. Geological fratures after P. F. FRIEND (1961).

B – Geological map of the area near Lykta, Dicksonfjorden (after T. S. WINSNES *et al. 1960, simplified, explanations modified). 1 – Kapp Kjeldsen Division (Lower Devonian, Wood Bay Series); 2 – Keltiefjellet Division (previously "Lykta Division", Lower Devonian, Wood Bay Series); 3 – Culm; 4 – Middle and Upper Carboniferous: 5 – Fault.*

during the Lower Devonian at Svalbard have been discussed by many authors, of which the more recent are the accounts by A. K. ORVIN (1940), D. L. DINELEY (*o. c.*), D. L. DINELEY and J. R. L. ALLEN (1960), P. F. FRIEND (*o. c.*) and K. BIRKENMAJER (1964).

Geological situation

The mountain Lykta is situated on the east coast of Dicksonfjorden, near the southern exposures of the main Devonian basin at Svalbard (Fig. 1 A). Lykta is built up of clastic deposits of the Wood Bay Series capped on the top by a small patch of the Middle-Upper Carboniferous deposits (Fig. 1 B). This is a well known locality for Agnathes and fishes characteristic of the Keltiefjellet Division (higher Siegenian-lower Emsian) *sensu* P. F. FRIEND (1961), known before under the name of the Lykta Division (S. FØYN and A. HEINTZ 1943; T. S. WINSNES *et al.* 1960).

The sedimentological observations were made by the present author on the southern slopes of Lykta between points 1 and 2 indicated in the excursion map (see T. S. WINSNES *et al.* 1960, Fig. 4) and, especially, near a ravine well visible there. Parts of the illustrations of the sedimentary structures presented in this paper, were made directly in the field, as the rest were drawn from the photographs taken. The figures refer both to beds *in situ* and to fallen blocks.

The south slope of Lykta is built up mostly of fine grained sandstones, red (chiefly), green and variegated, in layers 0.5–3 m thick, alternating with similarly coloured shales. Both sandstones and shales are micaceous; the ratio of sandstones to shales is variable: 5:1, 2:1. Near the ravine mentioned above, the sandstones are devoid of lower vertebrate fossils which, on the other hand, occur mostly in the intercalations of sedimentary breccias and intraclast conglomerates.

The fragments of sandstones and shales (angular) in the sedimentary breccias are 3–20 mm in diameter. Sedimentary breccias sometimes show orientation of the particles related to slump movements, and the fossils are mostly fragmentated. This may have been caused by redeposition (D. L. DINELEY 1960, p. 22; K. BIRKENMAJER 1964), partly by current action, partly by subaqueous slumping. It has also been found slump breccias composed of fragments of limestone, mostly green, sometimes red, 3–8 mm in diameter, and of fragments of lower vertebrates of similar dimensions. In the latter case either no horizontal orientation or vertical grading of the fragmentary material has been observed, or the fragments lay parallel to the bedding.

It should be added that on the SE slope of Lykta there occur very well preserved, more or less complete pteraspid and arthrodire fossils belonging mostly to the genera *Doryaspis* and *Arctolepis* (A. HEINTZ 1962). It could be, therefore, suggested that they occur at their place of living.

Sole markings

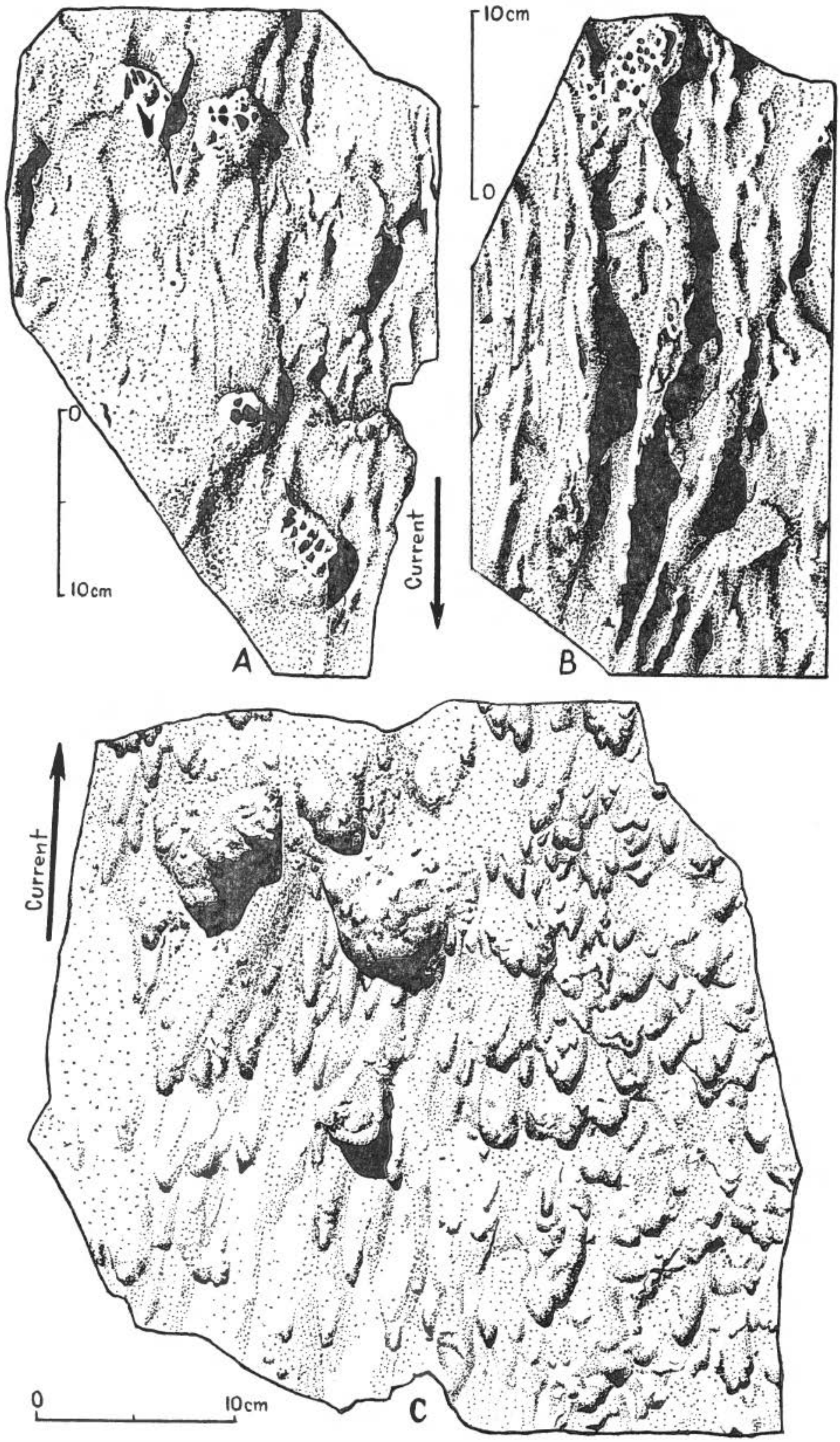
A variety of sole markings was recognized, most of them having directional significance. As there exists an extensive literature delining with this subject, there seems to be no need to discuss the principles of terminology, synonymy etc. in the present account. The origin and directional significance of the structures illustrated will be briefly characterized. For more information the reader is referred to synthetic papers by R. R. SHROCK (1948), K. BIRKENMAJER (1959), S. DZULYNSKI (1963), S. DZULYNSKI and J. E. SANDERS (1962) and others. The present descriptions and terminology are mainly based on the last definitions by DZULYNSKI.

Most of the sole markings present in the Old Red Sandstone at Lykta are related directly to the current action. They are current markings, among which we can distinguish scour markings produced by current acting alone, and tool markings, made by objects carried by a current.

Scour markings

The scour markings are represented by rill markings (casts), flute casts (turboglyphs) and crescent markings (casts). The sole of a sandstone layer presented in Fig. 2 B shows ridges 0.5–4 cm broad and up to 1 cm high, subparallel, slightly arcuate. They show tendency to meandering and anastomosing. There also occur flat-bottomed casts with shale fragments which can be regarded as casts of hollows produced in muddy bottom by small vortices, subsequently filled with sand. As a whole the sole presented in Fig. 2 B resembles a drainage sculpture pattern thus having much in common with the rill markings.

Fig. 2 A presents another sole of a sandstone layer where rill markings pattern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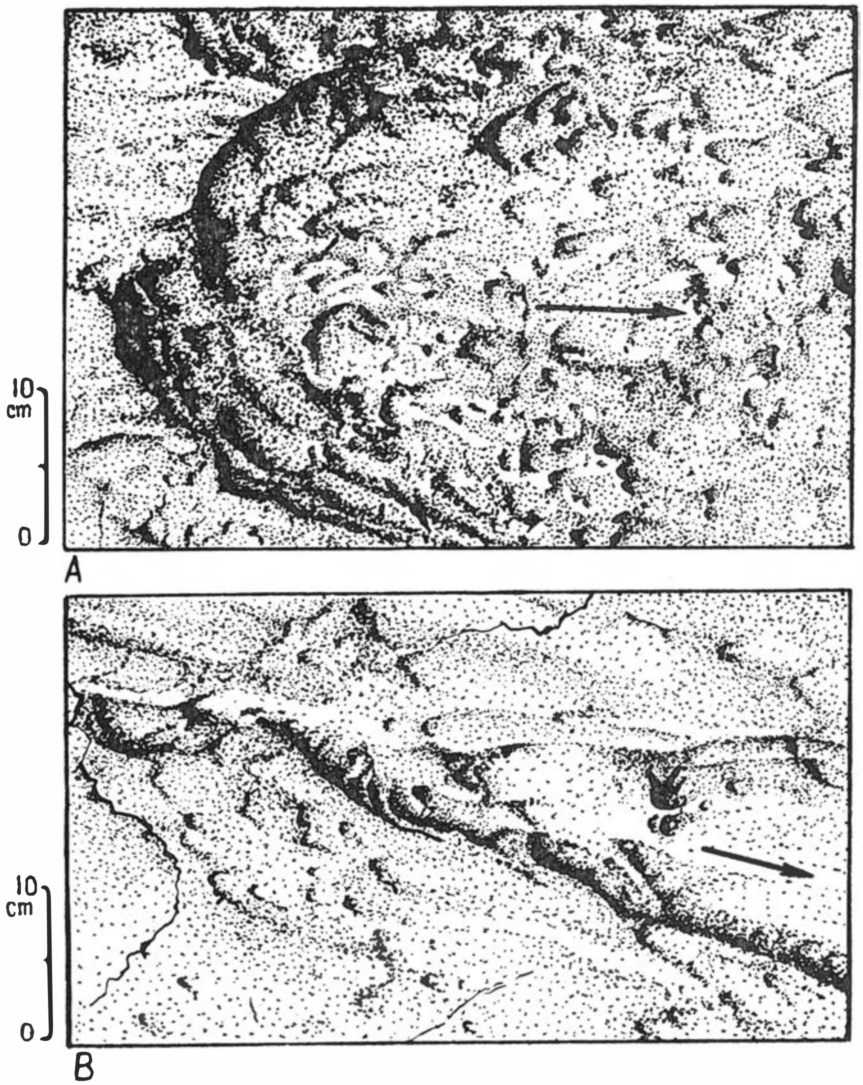


Fig. 3.

Sole markings of the Keltiefjellet Division at Lykta.

A – Large compound flute cast with subordinate flat flute casts. Arrow indicates current direction.

B – Counterpart of large triangular flat erosional depression (flute cast) accompanied by small flute casts. Note twisted knobs and ridges resembling corkscrew markings. Arrow indicates current direction.

Fig. 2.

Sole markings of the Keltiefjellet Division at Lykta.

A – Accumulations of shale fragments in vortex hollows (incipient flute casts). Current lineation of small rill casts visible.

B – Rill casts. Note accumulation of shale fragments in a cast of vortex hollow.

C – Flute cast pattern. Simple conical flute casts and compound flute casts (consisting of flat-, and simple conical flute casts). Note several casts of deeper vortex hollows in the upper left part of the figure.

is much more faintly developed, while casts of vortex hollows are better developed. The latter are angular, blunt at the up-current side and flaring at the other. The shale fragments present in the casts of holes may have acted as tools ("mill stones") when eroding soft bottom. The structures described seem to be transitional between rill markings and flute markings.

It seems possible that linear, branching markings illustrated by DINELEY (1960, Fig. 4) are another type of rill markings.

Fig. 2 C presents a typical flute cast pattern. The majority of flutes belong to the common type of simple conical flute casts ("einfachen Zapfenwülste" of H. RÜCKLIN, 1938). They are blunt at the up-current edge and flaring at the other, up to 3–5 cm long. Many of the simple flute casts join each other (right side of the figure) thus forming compound flute casts with two generations of flutes: the older and bigger of the type of flat flute casts ("Flachzapfen" of H. RÜCKLIN) and younger, superimposed on the former, in the type of simple conical flute casts. The third type of short, blunt flute casts representing counterparts of deep vortex hollows is visible in the upper left part of the figure.

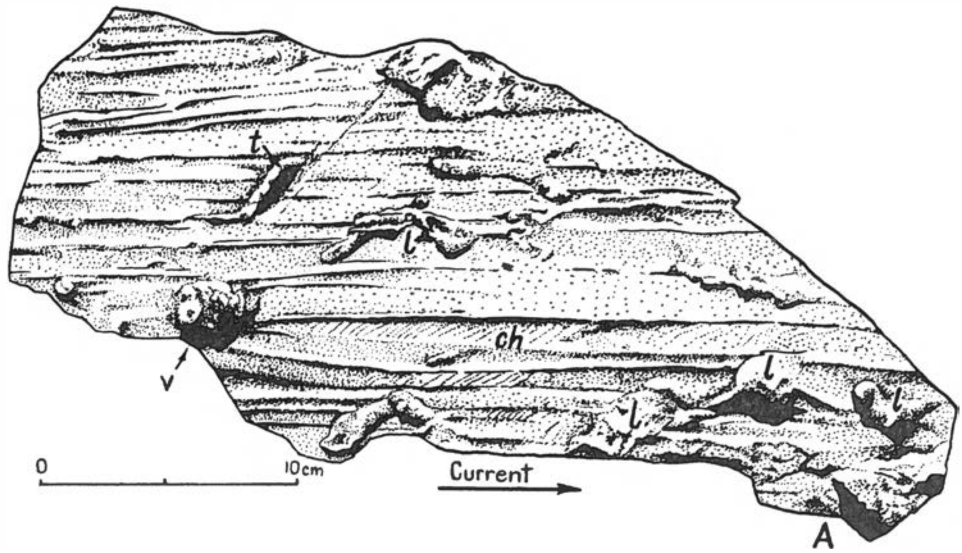
Another type of large compound flute casts is represented in Fig. 3 A. Here we see counterpart of a depression about 30 cm broad, arcuate at the up-current side, where the cast is about 2 cm high, shallowing at the down-current side, where it is covered by numerous subordinate flat flute casts. In Fig. 3 B we see counterpart of large, triangular and flat erosional depression (flute cast) of the muddy bottom, accompanied by small flute casts. Some parts of the large flute show presence of twisted knobs and ridges thus resembling to some extent the corkscrew markings ("Korkzieher Zapfen" of H. RÜCKLIN).

Still different are crescent markings which are hoof-like (horseshoe-shaped) counterparts of the bottom ("Hufeisenwülste" of H. RÜCKLIN) 1–3 cm across, elevated about 1–4 mm above the sole of the sandstone. They are casts of hollows produced by current erosion at the up-current side of small obstacles lying on soft muddy or silty bottom. In the case presented in Fig. 7 E the character of these obstacles is obscure, as nothing was found attached to the sole. They may have been fragments of fish plates. Very characteristic "shadows" formed by sand grains are visible at the lee (down-current) side of the markings, thus making the current lineation well visible.

The markings described above are unidirectional, contrary to the "horseshoe-shaped markings, possibly of organic origin" figured from the Lykta Division near Gygrestolen, Ekmanfjorden, by DINELEY (1960, Fig. 5). However, in the latter case the opposite directions of orientation of crescent markings may find explanation in changing direction of current generated for example by tides in flat, shallow lagoons.

Tool markings

Most of the groove casts presented in Figs. 4 A, 5 A, 5 B can be interpreted as tool markings (casts). The sole presented in Fig. 4 A is covered with flat, linear, continuous ridges 1–5 mm high, accompanied by normal chevron marks. It should be noted that the chevron marks are incomplete, as they developed only on one



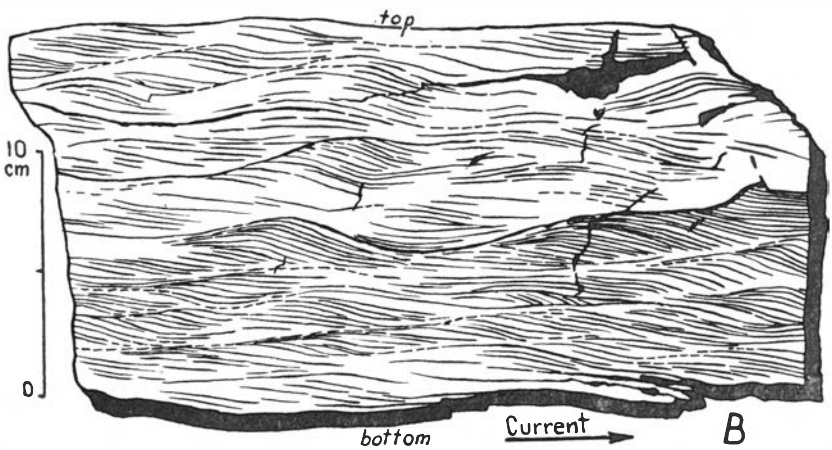


Fig. 4.

Sedimentary structures of the Keltiefjellet Division at Lykta.

A – Sole of a fine grained sandstone with flat linear groove casts prevailing. ch – normal chevron mark (singly ruffled groove), most probably drag cast; t – cast of an undetermined tool which changed its way leaving a deep groove obliquely to the current direction before it was lifted again and rolled off; v – cast of probable vortex hollow (note slight deviation of groove casts on its down-current side); 1 – different irregular load casts.

B – Transversal section of a finely grained sandstone showing ripple-drift cross lamination.

side of the grooves, which therefore could be termed singly ruffled grooves (see Dzulynski and Sanders, 1962). As normal chevron marks of such type are presumably produced by objects skimming rapidly over the bottom (*o. c.*) we may believe that the groove casts presented in Fig. 4 A are drag casts. The tools which produced them are unknown at the moment.

Minute discontinuous groove casts very sharply marked at the soles presented in Figs. 5 A, B may have been formed on muddy or silty bottom by acute frag-

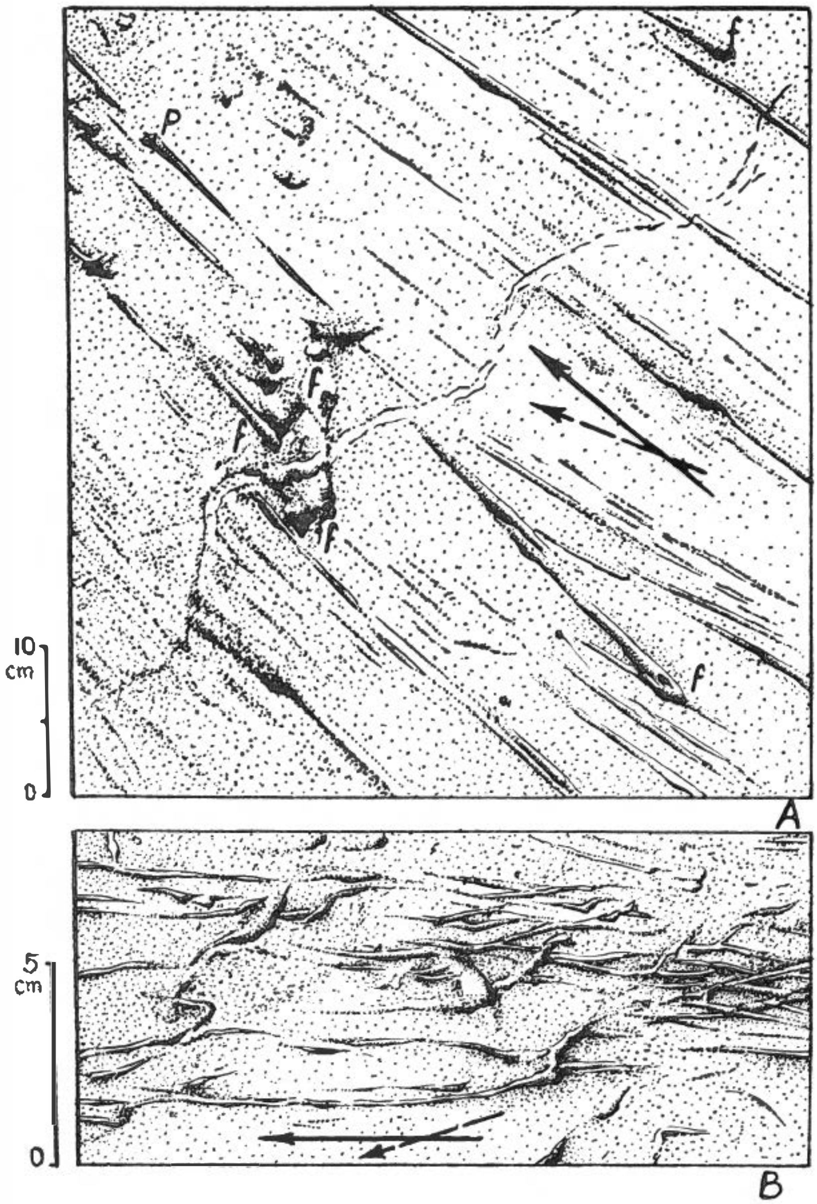


Fig. 5.

Sole markings of the Keltiefjellet Division at Lykta.

A – Sole of a fine grained sandstone. Two sets of thin discontinuous groove casts (in some cases resembling short prod casts – p). In the middle part of the figure some prod casts slightly modified by current erosion (f – incipient flute casts). Arrows indicate major and subordinate current directions, the dashed one being slightly older.

B – Sole of a fine grained sandstone. Two sets of fine groove (drag) casts (the dashed one slightly older), the younger slightly modified by current erosion to form incipient crescent markings.

ments of fish plates (e. g. spinal plates) or other elements of external or even internal parts of the lower vertebrate skeleton disintegrated after the death of the animal. In the case investigated no such tools were found, but it seems quite probable that they will be found in the course of more detailed observations in the field.

Figs. 5 A, B show two sets of groove casts crossing each other at low angle; this results from two subsequent currents of slightly different directions. The tools which had made the grooves have not been in continuous contact with the bottom, but have been subjected to saltation, leaving short aligned discontinuous grooves. Some of the tools had left prod markings (casts) i. e. short ridges with steep, blunt down-current side, as shown in Fig. 5 A.

It may be seen in Figs. 5 A, B that the grooves are partly modified by a subsequent current acting alone, thus being transformed into incipient flute casts (Fig. 5 A) or into crescent markings (Fig. 5 B).

Load casts

Load casts (part of "flow markings" of SHROCK 1948) formed by yielding of hydroplastic sediment to the weight of superimposed unequal load (PH. H. KUENEN, 1953) are rather uncommon. They are small irregular knobs at the sole of the sandstone (Fig. 4 A). The load-casting process played an important role in the formation of sand dunelets and convolute bedding.

Casts of unknown origin

Fig. 7 D presents two casts of unknown origin which are sharply delimited from the sole of the sandstone. The bigger one is maximum 1 cm high, about 18 cm long, and from several millimetres to 2 cm broad. The other one has still smaller dimensions. Both casts are slightly arcuate. The directional structures are lacking on the sole discussed. It is possible that the casts discussed are of organic origin. The grooves could have been left e. g. by spinal plates of some arthrodires when brushing the silty bottom. If this was the case, the movement of the animal could have been from right to left.

Bedding

The sandstones are either finely and evenly laminated or, more frequently, ripple laminated. Fig. 7 C shows transversal section of a channel (loose block) filled with cross bedded sandstone. Streaks of coarser clastic material appear in the lower part of the channel and, especially, at its bottom, where "flame structures" appear.

Fig. 4 B shows a typical ripple cross lamination of fine grained sandstones. The stoss (up-current) sides of the ripples are either eroded or show thinning of the laminae. Subsequent ripples (especially in the lower part of the figure) are climbing up the stoss slopes of the ripples immediately downstream. The dips of laminae are about 10° at the stoss side and up to 15° at the lee side. The sets show the absence of grading and lack of mud concentrations between the lee side

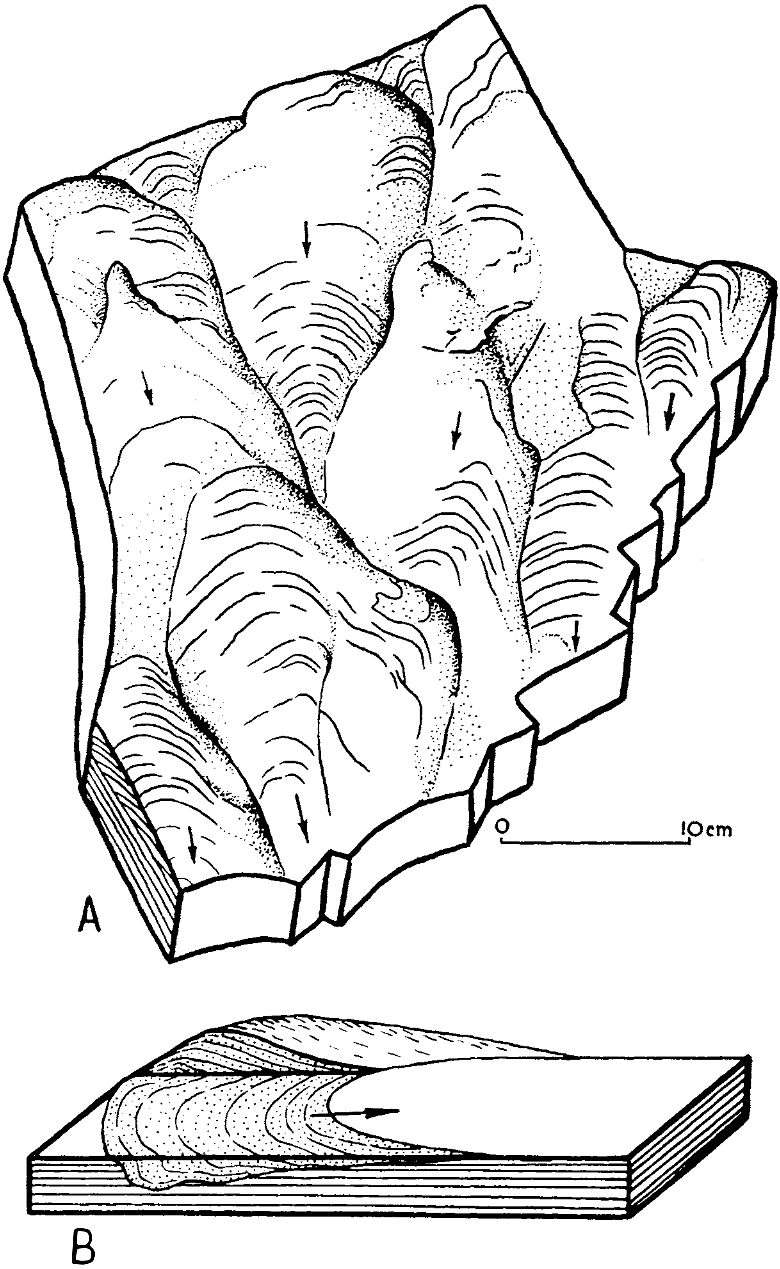


Fig. 6.

Sedimentary structures of the Keltiefjellet Division at Lykta.

A – Bottom surface of a sandstone layer showing bases of sand dunelets with arcuate growth lines of foreset laminae. Arrows indicate current directions. Particular dunelets are convex bottomwards due to load casting.

B – Diagram to show load casting (below the crest of the dunelet near its stoss side) and the relation of arcuate growth lines to the shape of the dunelet. Current indicated by arrow.

laminae, and in the depressions between the ripples, thus resembling "Type 1 of ripple-drift cross lamination" of R. G. WALKER (1963), who suggested that this type of ripples "is formed in fluvial and shallow water environments at times of net deposition of sediment". The ripples are formed at low traction current velocities characteristic of "transport in ripples».

In the example discussed there is a marked change in ripple indices between the lower and upper parts of the sandstone bed. In the lower part the ripple index averages to 17 and in the upper part it decreases to 8. There is also a small change in the thicknesses of the laminae of ripple sets in the vertical direction within the coset (terminology of E. D. MCKEE and G. W. WEIR 1953). There is no load casting of the ripples.

Fig. 6 A presents sole of a sandstone with linguoid downward convex bases of individual crescentic dunelets ("barchans in miniature" – cf. DZULYNSKI and SLACZKA, 1959; DZULYNSKI, 1963). Intersections of foreset lamination with the bottom surface are marked by arcuate lines. The unequal load of the ripple, highest under the crest of the dunelet caused plunging down the bases of the dunelets due to hydroplastic yielding of soft muddy bottom. The diagrammatic representation of a single dunelet in normal position is shown in Fig. 6 B.

Some sandstone layers show sedimentary disturbances of the lamination. Fig. 7 A presents a layer composed of three sedimentary units. In the lower unit we see traces of cross (current) bedding in the section normal to the current and, higher up – transverse sections of convolutional folds. In the middle unit we see sections of cross (current) lamination roughly normal to the current direction. This unit is sharply delimited from the lower one by an erosional surface. The convolutions belong to the type explained by KUENEN (1953) as produced by action of current on highly mobile sand forming ripples (convolute current ripple bedding of K. BIRKENMAJER 1959). Finally, the top unit in Fig. 7 A shows small convolutional balls and incomplete convolutions, as well as ironstone nodules and relics of cross lamination.

Another type of internal contortions of the laminated sandstone layer is presented in Fig. 7 B. These may well be transversal sections of either convolutional folds or of slump bedding. The Fig. 3 of D. L. DINELEY (1960) shows an accumulation of slump folds and sheets in section nearly parallel to the movement.

Conclusions

The above observations show that detailed sedimentological studies of the Old Red Sandstone of Vestspitsbergen may greatly help in reconstructing the conditions of deposition of this formation. These observations though incomplete confirm in general the conclusions as to the origin of this formation recently expressed i. a. by D. L. DINELEY (1960), D. L. DINELEY and J. R. L. ALLEN (1960) and P. F. FRIEND (1961). Shallow conditions of sedimentation prevailed during the formation of the Keltiefjellet Division of Lykta, as follows from the following summary.

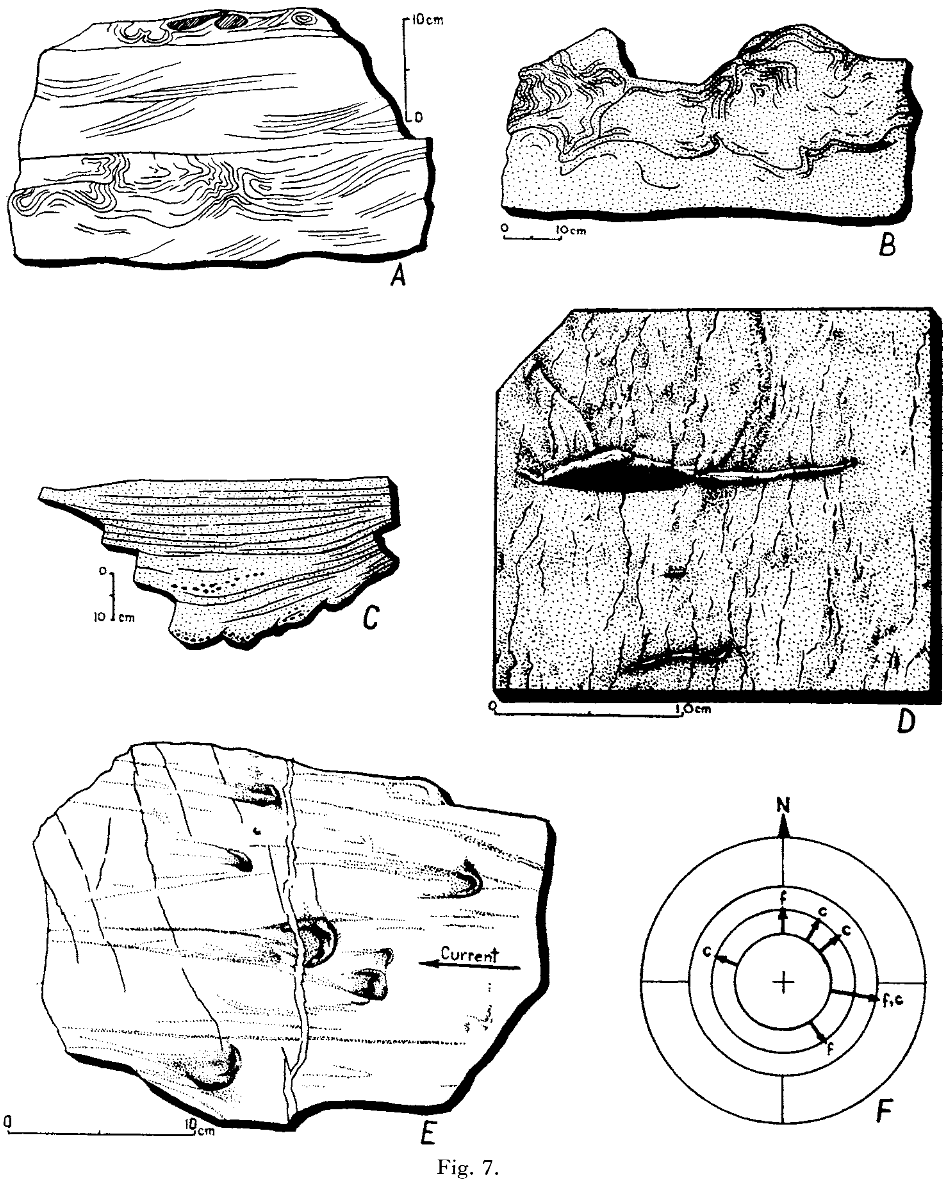


Fig. 7.

Sedimentary structures of the Keltiefjellet Division at Lykta.

A – Composite bedding of a sandstone layer (cross bedding and convolute bedding – closer description in the text).

B – Internal contortions of laminae in a sandstone layer (see the text).

C – Transverse section of a channel filled with cross bedded sandstone.

D – Sole of a sandstone with casts of unknown origin (possibly casts of grooves left by spinal plates of free swimming arthrodire).

E – Crescent markings (horsehoe-shaped markings). Note sand shadows at lee sides of the markings.

F – Diagram to show preliminary results of measurements of the direction of transportation. The distance between small circles corresponds to one measurement (altogether only 7 measurements). c – current bedding direction; f – flute cast direction.

1. Presence of cross (current) bedding, among which ripple-drift cross lamination, channel-fill structures and convolute bedding related to the current action are significant. The presence of ripple marks of interference type on upper surfaces of sandstones was also frequently stated in the field.[1]

2. Presence of an association of current markings represented by rill markings (casts), crescentic markings (casts) and of several types of flute casts, some of them much larger than those occurring usually in the deposits formed in deeper waters (e. g. flysch deposits).

3. Presence of a very simple and little differentiated association of tool markings (drag casts, chevron markings, prod casts), often modified by subsequent current action.

4. Presence of intraclast conglomerates and sedimentary breccias, partly interpreted as formed by slumping (slump breccias).

5. Presence of carbonized plant detritus often showing linear arrangement (current lineation) in green sandstones.

6. General absence of graded bedding and of lamined bedding characteristic of turbidite deposits (K. BIRKENMAJER 1959).

It should be added that some sedimentary structures (e. g. convolute bedding, drag casts etc.) which several years ago have been interpreted as indicators of turbidite deep water environment were found recently also in non-flysch deposits (R. H. DOTT and J. K. HOWARD 1962; S. DZULYNSKI 1963; K. BIRKENMAJER 1964) often of shallow-water origin. This was correctly pointed out already by D. L. DINELEY and J. R. L. ALLEN (1960) when discussing with K. W. BARR.

The measurements of direction of transportation made by the author at Lykta (Fig. 7 F) are too few to allow any more general conclusions. The prevalence of the directions of transportation within the first quadrant may well be local.

Further investigations of markings left by organisms (mostly lower vertebrates) during their life should be recommended as they are of interest both from sedimentological and ecological point of view. Burrowings by mud-eaters and organogenic sand pipes have not been observed by the present author, but such traces of organic life are recorded by DINELEY from Ekmanfjorden.

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The catches of polar bears in Arctic regions in the period 1945—1963

BY
ODD LØNØ[1]

Abstract

In table 1 and on Fig. 1 detailed informations are given on the amount of polar bears killed and living cubs taken by Norwegian sealers, hunters and trappers in Arctic regions during the period from 1945 to 1963. Table 2 gives the amount of polar bears shot by trophy-hunters in the years from 1952 to 1963.

In table 1 detailed information is given about how many bears have been killed and living cubs have been taken in the period from 1945 to 1963. The catch of the winter-season starting in the autumn, is registered on the following years, i. e. the winter catch of the 1946–47 season is recorded under 1947. From 1945 to 1963 the total catch of polar bears is 5887, with an average of 310 bears a year.

The information about the catches made by sealers at Newfoundland, Denmark Strait, Jan Mayen area, Barents Sea area and the summer expeditions to East Greenland, is taken from "Årsberetning vedkommende Norges Fiskerier 1945–1963" (Norwegian official statistics). These statistics also contain information about the amount of polar bears killed in East Greenland, at Jan Mayen proper and at Svalbard, but these figures are, however, not fully reliable. I have therefore tried to gather informations for the rest of table 1 from other sources.

The Governor on Svalbard has given me some informations about the catches made by the trappers at Svalbard, while the rest of the figures conserning the catches of the trappers at Svalbard and Greenland I have obtained directly from the trappers themselves.

The records from the weather-report stations on Jan Mayen, Isfjord Radio, Hopen and Bjørnøya I have become from the managers or the crews on the stations.

The records from the Norwegian mines are given me by Mr. KAARE ENGAN

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Table 1. *Catches of polar bears in the Arctic regions in the period 1945–1963.*

Years	New foundland Sealers No. of tours	New foundland Sealers Dead bears	Denmark Strait Sealers No. of tours	Denmark Strait Sealers Dead bears	Denmark Strait Sealers Living cubs	Jan Mayen area Sealers No. of tours	Jan Mayen area Sealers Dead bears	Jan Mayen area Sealers Living cubs	Barents sea area Sealers No. of tours	Barents sea area Sealers Dead bears	Barents sea area Sealers Living cubs	East Greenland Caught by trappers No. of trappers	East Greenland Caught by trappers Dead bears	East Greenland Caught by trappers Living cubs	East Greenland Summer expeditions (boats) Dead bears	East Greenland Summer expeditions (boats) Living cubs	Jan Mayen proper Caught by weather station crew Dead bears	Svalbard Caught by trappers No. of trappers	Svalbard Caught by trappers Dead bears	Svalbard Caught by trappers Living cubs	Svalbard Caught by weather station crew Dead bears	Svalbard Caught by weather station crew Living cubs	Svalbard Caught by Norwegian miners Dead bears	Svalbard Boats in Svalbard waters, expeditions and trophy hunters Dead bears	Svalbard Boats in Svalbard waters, expeditions and trophy hunters Living cubs	Total	Proportion of living cubs
1945	0	0	9	0	0	0	0	0	5	195	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	195	0
1946	1	0	13	4	0	16	1	0	26	311	55	0	0	0	0	0	0	1	5	0	27	0	2	0	0	405	55
1947	1	0	20	4	5	31	1	0	34	160	24	9	11	1	2	1	0	21	277	3	25	0	3	5	1	523	35
1948	4	1	19	4	0	51	25	0	37	146	21	10	4	1	0	0	0	13	184	10	43	2	3	0	0	444	34
1949	9	0	20	7	2	46	11	0	39	176	22	13	4	0	2	4	1	2	14	0	49	1	5	5	0	303	29
1950	14	1	13	6	0	41	44	5	48	388	55	12	14	0	0	0	0	1	0	0	21	0	2	0	0	536	60
1951	11	0	25	5	1	57	2	0	56	229	32	9	10	0	0	0	0	3	52	3	32	0	4	4	0	374	36
1952	11	0	13	5	0	47	7	0	20	63	12	9	5	0	0	0	0	2	2	0	32	0	5	16	5	152	17
1953	11	5	18	0	0	35	7	0	20	235	43	13	4	2	0	0	0	0	0	0	41	1	3	6	0	347	46
1954	0	1	12	0	0	41	1	0	21	126	19	7	10	0	0	0	0	0	0	0	22	0	3	27	0	209	19
1955	10	4	11	0	0	44	1	1	24	244	45	6	8	0	0	0	0	2	72	0	22	0	6	67	0	470	46
1956	10	0	14	6	0	43	8	0	27	183	43	6	11	0	4	2	0	1	7	0	42	2	4	29	0	341	47
1957	15	6	12	0	0	37	1	0	26	226	17	4	4	0	0	0	0	2	1	0	18	0	1	34	0	308	17
1958	13	1	12	0	0	42	33	2	13	47	0	2	0	0	0	0	0	4	1	0	29	0	2	45	0	160	2
1959	13	1	7	1	0	45	3	0	13	123	0	3	4	0	0	0	0	2	123	0	45	0	5	29	0	334	0
1960	16	3	8	1	0	44	7	0	10	0	0	0	0	0	0	0	0	3	57	0	70	0	9	26	0	173	0
1961	13	2	0	0	0	40	5	0	14	35	0	0	0	0	0	0	0	4	9	0	52	0	2	21	0	126	0
1962	13	0	0	0	0	42	22	0	9	18	2	0	0	0	0	0	0	6	11	0	83	2	14	25	0	177	4
1963	13	1	0	0	0	43	8	0	15	117	1	0	0	0	0	0	2	4	62	0	84	0	4	31	0	310	0
Sum:	178	26	226	43	8	745	187	8	457	3022	391	103	89	4	8	7	3	71	877	16	737	8	77	371	6	5887	

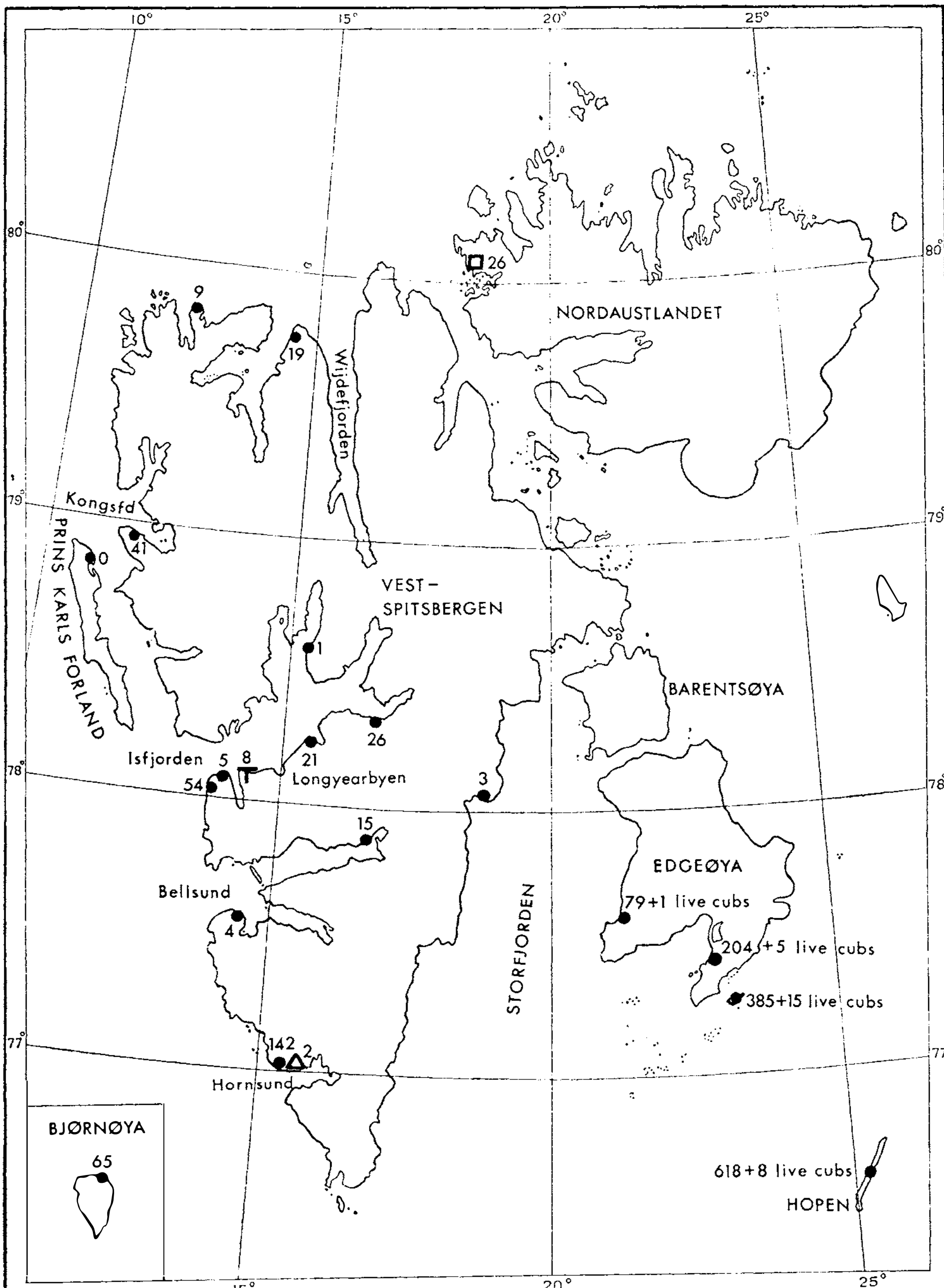

Fig. 1. *The map shows the places and numbers of polar bears that have been killed in the period from 1945 to 1963.*

□ *indicates where and the number of bears killed by the Swedish-Swiss expedition in Murchisonfjorden in 1957/58 and 1958/59.*

T *gives the number of bears caught by the Russians from 1955 to 1963.*

△ *indicates the place and number of polar bears killed by the Polish Scientific Expedition in Hornsund in 1957/58.*

for Ny-Ålesund and Mr. Fridtjof Løwø and others for Longyearbyen and Sveagruva.

The column named: "Boats in Svalbard waters, expeditions and trophy-hunters" contains the amount of polar bears caught by the crew of the Governor's vessel, Norwegian scientific expeditions, small hunting expeditions and trophy-hunters, besides five bears shot by the Norwegian crew on a German Svalbard Expedition.

The catches made by the trophy-hunters are recorded in table 2. The first of these expeditions to Svalbard waters after the war was in 1952. A German ship with German and Spanish tourists arrived in Tromsø to go on to Svalbard for hunting polar bears. The ship was stopped in Tromsø by the ship-control. However, a Norwegian shipowner arranges an Arctic safari for these tourists.

In the years 1953 to 1961 a small Norwegian boat M/S "Havella" that is specially built for trophy-hunters, brought tourists, mostly American, to Svalbard waters. In 1962 the number of such boats was increased to four, but polar bears were only hunted from two of them.

At the map on Fig. 1 the places are indicated where the polar bear have been trapped and hunted during the winters from 1945–46 to 1962–63, by wintering trappers, crew on the weather-report stations and the miners. Five of the polar bear cubs recorded here died before they got to Norway, so they are not mentioned in table 1. The Polish Svalbard Expedition wintering in Hornsund in 1957–58 killed 2 bears, which on the map is marked by a △. This information I have got from the leader of the expedition, Dr. S. Siedlecki. The Swedish-Swiss Expedition in Murchisonfjorden caught 22 polar bears in 1957–58 and 4 bears in 1958–59, and these catches are on the map marked by a □. The place where the Russian has caught polar bears is marked by a T. The Russians have given the

Table 2. *Catches of polar bears by the trophy-hunters.*

Years	Number of tours	Number of hunters	Catches of polar bears
1945 through 1951	0	0	0
1952	1	10	19
1953	3	5	6
1954	5	20	27
1955	6	24	26
1956	6	22	25
1957	4	16	29
1958	7	27	35
1959	8	28	23
1960	7	26	23
1961	7	24	21
1962	8	24	25
1963	11	41	31
		Total	290

following information to the Governor on Svalbard regarding their catches of polar bears:

1955–56	1 polar bear
1956–57	3 » »
1957–58	0 » »
1958–59	0 » »
1959–60	0 » »
1960–61	0 » »
1961–62	3 » »
1962–63	1 » »
All together	8 polar bears

The Russians have not been able to give exact information about the amount of bears caught in the previous years, but presumably only a few bears were shot during the period from 1945 to 1955. The catches made by the Polish Expedition, the Swedish-Swiss Expedition and by the Russians are not recorded in table 1.

Beside the bears imported to Norway, I have the following figures conserning bears being lost:

1947 3 cubs, caught by trappers, died
1948 1 cub, » » » »
1949 1 cub, » » » »
1958 24 bears and 2 living cubs lost in the shipwreck of M/S "Forland". (Information from the newspaper "Nordlys", August 8, 1958.)
1960 Ca. 50 bears lost in the shipwreck of M/S "Polarfangst". (Information from the newspaper "Aftenposten", August 17, 1960.)

The Norwegian catches at East Greenland take place between 71° to 76° l.N. "Ministeriet for Grønland", Copenhagen, has given me the information that the Eskimos and the Danes at East Greenland as a whole, have caught 881 bears in the periode from 1949/50 to 1960/61.

Iakttagelser over dyrelivet på Svalbard i 1963

(*Observations of the animal life in Svalbard in 1963*)

AV

NATASCHA HEINTZ

Abstract

All the fieldparties of Norsk Polarinstitutt working at Svalbard during the summer 1963, were asked to record what they saw of mammals and birds. The author has also taken contact with several other persons visiting the archipelago in 1963. The data concerning the perished moskox calves and reindeers have been taken from the official records.

Tab. 1 gives a review of the reindeers (*Rangifer t. spitsbergensis*) observed. In July it was reported that more then 50 dead reindeers had been seen at Edgeøya. However, when the place was revisited in September only 15 dead reindeers were found, all having winter fur. In April 3 moskox calves, being left by the herd, were found in Gangdalen. One of the calves was already dead, the two others died soon after. They were presumably about 11 months old and seem to have perished of underfeeding. During the summer compartively few moskoxen (*Ovibos m. moschatus*) were recorded. Polarfoxes (*Alopex lagopus*) were met at most places, i. e. in the central parts of Nordenskiöldbreen. A hare (*Lepus.* sp. indet) was recorded from Hornsund, here also a couple of times hare-tracks had been noticed. Two walruses (*Odobaenus rosmarinus*), a female and a young were seen several times in July in the vicinity of Smeerenburg. It is now many years since walruses have been recorded on the west coast of Vestspitsbergen.

Eiders (*Somateria mollissima*) were observed at most places, however, the number of ducklings seem to be comparatively small. Only near Isfjord Radio, where the eiders were protected by the men at the station, it was recorded as much as 8–10 eggs in the nests. Only male king eiders (*Somateria spectabilis*) were seen this summer. About 400 adult barnacle geese (*Branta leucopsis*) were registrated in Hornsund and the greater part of these birds were breeding. About 100 adult pale-breasted brent geese (*Branta bernicla hrota*) were met in Hornsund, where also some of these were breeding. The pink-footed geese (*Anser f. brachyrhynchus*) were noticed in small numbers in most places, and they seem to breed normally. Four new breeding colonies of ivory gulls (*Pagophila eburnea*) were found in the vicinity of Agarhdfjellet and Agarhdbukta. Ivory gulls were also met in Torell Land and on Nordenskiöldbreen. Only one hatch of Spitsbergen ptamigan (*Lagopus m. hyperboreus*) has been recorded this year. The following more rare birds were registrated: red-throated diver (*Columbus stellatus*), great black-backed gull (*Larus marinus*), herring-gull (*Larus argentatus*), ringed plover (*Charadrius hiaticula*), pintail (*Anas acuta*) and merlin (*Falco columbarius*).

Innledning

Sommeren 1962 fikk alle feltpartiene som arbeidet for Norsk Polarinstitutt på Svalbard, med et observasjonsskjema, hvor de ble bedt om å notere hva de så av pattedyr og en del nærmere angitte fuglearter. Resultatet av dette forsøket var meget godt og de innkomne data ble publisert i Årbok 1962 (N. HEINTZ 1963). Oppmuntret av dette ble det sommeren 1963 igjen sendt med observasjonsskjemaer. Disse var noe forandret og utvidet i forhold til fjorårets og dessuten ble alle partiene oppfordret til å notere det de så av planter, særlig på nunatakker og andre utilgjengelige steder (se SUNDING s. 169). Sommeren 1963 hadde nemlig Norsk Polarinstitutt to helikoptere til hjelp for det topografiske og geologiske arbeidet, som ble utført i Olav V Land, sydlige del av Ny-Friesland og tilgrensende områder, på steder som ellers er vanskelig tilgjengelig.

Jeg har forøvrig tatt kontakt med en del andre personer som jeg vet er interessert i dyrelivet og som i kortere eller lengre tid har vært på Svalbard i 1963. Fra flere av disse har jeg fått meget interessante opplysninger. Data angående de tre moskuskalvene som omkom i april 1963 og reinsdyrene som ble funnet døde på Edgeøya sommeren 1963 har jeg tatt fra de offisielle rapportene om disse sakene.

Jeg har her lyst til å nevne at det i og for seg ikke er noe helt nytt at det blir sendt med observasjonsskjemaer for dyrelivet. I 1930 fikk de norske fangstfolkene som skulle overvintre på Grønland med en liten bok til «Dagbokopptegnelser om dyrelivet» og boken ble bedt «Innsendt i utfylt stand til Norges Svalbard- og Ishavs-undersøkelser, Oslo», som også hadde utarbeidet boken. S. RICHTER som selv hadde med en slik opptegnelsesbok, forteller at en hel del av dem ble returnert til NSIU og at noen av fangstfolkene som etter å ha vært på Grønland, senere dro til Svalbard, tok den med dit.

Takk

Jeg vil her gjerne få takke alle partiene og enkeltpersoner for den interesse de har vist for innsamling av observasjoner. Særlig vil jeg uttrykke min takknemlighet overfor stud. real. THOR LARSEN og stud. real. MAGNAR NORDERHAUG for at de har stilt sine meget detaljerte iakttagelser om fuglelivet henholdsvis på nordvestkysten av Vestspitsbergen og i Hornsundområdet, til min disposisjon.

Pattedyr

Svalbardreinen (*Rangifer tarandus spitsbergensis*) ble sett på flere steder hvor Polarinstituttets partier arbeidet på den nordlige halvdelen av Vestspitsbergen i 1963. Likesom i 1962 ble det imidlertid som oftest bare påtruffet ett eller noen få voksne dyr sammen, og det var få kalver å se (Fig. 1). Den største enkelte flokken ble registrert i Sassendalen. Den var på 186 dyr, men også her var det lite kalver.

I juli ble det meldt til sysselmannen av en av helikopterførerne ved den amerikanske oljeletningsekspedisjonen at han på Edgeøya hadde observert mer enn 50 døde rein. I begynnelsen av september besøkte lege A. LAGER og sysselmannsbetjent O. STRØM Edgeøya for nærmere å undersøke de omkomne reinene. I mellomtiden hadde sysselmannen tatt kontakt med Veterinærdirektøren, som hadde anmodet om at det ble tatt en del nærmere angitte prøver av reinkadavrene, slik at man kunne undersøke disse, for om mulig å finne årsaken til at dyrene

Fig. 1. Reinbukken gresser i Sassendalen.

The reindeer is grazing in Sassendalen. Photo: E. FLIPSE

hadde omkommet. LAGER og STRØM fant i det oppgitte området i alt ca. 15 døde rein. De lå spredt over et større område og hadde alle vinterpels. Reinkadavrene var delvis oppspist av fugl og åtseldyr. Det var intet tegn til fettlag under huden og kadavrene virket uhyggelig magre. LAGER anslo vekten av dyrene uten innvoller til 10–15 kg. Da forråtnelsen var kommet svært langt, var det mulig bare å få tatt noen ganske få av de prøvene Veterinærdirektøren hadde bedt om. Både LAGER og STRØM mente imidlertid at det ikke kunne være tvil om at dyrene hadde sultet ihjel om vinteren, før de hadde skiftet til sommerpels. Bakteriologiske undersøkelser av de prøvene LAGER tok ble foretatt på Veterinærinstituttet og gav negativt resultat. Man kunne således ikke si noe om dødsårsaken på grunnlag av de undersøkte prøvene.

LAGER og STRØM så dessuten ca. 60 levende rein i det området de undersøkte. Disse dyrene var i godt hold og det var en del kalver blant dem. Beiteforholdene så ut til å være bra.

I Bockfjorden ble det i juli måned gjort to forsøk på å fange inn 8–10 rein, som etter planen skulle flyttes til Brøggerhalvøya. Innfangingsforsøkene ble imidlertid mislykket og planene måtte oppgis (se LARSEN s. 213).

Av særlig interesse er observasjonene av en flokk på ca. 20 rein som ble sett i

Tabell 1.
Observasjoner over rein (*Rangifer tarandus spitsbergensis*) sommeren 1963

Lokalitet	Datum	Antall dyr	Observert av	Anmerkninger
Revodden	4/8	3 ad.	E. Olsen	
Området Liefdefj.–Woodfj.–Sverrefjellet–Sjøvernbukta	/7	ca. 30 dyr	T. Larsen	dyrene befant seg i området
Sjøvernbukta–Roosneset	/7	ca. 150 dyr	»	–»–
Roosneset–Lernerøyane	/7	21 dyr	»	talt fra båt, antagelig flere dyr i området
Måkeøyane, Liefdefjorden	12/7	5 ♀♀	»	
Ved Annabreen, Liefdefjorden	14/7	3 ♀♀, 1 juv.	»	
Sassendalen	9/7	186 dyr	T. Siggerud	talt fra helikopter, få kalver
–»–	14/7	1 ♀, 1 juv.	»	talt fra helikopter
Nathorstdalen, Dickson Land	17/8	ca. 20 dyr	»	–»–
Edgeøya	2/9	ca. 60 dyr	A. Lager og O. Strøm	funnet dessuten 15 døde dyr, alle med vinterpels
Ytre De Geerdalen, Sassendalen	8/7	3 ad.	A. Hjelle	
Andøya, Liefdefjorden	/7–/8	4 ad.	H. Hornbæk	
Revneset	4/7	3 ad.	J. Hus	
Agardhdalen	10/8	1 ad.	D. L. J. Niemantsverdriet	
Fjellet mellom Ulvebreen og Haynesbreen	20/8	1 ad.	»	
Mohnbukta	23/8	1 ad.	»	
Mellom Agardhbukta og Dunérbukta	25/8	4 ad.	»	
2 km nord for Kreklingpasset	3/8	1 ad.	E. Flipse	
Vindodden	5/8	1 ad.	»	
Like ved Sveltihel	»	1 ad.	»	
Hjørnet Eskerdalen–Sassendalen	6/8	ca. 75 dyr	»	observert med kikkert utover Sassendalen
På grensen Fulmardalen–Sassendalen	»	1 ad.	»	
Fulmardalen, syd	7/8	1 ad.	»	
Eistradalen	13/8	4 ad.	»	
Vendomdalen	15/8	2 ad.	»	
Trehøgdalen	»	3 ad.	»	
Eskerdalen	»	4 ad.	»	

Nathorstdalen, Dickson Land. Her har det ikke vært rein på mange år, så det dreier seg om en nyinnvandring til dette området. Det fremgår forøvrig av tabell 1 hvor observasjonene er blitt gjort.

Moskusdyr (*Ovibos m. moschatus*). 15. april kom det beskjed til sysselmann F. B. Midbøe om at det i Gangdalen, ca. 30 km syd for Longyearbyen var blitt funnet en død og to døende moskuskalver. Det ble sendt ut en liten ekspedisjon, for om mulig å hjelpe de to kalvene som ennå var i live. Kalvene ble hurtig funnet, og var da i så elendig forfatning at det ble bestemt å forsøke å få de transportert ned til Longyearbyen. Ble de etterlatt ute, hadde de sikkert ingen sjanser til å overleve. Imidlertid døde den ene kalven under transporten og den andre nokså snart etter at man hadde fått den til Longyearbyen. Det var ingen tegn til ytre skader på dyrene, og konservator P. VALEUR, Zoologisk Museum, Bergen, som senere undersøkte det ene dyret i forbindelse med at han skulle stoppe det ut, sier i et brev: «Der var ingen leksjoner som kunne tyde på at den (moskuskalven) var drept av ras, men den var utrolig avmagret og virket som den hadde krepert hungersdøden, må i alle fall hatt liten motstandskraft under den strenge vinteren deroppe». Det samme ser også ut til å ha vært tilfelle med de to andre kalvene. Gruvearbeider E. JOHNSEN, som først fant kalvene, sier i sin rapport til sysselmannen at han var på tur i det området hvor kalvene ble funnet 13. april og da befant det seg en flokk på 8–10 moskusdyr i området og den ene kalven var allerede død. JOHNSEN returnerte to dager senere for å se etter moskusdyrene, men da var alle dyrene borte, med unntak av de to utmattete kalvene. Moskusdyrene hadde etter sporene å dømme, tatt vegen over fjellet fra Gangdalen. De som fant kalvene var naturligvis sterkt opptatt av årsaken til at de var omkommet. I den forbindelse besøkte R. KNUTSEN som var med på redningsekspedisjonen, Gangdalen en uke senere og samlet da inn en del moseprøver. KNUTSEN mente at muligens var noen av moseartene giftige eller i alle fall uegnete som føde for moskuskalvene. KNUTSEN nevnte forøvrig i sin rapport at i området hvor moskuskalvene ble funnet, var sneen mange steder sparket opp, men uten at det så ut til å være nevneverdig mat å finne for moskusdyrene.

Førstekonservator P. STØRMER, Botanisk Museum, Oslo, ble bedt om å bestemme moseprøven og sier i et brev til Norsk Polarinstitutt at «Ingen av disse mosene inneholder giftstoffer, og jeg kjenner overhodet ikke til giftige arter blandt mosene». Han fant følgende 8 mosearter i prøven: *Dicranum* sp. (rikelig tilstede), *Tomenthypnum nitens* (ganske rikelig), *Hylocomium spendius* (ganske rikelig), *Hypnum* sp. (sparsomt), *Aulacomnium palustre* (sparsomt), *Aulacomnium turgidum* (sparsomt) og *Polytrichum* sp. (sparsomt).

De tre omkomne moskuskalvene som alle var 1,2 m lange, må antagelig ha vært mellom 11 og 12 måneder gamle, da vi fra Grønland vet at moskusdyrene stort sett kaster sine kalver i slutten av april og begynnelsen av mai. En observasjon fra Svalbard viser at det antagelig er omtrent tilsvarende på Svalbard (LØNØ 1959). Iakttagelser fra Grønland går ut på at kalvene patter moren i alle fall i ca. 1 år og hvis hun ikke får en ny kalv det første året, hender det at kalven patter moren opptil 18 måneder. Ved siden av spiser den allerede fra den er ganske liten en hel del planteføde, som moren om vinteren ofte graver frem til kalvene.

Kalvene fra Gangdalen var således sikkert avhengig av moskuskuene både når det gjaldt melk og hjelp til å grave frem plantenæring. Det er rimelig å anta at de må ha vært i forholdsvis dårlig kondisjon allerede før de ble forlatt av flokken, men alene hadde de sikkert svært små sjanser til å klare seg. Tragedien i Gangdalen viser forøvrig hvor sårbare dyr er som lever i så ekstreme klimaforhold som på Svalbard. Ikke minst derfor er det så vesentlig at populasjonene er av noenlunde størrelse, slik at de kan tåle en desimering.

Sommeren 1963 ble det ikke gjort mange observasjoner av moskusdyr. I De Geerdalen, Sassen så T. SIGGERUD 8. juli fra M/S «Signalhorn» og 9. juli fra helikopter en flokk på 9 dyr, hvorav 2 kalver. A. HJELLE observerte 8. juli i ytre De Geerdalen en flokk på 13 dyr, og det er rimelig å anta at det delvis dreide seg

Fig. 2. To moskusdyr i Kreklingpasset.

Two muskoxen at Kreklingpasset. Photo: E. FLIPSE

om de samme dyrene SIGGERUD hadde sett. 20. august registrerte J. HUS på Lindbomhøgda i Adventdalen helt friske spor etter et voksent og et ungt individ. E. FLIPSE og J. D. ROEVER (Nederland) så 3. august først en enkel hann i Helvetiadalen nær Helvetiafjellet og senere samme dag ca. 1 km nord for Kreklingpasset traff de på en flokk på 15 moskusdyr, hvorav 2 kalver. De to nederlenderne ble angrepet av moskusdyrene og måtte flykte (Fig. 2). Det er all grunn til å anta at det delvis dreide seg om de samme dyrene som SIGGERUD og HJELLE tidligere hadde sett i De Geerdalen.

Isbjørn (*Thalarctos maritimus*). Isforholdene langs vestkysten av Spitsbergen var mer normale i 1963 og dette førte bl. a. til at, bortsett fra i ett tilfelle, ble det overhodet ikke registrert isbjørn i disse områdene. Den ene unntagelsen var en skadet isbjørn som ble påtruffet ca. 2 km nord for Skottehytta i Billefjorden. Da venstre bakben var revet av ved kneet, kunne den bare humpe sagte avgårde på tre ben. Isbjørnen ble skutt av folk fra Polarinstituttets leir i Billefjorden og viste seg å være en ung hann. Under et isrekognoseringstokt 3. juli over området ved Hopen, så T. LUNDE en isbjørn ute i isen som stod og spiste på en sel. Den ble tydelig engstelig da de fløy bare ca. 150 m over den, men den forlot likevel ikke sitt bytte.

Ved Brotneset, Hambergbukta så J. NAGY 25. juli en isbjørn, den kom tilbake 28. juli og da måtte de skyte den i selvforsvar.

Jakt av isbjørn i arktiske farvann spiller fremdeles en ganske stor rolle. Det har imidlertid fra flere hold i det senere vært fremhevet at det er behov for å regulere denne jakten, ikke minst i forbindelse med at det stadig blir arrangert flere og flere turistreiser hvor jakt på isbjørn inngår som en vesentlig del av programmet. Den samlete mengde isbjørn skutt i Svalbard-farvann i løpet av 1963 var 181 eksemplarer. Fordelingen på de forskjellige fangstfeltene osv. fremgår av LØNØ's artikkel (se s. 151).

Hare (*Lepus* sp.indet). I knauset terreng i området mellom Hyttevika og Isbjørnhamna i Hornsund, like under Rotjesfjellet så M. NORDERHAUG 26. juli en hare. NORDERHAUG oppgir at dyret ble sett bare noen få sekunder, men han rakk likevel å få iakttatt den i kikkert på ca. 35–40 m hold før den forsvant bak haugene. To ganger tidligere samme sommer hadde NORDERHAUG's parti sett spor som syntes å måtte være etter hare, men da de på det tidspunktet ikke visste om hare i denne delen av Vestspitsbergen, hadde de ikke undersøkt sporene noe nærmere.

J. HUS nevner funn av ekskrementer på en topp 614 m høy øst for von Postbreen, og mener at det måtte dreie seg om hareekskrementer. De lå i flere små hauger bortover den flate, stendekkete toppen, som ellers hadde et meget sparsomt plantedekke. Ekskrementene besto av små, rundete «nøtter» med en litt uttrukket spiss i den ene enden.

Polarrev (*Alopex lagopus*). Spredte eksemplarer ble sett de fleste steder hvor Polarinstituttet hadde folk i felten. A. HJELLE så friske revespor flere ganger inne på Nordenskiöldbreen, tildels langt både fra kysten og fra nunatakker. M. NORDERHAUG hevder at bestanden av rev i Hornsund var mindre i 1963 enn i 1962 og tilskriver dette at det hadde ligget 2 fangstmenn i Hornsund vinteren 1962/63 og tilsammen tatt ca. 80 rev. E. FLIPSE og J. D. ROEVER oppgir at de i Ny-Ålesund fant et revehi med 3 unger og 2 voksne, og ved Stuphallet et annet hi med 2 (3 ?) unger. Ellers så de flere enkelte rev i Ny-Ålesund området i slutten av juli.

Fjordsel (*Phoca hispida*). Da det var lite is på vestkysten, ble det ikke observert større ansamlinger av fjordsel, bortsett fra en flokk på ca. 80 individer som lå på fjordisen ved Diabasodden i Sassenfjorden i begynnelsen av juli og en annen flokk i Brepollen innerst i Hornsund omtrent på samme tid. Ellers ble det stadig sett enkelte individer i løpet av hele sommeren.

Storkobbe (*Erignatus barbatus*). I Hornsund holdt det hele sommeren til en fast bestand på 10 voksne individer.

Hvalross (*Odobaenus rosmarinus*). I området mellom Smeerenburg, Danskeøya og Amsterdamøya ble det i midten av juli både fra M/S «Nordsyssel» og M/S «H. U. Sverdrup» gjentatte ganger sett 2 hvalrosser, en voksen hunn og en unge av året. Dessverre ble de til slutt forstyrret, og ungen omkom da hunnen gikk på sjøen. Det er mange år siden man har registrert hvalross så pass langt vest, og dette viser at det ennå finnes en ytterst sparsom bestand av hvalross i Svalbardfarvann.

Fig. 3. Ærfuglhunnen ligger på redet. Blir den forstyrret og forlater redet uten å få dekket til eggene med dun, er polarmåken der med en gang og forsyner seg.

The female eider sits on the nest. If she is disturbed and leaves the nest without covering the eggs with down, the glaucous gull will be there immediately and take the eggs. Photo: K. A. Edin

Fugl

Mens mange av fuglene sommeren 1962 hadde liten eller ingen ungeproduksjon, var forholdene sommeren 1963 mer normale og det ble registrert gode ungekull hos mange arter.

Ærfugl (*Somateria mollissima*) (Fig. 3). På nordsiden av Vestspitsbergen foretok T. Larsen og hans parti en særlig undersøkelse over ærfuglbestanden. Både denne undersøkelsen og data innsamlet av andre tyder på at ærfuglbestanden fremdeles er minkende og dette skyldes sikkert at ærfuglene ofte blir meget sterkt beskattet både av mennesker og polarmåker. Som det fremgår av tabell 2 ser det dessverre ut til at ungeproduksjonen de fleste stedene i 1963 var forholdsvis beskjeden. Det største antall egg i redene ble registrert ved Isfjord Radio. Her var det gjennomsnittlig 6–8 egg pr. rede, noe som antagelig har sammenheng med at betjeningen på stasjonen skjøt alle polarmåker som kom i nærheten og forøvrig forstyrret fuglene minst mulig. Det kan ikke være tvil om at polarmåken i dag mange steder på Svalbard herjer stygt i ærfuglkoloniene. Finnes det polarmåker i nærheten av en ærfuglkoloni, må man være særlig varsom med å forstyrre ærfuglene. Går de av redet uten å få dekket eggene ordentlig til med dun, er polarmåken der med en gang og tar gjerne alle eggene før hunnen er tilbake.

Praktærfugl (*Somateria spectabilis*). 2 hanner ble sett ved Friedrichbreen i Bockfjorden 10. juli. På Store Dunøy var det 24. juli ca. 20 yngre og 8–10 gamle hanner og ved Elveflya ble det 21. august registrert minst 15 unge hanner. Derimot ble det hverken sett hunner eller unger i løpet av denne sommeren.

Hvitkinngås (*Branta leucopsis*). M. NORDERHAUG oppgir å ha sett ca. 400 voksne hvitkinngjess i Hornsundområdet. En stor del av bestanden hekket. Av 35 observerte ungekull varierte ungetallet fra 1 til 7, med et gjennomsnitt på 2,8 pr. rede. Hvitkinngåsen hekket således ganske rikelig i Hornsundområdet i hvert fall sammenlignet med året før, da man registrerte bare et par reder, mens det fantes minst 1000–1100 ikke hekkende fugler i området.

Ringgås (*Branta bernicla hrota*). På Andréøya ble 28. juli sett 1 hann, 1 hunn og 2 unger. På Dunøyane ble det i løpet av juli og august registrert i alt mer enn 100 voksne individer. Det ble også funnet noen få reder. Gjennomsnittet for 12 ungekull lå på 2,6.

Spitsbergengås – kortnebbgås (*Anser fabalis brachyrhynchus*). På Roosneset ble det 12. juli sett 10–12 voksne individer som var begynt å myte. Ca. 40 individer som holdt til på Måkeøyane (12. juli) var også begynt med myting. Ved Erikbreen i Liefdefjorden oppholdt det seg 13. juli ca. 30 voksne Spitsbergengjess, mens ved Annabreen ble det samme dag sett 1 hann, 1 hunn og et rede med 5 egg. På Lernerøyane var 6 voksne individer i full gang med mytingen 14. juli. I løpet av juli–august ble det ved Sofiakammen i alt sett 8–10 par med Spitsbergengjess og øst for Elveflya holdt 8 par til. I 16 kull som ble registrert, varierte antallet unger mellom 1–5 med gjennomsnitt på 2,5. Ved Skottehytta i Billefjorden oppholdt et voksent individ seg 4. juli, og på Fuglehuken i slutten av juli passerte noen få individer. I Eskerdalen ble 21. juli registrert 1 ad., i Sassendalen 16. juli ble det sett 10 ad. og i Agardhbukta ble det 26. august observert omkring 150 voksne individer.

Ismåke (*Pagophila eburnea*). I de senere årene har det blitt observert adskillige ismåker på Svalbard. 2. august fant D. L. J. NIEMANTSVERDRIET i Agardhfjellet en koloni på mellom 40 og 70 rugende individer. Samme dag ble 2 voksne individer sett spisende på restene av en død isbjørn. Omtrent i samme område fant to nederlandske studenter E. FLIPSE og J. D. ROEVER to nye hekkeplasser for ismåke (se LARSEN s. 257). Inne på Nordenskiöldbreen så A. HJELLE 17. juli 3 voksne individer og 2 reder ved Ekkoknausene. Ved den vestlige delen av Japetusryggen så han 4. august 4 individer og ved den sydlige delen av Blånuten registrerte han 8. august igjen 4 individer. Det er ikke utelukket at det i de to siste tilfellene dreier seg om de samme individene. På østsiden av Kronprinsenhalvøya holdt det hele sommeren til et voksent individ og det samme var tilfelle ved Skottehytta i Billefjorden. På Måkeøyane ble det 12. juli og 21. juli begge ganger sett 1 voksent individ. I området mellom Isbjørnhamna og Burgerbukta i Hornsund ble det i løpet av juli–august stadig observert enkelte spredte individer og ved Storbreen på Torell Land ble det sett 2 individer.

Spitsbergenrype (*Lagopus mutus hyperboreus*). 1 hunn ble sett ved Annabreen i Liefdefjorden 14. juli. Ved Ariekammen i Hornsund holdt 1 hunn til i juli. I Trehøgdalen ble det 25. juli registrert 1 hunn med 9 unger og 1. august ble det

Tabell 2
Observasjoner av ærfugl (*Somateria mollissima*) sommeren 1963

Sted (Lokalitet)	Datum	Antall fugl	Antall reder med egg, dun	Observert av	Anmerk.
Sjøvernbukta, Bockfjorden	9/7–10/7	ca. 60 ad[1]), 1 ♀, 8 juv.		T. LARSEN	[1]) sett på lang avstand
Måkeøyane	21/7	ca. 200 ad., vesentlig ♀♀, ca. 40 juv.		—	
Øy i Liefdefjorden, like ved Annabreen	13/7	ca. 20 ♂♂, ca. 100 ♀♀	30 reder, normalt med dun	—	
Sallyhamna	26/7	ca. 40 ad.		—	samlet i flokker på 10–15 ad. i hver
Barriereøya	29/7	ca. 25 ad.	bare gamle reder	—	
Fuglefjorden	29/7	ca. 200 ad.	21 nye reder, 1–4 egg, vanlig med dun, 150 gamle reder	—	
Nordre Norskeøy	2/8	ca. 40 ad.	2 nye reder med 3 egg hver, normalt med dun, 20 gamle reder lå ca. 100 m o. h.	—	
Cummingøya	5/8	ca. 70 ad.	10–15 gamle reder	—	
Mellom Gjøahavn og Smeerenburg	9/8	ca. 100 ad.		—	
Holme ved Virgohamna	9/8	ca. 70 ad.	15–20 gamle reder	—	
Biskayerhuken og 5 km vestover	12/8	mer enn 500 ad., 40–50 juv.		—	myteplass
Innerst i Woodfjorden	/7	ca. 10–15 ad.	ca. 10 reder	H. HORNBÆK	
Vestsiden av Kronprinsenhalvøya	/7– /8	Noen få ♀♀ med juv.		—	oppholdt seg ved leiren hele sommeren
Fuglehuken	30/7	Noen få ♂♂, ♀♀ og 1 juv.		FRØYSLID og LILLEVIK	
Mellom Agardhbukta og Ulvebreen	19/8	ca. 450 ad.		D. L. J. NIEMANTSVERDRIET	
Ebbadalen, Billefjorden	1/7–4/7	1 ♀	1 rede med 5 egg – lite dun	T. SIGGERUD og J. HUS	redet plyndret senere
Petuniabukten, Billefj.	27/7	9 ♀♀, 4 juv.		T. SIGGERUD	
— —	31/7	1 ♀, 4 juv.		J. HUS	
— —	/8	ca. 20 ♂♂		T. SIGGERUD	
Sofiakammen – Kvartsittodden	5/7	323 ad., av disse ca. 75 % ♀♀, resten♂♂	vanlig mellom 1–5 egg i redene	M. NORDERHAUG	vanskelig å foreta en ordentlig telling p.g.a. polarmåkene som forstyrret ærfuglene
Emoholmane, Store Dunøya, Nordre Dunøya, Fjørholmen, Nordre Isøya	/7– /8		tilsammen ca. 500 reder på disse øyene	—	ungekullene få og spredt
Isfjord Radio, innløp til Isfjorden	8/7	ca. 20 ♂♂, 2–300 ♀♀	2–300 reder med 6–8 egg pr. rede og normalt med dun	T. LARSEN	alle polarmåker i nærheten ble skutt og ærfuglene ble minst mulig forstyrret

samme sted sett 1 hunn med 6 unger. Det er ikke utelukket at det i det siste tilfelle dreier seg om det samme kullet, men at noen av ungene i mellomtiden var kommet bort.

Smålom (*Colymbus stellatus*). Fra Hornsundområdet i juli ble registrert: Nordre Dunøya, 2 reder med 2 egg i hvert rede, Store Dunøya 2 unger og minst 1 rede og Hyttevika 1 voksent par men intet rede. På Måkeøyane ble 21. juli funnet 4 reir med egg og 9. august ble på Smeerenburgsletta observert en hunn med unge.

Havelle – isand (*Clangula hyemalis*). Hekket fåtallig i Hornsundområdet i juli–august. På Måkeøyane ble 21. juli sett ca. 50 voksne individer, men ingen reir. Både i Bockfjorden og Liefdefjorden ble i løpet av sommeren spredte individer observert.

Svartbak (*Larus marinus*). En del voksne streifindivider ble sett i Hornsundområdet, nemlig: Nordre Isøya 11. juli 2 ad., Store Dunøya 24. juli 4 ad., Hyttevika 7. august 2 ad., Dunøyskjæra 19. august 1 ad., Nordre Dunøya 20. august 1 ad.

Gråmåke – sæing (*Larus argentatus*). Nordre Dunøya 24. juli 1 ad. og Store Dunøya 24. juli minst 1 ad.

Alkekonge (*Plotus alle alle*). På Tsjernysjovfjellet (1208 m o. h.) så J. Hus 19. juli at det passerte mellom 50–100 alkekonger på veg fra øst mot vest og senere kom ca. 150 individer flyvende den andre vegen. Senere på sommeren fant han ut at trafikken gikk til og fra Systertoppane, hvor alkekongene hekket, men allerede 8. august så det ut til at redeplassen var forlatt.

Havhest (*Fulmarus glasialis*). Havhest ble sett overalt på Svalbard, men av særlig interesse er å nevne at A. Hjelle, E. Olsen og J. Hus fant at de hekket inne på nunatakkene på Olav V Land. Hjelle så 24.–30. juli et par ved den østlige del av Japetusryggen og 3.–4. august et annet par ved vestlige del av Japetusryggen. Ved sydenden av Raudberget, Ytre Chydeniusbreen fant han 15. august 4 hekkende par i et sørvendt stup og litt lengre VSV for denne lokaliteten så han samme dag 3 hekkende havhestpar til. Rundt Backlundtoppen (1068 m o. h.) så Olsen omkring 50 havhester og de må ha hekket i dette området, for en del havhest fløy ut da noen sten rullet utfor toppen. Hus så ca. 50 havhester i østveggen av Elvepiggane, noen fløy rundt toppen og andre satt på hyller i fjellveggen. Det var tydelig at de hekket der.

Polarsvømmesneppe (*Phalaropus fulicarius*). I Hornsund ble følgende funn registrert: Isbjørnhamna 2 reder med 4 egg i hvert og Dunøyane minst 1 rede med 2 egg.

Sandlo – prestekrave (*Charadrius hiaticula*). I området Isbjørnhamna–Rotjesfjellet ble enkelte spredte, ikke hekkende individer sett i juli–august.

Stjertand (*Anas acuta*). På Nordre Dunøya ble 11. juli sett 3 hunner og 24. juli 4 hunner. Det er ikke utelukket at det delvis dreier seg om de samme individene.

Dvergfalk (*Falco columbarius*) ble av M. NORDERHAUG sett ved Rotjesfjellet 4. juli (se s. 255).

Polarsvømmesneppe (*Phalaropus fulicarius*). To individer ble sett på Måkeøyane 21. juli og på Cummingøya 3. august ble et individ i høstdrakt observert.

Steinskvett (*Oenanthe oenanthe*). Et dødt og inntørket eksemplar ble funnet i lageret i Sallyhamna.

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Plantefunn fra Vestspitsbergen sommeren 1963

(PLANT FINDS FROM VESTSPITSBERGEN THE SUMMER 1963)

AV

PER SUNDING[1]

Abstract

Collections of vascular plants made by fieldparties in Svalbard have been examined. The areas investigated are a series of nunataks in Olav V Land, at relatively great heights above sea level. Vascular plants (*Papaver dahlianum* and *Saxifraga oppositifolia*) have been found up to 1100 m above sea level. Interesting finds were made of *Festuca baffinensis* and *Erigeron eriocephalum.*

Under Norsk Polarinstitutts ekspedisjon til Svalbard sommeren 1963 arbeidet blant andre geolog AUDUN HJELLE og topograf JOHANNES HUS i området omkring søndre del av Ny Friesland og nordre del av Olav V Land. Ved denne anledning ble en rekke nunatakker i området besøkt, ved hjelp av helikoptertransport fra hovedkvarteret i Ebbadalen, Billefjorden. Samtidig med geologiske og topografiske undersøkelser ble det også gjort en del observasjoner over floraen på disse isolerte og høytliggende fjellpartiene, og presset plantemateriale ble brakt med tilbake. Planter ble samlet og notert på 11 lokaliteter, og i alt ble det funnet 19 arter blomsterplanter. Listen over funnene nedenfor bygger vesentlig på herbariematerialet; for noen ganske få og lett kjennelige arter er også notater tatt med.

Besøkte lokaliteter

1. Sørvestre hjørne av Raudberget, på Chydeniusbreens nordside, like innenfor Vaigattbogen. I sørstupet av fjellet, under hekkende havhest. 15. august. (8 arter).
2. Liten fjellknatt ved vestre ende av Raudbergbreens utløp i Chydeniusbreen. I sørsørøstvendt stup, med hekkende havhest i nærheten. 15. august. (9 arter).
3. Den sørligste knausen på Granittryggen, ca. 15 km nordnordøst for Newtontoppen. 3. august. (1 art).
4. Valetteknausen, ca. 12 km nordnordøst for Newtontoppen. 27. juli. (3 arter).
5. Nordøstenden av fjellrygg rett nord for Alexeisøkka, sør for Dolerittfjellet (ca. 13,7 km øst til østnordøst for Newtontoppen). 27. juli. (6 arter).
6. Den sydligste utløper av Astronomfjellets østligste del. 13. august. (2 arter).
7. Midtre del av Japetusryggen, nord for Grusdievbreen. 29. juli. (1 art).

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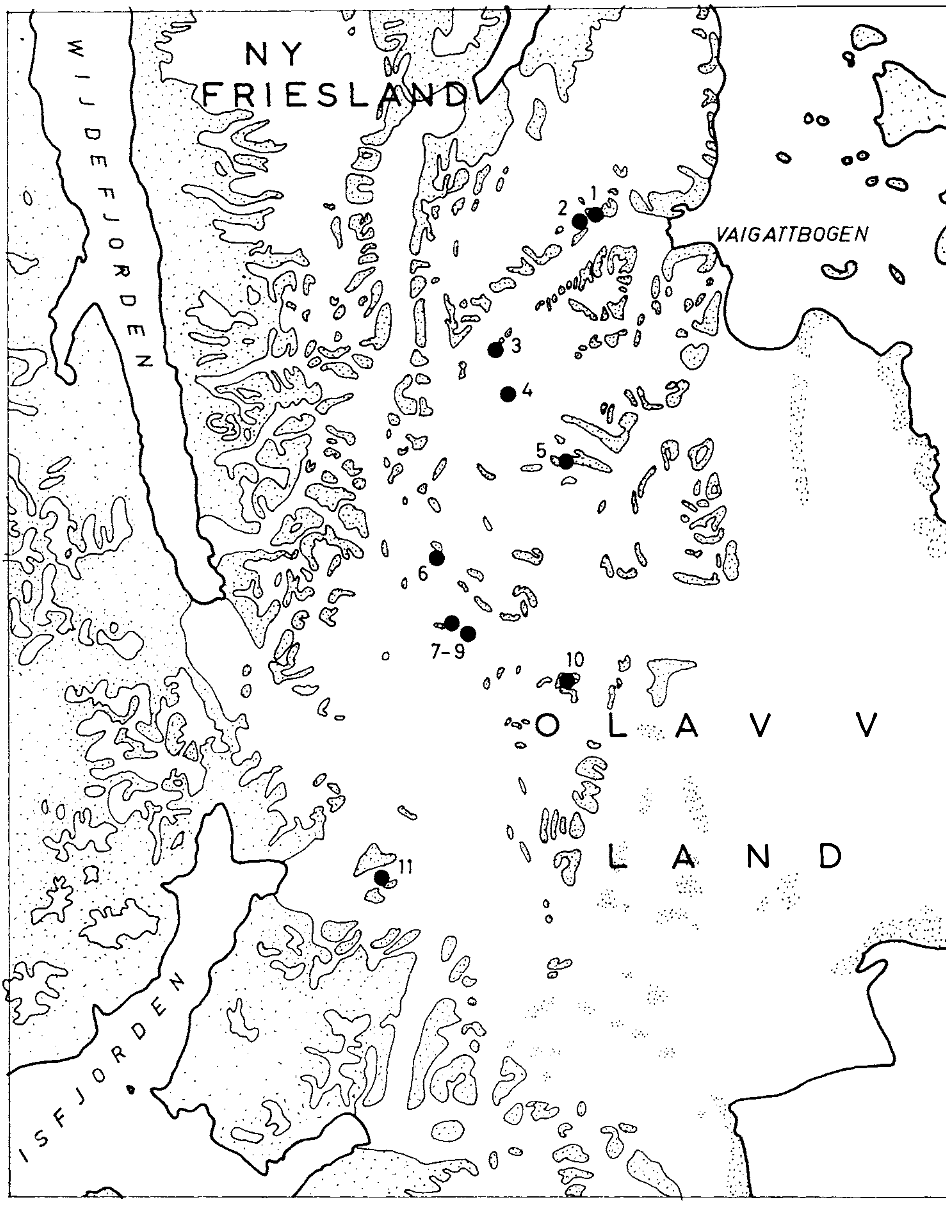

Fig. 1. *Lokaliteter i Ny Friesland og Olav V Land, som det er henvist til i teksten. Numrene viser til listen over lokalitetene.*
(Localities in Ny Friesland and Olav V Land mentioned in the text. Numbers refer to the list of localities.)

8. Sørøstre del av Japetusryggen, nord for Grusdievbreen. 24.–25. juli. (3 arter).
9. Japetusryggen. 25. juli. (3 arter).
10. Nordøstligste Ellevepiggane, sør for Grusdievbreen. 30. juli. (5 arter).
11. Ekkoknausane, Nordenskiöldbreen. Den vestligste av de to store midterste nunatakkene. På sørsiden i brattheng, ved hekkende ismåker. 17. juli. (10 arter).

Plantefunn

Listen nedenfor gir en kort oversikt over de plantefunn som ble gjort. Numrene henviser til listen over lokalitetene, samt til kartet (Fig. 1). Høydene for voksestedene er gitt i meter over havet, som oftest med en toleranse på ± 20 m.

Phippsia algida (SOL.) R. BR.
10 : 950 m
Festuca baffinensis POLUNIN
1 : 400 m, 2 : 430 m
Luzula confusa (HARTM.) LINDEB.
3 : 830 m
Salix polaris WAHLENB.
2 : 430 m, 4 : 1040 m, 5 : 840 m
Polygonum viviparum L.
11 : 720 m
Minuartia biflora (L.) SCH. et TH.
11 : 720 m
Cerastium alpinum L.
1 : 400 m, 2 : 430 m, 5 : 840 m, 8 : 1050 m, 10 : 950 m, 11 : 720 m
Ranunculus sulphureus SOL.
1 : 400 m, 11 : 720 m
Papaver dahlianum NORDH.
4 : 1040 m, 5 : 840 m, 6 : 1100 m, 8 : 1050 m, 9 : 1093 m, 10 : 950 m, 11 : 720 m
Draba cinerea ADAMS
2 : 430 m
Draba alpina L.
1 : 400 m, 10 : 950 m
Saxifraga oppositifolia L.
1 : 400 m, 5 : 840 m, 6 : 1100 m, 9 : 1093 m, 10 : 950 m, 11 : 720 m
Saxifraga tenuis (WAHLENB.) H. SM.
11 : 720 m
Saxifraga cernua L.
1 : 400 m, 2 : 430 m, 4 : 1040 m, 5 : 840 m, 8 : 1080 m, 9 : 1093 m, 11 : 720 m
Saxifraga groenlandica L.
1 : 400 m, 2 : 430 m, 5 : 840 m, 7 : 1050 m, 11 : 720 m
Potentilla pulchella R. BR.
2 : 430 m
Potentilla hyparctica MALTE
11 : 720 m
Erigeron eriocephalum J. VAHL
2 : 430 m
Taraxacum arcticum (TRAUTV.) DAHLST.
1 : 400 m, 2 : 430 m

De fleste av de artene som ble funnet, er nøysomme og livskraftige arter som er forholdsvis vanlige over hele Svalbard. For to av artene, *Festuca baffinensis* og *Erigeron eriocephalum*, er imidlertid finnestedene fra sommeren 1963 langt utenfor de hittil kjente voksesteder. *Festuca baffinensis* er tidligere kjent fra Isfjorden og Wijdefjorden, mens *Erigeron eriocephalum* bare har vært funnet ved Wijdefjorden og på Nordaustlandet (RØNNING 1964). Begge disse artene ble av A. HJELLE funnet på lokalitetene ved Raudberget, inn for Vaigattbogen, altså forholdsvis langt øst på Vestspitsbergen.

Opplysningene fra det undersøkte området er også meget verdifulle som et bidrag til å øke kjennskapet til arktiske planters økologi og deres mulighet for å klare seg i slike høytliggende strøk. Plantenes høydegrenser på Svalbard har hittil vært lite kjent, og særlig for de østlige deler av Vestspitsbergen og for Nordaustlandet har man hatt lite opplysninger av denne art.

De lokalitetene som ble besøkt sommeren 1963, var høyere beliggende enn de som hittil har vært undersøkt med hensyn på høydegrenser for planter, og som ventet ga dette seg utslag i en vesentlig økning i de kjente høydegrenser for en rekke arter. Høyere planter er med dette funnet helt opp til 1100 m o. h. (*Papaver dahlianum* og *Saxifraga oppositifolia*), på Astronomfjellets østlige del. Den tidligere høyeste angivelse for noen blomsterplante fra Svalbard var 940 m o. h. (*Papaver dahlianum*, SUNDING, 1962).

Det er også meget interessant at det er blitt konstatert at det selv på slike høytliggende og isolerte nunatakker kan opptre en forholdsvis rik flora. De undersøkte nunatakkene ligger i forholdsvis store høyder og inntil 25 km fra isranden. Man skulle tro at forholdene var temmelig ugunstige for noe slags plante- eller dyreliv. Likevel finnes mange arter av blomsterplanter, de fleste til og med i full blomst, såfremt en passende sydhelling er til stede, og det ble også angitt for flere av stedene at sjøfugl hekket i nærheten. At man kan finne en såpass rik flora så isolerte nunatakker, stemmer også med iakttagelser fra Grønland (se f. eks. SCHWARZENBACH 1961), og er et forhold det bør legges stor vekt på under diskusjonen om hvorvidt noe av Skandinavias fjellflora kan ha overvintret siste istid på nunatakker i Norges kystfjell eller i Trollheimen (GJÆREVOLL 1959).

Litteratur

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A radiocarbon-dated peat deposit near Hornsund, Vestspitsbergen, and its bearing on the problem of land uplift

BY

WESTON BLAKE, JR.,[1] INGRID U. OLSSON,[2] and ANDRZEJ ŚRODOŃ[3]

Abstract

A radiocarbon age determination shows that the basal peat in a bog 12 m above sea-level near Hornsund is 1390 ± 70 years old. The peat, at 55–60 cm depth, apparently did not start to accumulate until after the site had emerged from the sea. Uplift at a rate of less than 1 m per century, rather than the 2.3 m per century for the last 350 years that previously has been suggested for this area, would suffice to have raised the bog to its present elevation.

Introduction

Starting in 1956 a series of Polish expeditions worked in the vicinity of Hornsund, Vestspitsbergen (Fig. 1), and research was carried out in a wide range of scientific disciplines. As elsewhere in the islands of the Spitsbergen archipelago, raised beaches are well developed near Hornsund, and there they were studied, in particular, by Prof. A. JAHN and Dr. K. BIRKENMAJER. These two authors reached quite different conclusions as to the rate at which uplift of the land has progressed following deglaciation of the coastal regions, and in the present paper the first absolute dates from the Hornsund area are presented as a contribution to the discussion.

JAHN (1959 a, pp. 261–262; 1959 b, p. 174) studied the morphology of the beaches and the processes occurring at the shore today. He concluded that within the last 50 years any negative shift of the shoreline (i. e., uplift of the land relative to the sea) resulting from glacial rebound has been negligible and that uplift may have ceased altogether at the present time. In a separate study of raised marine features BIRKENMAJER (1958 a, p. 161; 1958 b, pp. 156–157; 1958 c, pp. 547–548; 1959, pp. 200–202; 1960 a, pp. 284–291; 1960 b, pp. 76–91; 1962, p. 39) employed his so-called "whale method". He assumed that whale bones found on raised beaches between 3 and 8.5 m above sea-level are the result of widespread hunting which started in the 17th century. Using the figure of 8 m, at which level many

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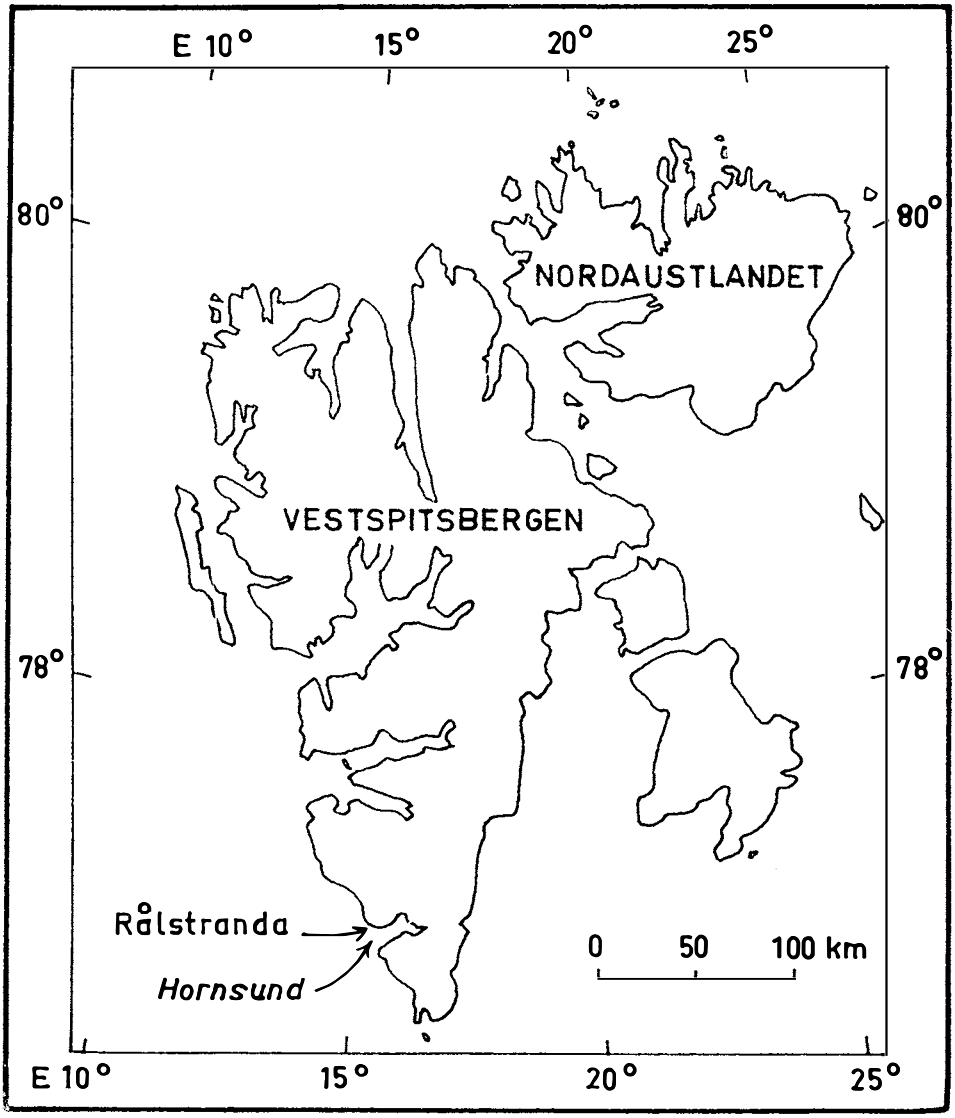

Fig. 1. *General map of Spitsbergen, showing the location of Hornsund.*

whale bones were concentrated near the Polish base at Hornsund, BIRKENMAJER obtained the extremely rapid rate of uplift of 2.3 m per century for the last 350 years.

Although a number of radiocarbon age determinations dealing with the problem of land uplift have been made on driftwood, shells, whale bones, and peat from various parts of the Spitsbergen archipelago since 1958, until recently no dates bearing on this problem were available from the Hornsund area. The two dated peat samples on which the present paper is based were collected by A. ŚRODOŃ, botanist of the Polish expedition in the summer of 1957. They were turned over to W. BLAKE, JR., who had been working on glacial geology elsewhere in Spitsbergen, and the age determinations were carried out by I. U. OLSSON as part of a series dealing with land uplift in the Spitsbergen archipelago.

Description of bog site and peat

The moss-bog investigated by ŚRODOŃ (1960, p. 13) is located on the northern shore of Hornsund, near the entrance to the fjord and on a part of the coastal plain known as Rålstranda (Fig. 2). The bog is situated about 0.5 km north of the first bay west of Worcesterpynten. The surface of the bog is approximately 12 m above sea-level. This elevation was determined by Paulin altimeter, and no tidal correction was made. The bog is near the inland edge of a marine terrace which is bordered on the north by an area of morainal debris. The terrace is truncated on its seaward (south) side by younger shore features, including the "3rd storm ridge". It is this storm ridge, whose surface is between 7.5 and 8.8 m above sea-level in the area to the east investigated by BIRKENMAJER, upon which many of the whale bones lie. JAHN (1959 b, p. 152), in a north-south profile in the general area of the bog, places the break in slope between the marine terrace and the moraine to the north at 12.8 m above sea-level, and the bog lies only a short distance south of this slope change.

An excavation into the bog revealed 60 cm of peat, of which the lower 30 cm were frozen. The stratigraphy from the surface downward, as given by ŚRODOŃ (1960, p. 13) is as follows:

0– 6	cm	contemporary peat
6–15	»	grey silt with plant remains
15–17	»	dark-brown peat, slightly decomposed
17–20	»	grey silt with plant remains
20–22	»	dark-brown peat, slightly decomposed
22–30	»	light-brown peat, unstratified; permafrost at a depth of 30 cm
30–55	»	light-brown peat, slightly decomposed and undulating in stratification
55–60	»	brown peat among moraine boulders

The surface vegetation at the Rålstranda bog is a hummocky moss-tundra with *Mnium* sp. (a moss), *Koenigia islandica*, *Ranunculus hyperboreus*, *Cerastium Regelii*, *C. alpinum*, *Cardamine pratensis*, *Cochlearia groenlandica*, *Chrysosplenium tetrandrum*, *Saxifraga rivularis*, *S. caespitosa*, *S. hirculus*, and *Salix polaris* (ŚRODOŃ, 1960, p. 9).

Two samples from the bog were chosen for dating. The first sample was taken from the basal peat at 55–60 cm depth. This brown peat is well compacted and is composed of coarse plant detritus, but a significant amount of inorganic matter is present also. An examination of a small part of this sample showed that it contains leaves of *Haplodon Wormskjoldii* R. BR. (determined by Prof. B. SZAFRAN), small fragments of *Salix* leaves, numerous tiny roots of two different terrestrial plants, and insect remains, consisting mainly of cocoons. According to Dr. M.

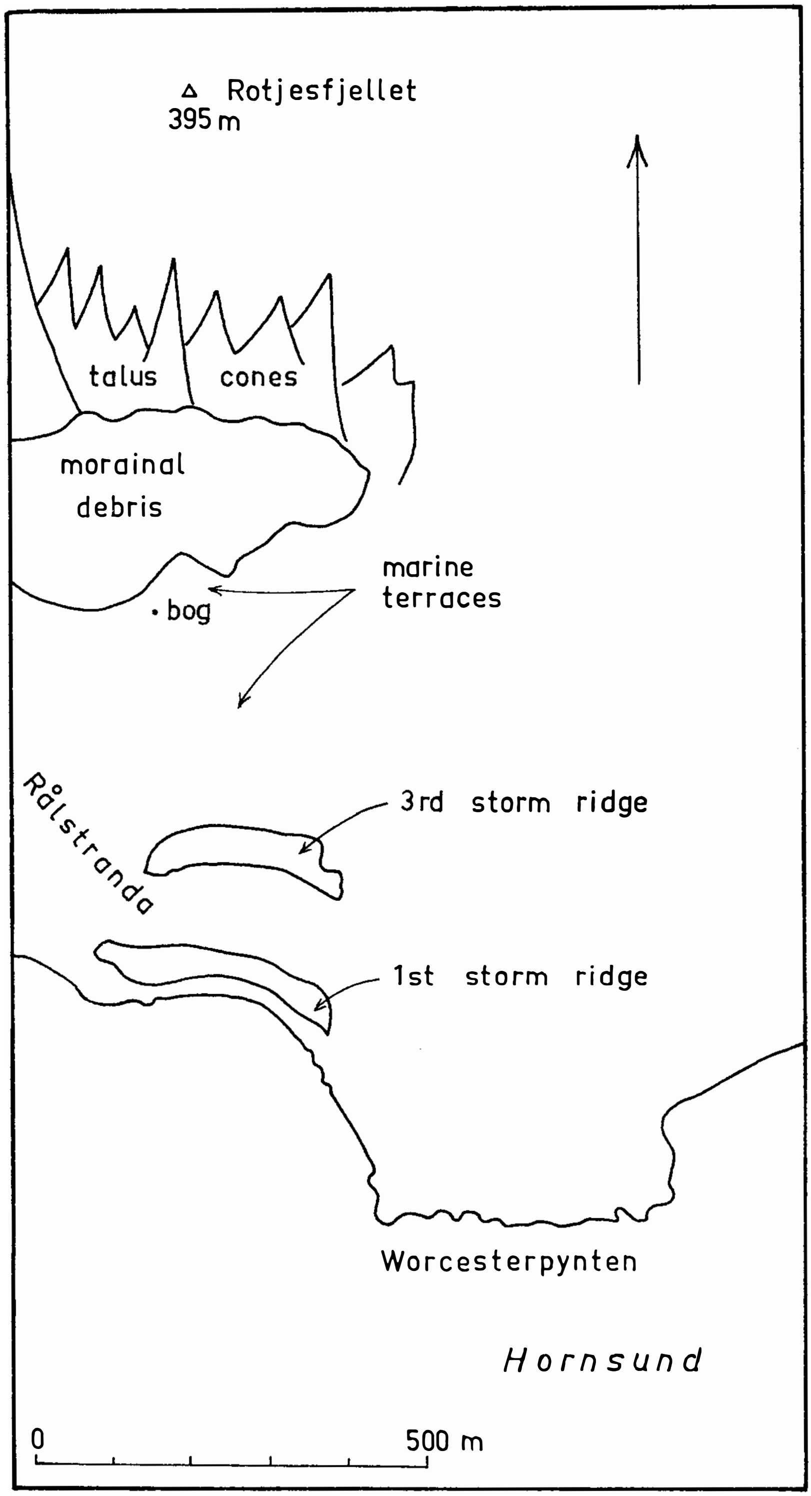

Fig. 2. *Map of a part of the north shore of Hornsund, showing the location of the Rålstranda bog* (adapted from BIRKENMAJER, 1960 b, Plate XII).

KUC, a bryologist who was with the Polish expedition to Hornsund in 1958, *Haplodon Wormskjoldii* is a common moss in the Hornsund area. It grows frequently on animal excrement and on the bodies of dead animals, as well as usually being common close to bird-rocks.

The second dated sample, from 54–55 cm depth, i.e., at the base of the slightly decomposed light-brown peat, is also well compacted and is richer in organic matter than the basal peat. This second layer of peat contains similar plant material, including fragments of *Salix* leaves. No modern roots reached down into either of these lower, frozen, peat layers.

An examination of the basal peat by Dr. J. TERASMAE and R. MOTT of the Geological Survey of Canada revealed that no diatoms, marine or otherwise, are present. Nor is there any other indication that the peat started to accumulate in salt or brackish water. The general absence of roots or woody parts of *Salix* in both samples suggests that some of the fragments of vegetation, including *Salix* leaves, may have been carried to the bog site by wind. However, it is believed that any windblown bits came from contemporaneous vegetation in the vicinity and hence have not affected the accuracy of the age determinations.

Radiocarbon dates

The results of the radiocarbon age determinations are listed in Table I. The two peat samples were boiled in dilute hydrochloric acid, washed in distilled water, treated with hot sodium hydroxide to dissolve the humus, washed again in distilled water, and finally acidified before being dried. The humus was precipitated with acid, and in one case there was enough humus for an age determination, although the gas had to be diluted.

Usually the humus fraction gives the same age as the insoluble part of the peat (OVERBECK *et al.*, 1957), but for a number of humus samples from areas with permafrost or traces of permafrost the ages of the two fractions do not agree within the limits of error (e. g., see OLSON and BROECKER, 1958, p. 598; OLSSON and KILICCI, 1964). In this case the apparent age difference between the two fractions is 360 years; i. e., larger than can be expected from the statistical errors.

The radiocarbon ages have been calculated using the commonly accepted half-life of 5570 years, although now a value of 5730 is believed to be more accurate (GODWIN, 1962, p. 984). In this case using the 5730 value would cause only slight changes in the results. The C^{13}/C^{12} determinations gave quite normal values, and corrections have been made for the small deviations in the ratios (OLSSON and KILICCI, 1964).

In addition the dates have been calculated on the assumption that the ratio between the concentrations of radioactive carbon atoms and stable carbon atoms in the atmosphere has remained constant for several thousand years and that the carbon dioxide used is taken from the air. However, it is well known that there have been deviations from the assumed constant value. One pronounced and rather well documented peak in the activity curve occurred about 500 years ago.

The implication is that the dates on both fractions of the upper peat sample are more likely to be too young than too old, and also that the age difference between the two fractions is probably less than that given in Table I. Few data are available regarding the activity 1400 years ago, but since the deviations in the ratio between the radioactive and stable carbon isotopes in the northern hemisphere have ranged up to ± 2 per cent (corresponding to ± 160 years) during the last 2000 years, the error must be increased if a factor covering this uncertainty is to be included. Thus we can only say that the lower peat sample is most probably more than 1100 years old.

Table I. *Radiocarbon dates on peat from Hornsund*

Sample material	Depth below surface	Uppsala dating number	Age, in years before 1950
Light-brown peat	54–55 cm	U–262	620 ± 80
Light-brown peat (humic fraction)	54–55 cm	U–275	260 ± 110
Brown peat (basal)	55–60 cm	U–261	1390 ± 70

Discussion

The presence of the 1400 year-old peat at an elevation of approximately 11.5 m is inconsistent with BIRKENMAJER's suggested rate of uplift of 2.3 m per century for the last 350 years, unless a recent *increase* in the rate of uplift has occurred. Instead, uplift relative to the sea (assuming a constant sea-level) at a rate of slightly less than 1 m per century would suffice to have raised the basal peat to its present elevation in 1400 years. Should the peat not be more than 1100 years old, uplift at a rate of slightly more than 1 m per century would have been sufficient. Furthermore, it does not appear that the peat started to accumulate until sometime *after* the terrace on which the bog is situated had emerged from the sea, i. e., at a time when the bog site was high enough and far enough from the shore to be protected from the damaging action of storm waves and sea ice. Thus it is possible that emergence has been taking place at an even slower rate.

Many more absolute dates on marine features around Hornsund are needed before details of the changing rate of uplift since deglaciation will be known. However, it has been shown further north in Vestspitsbergen (FEYLING-HANSSEN and OLSSON, 1959–1960, pp. 123–129) and in Nordaustlandet (the second largest island in the Spitsbergen group: see BLAKE, 1961 b, pp. 140–143; OLSSON and BLAKE, 1961–1962, pp. 59–62; BLAKE, 1962, pp. 275–278) that the rate of uplift has decreased with time, and there is no reason to believe that uplift in the Hornsund region has followed a different pattern. From their preliminary curve for central Vestspitsbergen FEYLING-HANSSEN and OLSSON (1959–1960, pp. 123, 127) concluded that uplift during the last 5000–6000 years had averaged 15–18 cm per century, and in Nordaustlandet, where the recent fluctuations of the shoreline are best documented, it has been possible to demonstrate that uplift during the last 100 to 160 years has not exceeded a few centimeters (BLAKE, 1961 a, pp. 104–109).

The dates reported in this paper, specifically that of 1390 $\pm$ 70 years for basal peat approximately 11.5 m above sea-level, lend support to the arguments of JAHN in favor of relatively slow uplift in the Hornsund region during the last few centuries.

Acknowledgements

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Climatological tables for Norway Station

(70° 30′S, 2° 32′W)

BY

TORGNY E. VINJE

Instruments and surface observations

The surface observations were taken every three hours starting at 0000 GMT. For the routine observations, we had quite ordinary instruments. The screen was a Norwegian type, specially constructed for high mountain stations. The walls and bottom consisted of double wicker-work which enabled the air to pass through. To increase ventilation when the wind speed was slight, a fan was mounted in one of the walls. The airstream produced was, however, too weak to reduce the radiation error to a reasonable degree, so it was necessary to use a ventilated Assmann psychrometer as well. This gave fairly reliable values for the temperature readings.

The difference in the temperature read on the screen thermometer and that read on the psychrometer is called the radiation error. In the table below the mean values of this error are compared with the mean values of the global radiation, G, and the wind speed. The upper part of the table refers to conditions when $G >$ 0.45 ly/min and the lower part represents readings when $0 < G < 0.45$ ly/min.

Mean wind speed, m/sec.	Mean radiation error, °C	Mean global radiation, ly/min.	Number of observations
1.5	1.95	0.86	21
3.6	1.17	0.78	48
7.1	0.49	0.82	57
13.3	0.37	0.80	24
1.5	0.48	0.12	10
3.9	0.50	0.16	26
6.7	0.25	0.15	44
11.6	0.16	0.24	11

It is seen from the table that the radiation error does not vanish even for quite high wind velocities. This may indicate that there is a upper limit for the speed of the air passing through the screen, and it may also mean that the mean temperatures for the summer can be a few tenths too high. This is because we did not as a rule use the Assmann psychrometer when the wind speed was fairly high. For the summer months the maximum temperatures in all probability are encumbered with considerable radiation errors. The maximum global radiation at Norway Station is about 1.4 ly/min, and for light winds we get from an extrapolation (by means of values given in the table above) a respective error which is about 3.5° C.

The air pressure was read on a Fuess station barometer and during the stay in Antarctica this instrument was several times compared with a Wild-Fuess normal barometer.

The wind speed was recorded with an ordinary Norwegian cup-anemometer placed at the height of 10 m in the meteorological mast.

For the radiation measurements an Ångstrøm compensation pyrheliometer was used for the calibration of the Moll-Gorczynski pyranometers. From a Schulze radiometer we derived the net radiation. The long-wave radiation calibration factor was found by means of the temperature difference between the snow surface and the instrument. It was found to be equal to the calibration factor derived for the diffuse shortwave radiation.

The radiation instruments had to be inspected at ordinary synoptic hours due to the formation of hoar frost on the domes. The hoar frost was easily removed from the pyranometers by brushing the domes with antifreeze. The radiometer was cleaned by the warm hand. When too much rime had formed on the sphere of the sunshine recorder, it was replaced with another which had been kept indoors. The new sphere remained clean for several hours.

Norway Station lies 56 m above sea level and ca. 34 km from the coast line. The surroundings are completely flat except for the nearly 400 m high ice-rise 8 km towards north west.

Climatological tables for Norway Station (70°30′S, 2°32′W)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Mean station pressure in millibars												
1957				981.8	987.6	980.8	977.1	983.7	982.4	979.1	986.7	989.4
1958	979.3	987.2	977.6	983.9	984.7	985.1	981.7	976.1	977.9	974.8	980.0	977.1
1959	981.6	977.5	978.4	980.2	984.2	984.1	977.9	983.1	978.2	977.1	971.8	986.5
Mean daily temperature in ° C												
1957				−16.3	−22.9	−17.6	−26.7	−27.0	−28.5	−19.3	−12.7	− 5.3
1958	− 3.5	− 9.3	−11.6	−20.3	−22.6	−23.2	−25.1	−26.6	−25.2	−15.4	− 9.6	− 7.5
1959	− 4.6	− 8.0	−16.0	−15.8	−18.0	−22.3	−21.6	−23.5	−28.5	−18.3	−11.9	− 6.1
Mean daily temperature range												
1957				7.9	8.9	8.4	8.2	11.2	11.4	11.6	10.5	8.4
1958	6.9	8.3	6.0	9.8	11.8	11.5	10.6	8.8	10.9	8.6	9.0	9.2
1959	8.2	6.9	11.2	9.3	10.2	9.8	8.6	8.6	10.7	12.3	9.4	9.0
Maximum temperatures												
1957				− 6.2	− 9.9	− 9.1	−11.8	− 8.8	−10.8	− 4.0	− 0.1	0.5
1958	2.3	0.6	− 1.0	− 8.7	− 7.7	− 9.8	−10.3	−14.2	− 2.9	− 0.8	− 0.1	− 0.2
1959	5.0	0.9	− 2.0	− 4.6	− 2.0	− 8.0	−10.6	−10.9	−12.0	− 3.5	− 3.2	2.5
Minimum temperatures												
1957				−31.1	−41.3	−34.2	−45.7	−47.3	−46.0	−35.0	−27.0	−15.4
1958	−12.6	−23.9	−27.6	−38.3	−40.6	−43.4	−42.4	−44.6	−43.0	−38.2	−23.5	−21.4
1959	−16.0	−24.5	−29.5	−30.4	−35.3	−47.1	−38.8	−43.0	−44.1	−38.8	−29.3	−19.4
Mean wind speed, m/s												
1957				7.7	7.6	12.3	8.0	5.8	5.5	5.7	5.8	6.3
1958	8.1	4.9	11.8	7.8	5.8	7.2	8.0	8.8	5.2	9.4	5.5	5.4
1959	7.2	9.9	6.6	9.4	9.9	7.2	10.7	9.8	6.8	7.3	8.2	7.0
Maximum wind speed, 10 min average												
1957				23.3	27.5	32.1	30.6	23.3	21.8	24.4	16.0	20.2
1958	22.8	13.5	29.0	22.3	15.5	23.3	43.5	36.3	20.7	30.6	27.5	15.0
1959	26.9	32.1	23.8	31.0	35.8	25.9	32.6	35.2	22.8	23.8	24.9	17.6
Frequency of wind speed above 15 m/s in per cent												
1957				6.7	9.3	24.2	15.3	7.7	2.5	6.9	0.0	3.6
1958	8.1	0.0	29.4	12.9	0.0	5.8	12.5	18.1	6.3	18.5	6.7	0.0
1959	6.0	25.0	5.6	17.1	22.2	17.5	23.0	18.1	5.4	7.7	7.5	1.6
Mean cloudiness in octas												
1957				6.0	5.0	6.9	5.0	5.0	4.0	3.9	5.0	5.1
1958	6.1	5.8	6.6	5.1	4.5	5.4	5.3	5.8	5.2	6.1	5.2	5.6
1959	5.6	6.4	3.8	5.7	5.8	5.0	6.0	5.3	3.9	5.6	6.0	5.4
Global radiation in ly/month												
1957				1410	99	0	34	886	4680	11846	18786	23569
1958	20025	12147	5668	1751	143	0	22	795	4146	9893	18371	23554
1959	20204	11577	7238	1920	141	0	24	731	4479	11129	17523	23259
Diffuse radiation in ly/month												
1957					90	0	26	506	2178	4376	10225	12374
1958	13225	7745	4381	941	74	0						
1959				1233	114	0	22	606	2400	6264	11769	13163
Sunshine in h/month												
1957						0	4.6	54.5	182.3	316.7	346.5	379.9
1958	233.3	184.4	71.5	88.1	31.3	0	1.6	53.7	127.2	146.1	297.4	328.2
1959	322.5	170.8	226.7	90.5	12.1	0	3.2	47.2	167.4	232.1	240.7	355.1
Net radiation in ly/month												
1958						−939	−926	−652	−611	50	724	2276
1959	1928	905	−710	−608	−585	−845	−1044	−851	−904	48	760	1782

Noen resultater av bremålinger i Norge i 1963

AV

OLAV LIESTØL

Abstract

On the Storbreen glacier the accumulation is measured every year in about 300 points along fixed lines evenly spread over the 5.42 km^2 (1963) glacier surface. Up to 600 points have been used in selected years, but from experience gained the system of less than 300 points has proved satisfactory for the construction of accumulation map as in Fig. 1. The total accumulation was 5.2 · 10^6 tonns or 96 g. pr. cm^2 on average. This is the lowest accumulation in the 15 years of observations the average is 136 g. pr. cm^2.

The ablation was measured at 27 stakes eight times during the summer. The total amount of ablation was 11.6 · 10^6 tonns or 214 g. pr. cm^2 on average. This is a relatively large ablation figure, the average for the years 1948–63 is 176 cm. The material balance was strongly negative, with an average mass loss of 118 g. pr. cm^2.

On the Hardangerjøkulen glacier which is 77 km^2 the westfacing arm (Rembesdalsskåki) with its firn area was investigated for the first time. Due to very difficult conditions, mainly a badly developed summer crust from the cold summer of 1962, complete accumulation measurements could not be made. The total ablation, measured at the stakes and also based on calculations was 270 g. pr. cm^2. The material balance was negative, with an average mass loss of ca. 140 cm.

The results of the fluctuations of different glacier tongues is given in table 1 (p. 192).

I 1963 ble Norsk Polarinstitutts breundersøkelser utvidet til også å omfatte målinger av materialhusholdningen på Hardangerjøkulen. Dette ble gjort etter en anmodning fra Statskraftverkene i samband med planleggingen av utbyggingen av Osa-Sima vassdragene.

På Storbreen ble de tidligere målinger av materialhusholdningen fortsatt. Den startet som vanlig i begynnelsen av mai med en undersøkelse av siste vinters akkumulasjon. Ved de første års undersøkelser på Storbreen ble akkumulasjonen bestemt ved meget detaljerte målinger av snødybden. Opptil 600 sonderingspunkt jevnt fordelt over breen ble benyttet. Det har imidlertid vist seg at langt færre punkt er tilstrekkelig for måling av akkumulasjonen. Fordelingen av snøen på breen er nemlig meget lik fra år til år, selv med tilsynelatende svært forskjellige klimatiske forhold i løpet av vinterhalvåret, og med store forskjeller i den totale nedbør. Det mønster som snøakkumuleringskartene viser blir derfor meget likt fra år til år. I de senere år er derfor målingene forenklet ved at sonderingene er foretatt langs noen få bestemte ruter der erfaringsmessig akkumulasjonen er representativ for breen. Snøens egenvekt ble målt i to sjakter henholdsvis i 1570

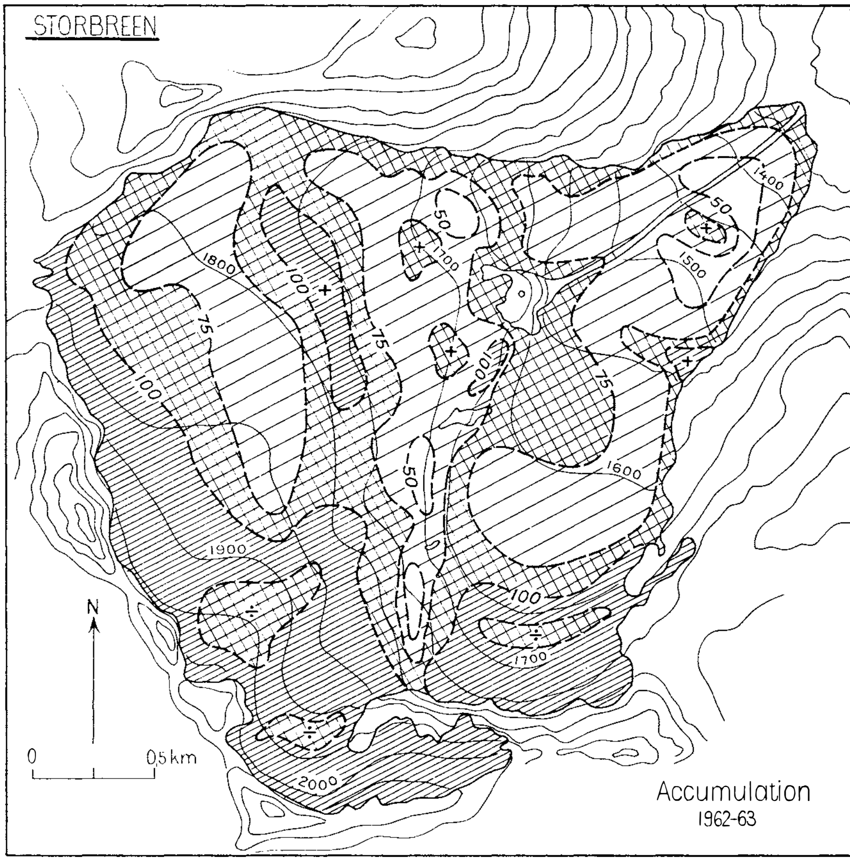

Fig. 1. Akkumulasjonskart over Storbreen i Jotunheimen.

Accumulation map of Storbreen in Jotunheimen.

og 1870 m o. h. Fig. 1 viser snøens fordeling omregnet til g pr. cm^2. Akkumulasjonen startet meget tidlig høsten 1962. Allerede 3. august begynte breen å vokse. Det var noenlunde normal nedbør utover høsten, men fra november til mai var den usedvanlig liten.

Totalt ble det på Storbreen akkumulert 5,2 · 10^6 tonn svarende til 96 g pr. cm^2. Dette er den lavest målte akkumulasjon i de 15 år målingene har pågått. I gjennomsnitt har akkumulasjonen vært 136 cm (1948–63).

Ablasjonsstengene ble sommeren 1963 avlest i alt 8 ganger, siste gang 10. oktober da breen var dekket med nysnø. Totalt var ablasjonen 11,6 · 10^6 tonn svarende til 214 g pr. cm^2. Dette er en relativt stor ablasjon (middelverdien for årene 1948–63 er 176 g pr. cm^2). Den kan hovedsakelig tilskrives den høye gjennomsnittstemperatur, som for tiden 1/5 til 31/9 var 1,3° over normalen for den undersøkte 15 års periode. En annen medvirkende faktor var også den unormalt lave akkumulasjon som forårsaket at is og eldre snø med lavere albedo kom frem tidligere enn normalt, slik at ablasjonen på grunn av stråling ble større.

Den usedvanlig lave akkumulasjon sammen med høy ablasjon, førte til at

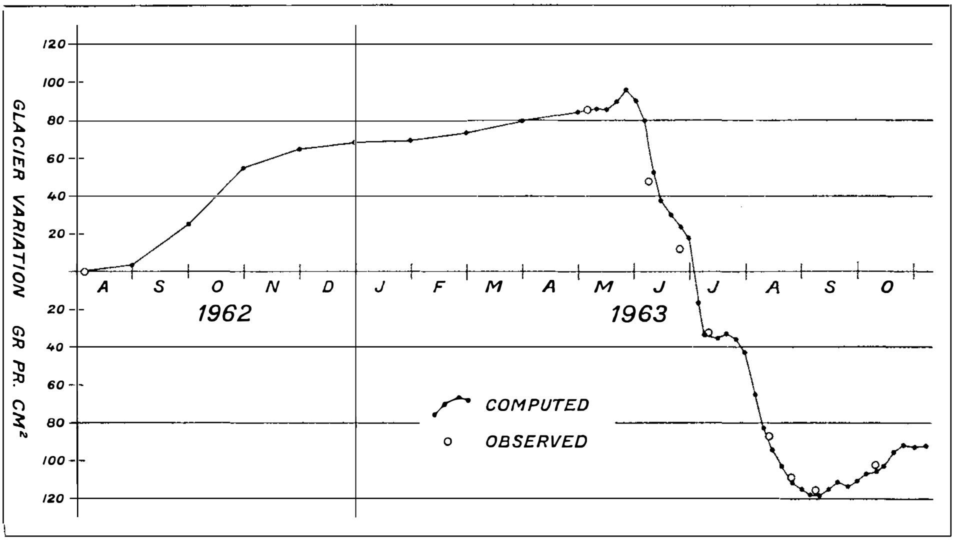

Fig. 2. Diagrammet viser variasjonen i bremassens volum med tiden regnet i g pr. cm².

Diagram showing net mass flux as functions of time.

materialbalansen viste et stort underskudd. Minkingen ble 6,4 · 10^6 tonn, svarende til 118 g pr. cm².

Fig. 2 viser variasjonen i brevolumet omregnet i g pr. cm² gjennom budsjettåret 1962–63. For å få et mer detaljert bilde av variasjonen for sommermånedene, er der også tatt med beregnete verdier av brevolumet. Verdiene er beregnet av OLAV DYBVADSKOG og forfatteren på grunnlag av direkte observasjoner på breen sammenholdt med registreringer fra nærliggende meteorologiske stasjoner. Hvert døgn er beregnet for seg, og summert til 5 dagers perioder. All nedbør som faller ved temperaturer under +1,5° er regnet som snø. Dette er gjort for hvert 100 m høydeintervall og siden integrert over hele breen. Som ablasjonsfaktor for graddøgnet er brukt 0,45.

Fig. 3 viser skjematisk hvorledes materialhusholdningen har vært på Storbreen i 1962–63. Av beregningene kan man finne at den høyde snøgrensen må ha for at breen skal være i likevekt er 1690 m o. h. I den tid målingene har foregått på Storbreen har den ligget på 1770. Av diagrammet for 1963 ser man at den ligger på ca. 1900 m o. h. Dette vil si at bare de aller øverste områder har bevart noe av siste vinters snø.

Hardangerjøkulen er ifølge de siste kartleggingsarbeider 77,5 km². Den er således nr. 5 i størrelse av våre isbreer. Som bretype må den klassifiseres som en kåpebre, eller som en typisk representant for den norske bretype.

Fjellgrunnen som danner underlaget for breen er en rest av de kaledonske skyvedekker som øverst består av gneis og gneisgranitt. Dette hårde dekke er av den glaciale erosjon oppdelt i flere daler og botner som hver for seg drenerer sin del av breområdet. Dette underliggende relieff gjenspeiler seg til en viss grad i breens overflateformer til tross for at breens utjevnende virkning er ganske stor. På den

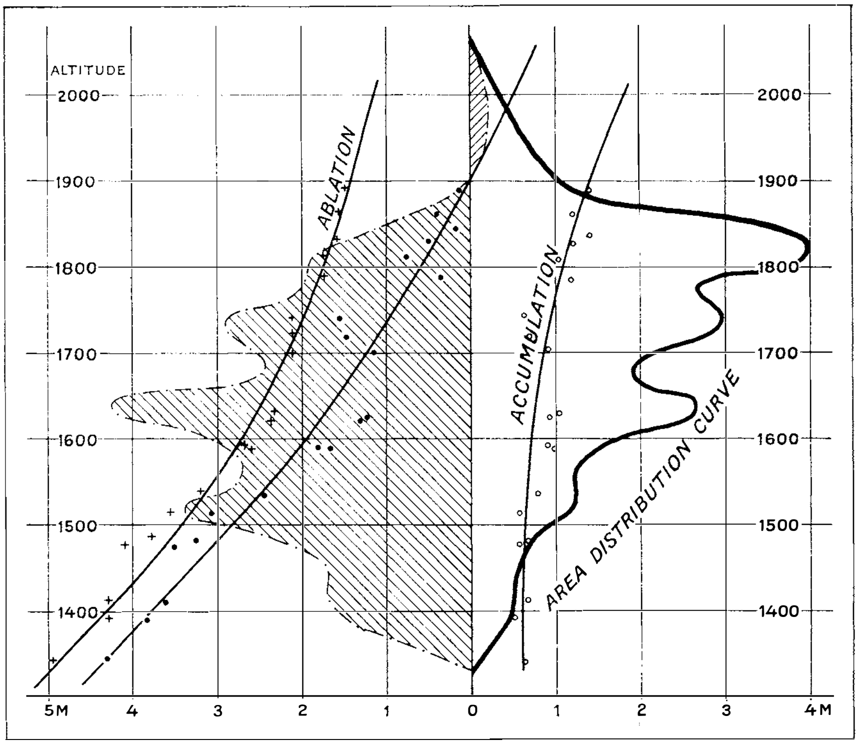

Fig. 3. Diagrammet viser materialhusholdningen på Storbreen 1962–63. Kurvene representerer akkumulasjon, ablasjon og breens øking og minking i relasjon til høyden over havet. Det skraverte areal angir volumet av breens øking og minking.

The diagram shows the regime of Storbreen glacier in the year 1962–63. The curves represent accumulation, ablation and the variation in the glacier mass with height. The shaded area represents the volum of increase and decrease of the glacier during the budget year.

vide jevne forsenkning som dreneres ned til Rembesdalsskåki fra toppen av jøkulen, ble der av Geologisk Institutt i Bergen foretatt en seismisk dybdemåling. Langs et ca. 3 km langt profil ble der registrert dyp på over 350 m i den midtre del av forsenkningen. Det er med andre ord en veldig botn i den sentrale del av Hardangerjøkulen.

Av hele Hardangerjøkulens areal dreneres 23 % eller 17,8 km² til Rembesdalsskåki. I Rembesdalsskåkis nedslagsområde ble det 21.–25. april boret ned 26 stenger for senere måling av ablasjon og akkumulasjon. Dessverre ble det ikke, på grunn av transportvanskeligheter, satt ned stenger på den laveste del av bretungen. Tallene for dette område må derfor ekstrapoleres. En feil i denne ekstrapolasjon vil imidlertid ikke slå særlig ut i det samlede budsjett da området er mindre enn 10 % av det samlede areal. Normalt vil man om våren kunne finne vinterens akkumulasjon uten bruk av stenger. Man graver seg da ned til siste høsts breoverflate som gjerne er vel markert med støvlag og grovere krystallstruktur. Sommeren og høsten 1962 var imidlertid i høy grad unormal. Allerede i begynnelsen av august kom det store snøfall, og høsten vekslet stadig mellom

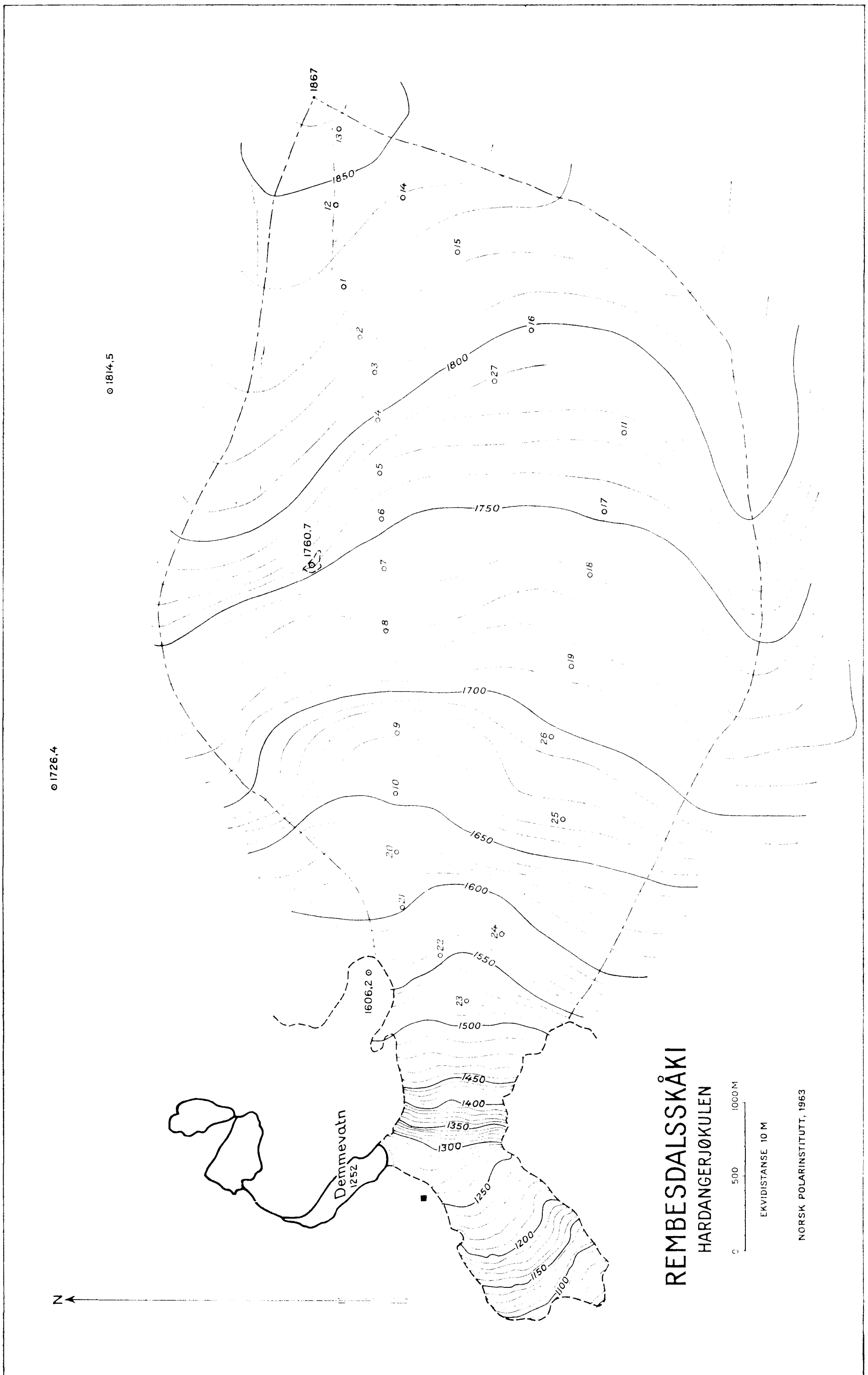

Fig. 4. Kartet er basert på forfatterens målinger fra 1963 og viser den del av Hardangerjøkulen som dreneres av Rembesdalsskåki.

Map showing the part of Hardangerjøkulen drained by Rembesdalsskåki.

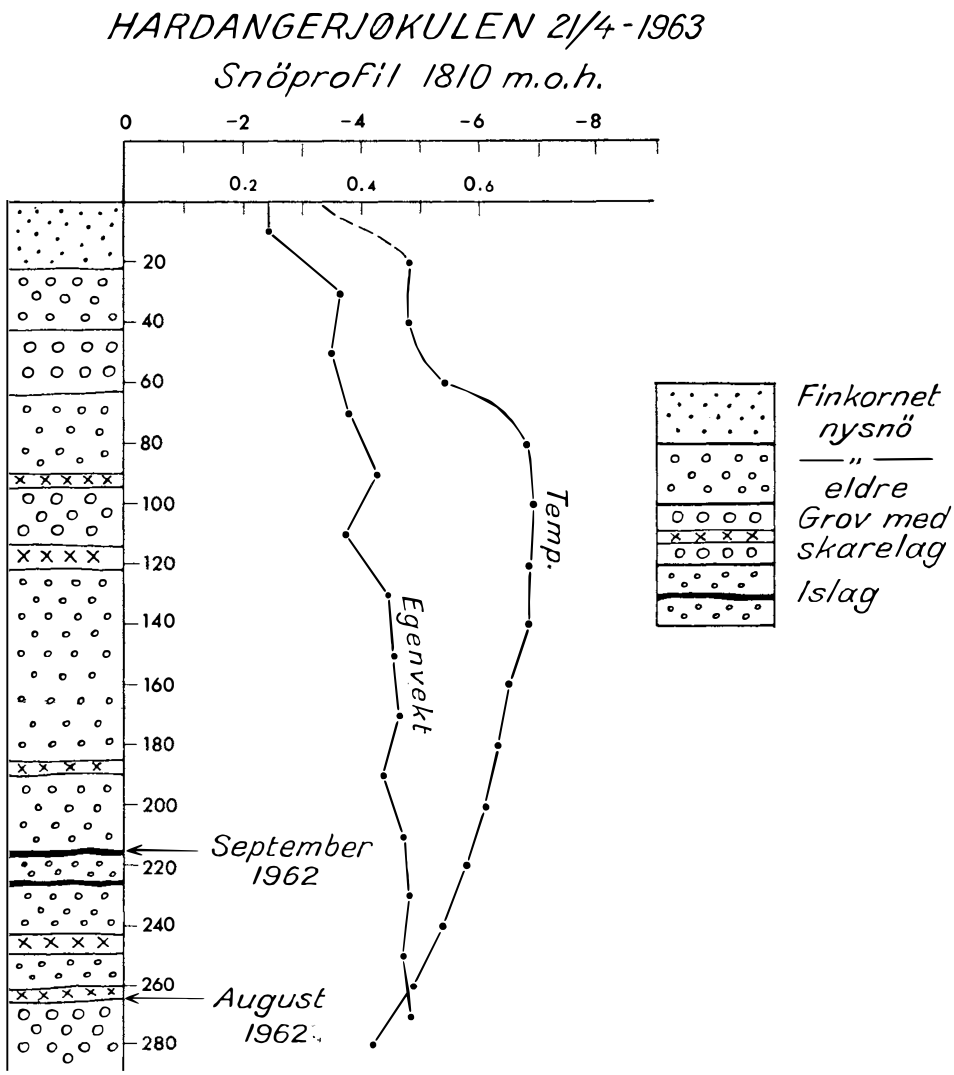

Fig. 5. Diagrammet viser et snøprofil fra Hardangerjøkulens øvre del.

Diagram showing a snow profile from the upper part of Hardangerjøkulen.

smelting og akkumulasjon. Det ble derfor ikke noe skarpt skille mellom snøen fra 1961–62 og 1962–63. De beregninger som er gjort over snøakkumulasjonen er derfor usikre.

Med beregnet tillegg av den snømengde som falt etter målingene i slutten av april, er den totale akkumulasjon 1962–63 beregnet til $21 \cdot 10^6 \text{ m}^3$, svarende til 115 gr./cm^2 i gjennomsnitt. Dette er betydelig under det normale som etter de foreløpige beregninger kan settes til 170 cm.

Fig. 4 er et kart av den aktuelle del av Hardangerjøkulen basert på målinger i mai 1963. Ablasjonsstengenes posisjon og nr. er angitt. I diagrammet Fig. 5 er snøens egenvekt avsatt som funksjon av snødybden i et profil fra den sentrale del

Fig. 6. Diagrammet viser materialhusholdningen på Rembesdalsskåki, en vestlig utløper fra Hardangerjøkulen.

Diagram showing the regime of Rembesdalsskåki, a westfacing outlet of Hardangerjøkulen.

av breen. Som ovenfor nevnt er det vanskelig for dette første år å sette opp noe fullstendig budsjett for materialhusholdningen på grunn av de vanskelige akkumulasjonsmålinger. Ved en feil var der ikke som vanlig montert et isolerende materiale i ablasjonsstengenes nedre ende. Dette har sannsynligvis forårsaket en synkning av stengene i det øverste område slik at de målte verdier er blitt for små. På samme måte som er nevnt for Storbreen kan imidlertid ablasjonen beregnes. Dette er gjort ved hjelp av den meteorologiske stasjon Slirå som ligger ved Bergensbanen, 1300 m o. h., og bare 8 km fra Hardangerjøkulen. Resultatet viser en meget god overensstemmelse med observasjonene på de midtre og nedre stenger på Rambesdalsskåki. Diagrammet Fig. 6 er en budsjettoppstilling for det målte breområde. Som man vil se har der i 1962–63 likesom på Storbreen, vært et betydelig underskudd i materialbalansen.

Som resultat får man således på denne del av Hardangerjøkulen en akkumulasjon på 115 cm, en ablasjon på 255 cm og et derav følgende underskudd på 140 cm.

Den årlige måling av brefrontenes fram- eller tilbakegang er foretatt ved i alt 17 breer. Resultatet sees i nedenstående tabell:

Tabell 1. *Forandringer i brefrontenes stilling 1962–63.*

	Målt forandring i m:		
	1960–61	1961–62	1962–63
Jotunheimen			
Storbreen	– 25	– 5	– 20
Leirbreen	– 7	– 2	– 6
Bøverbreen	– 13	x	– 48 (2 år)
Storgjuvbreen	– 36	x	x
Veslegjuvbreen	– 2	0	– 6
N. Illåbreen	– 20	x	x
S. Illåbreen	– 16	x	x
Styggbreen	– 8	x	– 22 (2 år)
Tverråbreen	– 23	– 4	– 24
Hellstugubreen	– 14	– 10	– 12
Styggedalsbreen	– 10	– 6	– 11
Jostedalsbreen			
Åbrekkebreen	+ 7 (2 år)	+ 3	x
Briksdalsbreen	+ 6	– 18	– 11
Stegholtbreen	– 17	– 35	– 51
Lodalsbreen	– 51	– 7	– 35
Fåbergstølbreen	– 62	– 28	– 43
Nigardsbreen	– 55	– 30	– 65
Austerdalsbreen	– 27	– 21	– 21
Folgefonni			
Bondhusbreen	+ 3	– 8	x
På Møre			
Trollkyrkjebreen	– 7	0	– 11
Veslelangsdalsbreen	– 4	0	– 10
Finnebreen	– 1	0	– 9
Svartisen			
Østerdalsisen	– 10	– 12	x

(x betyr at ingen observasjon foreligger)

Som man kunne vente etter en såvidt høy sommertemperatur, er tilbakegangen det siste år i gjennomsnitt større enn forrige år. Dessverre ble der ikke i 1963 tatt målinger av Åbrekkebreen, men det er sannsynlig at også den er på tilbakegang etter å ha gått frem i over fem år.

On the cooling power in Norway

BY

TORGNY E. VINJE

In 1957–58 measurements of the cooling power of wind and temperature on four kata thermometers were made at Norway Station, Antarctica (VINJE 1961). For a given temperature and wind speed the thermometers gave not the same value of the cooling power, (H mcal/cm²/sec.). Taking the mean values of the four instruments as a reference, one finds that the individual values in mean deviate as much as $\pm$ 20 %. However, great differences have also been found between the various kata formulas derived from measurements taken in Europe. Disregarding one of the oldest formula, one finds that the individual deviation from the mean values also here amounts to about $\pm$ 20 %. There is thus an agreement between the results obtained in Antarctica and in Europe and this suggests that comparisons of quite different climates can be done, if one uses the cooling power derived from one and the same formula. It is an advantage (for the calculations) to use wind and temperature observations from the international standard heights. From the measurements taken in Antarctica we find

$$H = (0.46 + 0.08\ V)\ (36.5 - t)\ (\mathrm{mcal/cm^2/sec})$$

where V refers to the wind speed at 10 meter and t gives the temperature (° C) at the 2 meter level. The constant 36.5 is the temperature of the kata thermometer.

The cooling power has often been used as a relative comfort index for man. One has, however, not yet agreed upon a special scale. This might perhaps be due to the great differences in the formulas applied. In the last years the formula of SIPLE and PASSEL (1945) has been used to some extent, with the argument that it gives values of the cooling power which are in better agreement with the actual heat loss from the human body. (See e. g. WILSON (1963).) This formula is based on measurements taken with a special equipment in Antarctica and it gives less cooling power than the kata thermometers. Compared with the expression given above, the difference varies from 10–60 %. However, STONE (1943) indicates that the heat loss from the kata thermometer is from 30 to 1000 % (!) greater than that from the human body. According to this the SIPLE and PASSEL formula therefore represents a slight improvement, when the aim is to find a heat loss comparable to that from the human body. As we will consider the cooling power as a climatic index of the combined effect of wind and temperature on a defined in-

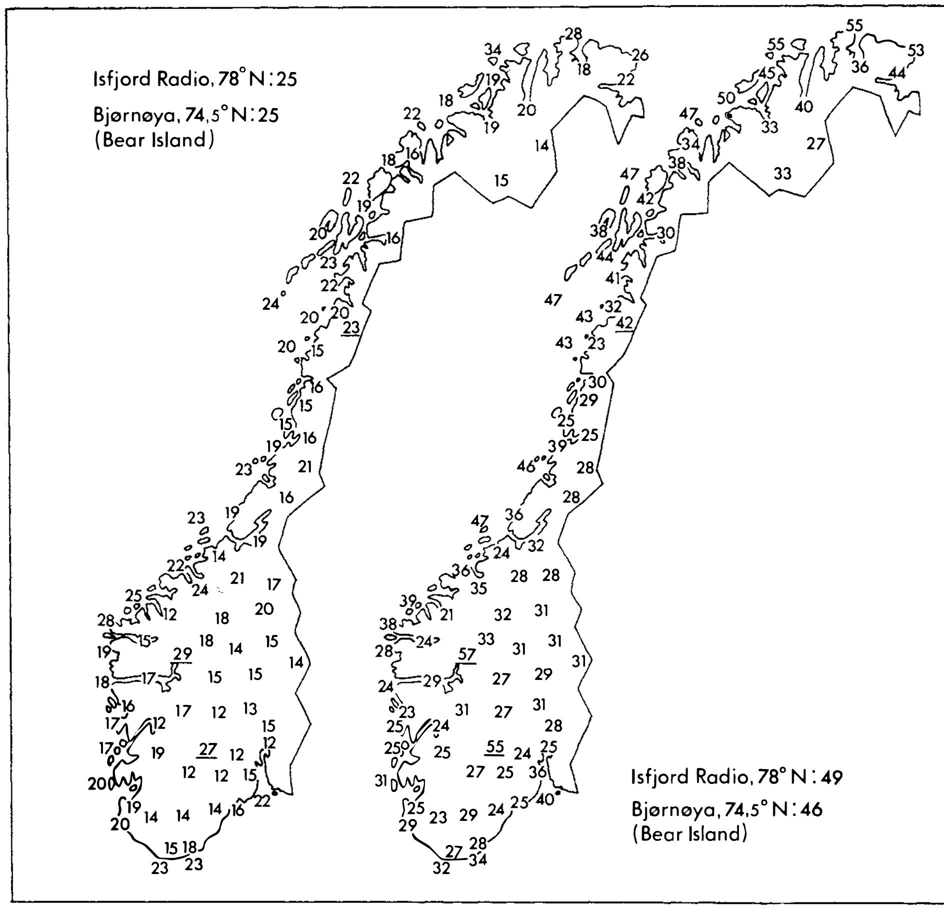

Fig. 1. *The monthly mean cooling power in mcal/cm²/sec, for July (left) and for January (right). The under-lined figures represent high mountain stations.*

strument, and as moreover the kata formula is shown to be similar in quite different climates, we have applied the expression given above in the following calculations.

The monthly mean values of the cooling power have been calculated for different places in Norway for the months January and July (1963). For Bjørnøya and Isfjord Radio the figures represent the mean for three years (1956–57–58). We have used the data given in "Klimatisk oversikt" (1963) and "Norsk Meteorologisk Årbok" (1957–58–59). The results are shown in Fig. 1. The highest mean cooling power, both for the summer and the winter, is found along the coast and at the high mountains stations. It is noticed that many of these stations have a greater index than the stations at Svalbard. The highest index for July, 34, is found at the coast of Northern Norway. The cooling power found here can be compared with those found at the Antarctic Peninsula. In Norway during the summer the lowest index is found at places lying at some distance from the coast. The minimum value, 12, is found in Oslo and in the surrounding areas, and also in some fjords in the western part of Norway. For January the minimum values,

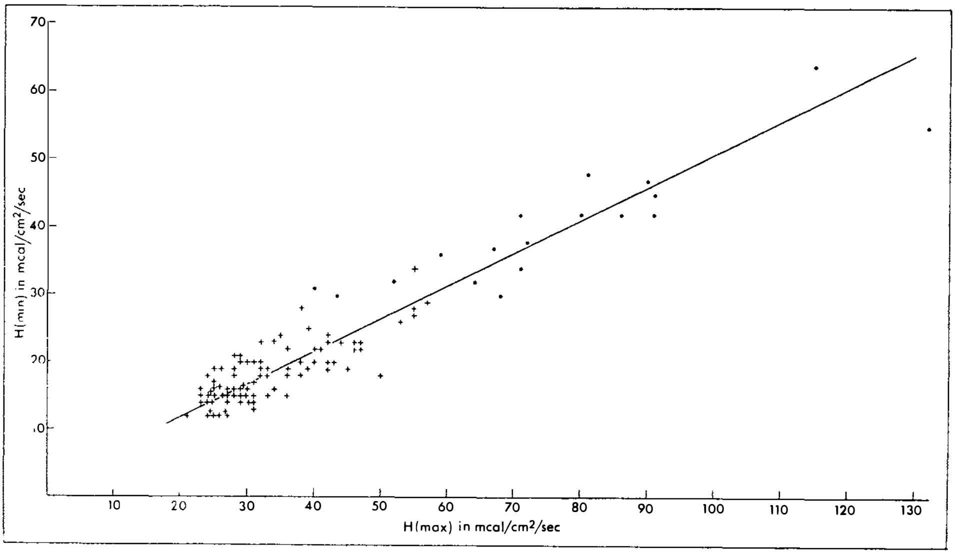

Fig. 2. *The monthly mean cooling power for January, H (max), represented with respect to the monthly mean cooling power for July, H (min).*

21–23, in Western Norway, are only slightly lower than the indexes for the south eastern part of the country. The lowest cooling power for the winter month, 21, is found in Tafjord (north Western Norway). This place also has a relatively low index for the summer month. It is otherwise seen that the cooling power on Finnmarksvidda (central part of Northern Norway) is about the same as in the central parts of Eastern Norway, for both July and January. For the sake of comparison it can be mentioned that the highest monthly mean value of the cooling power in Antarctica was found to be 132 mcal/cm²/sec. This value was calculated for some stations on the coast of Adelie Land where the annual mean wind speed amounts to about 20 m/sec.

The mean cooling power for January and July will generally give the maximum and minimum monthly values for the year. We will shortly consider the relation between these two figures, which we have denoted H (max) and H (min), respectively. For Norway we have calculated the values for 85 stations, indicated on Fig. 1, and for Antarctica for 18 stations (Vinje 1961). H (max) is represented in relation to H (min) in Fig. 2. It is natural that there is a quite close connection between the maximum and minimum values of the cooling power. As the linear correlation coefficient here is as high as 0.94 our calculations indicate that the mean annual range of the monthly means of the cooling power can, with a good approximation, be determined by one and the same *linear* equation for quite different climates. Taking the arithmetic mean of the two equations for the lines of regression, we get

$$H\,(\text{min}) = 2 + 0.48\ H\,(\text{max}) \qquad (\text{mcal/cm}^2/\text{sec}).$$

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Fra et besøk på Bouvetøya

AV

TORBJØRN LUNDE[1]

Abstract

Bouvetøya, the Norwegian island at 54° 26′ S, 3° 24′ E, is the southernmost island on the Mid-Atlantic ridge. The island covers an area of 50 km² of which 95 % is covered by an ice-cap, that disperses from the crater edge at an altitude of 935 m and down to sea level (Fig. 1).

From March 29 to April 2 1964 a joint South African and English expedition with totally three helicopters was at Bouvetøya. The author followed the South African ship as a glaciologist. The aim of the South Africans was to find possible sites for a future meteorological station.

On the west side of the island a new area nearly 2000 by 500 m is originated by volcanic eruption between January 1955 and January 1958 (Figs. 2 and 3). Probably as a result of earthquake during the eruption a landslide of considerable dimension has filled up the area between the volcano and the main island. Aagaardbreen has thus nearly disappeared during this process.

During a visit on April 2, the only plant specimen found was a green, soft moss. Of mammals there were sea elephants and fur seals and of birds we saw rockhopper- and chin stripe penguins, a few skuas and petrells – the last ones are numerous at the steep cliffs on the south side of the island.

The accumulation on the eastern ice slope is probably not very heavy – most likely much of the snowfall is transported directly into the sea. Streams which came out underneath the glacier, indicated a considerable ablation. It is believed that the firnline this year was at least at an altitude of 200–300 m. There is probably considerable difference in the state of the glacier from year to year, and there is reason to believe that the budget of the glacier for 1963/64 was much below balance.

The only possible sites for a manned station are: Wilhelm II Platå, Rustadkollen, and some 2 km from the east coast. All these places are on the ice cap and can only be reached by helicopter. As the cloud level normally is low and the wind speed high, helicopter operations would be very difficult.

It is believed that after the first one or two years, it will take a lot of doing to get the necessary staff for such a station, for a year at Bouvetøya will be more unpleasant than at any other place known to the author.

Bouvetøya ligger på 54°26′ S, 3°24′ E. Den er den sørligste av de vulkanske øyene på den midtatlantiske ryggen som begynner med Jan Mayen og Island i nord.

Bouvetøya er ca. 9,5 km lang og 7,5 km bred og dekker et areal på 50 km² (Fig. 1). Maksimum 2,5 km², eller 5 % av øyas areal er bart land, resten er dekket av en kåpebre som siger ned i alle retninger fra krateret, hvis kanter når opp i en høyde på 935 m. En så total glasiasjon på en så lav bredde kjennes ikke fra noe annet sted på kloden.

[1] Mandal, Norge.

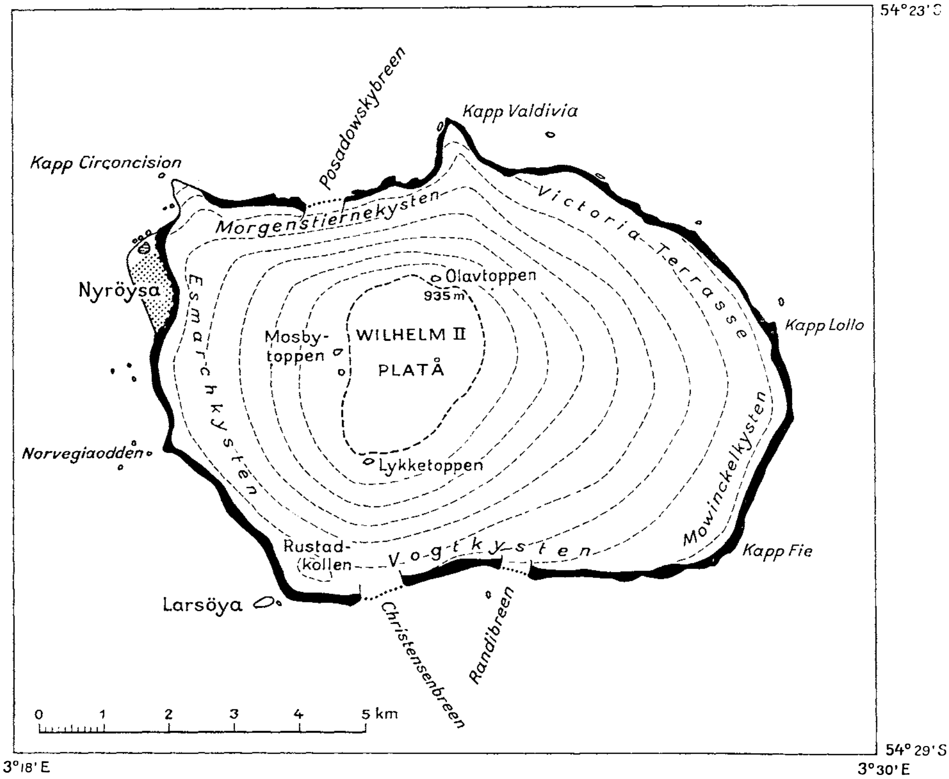

Fig. 1. Bouvetøya etter sørafrikansk radarkart 1955, norsk radarkart 1958 og egne iakttagelser 1964.

Bouvetøya from South African radar-map 1955, Norwegian radar-map 1958 and my own observations.

Rundt den austlige delen av det sørlige Atlanterhav finnes det bare meteorologiske stasjoner i Sør Afrika, Marion Island, Dronning Maud Land og Gough Island. Diagonalene i denne firkanten er av størrelsesorden 4000 km og det er klart at en meteorologisk stasjon på Bouvetøya, som ligger nær sentrum i dette området, ville være av overmåte stor betydning for værvarslinga på den sørlige halvkule. I den hensikt å utforske mulighetene for opprettelsen av en meteorologisk stasjon var en sør-afrikansk og en engelsk ekspedisjon med tilsammen tre helikoptere ved Bouvetøya i tidsrommet 29. mars til 2. april 1964. Forfatteren fulgte med det sør-afrikanske skipet som glasiolog.

Den 2. april var vi i land på den nye flaten på vestsida av øya (Fig. 2). Det ble konstatert at denne flaten er dannet vesentlig ved et vulkansk utbrudd i tidsrommet mellom januar 1955, da en sør-afrikansk ekspedisjon var ved øya, og januar 1958, da flaten ble fotografert fra et amerikansk helikopter. Den nye vulkanen er bortimot 2000 m lang og 500 m brei, dens største høgde er ca. 40 m. Det er en uvanlig dannelse der blokkene ligger hulter til bulter og det er absolutt umulig å spore noen spesiell lavastrøm, enn si krater (Fig. 3). Dette kommer trolig av at utbruddet har foregått under vann, – noe som blant annet vises på en del knauser med istykkersprengt putelava, forøvrig de eneste bergartene som

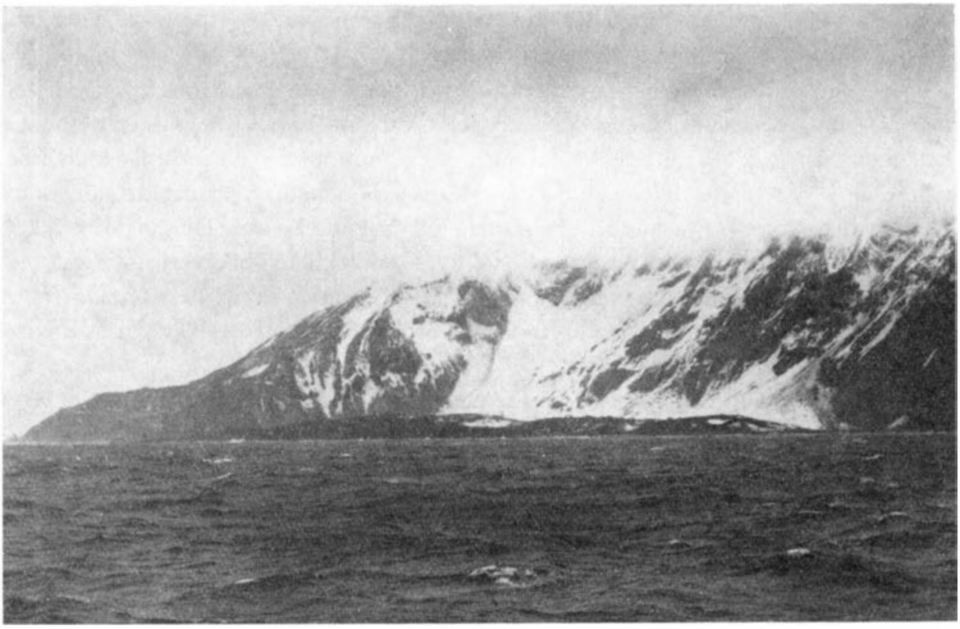

Fig. 2. Nyrøysa fotografert fra vest.

Nyrøysa photographed from west. Photo: TH. S. WINSNES

trolig finnes in situ. Området mellom vulkanens høgste punkt og selve øya er oppfylt av ras. Man kan her finne tykke islag under blokkmaterialet. Denne isen stammer fra Aagaardbreen, som nå er av nokså beskjeden størrelse høgt oppe i fjellsida. Raset har antakelig oppstått i forbindelse med jordskjelv under vulkanutbruddet.

Vulkansk utbrudd har aldri vært observert på Bouvetøya, man har imidlertid ved forskjellige anledninger sett damp som har kommet ut fra fjellet: ved Kapp Valdivia i 1926, ved Kapp Circoncision i 1929 (CHRISTENSEN 1935, p. 132) og samme sted i 1955 (pers. medd. fra meteorolog CRAWFORD). Vi observerte ingen slike tegn til vulkansk aktivitet.

Plantelivet var som rimelig kan være temmelig sparsomt, noen små puter av en grønn, myk moseart var det eneste vi så.

Dyrelivet er derimot svært rikt. Flere hundre sjøelefanter (*Mirounga leonina*) og trolig mer enn tusen pelssel (*Arcto cephalus tropicalis*) «befolket» strendene. Av fugler så vi ringpingvin (*Pygoscelis antarctica*) og gulltoppingvin (*Eudyptes chrysolophus*), samt noen få skua (storjo) (*Stercorarius skua macckormicki*) og petreller (*Fulmarus glacialoides*) – disse siste finnes imidlertid i titusener i de bratte fjellene på sydsida av øya.

På grunn av det dårlige været med kuling eller storm hver dag, og skybasis sjelden over 300 m, var det planlagte besøket på iskappa umulig å gjennomføre Breen blei således bare observert gjennom kikkert fra skuta samt fra helikopter under en kort tur over randområdene av øya. Det er bare den austlige delen –

under 300–400 m o. h. – som har vært iakttatt noe nøyere, og det som sies i det følgende, gjelder bare denne delen av brekappa.

Breen har en nokså bølgete og sterkt oppsprukket overflate. Snøen var smeltet bort fra «bølgetoppene», mens det fremdeles var snø i «bølgedalene». Årets snø dekker ca. 50 % av overflaten i det observerte området – naturligvis mer i de høgere enn i de lavere delene. Overflaten er delvis dekket av brungrått støv som trolig er blåst over fra de snøbare områdene på vestsida av øya. Helhetsinntrykket av brekappa var at den var «tynn» og lite aktiv. Det blei ikke observert noen kalving mens vi var ved øya og bare ved én anledning så jeg noen få og meget små isbiter i sjøen. Store, uforstyrrede snøfonner foran brekanten – der det var plass til slikt – tydet også på at bevegelsen er liten.

Ved Bouvetøya er middeltemperaturen for varmeste måned (februar) trolig +3 til +4° C ved havflaten. Strålingen er relativt liten på grunn av det nesten permanente skylaget. Når de lavere deler av øya likevel har et negativt budsjett, tyder det på at akkumulasjonen ikke kan være så svært stor. Det ligger nær å anta at årsaken til dette ikke er at snømengdene er små, men at de sterke vindene fører mye av snøen på sjøen etterhvert som den faller.

Da vi passerte Bouvetøya 3. februar 1959, var iskappa mye mer snødekt enn hva tilfellet var nå. Beretninger fra tidligere ekspedisjoner gir også inntrykk av større snødekning. Årsaken er naturligvis for en stor del det sene tidspunktet for

Fig. 3. Overflateformer på Nyrøysa, materialet er fordelt fra finsand til store blokker.

Surface relief at Nyrøysa, the size of the rockmaterial ranges from fine-grained sand to big boulders. Photo: T. LUNDE vårt besøk – nær slutten av ablasjonssesongen (fremdeles rant det ganske store bekker fram under breen på en del steder), men det er også sannsynlig at året 1963/64 ga Bouvetbreen et særlig stort underskudd. Det er nemlig vanskelig å forstå at breen i lengda kan dekke øya så totalt når den er i en så elendig forfatning. Fig. 4 viser Bouvetøya fotografert fra aust i 1928 og i 1964. De svært små forskyvningene av brekanten som kan spores, viser en større utbredelse i 1964 enn i 1928. Da kysten av øya danner en naturlig grense for breens utbredelse, er det mulig at denne lille forskjellen betyr at det har vært en klimatisk forverring de siste 35 år.

Å dømme etter utseendet og snødekket, må firnlinja dette året ligge minst 200–300 m o. h., mens det tidligere har vært nokså vanlig å anta at den lå i havets nivå (ENGELMANN 1923, pp. 93, 94).

LARS CHRISTENSEN gjør i sin bok «Such is the Antarctic», oppmerksom på at det til samme årstid, er konstatert store forskjeller fra år til år i Bouvetøya's bredekke. Sannsynligvis har CHRISTENSEN rett, man må dog likevel være klar over at en del eldre beretninger om Bouvetøya er altfor fantastiske til at de kan taes alvorlig. Således fortelles det fra Bouvetekspedisjonen at de hadde sett adskillige trær da de var der i begynnelsen av januar 1739, og da det tyske skipet «Meteor» var ved Bouvetøya i februar 1926 skulle de svakt skrånende klippene bare være dekket med is og snø halvvegs ned til sjøen.

Som mulige steder for en permanent meteorologisk stasjon har vært satt opp følgende alternativer:

1. Lavt nede på den svakt skrånende breoverflaten på austsida av øya (dette er imidlertid utelukket, da det er umulig å ferdes i et så sterkt oppsprukket område).
2. Den nydannede flaten på vestsida av øya (denne må man også se bort fra, da man ikke godt kan plasere mennesker på en ny vulkan der det ikke finnes fluktmuligheter.
3. Kapp Circoncision (toppen av dette er bare en smal egg der det ikke er plass for noe som helst).

   De mulige stedene som man da har igjen er:

4. I krateret på selve toppen av øya.
5. Rustadkollen på sørvestsida av øya.
6. 1500–2000 m fra austkysten av øya der forholdene trolig skulle være bedre enn nær stranda.

Disse siste tre alternativene ligger så høgt at de vil få tåke det meste av tida, derfor tar ikke sørafrikanerne dem i betraktning. Alt utstyret til en slik stasjon må fraktes opp med helikopter som må ha gode siktforhold og rimelige vindforhold for å kunne operere. Alle tre stedene er på breen, og i det milde klimaet må man følgelig finne fram til en spesiell huskonstruksjon for å holde vannet ute. Fundamentering og bardunering av stasjonen vil også by på store problemer. Disse forholdene fører til at opprettelse og drift av en stasjon på Bouvetøya vil bli et overmåte kostbart foretagende. Man vil sikkert få mannskap til en slik stasjon det første – og kanskje det andre – året, men etter det vil trolig forrådet av «eventyrere»

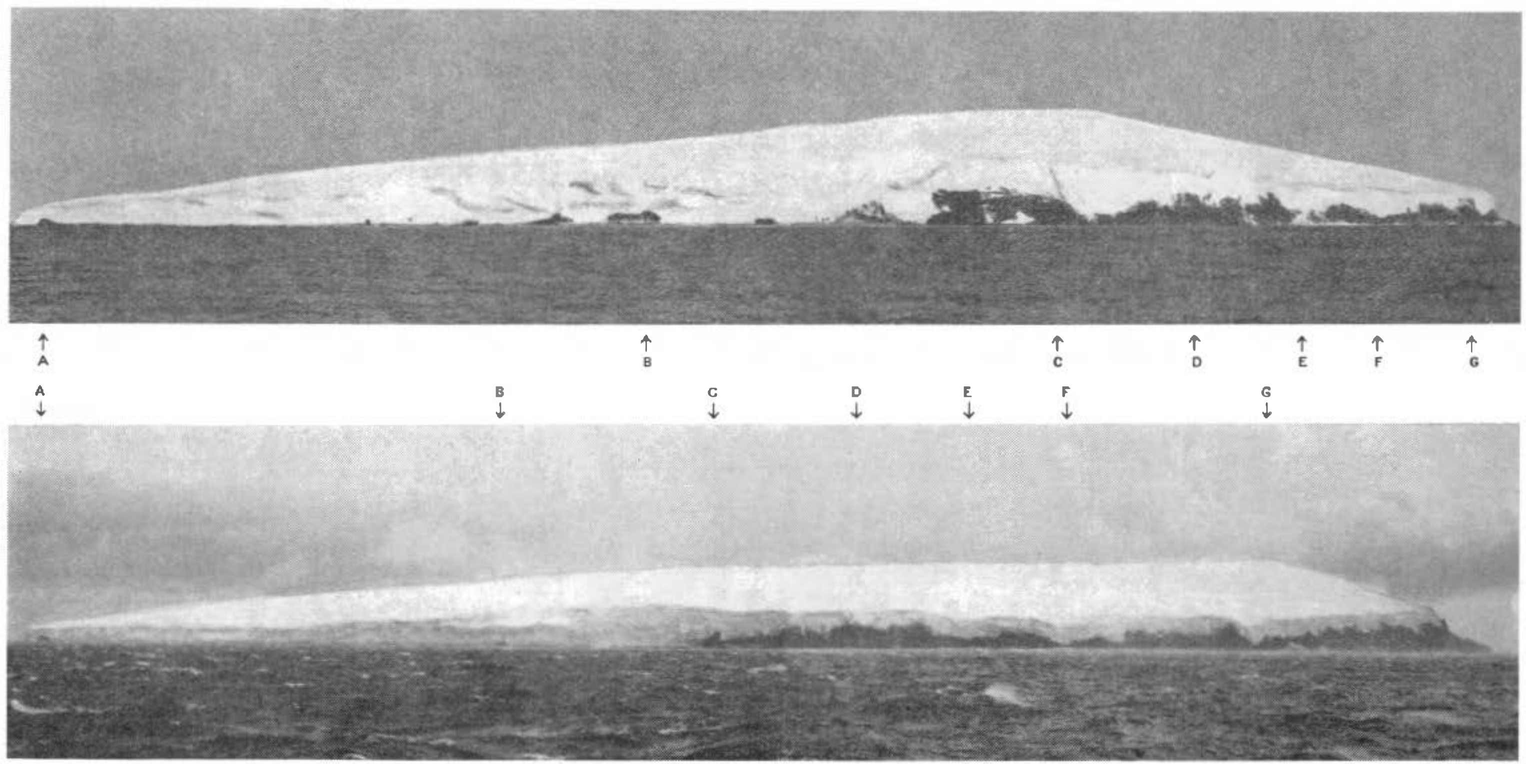

Fig. 4. Bouvetøya sett fra aust i 1928 (øverst) og 1964 (nederst). Bokstavene viser til punkter som kan kjennes igjen på begge bilder. Breen ligger litt lenger framme i området B–F i 1964 enn i 1928.

Bouvetøya photographed from east in 1928 (top) and 1964 (bottom). The letters refer to points which can be recognized in both pictures. The glacier has advanced a little between points B and F in the period from 1958 to 1964. Photo: Norvegiaekspedisjonen and T. LUNDE være brukt opp. Det er tross alt grenser for hva menneskene ønsker å utsette seg for, og Bouvetøya som overvintringssted vil være betydelig værre enn noe annet jeg kjenner til.

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The weather in Svalbard in 1963

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 1963. 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 1947–62, the basis of these indications being mainly the temperature observations from Isfjord Radio.

1963	
1–13 Jan.	An easterly to northerly air stream over Svalbard in connection with depressions moving eastward farther to the south. Cold.
14–17 Jan.	Depressions from the west pass the Svalbard area. Southerly winds and considerably milder.
18–30 Jan.	Winds between east and north and colder again.
31 Jan.–3 Feb.	A cyclonic centre approaches over Greenland and the wind veers south. Temporarily milder. Wind between west and north in the rear of the cyclone and colder again.
4–11 Feb.	An extensive high pressure area approaches Svalbard from the southwest. Comparatively calm, cold weather most of the period.
12–24 Feb.	An anticyclone develops over the Polar Basin and the eastern part of Greenland. Northerly, later easterly winds and very cold.
25 Feb.–5 March	A series of cyclones from the southwest pass Svalbard. Variable winds and milder.
6–15 March	The depressions take a more southerly course. Winds between east and north. Cold.
16–20 March	The cyclonic paths shift northwards again. Strong southerly winds and considerably milder.
21–30 March	An anticyclone passes Svalbard from the west and becomes stationary near Franz Josef Land. For most of the period winds between north and east, and cold.

31 March–7 Apr.	Cyclones over Greenland and the Norwegian Sea bring warmer air over Svalbard. Winds of variable direction and mild.
8–19 Apr.	A stream of cold air from the northeast between a high pressure area over northern Canada, Greenland and adjacent oceans, and depressions to the south and southeast.
20–22 Apr.	In connection with the passage of an anticyclone: weak, variable winds and gradually increasing temperature.
23–27 Apr.	A series of cyclones from the southwest passes Svalbard. Winds of changing direction as the cyclones pass. Mild.
28 Apr.–10 May	The cyclones travel farther to the south and a cold northeasterly to northerly wind dominates most of the period.
11 May–7 June	Depressions from the south and southwest, most of them very weak, pass the Svalbard area. Relatively mild.
8–27 June	An extensive anticyclone over the Polar Basin or adjacent regions. Weak winds or calms and temperatures about or slightly below the normal for the season.
28 June–4 July	Relatively weak depressions from the south and the southwest pass Svalbard. Weak, variable winds. Cool at the end of the period.
5–13 July	High pressure areas to the north and west. The wind continues to be weak or moderate. Gradually increasing temperatures.
14–20 July	The circulation pattern is governed by a low pressure area that extends from the regions around the Faroe Isls. towards Novaya Zemlya. In this trough weak depressions pass close to Svalbard. Temperatures slightly below normal.
21–24 July	A northerly air stream over Svalbard between an anticyclone over Greenland and cyclones to the south. Temperatures about the normal for the season.
25 July–2 Aug.	The cyclones take a more northerly path and pass near or, at the end of the period, over the Svalbard area. Changing temperature and wind conditions as the cyclones pass.
3–7 Aug.	A high pressure ridge extends from northern Europe towards Svalbard. Weak winds or calms. Temperatures slightly below normal.
8–20 Aug.	The high pressure area moves eastwards. However, most of the period it governs the air circulation over Svalbard. Calms or weak to moderate winds. Mostly mild, fair weather.
21 Aug.–2 Sept.	Cyclones are passing from the south. Variable but mostly about normal temperatures.
3–9 Sept.	An anticyclone over the Polar Basin spreads towards Svalbard and the cyclonic paths are shifted southwards. Calms or weak winds and temperatures about the normal.

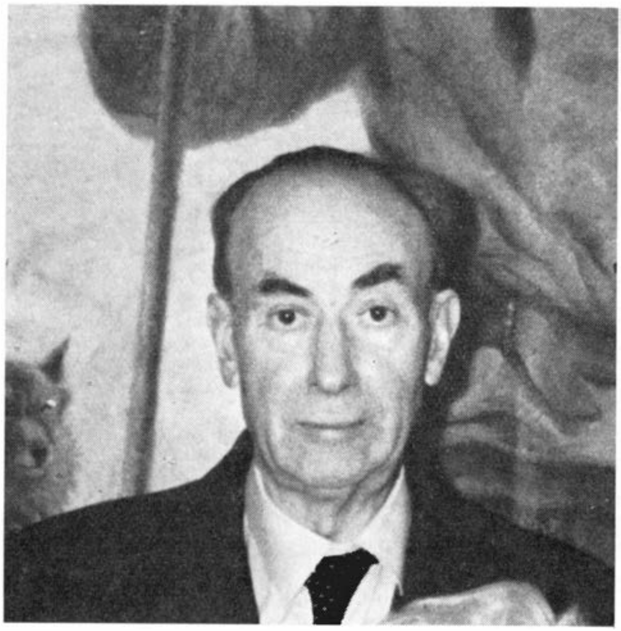
10–15 Sept.	Depressions approach from the southwest and give rise to strong easterly winds. Relatively mild.
16–19 Sept.	The pressure field, and accordingly the wind field, is very weak. Cool.
20–25 Sept.	Strong cyclones from the southwest. Mild at the start of the period, but gradually cooler.
26 Sept.–8 Oct.	The cyclonic paths are shifted southwards again. Easterly winds. The temperature rises and it is mild during most of the period.
9–17 Oct.	Comparatively intense cyclonic centres pass just south of Svalbard. Easterly to northerly winds and cool towards the end of the period.
18–26 Oct.	A low pressure system is passing from the southwest. Temperatures considerably above normal, especially during the first part of the period.
27–29 Oct.	A northerly air stream over Svalbard between a high pressure area to the north and west and a depression to the east. Cool.
30 Oct.–1 Nov.	Cyclones from the southwest again reach the Svalbard area. Milder.
2–22 Nov.	An anticyclone develops over the Polar Basin and Greenland. Between this anticyclone and cyclones travelling farther south a cold northerly to northeasterly air stream dominates most of the period. Temperatures mostly considerably below normal.
23 Nov.–12 Dec.	The cyclones have now a more northerly course. Some quite intense centres pass Svalbard. Relatively mild and cold periods alternate.
13–24 Dec.	Most of the time a northerly to northwesterly air stream between an extensive low pressure area to the southeast and an anticyclone over Greenland. Cold.
25–31 Dec.	More variable winds and temporarily milder at the start of the period. A cold northeasterly wind dominates towards the end of the period.

In the table below are given preliminary monthly mean temperatures for Isfjord Radio for 1963 as well as their deviation from the means of the period 1947–62. (The final data for 1963 are not yet available. They will be published later in "Norsk meteorologisk årbok 1964".)

Mean temperatures (°C) Isfjord Radio

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1963 means	−17.0	−20.4	−14.4	−12.0	−2.9	1.2	3.9	4.9	0.9	−1.2	−10.9	−12.5
Deviation of 1963 means from 1947–62 means	− 6.7	− 9.9	− 2.6	− 3.4	0.4	−0.6	−0.7	0.6	−0.3	1.4	− 5.3	− 3.4

The greater part of 1963 was colder than normal. This applies especially to the winter months.



Bernhard Luncke

BY

KAARE Z. LUNDQVIST

Ingeniør BERNHARD LUNCKE, topograf ved Norsk Polarinstitutt, avgikk ved døden 9. april 1963 etter lengre tids sykeleie.

B. LUNCKE var født 15. mai 1894 i Øyer i Gudbrandsdalen. Etter eksamen fra Kristiania Tekniske Mellomskole i 1914 arbeidet han ved Ing. Dahls Opmaaling frem til 1917 og deretter ved Norsk Kulelager A/S til 1921. De to følgende årene studerte han ved Technische Hochschule i Danzig og ble deretter ansatt ved De Norske statsunderstøttede Spitsbergenekspeditioner, som i 1928 ble omdannet til Norges Svalbard- og Ishavs-undersøkelser og i 1948 omorganisert i Norsk Polarinstitutt.

Siden 1923 har ingeniør LUNCKE vært med på 19 ekspedisjoner, med arbeidsområder som bare få kan rekke å delta i. Han har arbeidet i Norge, på Svalbard, Øst-Grønland, Jan Mayen og i Antarktis. Innen flyfotogrammetri var han en pioner og en anerkjent fagmann såvel i Norge som i utlandet. Ved sin planlegging og deltagelse i de store flyfotograferingsarbeider i de nevnte områdene og ved kartutarbeidelse av materialet, ervervet han seg et større kjennskap til disse metodene enn noen annen i vårt land. Hans tallrike flyfotografier, og da særlig de fra Svalbard, har vært og er et meget viktig grunnlag for en mengde vitenskapelige ekspedisjoner innen forskjellige forskningsfelt.

BERNHARD LUNCKE kunne ha sine bestemte meninger og han gjennomførte sitt

Fig. 1. *Ett av de mer enn 6000 flyfotografier som ingeniør* BERNHARD LUNCKE *tok av Svalbard i løpet av somrene 1936, 1938, 1950 og 1956. Bildet viser i forgrunnen Magdalenafjorden med Hoelhalvøya til høyre. Innover ser vi mot fjell- og breområdene i Haakon VII Land.*

arbeid med nitid nøyaktighet, egenskaper som kom vel med i det lange tidsrommet han sto som leder av den topografiske avdelingen ved Norsk Polarinstitutt. Som ekspedisjonsmann var han et utmerket eksempel for andre, noe han i høyeste grad beviste ved så sent som i sitt 65. år å forberede, lede og personlig delta i en flyfotograferingsekspedisjon i Dronning Maud Land, Antarktis.

De han samarbeidet med både i felten og hjemme, vil med særlig glede minnes hans tørre humor og savne de gode råd han kunne gi med bakgrunn i sin lange erfaring.

Ingeniør B. LUNCKE har i alt deltatt i 15 kartleggingsekspedisjoner i Arktis, en i Antarktis og arbeidet tre somrer i Nord-Norge, som det fremgår av listen nedenfor:

1923 og 24:	Terrestriske arbeider på Bjørnøya. Den andre sommeren som leder.
1925 og 28:	Terrestriske arbeider på Svalbard.
1929, 31 og 33:	Terrestriske arbeider på Øst-Grønland.
1936 og 38:	Leder for flyfotografering på Svalbard.

1945 og 46:	Terrestriske arbeider i Nord-Norge, den siste sommeren som leder.
1947:	Terrestriske arbeider på Svalbard.
1948:	Leder for flyfotografering på Svalbard.
1949:	Leder av flyfotografering på Jan Mayen.
1950:	Leder for flyfotografering på Svalbard.
1952:	Flyfotografering i Nord-Norge. Leder av ekspedisjonen.
1955:	Flyfotografering på Jan Mayen og i Norge. Leder av ekspedisjonen.
1956:	Leder for flyfotografering på Svalbard.
1958–59:	Leder for flyfotografering i Dronning Maud Land, Antarktis.

Et forsøk på fangst og flytting av Svalbardrein(*Rangifer tarandus spitsbergensis*) i Bockfjordområdet på Vestspitsbergen

AV

THOR LARSEN[1]

Abstract

During the summer 1963 an attempt was made to capture Spitsbergen reindeers in the Bockfjorden area, and to have them transferred to Brøggerhalvøya near Ny-Ålesund. The aim of this experiment was once again to utilize the grazing land in the areas, where the reindeers more than 100 years ago had been eradicated. The request came from the population in Ny-Ålesund and was passed to the Norwegian authorities by sysselmann F. B. MIDBØE. The Bockfjorden area was chosen because this area has a fairly large reindeer-population within a limited area, the animals were supposed to be hardly shy here, and the transport would be fairly easy without much difficulties with ice.

The capture was supposed to be performed with immobilizing agents as succinylcholin chloride or drugs of the nicotine group. However, the necessary permission to use these drugs was not granted, and alternative methods had to be considered. It was decided to build a trap system, with two fences 1000 m and 500 m long to form an open V, and leading to an enclosure at the bottom of the V. The enclosure and the first part of the fences were built of wooden materials, while the rest was made of wire, hung with aluminium sheets.

Two attempts were made to capture the animals by chasing them carefully along the fences into the pen. We failed both times for two reasons. First, the animals ran through the fences and some were close to get severely hurt. Second, the reindeers behaved different from what had been expected. They were unusual shy, and showed no herd instinct. Cartridgecases and burried skins were found near the camp, and it must be presumed that the animals had been hunted quite recently. This probably explains their shyness.

Countings of the reindeer population indicate that no significant increase of the population has taken place since 1958. This may partly be explained by the heavy grazing of this limited area.

A new attempt to transfer reindeers to new pastures could be of great interest. The number of reindeers in Svalbard would probably increase if this is done. On Fig. 1 is shown that only a little part of the grazing land has a reindeer population to day.

Takk

Jeg vil med dette takke alle de personer og institusjoner som hjalp til med forberedelsene og gjennomføringen av fangstforsøket av rein på Svalbard sommeren 1963. I første rekke vil jeg takke stud. real. ODDVAR BREKKE og stud. real. EIGIL REIMERS for enestående hjelp både under forberedelsene og med selve feltarbeidet.

[1] Zoologisk laboratorium, Universitetet i Oslo, Blindern.

Jeg vil dernest rette takken til Norsk Polarinstitutt; Statens Viltundersøkelser; Generalinspektøren for Hærens Samband; Generalintendanten; Chief Biologist A. T. BERGERUD; Dr. H. K. BUECHNER; dr. philos. KÅRE ELGMORK; Superintendent LEMUEL A. GARRISON; Wildlife Biologist CURTIS H. HALVORSSON; veterinær GUNNAR HOLT; Research Biologist CHAS. JONKEL; lektor ODD LØNØ og cand. mag. AKSEL SARA.

En spesiell takk til direktør T. GJELSVIK, hydrograf H. HORNBÆK og deres assistenter, sysselmannsfullmektig K. VADLA og mannskapet på M/S «Nordsyssel» for velvillig hjelp under selve fangstforsøket.

Reinens tidligere utbredelse og nåværende forekomst

Over alt på Svalbard der man kan finne større sammenhengende områder med beiteland, kan man også finne rester etter rein (LØNØ 1959). Ved å studere kartet over mulig beiteland (Fig. 1), vil man få et brukbart bilde av Svalbardreinens tidligere utbredelse. Det ser ut til å ha vært en mer sparsom bestand på landet fra Hornsund og sørover, og på Prins Karls Forland, mens derimot i Kongsfjordområdet, Krossfjordområdet, på Isfjordhalvøya og i Wijdefjordområdet har det vært langt flere dyr. Reinen på Svalbard har imidlertid vært utsatt for en meget hård beskatning i form av jakt, noe som har ført til at stammene i enkelte områder er blitt helt utryddet, og andre steder er gått sterkt tilbake. Man regner med at i Hornsundområdet var reinen utryddet omkring 1820, i Kongsfjord- og Krossfjordområdet omkring 1860, mens siste melding om rein fra Wijdefjorden skriver seg fra 1936 (LØNØ).

Svalbardreinen ble fredet ved lov i 1925, og har siden den tid steget i antall innen de avgrensete områder der den i dag finnes. I krigsårene fikk, særlig reinen på Isfjordhalvøya en ny knekk, idet dyrene ble jaget av forvillede hunder. Senere har stammene stort sett fått være i fred, og har økt i antall igjen.

I dag forekommer reinen på fire avgrensete områder (Fig. 1): Nordaustlandet 300–400 dyr, Bockfjorden–Reinsdyrflya 200–300 dyr, Isfjordhalvøya over til Agardhbukta ca. 200 dyr, Edgeøya 500–600 dyr.

Som nevnt er reinen i dag totalfredet, og dyrene har heller ingen naturlige fiender. Krypskytteri forekommer dessverre i enkelte områder, noe vi fikk bevis for sommeren 1963, i det vi fant patronhylser og nedgravde skinn ved Sjøværnbukta. Dette forholdet, ved siden av at reinstammene innen de avgrensete områdene synes å vise liten tendens til å trekke ut til nye, ubrukte beiteområder, forklarer muligens delvis det faktum at det har vært en tildels meget langsom økning av bestandene.

Bakgrunnen for fangstforsøket

Når man ser på Svalbardreinens tidligere utbredelsesområde og dessuten tar i betraktning de ekspansjonsmuligheter de avgrensete stammene har i dag, vil naturlig nok tanken melde seg om å foreta en flytting av dyr til tidligere benyttede beiteområder. I disse områdene er ernæringsforholdene i dag ideelle, og alt burde ligge til rette for at en slik overføring kunne falle heldig ut. Lignende forsøk med utsetting av rein til andre områder har vist at et mindre antall dyr som oftest er

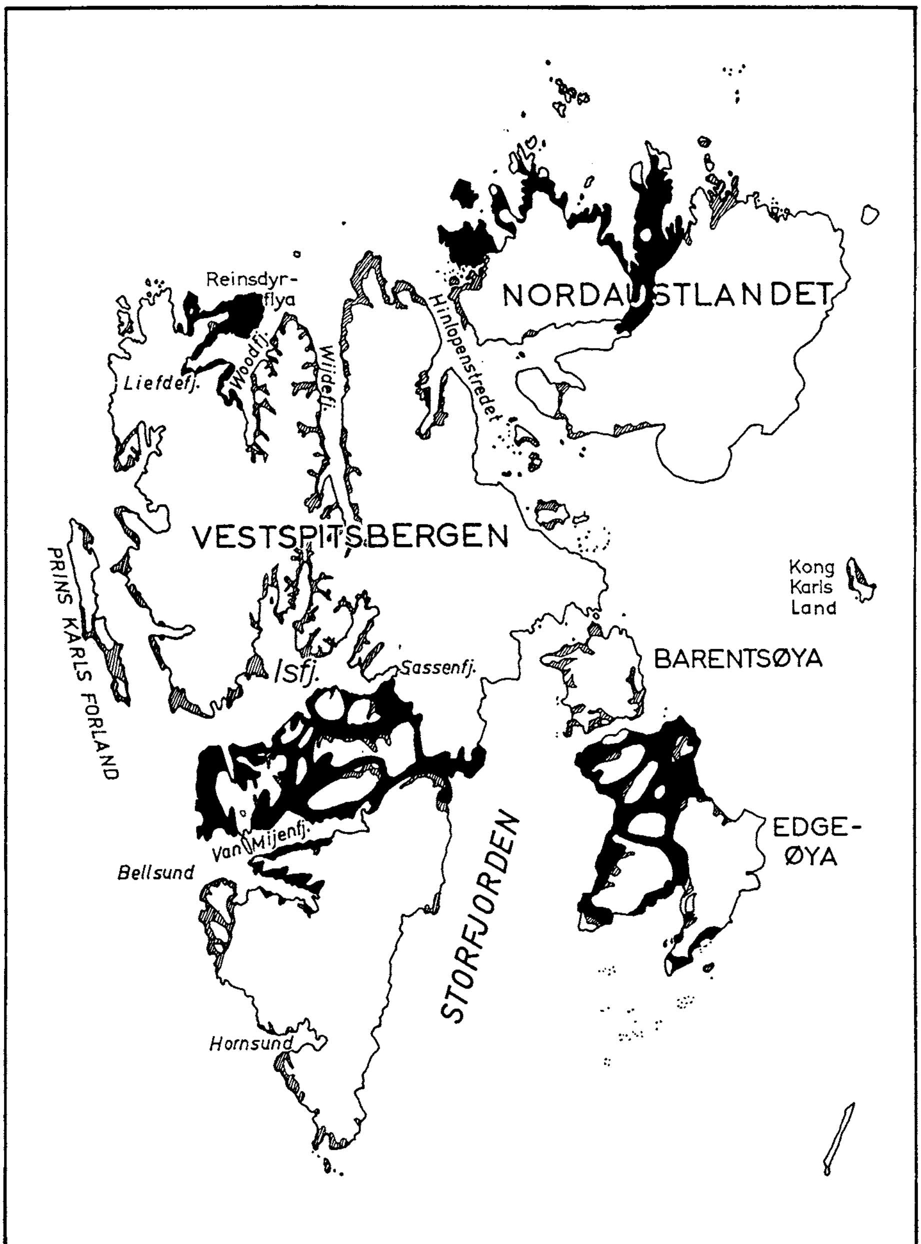


Fig. 1. De sorte feltene angir hvor det i dag finnes rein på Svalbard. De skraverte områdene viser steder med reinbeite, men hvor det ikke finnes rein i dag. Tallrike rester etter rein viser imidlertid at det tidligere også har levet rein i disse strøkene.

The black spots are the places where the reindeers are living to-day at Svalbard. The hatched areas indicate places where it is enough grazing land, but no reindeers are found. Numerous antlers indicate that in earlier times the reindeers have been living in these regions also.

(Etter O. LØNØ (1959).)

tilstrekkelig til å få opp en skikkelig, levedyktig bestand (ØYNES 1960). Syv simler og tre bukker burde således være nok når dyrene settes ut i et avgrenset område.

Med ønsket om på ny å få en reinstamme i området rundt Ny-Ålesund, henvendte befolkningen i denne gruvebyen seg til daværende sysselmann F. B. MIDBØE og ba ham ta opp saken. Sysselmannen tok kontakt med Industridepartementet, som igjen forela problemet for Norsk Polarinstitutt. Polarinstituttet stilte seg med en gang positiv til denne tanken og tok den opp med Statens Viltundersøkelser. Den praktiske gjennomføringen av saken ble overlatt til forfatteren.

Det var spørsmål om enten å flytte reinen til Kapp Mitra eller Brøggerhalvøya, men det siste området ville av flere grunner utvilsomt være det heldigste. Her hadde dyrene gode ekspansjonsmuligheter sørover, og befolkningen i Ny-Ålesund kunne holde øye med bestanden for å se hvordan den tilpasset seg. Dersom forsøket falt heldig ut, kunne feltet senere danne utgangspunkt for videre innfanging og forflytning.

Fangstmetodikk

I forbindelse med selve innfangingen ble forskjellige brukbare metoder drøftet bl. a. med Norsk Polarinstitutt, Statens Viltundersøkelser, Veterinærinstituttet og lektor ODD LØNØ. Vi kom frem til at det beste ville være å benytte muskellammende midler. Det finnes i dag spesialkonstruerte våpen som skyter ut et sprøyteformet projektil, fylt med flytende bedøvningsmidler av forskjellige typer. Ved anslaget trenger kanylen inn i dyrets muskulatur og avgir preparatet. Midlene som har vært benyttet hører til en av de to hovedtypene, nemlig nikotin- eller curarepreparater (BUECHNER *et al.* 1960, CROCKFORD *et al.* 1958, ERIKSEN 1963, TALBOT *et al.* 1962, m. fl.). Alle preparater har sine bestemte fordeler, men også en rekke uheldige egenskaper som man må være oppmerksom på. Felles for alle er at det kreves en meget nøyaktig dosering avhengig av dyrearten, dyrets vekt, kondisjon, alder, kjønn m. m. Enkelte preparater gir uheldige ettervirkninger som kan holde seg opp til et par døgn. Den paralyserte tilstanden som fremkalles oppnås etter to hovedprinsipper:

Curarepreparatene virker på den tverrstripete muskulaturen ved at de motoriske nervenes endeplater i muskelfibrene påvirkes slik at nerveimpulsen fra nerven til muskelen hindres.

Nikotinpreparatene derimot virker ved at synapsene i alle de perifere autonome ganglier blokeres.

Samtlige preparater virker etter kort tid, som regel under ti minutter. En underdosering gir som regel ingen påviselig effekt, mens en overdosering gjerne fører til at respirasjonsmuskulaturen lammes og dyret kveles. Dette kan man ofte hjelpe på med kunstig åndedrett.

Geværene som hittil har vært i bruk har vært lite effektive. Projektilene har blitt drevet med komprimert CO_2 gass, og våpenet har ikke hatt effektiv rekkevidde på mer enn 20–30 m. Rekkevidden har vært betydelig redusert i kaldt vær, hvilket har ført til store vanskeligheter bl. a. ved forsøk i Norge. Vi fikk imidlertid vite at både i U.S.A. og på New Zealand var det nettopp blitt konstruert et kruttladet injeksjonsgevær med en effektiv rekkevidde på 70–120 m. Et gevær av denne typen ble bestilt fra U.S.A., men måtte siden avbestilles, da Landbruksdepartementet i siste øyeblikk ikke ga tillatelse til å benytte paralyserende preparater til innfangingen.

Etter dette måtte vi forsøke å gjennomføre innfangingen ved hjelp av innhegning og lange ledegjerder. Slik fangst er kjent fra mange steder både i gammel og ny tid. Således kan man den dag i dag på Hardangervidda se rester etter fellesystemer som har vært benyttet under jakt på villreinen i dette området, ved siden av at lignende metoder den dag i dag benyttes flere steder i Norge under tamreindriften (Tambs Lyche 1947). Metoden er også kjent fra reinjakt på Grønland (Rosing 1956). I Yellowstone National Park har man benyttet en tilsvarende metode med flere kilometer lange ledegjerder, store samleinnhegninger og to helikoptere til å drive dyrene inn i systemet. 1400 elg (*Cervus canadensis*) har blitt fanget på denne måten (meddelelse til forfatteren fra L. H. Garrison). Tilsvarende metoder har dessuten vært benyttet under fangst av pronghorns (*Antilocapra americana*) i Colorado. Her ble små sportsfly brukt under drevet inn i fellessystemet (Hoover *et al.* 1959).

I en meddelelse til forfatteren oppga A. T. Bergerud at de i Newfoundland har benyttet følgende fangstmetode på caribou (*Rangifer tarandus*) med godt resultat. Dyrene ble jaget på sjøen, helst ved hjelp av helikoptere eller små fly, og merket eller fanget i vannet fra båter eller pontongene på helikopteret. Man kunne også selv jage dyrene til sjøs dersom det var nok folk på land.

Det ble derfor bestemt at vi skulle forsøke å fange reinen ved hjelp av en av disse to metodene, primært ved bruk av et fellesystem. Som innfangningssted

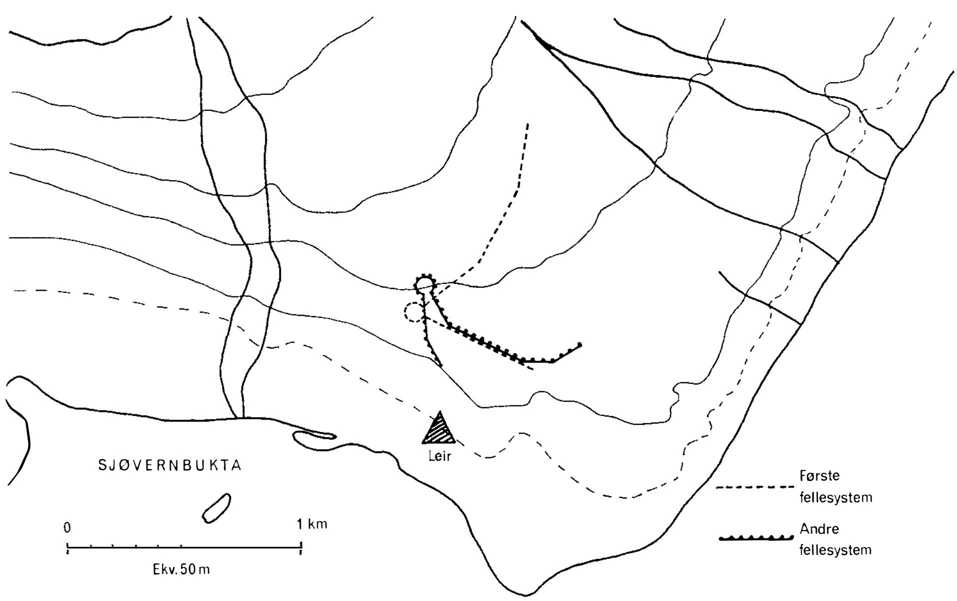


Fig. 2. Kartskissen viser de to fellesystemene som ble bygget i Sjøvernbukta.

The map shows the two traps which were built in Sjøvernbukta.

valgte vi området Bockfjorden–Reinsdyrflya på nordsiden av Vestspitsbergen. Her finnes en forholdsvis stor reinstamme innen et avgrenset område, og vi regnet dessuten med at dyrene her var mindre sky og derfor lettere å arbeide med enn på andre steder. Til slutt var det forholdsvis kort transport herfra til Brøggerhalvøya, og vi kunne stort sett regne med få isvanskeligheter.

Vi ankom til Sjøvernbukta i Bockfjorden 9. juli og gikk straks i gang med rekognoseringer for å finne den beste plassen for å sette opp fangstapparatet. Etter noen dager kom vi frem til at terrenget rundt leiren faktisk bød på det beste fangstområde. Her fantes adskillige rein og terrenget hadde en utforming som passet bra. Vi bygget så to lange ledegjerder som ble satt opp i V-form. Gjerdene var henholdsvis ca. 1 km og 500 m lange og hadde en høyde på 1,5 m. De første 50 m var de bygget av trematerialer, deretter besto de av ståltråd strukket i enkel høyde og tett behengt med flagrende aluminiumsfolie. Enkelte steder var gjerdene forsterket med sekkestrie, gamle torskegarn, tøyfiller etc. Fellesystemet gikk parallelt med stranden (Fig. 2) og innhegningen som ble bygget i V-ens spiss, og besto av planker i to eller tre høyder, med ett lé til å skyve på plass. Diameteren på innhegningen var ca. 15–20 m.

Det første drevet gikk 19. juli med fem mann i drevet, og en mann til å stenge innhegningen når dyrene var kommet inn. Lukene mellom driverne var 100–150 m, og drevet startet vel 3 km bak fellesystemet. Det viste seg snart at dyrene var meget uvillige til å la seg dirigere, selv om vi var meget forsiktige og ikke presset på uten der det var nødvendig. Det ble snart klart at reinen var atskillig mer sky enn vi hadde regnet med. Forklaringen på dette var nok at flokkene hadde vært utsatt for jakt og var blitt skremt, for som nevnt fant vi ganske nye geværhylser og nedgravete skinn i området.

Under drevet var det stadig dyr som snudde og sprang ut mellom driverne. Da vi nærmet oss innhegningen, slo tre store bukker seg gjennom et dobbelt torskegarn som hang over ståltrådgjerdet, og til slutt var det bare en liten kalv igjen, som vi lot gå.

Etter dette forsøket ble fellesystemet ombygget etter anvisning fra O. ANDERSEN, en av assistentene til hydrograf HORNBÆK. Han hadde stor erfaring fra tamreindrift, og mente derfor at systemet ville virke dersom drevet gikk mer mot fjellet enn det hadde gjort under det første forsøket. Vi flyttet derfor hele systemet, slik at gjerdene pekte mer mot fjellet, og innhegningen lå bedre skjult enn tidligere. Dessuten ble gjerdene forsterket med drivved slik at de første 100 m besto av trematerialer, deretter 100 m med to høyder tauverk og ståltråd, behengt med sekkestrie, garn o. l. som tidligere. Det øverste ledegjerdet var nå vel 700 m og det andre omkring 300 m langt (Fig. 2).

Etter en ukes arbeid var fangstapparatet klart igjen, og 25. juli ble det gjort et nytt forsøk, denne gang med 17 mann som drivere. Vi fikk nå hjelp fra direktør GJELSVIK og hydrograf HORNBÆK med assistenter, sysselmannsfullmektig K. VADLA og mannskapet på M/S «Nordsyssel». Også denne gang startet vi omkring 3 km bak gjerdene. Imidlertid kom drevet noe skjevt inn mot gjerdene, slik at de fleste av de 40–50 dyrene vi hadde foran oss slapp ut over det øvre gjerdet. De dyrene som kom inn i fellesystemet, gjorde det fort klart for oss at det ikke var

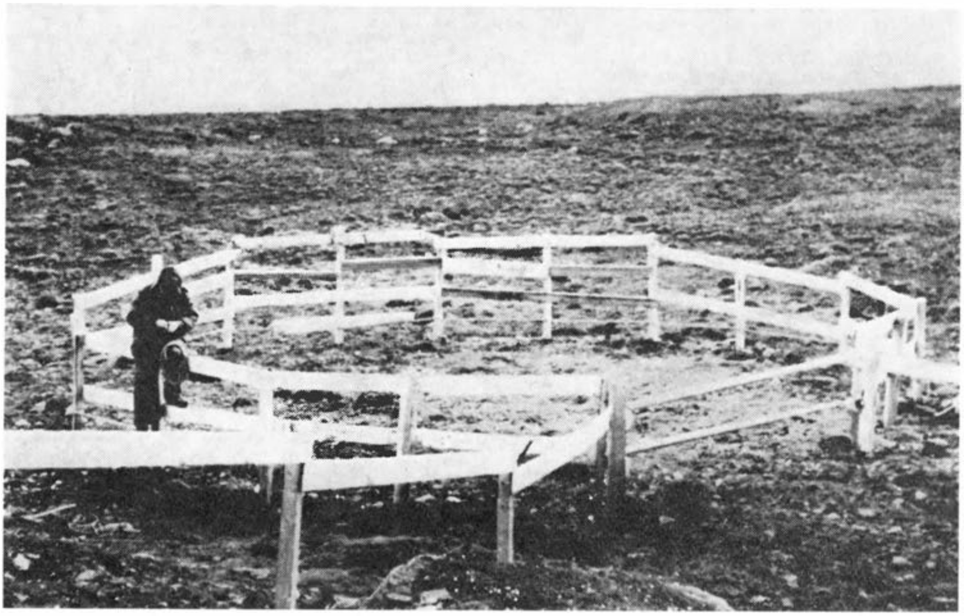


Fig. 3. Innhegningen i fellesystemet.

The pen in the trap system. Foto: T. LARSEN

brukbart. To simler brøt gjennom ledegjerdene og hadde nær skadet seg alvorlig på ståltråden, idet den ene fikk viklet venstre bakbein inn i tråden og hadde et stygt fall. Vi fant etter dette forsøket at innfanging på denne måten ikke lot seg gjennomføre, og videre forsøk ble derfor oppgitt.

Under et besøk på Måkeøyane 12. juli traff vi fem simler på den største av øyene. Et forsøk på å drive dyrene på sjøen viste seg umulig, da vi var for få til å drive. Det synes vanskelig å gjennomføre fangst fra sjøen dersom man ikke tilfeldigvis skulle treffe på svømmende dyr.

Reinbestandens størrelse i dag i Bockfjord-Liefdefjordområdet

Telling av reinbestanden i området Bockfjorden–Liefdefjorden i perioden 9. til 25. juli ga følgende resultater:

Sverrefjellet–Sjøvernbukta	minst	30	dyr
Sjøvernbukta–Roosneset	ca.	150	»
Roosnesets vestside	minst	21	»
Måkeøyane		5	»
Sum	minst	206	dyr

Bestanden i området Sjøvernbukta–Roosneset ble talt flere ganger, slik at en kan regne med at dette gir et forholdsvis sikkert bilde av bestandens størrelse. For øvrig, bortsett fra reinen på Måkeøyane, ble tellingene utført fra båt, og derfor regner jeg med at det antall dyr som ble observert må betraktes som minimumstall.

Den nordlige delen av Roosneset er avgrenset av en bratt fjellvegg og har bare en smal stripe land helt nede ved stranden, noe som gjør det lite sannsynlig at noen av dyrene er blitt talt flere ganger. Telling på vestsiden av Liefdefjorden og Reinsdyrflya ble ikke utført. Kalvene utgjorde nærmere 10 % av den samlede bestanden. Jeg vil til slutt presisere at tellingene vanskelig kunne utføres mer nøyaktig, selv om dette nok ofte kunne være ønskelig. Takseringer, beiteundersøkelser o. l. måtte nødvendigvis bli overfladiske, da dette var sekundære oppgaver, som vi fikk lite tid til.

Diskusjon

Vi hadde dessverre ikke anledning til å foreta tellinger på selve Reinsdyrflya, men ifølge opplysninger fra ekspedisjoner som var i dette området, er det neppe mer enn 150–200 rein i dette området. Tilsammen skulle stammen altså være på ca. 400 rein. Når man sammenligner dette resultatet med tidligere takseringer som er blitt gjort i området (LØNØ 1959), vil man se at det er liten forskjell. Det har således neppe vært noen større bestandsøkning, til tross for at reinen er totalfredet og ikke har vært utsatt for annen beskatning enn gjennom krypskytning. Når man sammenligner beitelandet i områder der det finnes rein i dag og der dyrene er blitt utryddet for lang tid siden, blir man slått av den store forskjellen i plantemengder. En liten og meget overfladisk beiteanalyse som ble foretatt i områder med og uten rein, synes å tyde på at de benyttede områdene i dag er meget hårdt beskattet. Det er derfor vanskelig å vente noen ytterligere bestandsøkning i Bockfjordområdet. Til tross for at breer, islagte fjorder og fjell ikke burde være noen uoverstigelige barrierer for reinen, er det likevel et faktum at stammene i meget liten grad trekker ut til nye, ubenyttede beiteområder på Vestspitsbergen. Dette gjelder f. eks. for reinstammene i Bockfjorden og i Van Keulenfjorden.

Av flere grunner ville det derfor være interessant å foreta et flytningsforsøk ved en senere anledning. For det første er det rimelig å anta at en flytning til tidligere benyttede beiteområder ville gi en generell bestandsøkning. For det andre ville et slikt eksperiment kunne gi et meget interessant studieobjekt m. h. t. dyrenes tilpasning til det nye feltet, formeringsevne, levealder, vandringer etc. Dersom forsøket faller heldig ut, kunne et slikt felt danne utgangspunkt for nye flytninger. Det er derfor å håpe at Norsk Polarinstitutt vil få anledning til å satse på et nytt forsøk, og da med andre og bedre fangstmetoder enn de som ble benyttet sommeren 1963.

Det er lite sannsynlig at det nytter å bruke de fangstmetodene som vi forsøkte i Sjøvernbukta. I så fall vil den eneste muligheten være å benytte mer solide ledegjerder, bygget av trematerialer, og helikoptere i selve drevet. En slik innfanging ville imidlertid falle uforholdsmessig dyr. Det ville da være langt mer hensiktsmessig å benytte paralyserende preparater, skutt ut med kruttladet injeksjonsgevær. Denne metoden er forholdsvis ny innen viltbiologiske undersøkelser, og hvert eneste år kommer det nye og forbedrede preparater på markedet med bl. a. større toleranseområder og mindre bivirkninger. Innfanging med slikt utstyr vil derfor i fremtiden neppe by på særlig store praktiske vanskeligheter.

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Norsk Polarinstitutts virksomhet i 1963

AV

TORE GJELSVIK

Organisasjon og administrasjon

Personale

Ved Stortingsbeslutning fikk Norsk Polarinstitutt fra 1. januar 1963 fem nye stillinger, slik at instituttet ved utgangen av året hadde 29 regulære stillinger. De nye stillingene var: operasjonssjef (leder av helikopteroperasjoner), to geolog-II, en konstruktør-I og en karttegner-III. Den ene stilling som geolog-II ble midlertidig omgjort til vitenskapelig assistent, da den som ble ansatt ikke hadde full embetseksamen. Stillingene som operasjonssjef og karttegner-III ble midlertidig besatt for året 1963.

Stillingene som geodet-II og topograf-II ble gjort om til henholdsvis geodet-I og topograf-I. De ble besatt fra henholdsvis 19. januar og 1. februar. En geolog-II-stilling var ubesatt fra 1. februar og ut året. Kontorsjefstillingen sto fortsatt ubesatt i hele 1963. En stilling som fullmektig-II ble gjort om til fullmektig-I fra 1. juni 1963. Elleve personer var midlertidig engasjert for kortere eller lengre tid, hvorav fire med oppgaver vedrørende Antarktis.

Den faste staben:

Direktør:	TORE GJELSVIK, dr. philos.
Operasjonssjef:	THOR SIGGERUD, cand. real. Tiltrådte 1. februar.
Geolog-I:	HARALD MAJOR, cand. real.
Geolog-I:	THORE S. WINSNES, cand. real.
Geolog-II:	THOR SIGGERUD, cand. real., til 31. januar.
Geolog-II:	AUDUN HJELLE, cand. real. Tiltrådte 1. mars.
Geolog-II:	JENÖ NAGY, stud. real. Ansatt som vitenskapelig assistent fra 1. februar.
Glasiolog-I:	OLAV LIESTØL, cand. real.
Geofysiker-II:	TORBJØRN LUNDE, cand. real.
Meteorolog:	VIDAR HISDAL, cand. real.
Hydrograf-I:	KAARE Z. LUNDQUIST, o/kapt.
Hydrograf-II:	HELGE HORNBÆK
Førstetopograf:	SIGURD G. HELLE, cand. mag.

Topograf i særklasse:	HÅKON HILL, jordskiftekandidat.
Topograf-I:	JOHANNES HUS, jordskiftekandidat. Tiltrådte 1. februar.
Geodet-I:	EINAR OLSEN, jordskiftekandidat. Tiltrådte 19. januar.
Konsulent I:	NATASCHA HEINTZ, cand. real.
Bibliotekar:	SØREN RICHTER, mag. art.
Kontorsjef:	Stillingen ubesatt.
Karttegner-I:	BJØRN ARNESEN
Karttegner-II:	BJARNE EVENSEN
Karttegner-III:	MAGNE GALÅEN. Midlertidig ansatt fra 1. februar.
Konstruktør-I:	EINAR NETELAND, tekniker. Tiltrådte 25. mars.
Laborant-I:	WILLY INGEBRETSEN
Fullmektig-I:	EVA ANDERSEN
Fullmektig-I:	SIGNE ØVERLAND, fullmektig-II til 1. juni.
Fullmektig-II:	MARTHA LUNCKE
Fullmektig-II:	GUDRUN EDWARDSEN
Vaktmester og bud:	KIRSTEN DANIELSEN

Midlertidig engasjerte:

Cand. real. TORGNY E. VINJE.
Ingeniør THOR ASKHEIM.
Ingeniør WILHELM SOLHEIM.
Jordskiftekandidat JOHANNES HUS til 31. januar.
Jordskiftekandidat EINAR OLSEN til 18. januar.
Jordskiftekandidat WILHELM FLAATA fra 5. juni.
Karttegner MAGNE GALÅEN til 31. januar.
Fullmektig ELI HOLMSEN, i deltidsstilling.
Meteorologassistent JOHAN L. B. PETTERSEN til 15. september.
Assistent HANS RUDOLF FRITSCH fra 1. september.
Fullmektig SYNNØVE ROGSTAD periodevis som vikar.

Stipendier:

Cand. mag. OLAV DYBVADSKOG, stipend til bearbeidelse av glasiologisk materiale.
Stud. real. MAGNAR NORDERHAUG, stipend til bearbeidelse av ornitologisk materiale samlet på Svalbard.

Tjenestefrihet og permisjon:

HÅKON HILL hadde fortsatt tjenestefri frem til 27. august, for å gjennomgå et kurs i fotogrammetri ved det internasjonale fotogrammetriske sentret (ITC) i Delft, Nederland.
THORE S. WINSNES hadde permisjon fra 1. oktober for å virke som geolog for FN i Iran.

REGNSKAPET FOR 1963

Kap. 950 *Poster:*	*Bevilget*	*Medgått*
1. Lønninger	kr. 796 500	kr. 733 950
10. Kjøp av utstyr	» 15 000	» 14 990
15. Vedlikehold	» 2 000	» 400
20. Ekspedisjon til Svalbard og Jan Mayen	» 1 432 000	» 1 420 160
21. Undersøkelse av Statens kullfelter	» 50 000	» 50 850
29. Andre driftsutgifter	» 150 000	» 163 050
70. Stipend	» 30 000	» 19 320
	kr. 2 475 500	kr. 2 402 720
Kap. 31. Fyr og radiofyr på Svalbard	kr. 40 000	kr. 15 141
Kap. 338. Antarktisekspedisjonen 1956–60		
1. Lønninger	» 114 100	» 83 326
29. Andre driftsutgifter	» 130 000	» 89 416
	kr. 244 100	kr. 172 742

Kap. 3950	*Budsjettert*	*Innkommet*
1. Svalbard-budsjettet	kr. 1 175 000	kr. 1 175 000
2. Inntekter (salg m. m.)	» 10 000	» 10 846

Kommentar til regnskapet:

Besparelsen på lønningsposten skyldes ubesatte stillinger.

Post 20 var opprinnelig budsjettert med bl. a. kr. 30 000 til utgifter i forbindelse med disponering av helikoptere fra Luftforsvaret. Da dette likevel ikke så seg i stand til å avse passende helikoptere, ble posten tillatt forhøyet med kr. 120 000 (inkludert i oppstillingen). Av dette ble kr. 10 000 tatt fra stipendposten (opprinnelig på kr. 40 000), kr. 75 000 som ekstraordinær bevilgning fra Svalbardbudsjettet og kr. 35 000 som ekstrabevilgning fra statsbudsjettet.

Under ekspedisjoner er også tatt med en engangsbevilgning på kr. 813 000 til innkjøp av elektronisk posisjonssystem Hi-Fix (medgått kr. 813 500).

Merforbruket på post 29 skyldes vesentlig en tillatt overskridelse på omtrent kr. 10 000, som sto igjen fra 1962 til trykning av materiale fra Antarktisekspedisjonen 1949–52.

Besparelsene på post 70 skyldes at Instituttets forslag om anvendelse av kr. 10 000 ikke ble godkjent av departementet og der var for liten tid til nytt, gjennomarbeidet forslag.

Under fyr og radiofyr på Svalbard ble der innspart fartøyleie.

Regnskapet for Antarktisekspedisjonen 1956–60 viser også i år store besparelser fordi beskjeftigelsesgraden ble lavere enn antatt. Også kartfremstillingen gikk senere enn forutsatt.

Av bevilgningen fra Svalbardbudsjettet er kr. 300 000 ordinært, kr. 800 000 ekstraordinært til anskaffelsen av Hi-Fix systemet samt kr. 75 000 ekstrabevilgning til helikoptertjeneste.

Diverse

KAARE Z. LUNDQUIST assisterte fortsatt direktøren med administrasjonsarbeidet. THOR SIGGERUD forberedte sammen med HELGE HORNBÆK innflytningen til de nye kontorlokalene i Middelthuns gate 27 B.

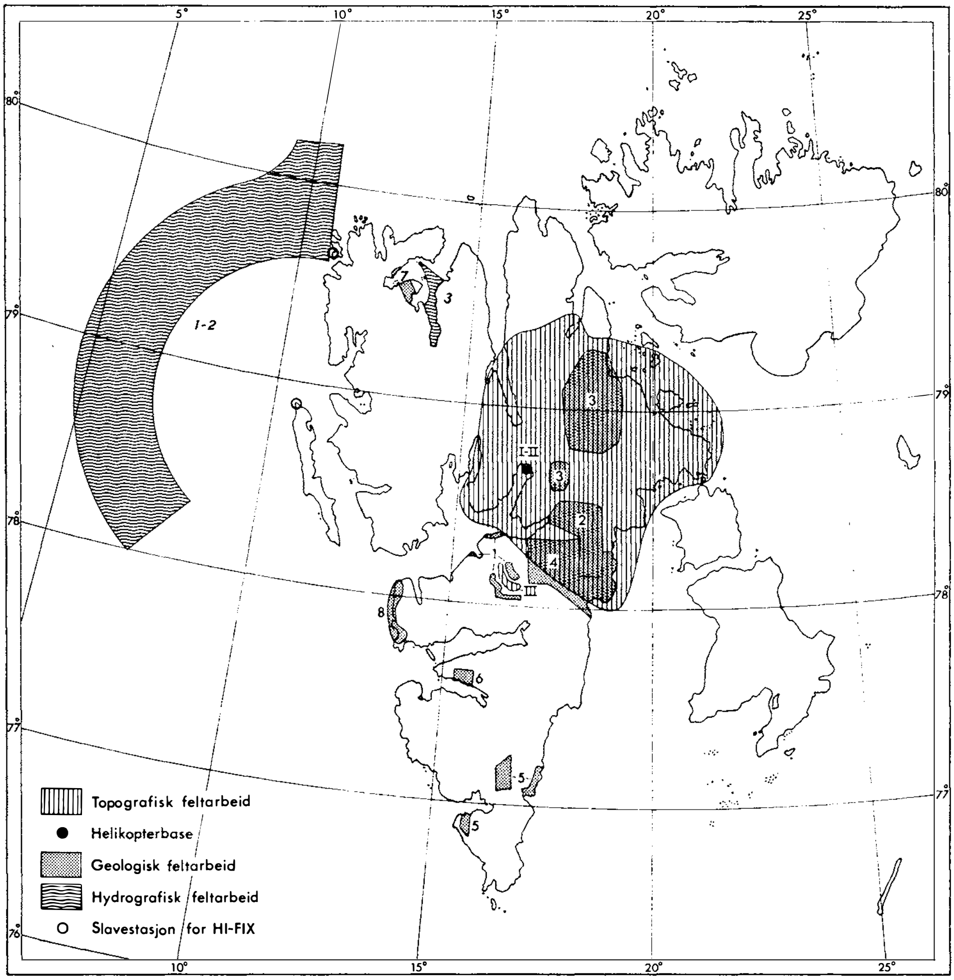

Fig. 1. *Kartet viser hvor Norsk Polarinstitutts feltpartier arbeidet sommeren 1963. Tallene 1–2, 3 (kursiv) angir hydrografenes arbeidsområde, I–II, III viser topografenes arbeidssteder og 1, 2, 3, 4, 5, 6, 7 og 8 refererer seg til de områdene som ble undersøkt av geologene.*

Ekspedisjonsvirksomheten

Svalbard

Isforholdene i Svalbardfarvannene under feltsesongen 1963 var betydelig bedre enn i 1962. Fjordisen var imidlertid tykk på grunn av den strenge vinterkulden, hvilket skaffet adskillige isvansker for kullskipningen i begynnelsen av sesongen. Likeledes var isforholdene i Storfjorden og i Barentshavet ned til Bjørnøya vanskelige i største delen av sesongen. I juli var det de fleste steder mye skodde eller lavt skydekke og vintersnøen lå lenge. Været bedret seg imidlertid i august slik at sommerens værforhold som helhet må kunne betegnes som forholdsvis normale.

Ekspedisjonsvirksomheten ble innledet med at havisforsker TORBJØRN LUNDE 3. juni og 2. juli gjennomførte to isrekognoseringstokter. Disse toktene kom i stand ved velvillig imøtekommenhet fra Luftkommando Nord-Norge som stilte ett av Luftforsvarets Albatross-fly til instituttets disposisjon for disse to toktene.

Ekspedisjonsvirksomheten sommeren 1963 var i flere henseender preget av at moderne hjelpemidler kunne tas i bruk og dette kom særlig sjø- og landkartleggingen til gode. Det nyanskaffete elektroniske systemet (Hi-Fix) for posisjonsbestemmelse gjorde at opploddingen kunne foregå også i skodde og ved lavt skydekke. Dessuten hadde instituttet fra Forsvarets Forskningsinstitutt fått leiet M/S «H. U. Sverdrup», slik at sjømålingene kunne foregå uhindret av den øvrige ekspedisjonsvirksomheten. Til hjelp for landpartiene hadde man foruten ekspedisjonsfartøyet M/S «Signalhorn», også hjelp fra sysselmannsbåten M/S «Nordsyssel».

Landkartleggingen ble drevet fra en fast base i Billefjorden ved hjelp av to Bell-helikoptere (Bell 47 G 2 og Bell 47 D 1), leiet fra Bergen Air Transport (BAT). De geologiske partiene fikk også noen hjelp av helikopterne, i første rekke til å sette snøscotere og annet utstyr på isbreene og til rekognoseringsturer.

De samlete resultatene av helikoptervirksomheten ble over all forventning og det hele ble gjennomført uten uhell av noen art.

For det geologiske arbeidet på Svalbard viste det seg at kombinasjonen helikopter/snøscooter var en heldig løsning av de ofte meget vanskelige transportforholdene.

Norsk Polarinstitutts ekspedisjonsvirksomhet på Svalbard er langt mer variert enn de øvrige ekspedisjonene som arbeider på Svalbard. De har gjerne bare ett enkelt formål, det være seg vitenskapelig eller økonomisk. Instituttet kan derfor ikke uten videre overføre andres erfaringer til sine formål. Selv om årets ekspedisjon på mange måter hadde karakteren av et eksperiment, er det hevet over enhver tvil at ekspedisjonen 1963 var meget vellykket. Instituttet kan derfor trygt bygge på de erfaringene som ble høstet denne sommeren for sin ekspedisjonsvirksomhet i de nærmeste årene fremover.

Sommerens ekspedisjon besto i alt av 19 større og mindre partier på tilsammen 55 mann. Sammen med mannskapet på de to ekspedisjonsfartøyene og besetningen og mekaniker til helikopterne utgjorde ekspedisjonene i alt 76 mann, og var den største ekspedisjon i instituttets historie hittil. Tre av partiene arbeidet for Statens kullfelter. Norsk Polarinstitutts medarbeidere sendte over til bergmesteren for Svalbard i alt 33 anmeldelser av funnpunkter.

Ekspedisjonsfartøyene. – Ekspedisjonsfartøyet M/S «Signalhorn» med Bjarte Brandal som fører, ble overtatt av Kaare Z. Lundquist i Åndalsnes 25. juni. I Harstad forlot Lundquist «Signalhorn» og overtok M/S «H. U. Sverdrup» – fører Olav Nordhus, mens Thor Siggerud overtok «Signalhorn». Båten kom til Hornsund 2. juli, hvor de første partiene ble satt på land, og gikk så videre nordover og ankom Longyearbyen 7. juli. De fleste av ekspedisjonsdeltagerne reiste med kullbåten «Ingertre» fra Mo i Rana 4. juli og var i Longyearbyen 7. juli. Så å si alle partiene ble satt ut med «Signalhorn», bortsett fra de som skulle til nordkysten, som ble med sysselmannsbåten M/S «Nordsyssel». Denne bragte senere også proviant til disse partiene og hentet et par partier tilbake fra Bockfjorden.

«H. U. Sverdrup» returnerte til Nord-Norge 7. august, og LUNDQUIST overtok da igjen «Signalhorn». Deretter ble fyrene ettersett. Da helikopterbasen i Billefjorden ble oppløst noe tidligere enn beregnet, reiste de fleste som hadde arbeidet i tilknytning til basen, tilbake til Norge ca. 20. august med kullbåt. «Signalhorn» begynte hentingen av de øvrige partiene 26. august, og kom til Åndalsnes 4. september.

Hydrografparti 1 og 2. – Leder KAARE Z. LUNDQUIST med kapteinløytnant FINN BIE som assisterende hydrograf, EINAR NETELAND og assistenter ODD CHRISTIANSEN, KJELL FRØYSLID, FINN LILLEVIK og ARNE STANGNES.

Tre teknikere fra Decca Navigator Co. sto for installasjon og prøving av de nye Hi-Fix instrumenter ombord i M/S «H. U. Sverdrup» i Harstads havneområde. Den ene av teknikerne, D. CASSADY, fulgte med på fartøyets tokt.

Det oppsto en del vanskeligheter og man kom ikke avgårde fra Harstad før 11. juli. Det viste seg dessuten å være mye is i det planlagte arbeidsområde Bjørnøya/Hopen/Sørkapp. I stedet ble det foretatt opplodding i et improvisert arbeidsområde utenfor nordvestkysten av Vestspitsbergen. Partiet arbeidet med hovedsenderen ombord mens de to «slave»-stasjoner ble plasert på Fuglehuken og Amsterdamøya, og fikk i de 10 dagene stasjonene var i full drift ekkogrammer fra ca. 1350 nautiske mils opplodding.

Fartøyet deltok som sikringsfartøy i Billefjorden ved redningsaksjonen etter en engelsk student som var blitt livsfarlig skadet. For øvrig grunnstøtte fartøyet en gang. Det kom av ved egen hjelp og hadde ikke fått noen nevneverdige skader.

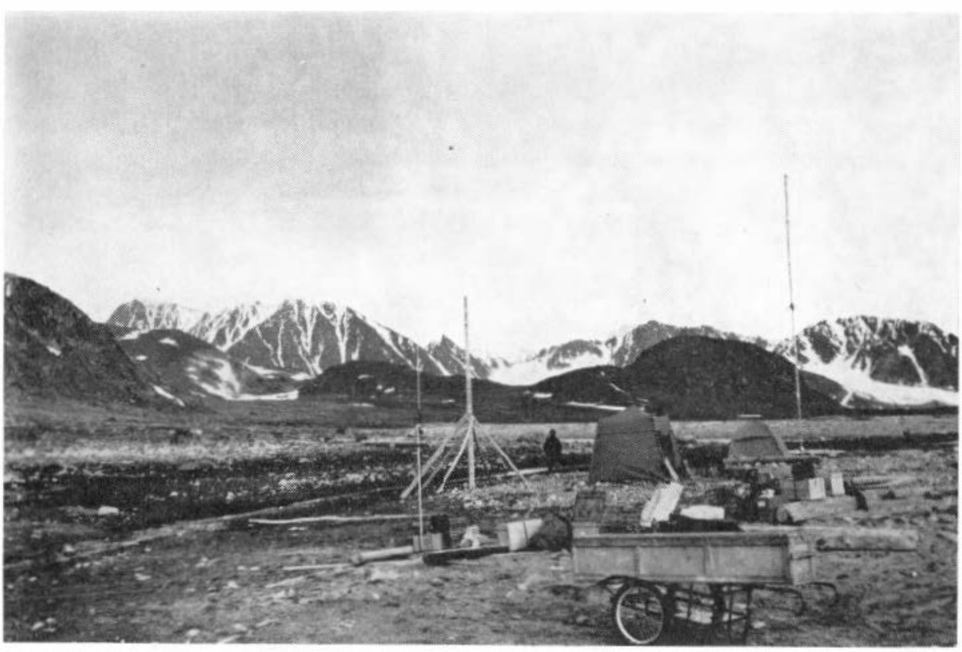

Fig. 2. *«Slavestasjonen» for Hi-Fix-anlegget på Danskøya.* Foto: K. Z. LUNDQUIST

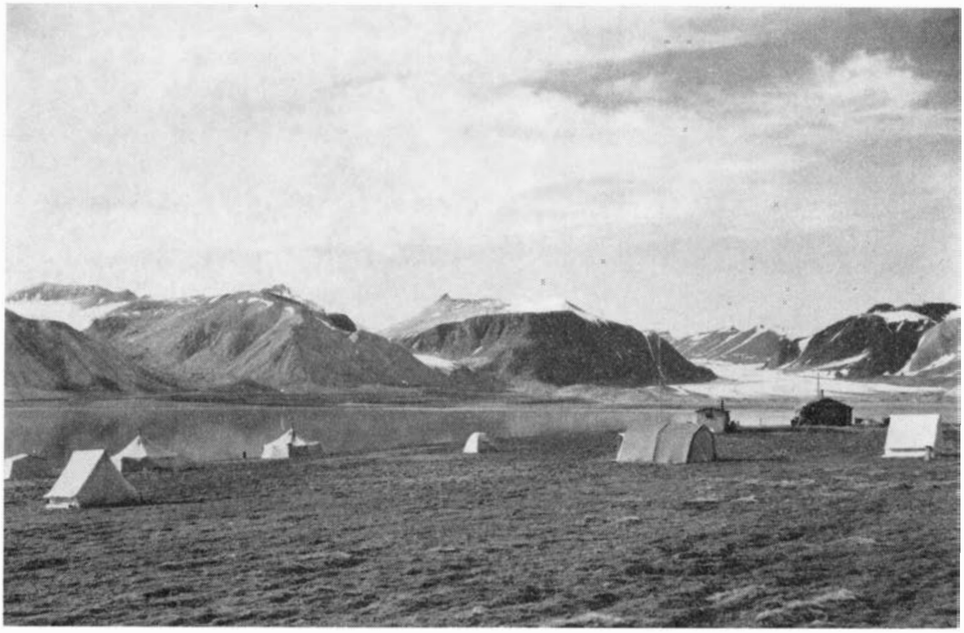

Fig. 3. *Helikopterbasen i Ebbadalen, Billefjorden.* Foto: T. SIGGERUD

Arbeidet ble avsluttet 3. august, da fartøyet måtte tilbake til Norge for andre arbeidsoppgaver.

Hydrografparti 3. – Leder HELGE HORNBÆK med assistenter ODIN ANDERSEN, KJELL HAUG og SIVERT UTHEIM. Opploddingen foregikk i Woodfjorden med hydrograferingsbåten «Svalis» og selv om det var mye skyet vær og nedbør, ble det få liggedager fordi det var lite vind og is og høy gjennomsnittstemperatur. (Fig. 1.) Woodfjorden ble således ferdigloddet ut til Jakobsenbukta–Stasjonsøyane. Partiet hjalp dessuten GJELSVIK med transporter mellom Bockfjorden og Liefdefjorden, og deltok i et forsøk på å fange rein på Rossflya.

Helikopterbasen. – Leder THOR SIGGERUD med assistenter TRULS ERIK JOHNSRUD, GUNNAR HOPE, ARNE LØVSTRAND (kokk) og KARL TINDELAND, samt den første tiden også WILLY INGEBRETSEN.

Baseleiren ble først etablert med telt ved siden av «Skottehytta» i Ebbadalen i Billefjorden. Hytta ble senere overtatt, rengjort og satt i stand til kjøkken og messe etter at et engelsk geologparti hadde flyttet derfra. En liten lemmebrakke, som var tatt med fra Norge, ble satt opp ved siden av «Skottehytta» og ble benyttet til kontor og radiohus. Leiren besto forøvrig av to 16-manns telt og en rekke mindre telt (Fig. 3).

Helikopterbesetningen bestod av førerne TERJE BAKKE og ROLF MARTINSEN og mekanikeren JAN OLSEN.

Topografene bodde hele tiden i leiren og ble fløyet ut og hentet tilbake alle dager været tillot det. Radiokontakten med geologpartiene i felten og de andre radiostasjonene var god, men sambandet med helikopterne var ikke tilfredsstillende.

Topografene brukte i alt 71 flytimer, mens geologene fikk 38 timer. Været var lite gunstig for helikopteroperasjonene i juli, men særlig i tidsrommet 11.–18. august ble det meget bra, og arbeidet gikk godt unna. Topografene fikk gjort langt mer enn planlagt på forhånd, men også geologene fikk mer hjelp av helikopterne enn opprinnelig beregnet. Dette gunstige resultatet skyldes for en stor del avtalen med helikopterselskapet (BAT) om at helikopterflyverne skulle delta som assistenter for topografene i felten, slik at det ikke var nødvendig å ta med en ekstra assistent. Dermed ble vekten kuttet ned under transporten, og flytiden meget mer effektivt utnyttet.

En ambulanseflyvning til Faraofjellet ble gjennomført 17.–18. juli, etter at en av deltakerne i Cambridge-ekspedisjonen hadde styrtet ned og blitt meget alvorlig skadet. Ett av helikopterne hentet straks legen i Longyearbyen, ARVID AHRFELDT, og dro deretter til ulykkesstedet. Her ble det liggende værfast i ca. 1 døgn på grunn av tett skodde. Da det ikke var radiokontakt med helikopteret under bakkeopphold, kunne ikke baseledelsen være sikker på årsaken til at helikopteret ikke straks returnerte. En ekspedisjon på 3 mann ble derfor sendt fra basen til fots. Heldigvis lettet skodden, og den hårdt skadede kunne bli brakt til sykehuset i Longyearbyen.

Helikopteroperasjonen 1963 ble gjennomført på en effektiv og sikker måte, selv om dette var instituttets første større operasjon av dette slag.

Topografparti 1 og 2. – Ledere henholdsvis JOHANNES HUS og EINAR OLSEN. De arbeidet ut fra helikopterbasen i Billefjorden og hadde delvis med assistenter derfra, men som oftest fikk de assistanse av helikopterflyverne. Trianguleringsarbeidet ble utført i området mellom Billefjorden og Wijdefjorden og østover hele Kong Olav V Land. Dessuten ble det foretatt noen utfyllende målinger sørøstover mot Agardhbukta (Fig. 1). Arbeidet i felten begynte 12. juli og ble avsluttet 20. august. Foruten triangulering, passpunktbestemmelser og bygging av varder ble det ved hjelp av tellurometer målt 4 basislinjer. OLSEN foretok observasjoner fra i alt 38 stasjoner, hvorav seks var målt inn under tidligere ekspedisjoner, mens HUS observerte fra i alt 32 nye stasjoner. I alt ble det bygget 24 nye varder og 10 gamle ble reparert. Til tross for at værforholdene ikke var spesielt gunstige, ble resultatet av de trigonometriske målingene sikkert det mangedobbelte av hva det ville ha vært uten helikopterassistanse, og en rekke topper ville det dessuten trolig ikke vært mulig å nå uten helikopter. Det må således trygt kunne sies at for topografisk feltarbeid i det indre av Svalbard er helikopter et helt uunnværlig hjelpemiddel. Ved helikopterbasen ble det ved flo og fjære daglig ført vannstandsobservasjoner.

Et par dager på slutten av feltsesongen utførte topografpartiene 1 og 2 tellurometermålinger i Adventdalen. Disse skulle brukes av topografparti 3 under arbeidet med oppmålingen av «Gruve VII»-området.

Topografparti 3. – Leder WILHELM FLAATA med assistenter ODD FJORDHEIM, STEINAR KJENSTAD og HANS JACOB URBYE. Etter henstilling fra Industridepartementet om kartlegging av «Gruve VII»-området ble det utført tachymetrering og terrestriske fotogrammetriske opptak i Adventdalen, på begge sider av Bolterdalen inn til Riperbreen, vestre side av Foxdalen og nordre del av Breinosa. Arbeidet ble utført i tiden 13. juli til 31. august. Etter planen var det meningen å bruke to feltsesonger på dette arbeidet. Da imidlertid topografparti 3 mot slutten av august fikk hjelp av helikopter og topografene HUS og OLSEN, lyktes det å bli ferdig på én sommer.

Geologparti 1. – Leder HARALD MAJOR med assistenter GUNNAR B. LUND og MAGNE LØVFALDLI. MAJOR assisterte først FLAATAS parti med tilrettelegging av sommerens arbeid. Videre sørget partiet for merking av 60 kullavdekninger i Bolterdalen og 18 i Foxdalen med varder og signalduk, og foretok innmåling av fløtshøyder i relasjon til høyden på vardene. To funnpunkter for kull i området mellom Adventdalens kullfelt og Skoltenantiklinalen ble merket, og til dette fikk partiet traktorassistanse fra Store Norske Spitsbergen kullkompani (S.N.S.K.). Under den videre avmerking av 8 funnpunkter for kull i de ytre områdene av Adventdalens kullfelter – ble det benyttet helikopter. MAJOR utførte videre stratigrafiske undersøkelser og oppmålinger av profiler på en rekke steder innenfor kartbladet Adventdalen. Etter oppfordring fra fungerende bergmester tok han kullprøver fra Vestre Senterfelt ved Ny-Ålesund. Prøver fra «Gruve V» ved Longyearbyen ble tatt for å studere variasjonen av svovelinnholdet i kullfløtsene.

Etter oppfordring fra fungerende bergmester deltok MAJOR i dennes inspeksjon av kullgruvene i Barentsburg og Pyramiden. Han hjalp også bergmesteren på annen måte og ytet assistanse til S.N.S.K. når det gjaldt klarlegginen av de geologiske forholdene i «Gruve V», og med råd angående selskapets utmålsarbeider.

Geologparti 2. – Leder THORE S. WINSNES med assistenter GJERMUND BERGAUST og BJARNE LIEUNGH. Partiet ble satt i land ved Von Postbreen i Billefjorden 9. juli og undersøkte karbonlagene her, mens de ventet på helikoptertransport. De ble 11. juli med utstyr og en snøscooter flyttet med helikopter 10 km innover i østlig retning. Partiet kartla geologisk og utførte detaljerte stratigrafiske og paleontologiske undersøkelser i karbon-perm- og trias-lagene over et stort område nordøst for Tempelfjorden. WINSNES hadde også lagt opp arbeidet for geolog D. L. J. NIEMANTSVERDRIET og besøkte hans leir i Fulmardalen i løpet av sommeren. WINSNES fikk hjelp av helikopter til et par rekognoseringsturer, men brukte ellers snøscooter til transport, som stort sett virket tilfredsstillende, bortsett fra i begynnelsen av sesongen da det bød på store vanskeligheter å krysse områder med sørpe og oppbløtt snø.

Geologparti 3. – Leder AUDUN HJELLE med assistenter HANS RUDOLF FRITSCH og KNUT STØREN. Partiet ble satt ut med helikopter fra hovedbasen i Ebbadalen til Bumerangkammen ved Nordenskiöldbreen. De hadde til oppgave spesielt å undersøke granittkontaktene i de indre, høyereliggende delene av Ny Friesland og å utføre utfyllende geologiske undersøkelser i det samme området. Sommerens feltarbeid viste at det ved Nordenskiöldbreen ikke fantes et homogent granittområde, men at hovedbergartene er gangformete intrusjoner av diorittisk sammensetning, tildels med migmatittiske overganger mot eldre suprakrustale Hecla

Fig. 4. *Helikopteret er kommet på besøk til en av geologpartienes leir inne på Nordenskiöldbreen.*
Foto: J. Hus

Hoek-bergarter. Det ble også funnet gabbrointrusjoner, øyegneis og kvartsitter med bølgeslagsmerker. Med snøscooter flyttet partiet senere innover til Blånuten, og her ble det tatt opp detaljerte stratigrafiske undersøkelser over en ca. 2 000 m mektig, variert serie av Hecla Hoek-bergarter. Lagene består hovedsakelig av gråvakker og kvartsitter. Fra basen ved Blånuten ble det flere ganger brukt helikopter, i første rekke for å undersøke Chydeniusgranitten og dens kontaktbergarter. Chydeniusgranitten er til dels massiv og ofte rik på mørke inneslutninger, men kontakten til Hecla Hoek-bergartene som består av skifre, kvartsitter og karbonatbergarter, er sjelden blottet. Geologiske ekspedisjoner fra Universitetet i Cambridge har tidligere arbeidet i dette området, og de hadde elskverdigst stillet sitt kartmateriale til disposisjon. Partiet hadde som spesialoppgave å lete etter malmforekomster, men noen mineraliseringer av økonomisk betydning ble ikke funnet.

Partiet satte opp 4 varder til hjelp for topografene.

Geologparti 4. – Leder Dinand L. J. Niemantsverdriet (Nederland) med assistenter Richard E. Binns (England) og Jarle Land. Partiet ble med helikopter satt på land innerst i Sassendalen og senere flyttet over til Agardhbukta. Det arbeidet ut fra disse to stedene og utførte til dels meget detaljerte stratigrafiske undersøkelser og kartlegging innen et område på ca. 1000 km² mellom Sassenfjorden og Storfjorden.

Geologparti 5. – Leder JENÖ NAGY med assistenter STIG OTHAR BANG og TORE VRÅLSTAD. Partiet ble først landsatt i Hornsund og fretok undersøkelser av Grimfjellområdet på Torell Land, hvor det tidligere var anmeldt noen funnpunkter på kull. Feltarbeidet i forbindelse med anmeldelse av i alt 10 funnpunkter på et område på ca. 100 km² ble utført. Partiet flyttet deretter tilbake til Hornsund og undersøkte et kullførende område i Lisbetdalen–Hornsundneset, hvor 6 funnpunkter ble bestemt. Det dreier seg her om to kull-lag av vekslende karakter og mektighet.

I slutten av juli ble partiet av «Signalhorn» flyttet til Hambergbukta i Storfjorden. Her tok de opp undersøkelser av de kullførende lagene, som var påbegynt i 1962. I alt ble syv nye funnpunkter for kull bestemt i dette området, slik at dette partiet til sammen sommeren 1963 anmeldte 23 funnpunkter.

Geologparti 6. – Leder cand. mag. EIGILL NYSÆTHER (Bergen) med assistenter KARSTEN LIED og ERLING MADSEN. Partiet fortsatte undersøkelsene på nordsiden av Van Keulenfjorden mellom Louiseberget og Davisdalen som ble påbegynt i 1962. Videre ble området mellom Penckbreen og Basilikafjellet undersøkt, og de indre områdene av fjorden i retning av Van Mijenfjorden ble besøkt. Partiet arbeidet vesentlig med sedimentenes strukturer og stratigrafiske undersøkelser. Det ble også foretatt observasjoner av betydning for de tektoniske forhold, og det ble konstatert flere mindre overskyvninger.

Geologparti 7. – Leder TORE GJELSVIK med PER JOHNSON som assistent og Dr. JAN SZUPRYCZYŃSKI (Polen) som deltok med eget program. GJELSVIK utførte petrografiske og malmgeologiske undersøkelser, først i øygarden utenfor nordvesthjørnet av Vestspitsbergen, og senere mellom Bockfjorden og Liefdefjorden, og da vesentlig i Heckla Hoek-bergarter. Et par dager ble også brukt til studier av Sverre-vulkanen i Bockfjorden og til å undersøke kontaktforholdene til devonformasjonen på begge sider.

Lave skyer omtrent hver dag gjorde det vanskelig å arbeide i høyden, men det lyktes likevel å få kartlagt Hecla Hoek-stripen mellom Bockfjorden og Liefdefjorden. Lagene ligger her i en antiform med akse fallende nordover mot Liefdefjorden. Bergartene består nederst av migmatittiske gneiser gjennomsatt av forskjellige granittganger. Oppover mot den overliggende mektige marmorserie avtar migmatiseringen. Marmorserien er til dels intenst småfoldet og inneholder skiferlag av rusten karakter. En samling fiskefossiler fra devon ble funnet på en ny lokalitet på Roosstranda, nær Sjøværnbukta.

Et par dager ble også brukt til studier av Hecla Hoek-formasjonene på nordsiden av Liefdefjorden, hvor de tektoniske forhold synes å være betydelig mer kompliserte, og hvor det også finnes en stor karbonat-serie. Undersøkelsene strakte seg over et tidsrom av vel 2 uker.

Den polske kvartærgeologen JAN SZUPRYCZYŃSKI skulle etter planene ha foretatt kvartærgeologiske undersøkelser, særlig av morenene i isbreenes marginalsoner og delvis også av de «gamle» moreneryggene. Videre var det meningen at han skulle utføre spesielle kvartærgeologiske undersøkelser ved Sverre-vulkanen for å få en bedre bestemmelse av dennes alder. Dessverre måtte SZUPRYCZYŃSKI avbryte sine undersøkelser etter et par uker og reise tilbake til Polen, samtidig med at direktør GJELSVIK returnerte. Assistent PER JOHNSON sluttet seg da til THOR LARSENS parti.

Geokjemiparti. – Leder WILLY INGEBRETSEN. Etter at INGEBRETSEN først hadde deltatt i leirarbeidet i helikopterbasen, dro han 9. august med «Signalhorn» til Kapp Linné for å fortsette å samle bekkesedimenter for geokjemiske undersøkelser på strandflaten og i fjellskråningene fra Kapp Linné og sydover mot Bellsund. INGEBRETSEN hadde med en trehjuls varesykkel og hadde planlagt å bruke den til transporter sydover på strandflaten. Vannføringen i Orustelva var så stor at det var umulig å krysse denne, og han kom derfor først en uke senere frem til sitt arbeidsområde på den sydlige delen av strandflaten og fjellskråningene, og da med båt fra stasjonen på Isfjord Radio. I mellomtiden tok han en del supplerende prøver i det området hvor det ble tatt prøver året før. Arbeidet i den sydlige delen av området ble dessverre sterkt hindret av dårlig vær, og programmet ble derfor ikke fullført under denne ekspedisjonen.

Biologparti 1. – Leder stud. real. THOR LARSEN (Oslo) med assistenter ODDVAR BREKKE og EIGIL REIMERS. Etter anmodning fra Sysselmannen på Svalbard og på vegne av befolkningen i Ny-Ålesund hadde Norsk Polarinstitutt påtatt seg å forsøke å flytte åtte–ti rein til Brøggerhalvøya, hvor den tidligere reinbestanden forlengst er utryddet. En gruppe på tre realstudenter hadde påtatt seg oppdraget og hadde i samarbeid med Statens Viltundersøkelser og Veterinærinstituttet utarbeidet planer for innfanging og overføring av dyrene. Man var kommet til at det beste ville være å bruke muskellammende midler til fangsten, en metode som nå brukes til tilsvarende formål i flere land. Veterinærdirektøren ga imidlertid ikke tillatelse til å benytte denne metoden. Avslaget kom akkurat idet ekspedisjonen skulle reise nordover, og det ble således meget knapp tid til å utarbeide alternative fangstmetoder. Det ble imidlertid forsøkt å drive dyrene inn i en innhegning ved hjelp av V-formede ledegjerder. Under inndrivningen som første gang ble foretatt med assistanse fra GJELSVIKS og HORNBÆKS partier og annen gang også med assistanse fra mannskapet på «Nordsyssel», unnslapp alle dyrene delvis gjennom og delvis over ledegjerdene. Forsøkene ble deretter oppgitt, bl. a. fordi dyrene var så sky og bare kastet seg mot innhegningene, og man var redd for at de kunne brekke bena eller få andre skader.

Reinbestanden i Liefdefjorden-området ble anslått til ca. 150 dyr, hvorav de fleste befant seg på Roosflya. Beiteforholdene så ikke ut til å være særlig gode, og det er en mulighet for at bestanden var for stor akkurat innen dette spesielle området. En nøyaktig beiteanalyse ble ikke gjennomført. Etter at reinflyttingen var oppgitt, flyttet partiet etter råd fra direktør GJELSVIK til Sallyhamna i Svenskegattet. Her ble det tatt opp ornitologiske undersøkelser, særlig med henblikk på å taksere bestandene av ærfugl, polarmåke og alkefugler. Følgende fugler ble ringmerket: Ærfugl (*Somateria m. borealis*) 7 unger; vestlig ringgås (*Branta bernicla hrota*) 1 unge; fjæreplytt (*Calidris maritima*) 4 unger; polarmåke (*Larus* *hyperboreus*) 18 unger; rødnebbterne (*Sterna macrura*) 3 voksne, 4 unger; alkekonge (*Plautus alle*) 1000 voksne; polarlomvie (*Uria lomvia*) 10 voksne, 40 unger; polarlunde (*Fratercula arctica*) 10 voksne. Til fanging av alkekonger for merking, ble brukt en mindre og lettere type av flegjehov, enn den som ble benyttet i Hornsund i 1962. Denne nye hovtypen viste seg også å være anvendbar til fanging av lomvi, lundefugl og rødnebbterne. Mageinnholdet på 64 polarmåker ble undersøkt.

Biologparti 2 og *3*. – Leder cand. mag. MAGNAR NORDERHAUG og stud. real. NILS G. GULLESTAD (Oslo) med assistenter HANS PETTER GULLESTAD, KARL HAGELUND og RAGNAR SYVERTSEN. Begge partiene arbeidet i Hornsundområdet, vesentlig mellom Luciapynten og Isøyane, med hovedstasjon i den polske vitenskapelige stasjon i Isbjørnhamna. Mye vind og stor nedbør vanskeliggjorde arbeidet.

NORDERHAUG fortsatte studiene av alkekongens (*Plautus alle*) biologi, som ble påbegynt i 1962. Det ble arbeidet med undersøkelser av ernæringsforhold og forplantningsbiologi og 2686 fugler ble merket, fordelt på følgende arter: Havhest (*Fulmarus glacialis*) 320 voksne; fjæreplytt (*Calidris maritima*) 2 voksne, 19 unger; polarsvømmesneppe (*Phalaropus fulicarius*) 1 voksen, 2 unger; tyvjo (*Stercorarius parasiticus*) 4 voksne, 4 unger; polarmåke (*Larus hyperboreus*) 15 unger; krykkje (*Rissa tridactyla*) 92 voksne, 8 unger; rødnebbterne (*Sterna macrura*) 1 voksen, 155 unger; alkekonge (*Plautus alle*) 1870 voksne, 31 unger; polarlomvie (*Uria lomvia*) 29 voksne, 27 unger; snøspurv (*Plectrophenax nivalis*) 20 voksne, 67 unger. Videre ble det foretatt observasjoner av både hvitkinngjess (*Branta leucopsis*) og ringgjess (*Branta bernicla hrota*).

GULLESTAD fortsatte undersøkelsene av røye (*Salmo alpinus*) i Revvatnet og Revelva. Han fanget i alt 76 fisk i lengde varierende fra 4 til 65 cm. Dessuten ble det tatt 2 sett med vannprøver, planktonprøver, bunnprøver fra elven og samlet inn insekter. I alt 47 fisk ble merket med et lite merke festet i forkant av ryggfinnen.

Et privat norsk selskap «Norsk Polarnavigasjon A/S» foretok oljeundersøkelser på Brøggerhalvøya og vestsiden av Grønfjorden.

Utenlandske ekspedisjoner til Svalbard.

American Overseas Petroleum Ltd., Norsk Caltex Oil A/S: Selskapet fortsatte sine oljeundersøkelser, som vesentlig ble konsentrert om Edgeøya og Barentsøya. Leder A. S. WESTERHOLM. Leiet ekspedisjonsfartøy M/S «Polarøy» og 2 helikoptere.

Sovjet-russisk ekspedisjon sendt ut av Institutt for Arktisk Geologi i Leningrad. Den arbeidet med kull- og oljeundersøkelser, men også med mer generelle geologiske arbeider og undersøkelser etter andre nyttige mineraler og malmer.

University of Cambridge, Sedgwick Museum: Geologiske og botaniske undersøkelser i de nordlige og sentrale deler av Vestspitsbergen. Leder A. H. NEILSON – 28 deltagere. Egen motorbåt «Salterella» og en del småbåter.

Tysk ekspedisjon fra Zoologisches Staatsinstitut und Zoologisches Museum, Hamburg: Biologiske studier i området ved Ny-Ålesund. Leder S. GERLACH – 2 deltagere.

Fransk ekspedisjon fra Arctique et Montagne, Caluire (Rhône): Geografiske og geologiske studier i området Ny-Ålesund og Prins Karls Forland. Leder Professor J. CORBEL.

Tysk ekspedisjon fra Geologisch-palaeontologisches Institut und Museum der Rhein, Fredrich-Wilhelms-Universität, Bonn: Geologiske-paleontologiske studier i området Isfjorden–van Mijenfjorden. Leder: Dr. H. J. SCHWEITZER – 6 deltagere.

Finsk ekspedisjon fra Oulu-universitetet: Ornitologiske studier i området ved Kapp Linné. Leder E. S. NYHOLM – 3 deltagere.

Dessuten flere klatreekspedisjoner og andre mer turistbetonte grupper.

Jan Mayen.

Norske ekspedisjoner

Med støtte fra Norsk Polarinstitutt organiserte stud. real. CHRISTOFER BANG (Oslo) og stud. real. STIG SKRESLET (Oslo) en ekspedisjon med det formål å samle inn materiale til hovedoppgaver i marin zoologi. Ekspedisjonen reiste fra Norge 15. juni med M/S «Polarhav» og kom til Jan Mayen 17. juni, hvorfra de igjen reiste 23. august. En del av planen kunne ikke bli gjennomført, da den medbragte motorbåten havarerte under en storm i slutten av juni. Det ble samlet inn røye (*Salmo alpinus*) i Nordlaguna og de hydrografiske forhold her ble også undersøkt. Ellers ble det samlet noe zoologisk materiale i littoralsonen langs kysten.

Utenlandske ekspedisjoner

The 1963 Imperial College Beerenberg Expedition, London: Geologiske studier på Nord-Jan. Leder: J. W. SHEARD – 14 deltagere.

Engelsk ekspedisjon: Arbeidet vesentlig 50–100 nautiske mil vest av Jan Mayen, men skulle også gå til øya for å prøve diverse utstyr. Leder: D. H. LEWIS – 5 deltagere.

Dronning Maud Land, Antarktis

Utenlandske overvintringsekspedisjoner

Overvintringsstasjonene var de samme som året før, nemlig:

1. SANAE, 70°19′ S, 2°22′ W, sørafrikansk ekspedisjon, 13 overvintrere.
2. Novolazarevskaja, 70°46′ S, 11°49′ E, russisk ekspedisjon.

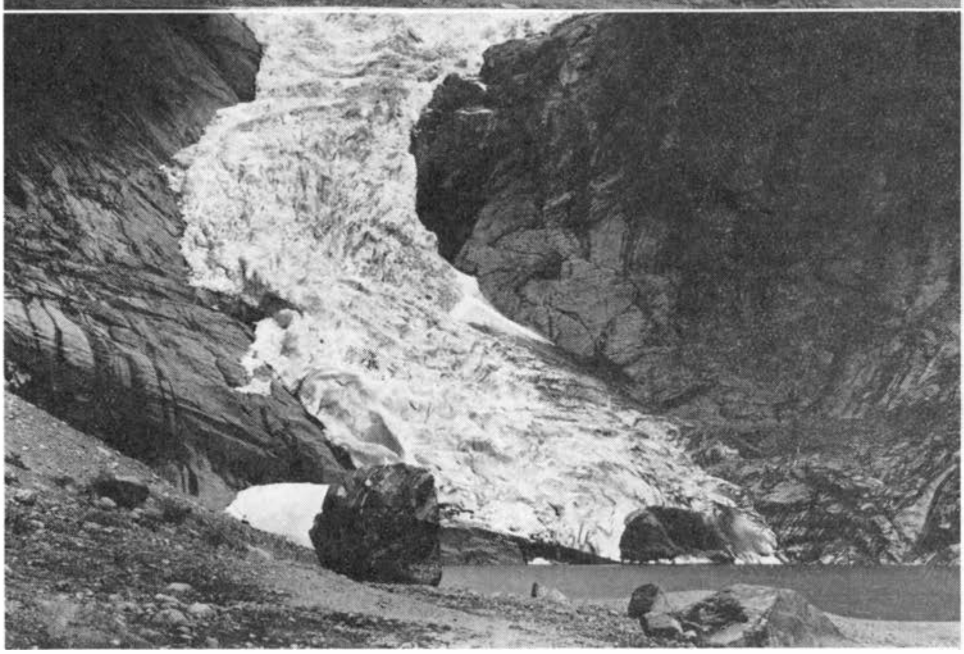

Fig. 5. *Bildene viser Briksdalsbreen, en nordvestlig utløper fra Jostedalsbreen, som har blitt undersøkt av glasiolog* O. LIESTØL *ved Norsk Polarinstitutt. Det øverste bildet er fra 1959, da breen var under framrykking. De siste to årene har den igjen minket, som det nederste bildet fra 1963 viser.*
Foto: O. LIESTØL

Breundersøkelser i Norge

I april 1963 begynte OLAV LIESTØL i samarbeid med Vassdragsvesenet på en ny undersøkelse av Hardangerjøkulen, med å kartlegge Rembesdalsskåki for å få et grunnlag for undersøkelse av materialhusholdningen på denne breen. Det ble i den forbindelsen konstruert et kart over Rembesdalsskåki i målestokk 1:20 000. Det ble ytet hjelp til de seismiske undersøkelsene som Geologisk Institutt i Bergen utførte på Hardangerjøkulen for å bestemme dens tykkelse og man kom til at jøkulens største mektighet er 300 m.

I mai ble vinterens akkumulasjon på Storbreen i Jotunheimen målt, og det viste seg at det bare var 60 % snø av hva som kommer i et normalt år. Hardangerjøkulen og Storbreen ble besøkt senere på sommeren, den siste i alt 8 ganger for måling av ablasjonen. Undersøkelsene på Nigardsbreen fortsatte og breen ble besøkt flere ganger. Stereofotogrammer ble tatt fra flere stasjoner for måling av hastighet og volumforandring. I slutten av august ble det tatt opp fotogrammer over Briksdalsbreen og frontene foran en rekke breer i Jotunheimen ble målt inn. De siste målingene på Hardangerjøkulen (i september) og på Storbreen (i oktober) ble utført av OLAV DYBVADSKOG. Arbeidet på Storbreen viste at Storbreen dette året hadde et meget stort underskudd, idet det kom bare 5,2 mill. tonn snø, mot normalt 7,4 mill. tonn, mens det smeltet 11,8 mill. tonn, mot normalt 9,5 mill. tonn (gjennomsnittlig for siste 15 år) og dette resulterte i at breen gjennomsnittlig minket 118 cm i tykkelse.

Hovedfagsstudentene RANDI PYTTE og OLAV DYBVADSKOG har med støtte fra Norsk Polarinstitutt fortsatt sine undersøkelser av henholdsvis Hellstugubreen og Tverråbreen. Stud. real. OLAV ORHEIM fra Universitetet i Bergen begynte høsten 1963 på en undersøkelse av Suphellebreen i Fjerland for hovedfag glasiologi. Han får også støtte fra Polarinstituttet.

Fra de faste observatørene har instituttet fått inn måleresultater fra 10 forskjellige breer, som alle i 1963 viser tilbakegang.

Bearbeidelse av materiale fra Svalbard

Hydrografisk avdeling

KAARE Z. LUNDQUIST arbeidet med kartredaksjon og en del mindre kartografiske arbeider. Han beregnet kartgrunnlaget for opploddingen Bjørnøya–Sørkapp–HOPEN, og forberedte bruken av det elektroniske posisjonssystemet Hi-Fix.

HELGE HORNBÆK beregnet målebordsoriginaler for Woodfjorden og vestkysten og førte over konturer til de førstnevnte. Videre konstruerte han originaler for opploddingen med Hi-Fix og foretok delvis montasje for fornyelse av sjøkart nr. 503 og nytt sjøkart over nordvest-hjørnet av Svalbard. Han tegnet dessuten et kart til internt bruk av det sistnevnte området.

EINAR NETELAND foretok ettersyn av Hi-Fix-materialet og kontrollerte instituttets radio- og radiotelefoniutstyr.

Topografisk-geodetisk avdeling

Det ble utarbeidet skjemaer til bruk ved geodetiske beregninger samt kartotekkort for trigonometriske punkter. Det ble utført en del trigonometriske beregninger etter gamle observasjoner. De trigonometriske observasjonene fra 1956 i området rundt Raudfjorden ble beregnet. De gjenstående trigonometriske beregningene etter observasjonene i Woodfjorden i 1962 ble fullført. Beregninger av sommerens målinger i Olav V Land, Ny Friesland og Bolterdalen–Foxdalen (Gruve VII) ble påbegynt. Det ble konstruert en del kystkonturer i Woodfjorden og Bockfjorden særlig for hydrografene. Kartbladene Vestspitsbergen søre del og Vestspitsbergen nordre del i målestokk 1:500 000 ble ferdige til trykking. Det er tegnet diverse kart spesielt til bruk for navnsetting.

Geologisk avdeling

HARALD MAJOR har ledet redigeringen og tegnearbeidet på det geologiske kartet C 9 Adventdalen (1:100 000), som er beregnet ferdig i løpet av 1964. Han har videre stått for inntegningen av Svalbards kullforekomster på et kart over Europas kullforekomster, og har deltatt i utarbeidelsen av driftskart for den planlagte «Gruve VII» i Adventdalen. MAJOR utførte konsulentarbeid vedrørende Svalbard-kull som råstoff for Norsk Koksverk og avga uttalelse om kullforekomstene i Grønfjorden i anledning søknad fra Artikugol om leie av Store Norske Spitsbergen Kulkompanis kullrettigheter der. Videre ble alle tilgjengelige utmålsdata for Vestspitsbergen tegnet inn på et kart i målestokk 1:400 000.

Thore S. WINSNES bearbeidet fossilmateriale som han samlet inn på Spitsbergen i 1961, sammenstillet de stratigrafiske data for karbon og perm og tegnet profiler for en sammenfattende oversikt over disse to periodene på Svalbard. Videre samlet han data om karbonavleiringene på Grønland for å kunne sammenligne med utviklingen i Svalbardområdet.

THOR SIGGERUD har bearbeidet det innsamlete materiale fra Kongsfjorden og St. Jonsfjorden og skrevet en oversikt over marmorforekomsten på Blomstrandhalvøya til Årbok 1962. Da SIGGERUD fra 1. februar midlertidig overtok stillingen som operasjonssjef, har mye av hans tid gått med til planlegging av sommerens helikopteroperasjon og dermed forbundne feltarbeid.

AUDUN HJELLE har siden han ble ansatt 1. mars foretatt mikroskopiske undersøkelser av en del bergarter fra Svalbards nordlige områder og bearbeidet det materiale som han samlet inn i de sentrale delene av Vestspitsbergen sommeren 1963. Han har videre gjort en del forarbeid for å undersøke mulighetene av kromatografisk identifisering av mineraler og eventuelt bergarter.

JENÖ NAGY har sammenholdt sine resultater på den østlige delen av kartbladet «Markhambreen» med det arbeidet K. BIRKENMAJER har utført på den vestlige delen av kartbladet, og geologien på dette kartbladet foreligger nå i hovedtrekkene ferdig rentegnet. NAGY har videre utarbeidet et struktur-konturkart over området ved Grimfjellet i Torell Land. 45 bunnprøver samlet på Svalbard i 1962 og 1963 er blitt analysert ferdig og ellers er en del fossilmateriale blitt preparert og fossilene artsbestemt.

NATASCHA HEINTZ har gjort ferdig et arbeid om dinosaurier på Svalbard i krittperioden og skrevet en kort artikkel om øglesporene på Festningsodden i det amerikanske tidsskriftet «Curator». Videre er bearbeidelsen av devonfisk-materialet fra Svalbard nesten avsluttet og den første halvdel av manuskriptet ferdig skrevet.

WILLY INGEBRETSEN har laget geologiske og paleontologiske preparater for instituttets geologer. Han har også, delvis i samarbeid med Norges geologiske undersøkelse i Trondheim, utført geokjemiske undersøkelser av de bekkesedimentprøvene han samlet inn i området mellom Isfjorden og Bellsund.

Den geologiske avdelingen har siden mai måned hatt et betydelig arbeid med uttalelser til myndighetene om spørsmål angående utmålskrav basert på geologiske indikasjoner.

Geofysisk avdeling

OLAV LIESTØL hadde frem til august hjelp av cand. mag. OLAV DYBVADSKOG til bearbeidelse av det glasiologiske materialet. Kartet over Finsterwalderbreen på Spitsbergen ble konstruert ferdig i løpet av året.

VIDAR HISDAL har som vanlig inspisert de meteorologiske stasjonene ombord på de norske hvalkokeriene. Han har skrevet en kort oversikt over været på Svalbard i 1962 for Årbok 1962.

TORBJØRN LUNDE har den vesentligste del av året bearbeidet de innkomne isobservasjonene og bl. a. konstruert midlere isgrenser for månedene februar–september for perioden 1946–63. Isobservasjonene fra fly tilhørende Luftkommando Nord-Norge, og fra ishavsstasjonene har kommet inn regelmessig, men derimot har det vist seg vanskelig å få tak i observasjoner fra skip, og da særlig fangstskuter, som ferdes i det aktuelle området. De innkomne isobservasjonene er ettersom de har kommet inn, blitt videresendt til interesserte. Således har Store Norske Spitsbergen Kulkompani fast fått isobservasjoner, og disse har også blitt sendt til Meteorological Office i England, som innarbeider dem i sine oversiktskarter over forholdene i Arktis.

Biologisk arbeid

NATASCHA HEINTZ har utvidet og delvis omarbeidet observasjons-skjemaet for biologiske data, som første gang ble brukt i 1962, og dessuten tatt med et tillegg for botaniske observasjoner. Tilsvarende til året før ble observasjonsskjemaet sendt med alle partiene som arbeidet på Svalbard sommeren 1963. De innkomne data ble bearbeidet i løpet av året og en ny oversikt gjort ferdig til trykking. Det forberedende arbeidet med flytting av rein fra nordkysten av Svalbard til Brøggerhalvøya tok en del tid og likeledes ble det ytet en del hjelp til zoologistudenter som skulle arbeide på Svalbard sommeren 1963. En rekke forespørsler angående fredningsarbeidet på Svalbard er blitt besvart i løpet av året.

Bearbeidelse av materiale fra Antarktis

Kartarbeider

Kystkonturen i Dronning Maud Land fra 0° lengde og østover ble konstruert. Dessuten ble det foretatt en del utfyllende konstruksjoner i Fimbulheimen. Konstruksjonen av kart over Sør-Rondane fortsatte. To kartblad i serien Dronning Maud Land 1:250 000, L6 Glopeflya og M6 Hoelfjella Sør ble gjort ferdig til reproduksjon. Rentegningen av kartbladene L5 og M5 i samme serie ble påbegynt. Det avsluttende arbeidet på kartene Kronprinsesse Märtha Kyst – Maudheimvidda (1:1 000 000) og Maudheimvidda Aust (1:500 000) ble utført. De to sistnevnte kartene er bilag til rapporten om Norsk-Britisk-Svensk Antarktisekspedisjon, 1949–52.

Glasiologi

TORBJØRN LUNDE har fullført og levert til trykking en artikkel: «On the firn temperature and glacier flow in Dronning Maud Land».

Meteorologi

VIDAR HISDAL har i 1963 fullført en analyse av tidevannsregistreringene fra Polarsirkelbukta ved Norway Station og en kompletterende undersøkelse av tidevannets innflytelse på lufttrykkobservasjonene ble påbegynt. Til tross for de korte observasjonsseriene synes resultatene å bli relativt sikre. De passer godt med det man skulle vente ut fra tidevannsdata fra nærliggende områder i Antarktis. HISDAL har også i 1963 utført redaksjonelt arbeid i forbindelse med de nye publikasjonene: Vol. I, part 1C; Vol. II, part 2B og Vol. VI, part 3 i «Maudheimserien».

TORGNY E. VINJE har gjort ferdig til trykking et arbeid over strålingsbalansen og en del mikro-meteorologiske målinger fra Norway Station. Med henblikk på en klimatologisk oversikt over det samme området er det foretatt databehandling av de vanlige bakkeobservasjonene. Med tanke på senere bearbeidelse er verdiene for temperatur og vindhastighet tatt ut fra registreringene fra det meteorologiske tårnet på Norway Station.

Bidrag til innsamlinger og bearbeidelse utført av andre forskere

Fra Norsk Polarinstitutt har følgende mottatt bidrag til forskningsoppgaver: Stud. real. NILS G. GULLESTAD til bearbeidelse av zoologisk materiale fra Svalbard. Cand. mag. OLAV DYBVADSKOG og cand. mag. RANDI PYTTE til innsamling og bearbeidelse av glasiologisk materiale fra Norge. Arktisk Forening, Tromsø til innsamling av isobservasjoner fra Nordishavet.

Biblioteket

I det siste året er det mottatt og registrert nye publikasjoner og karter fra i alt ca. 260 faste bytteforbindelser, med tilsammen ca. 3500 nummer.

69 bøker er blitt kjøpt inn, vesentlig forskjellige håndbøker til den geologiske

avdelingen og 17 bøker og småskrifter er blitt mottatt som gaver. Universitetsforlaget har også i det siste året sørget for utsendelsen av instituttets publikasjoner til de faste bytteforbindelsene, men likevel har bibliotekaren hatt meget å gjøre med mer spesielle forsendelser. I forbindelse med den forestående flytning, har bibliotekaren hatt en del å gjøre med utarbeidelsen av planene for det nye biblioteket.

Konsulent- og informasjonsvirksomhet

Interessen for Svalbard og arktiske strøk i det hele tatt, er for tiden meget stor og dette kan godt merkes ved Norsk Polarinstitutt, hvor det daglig kommer forespørsler både fra enkeltpersoner og institusjoner i inn- og utland. En meget vesentlig del av arbeidet med å besvare alle disse forespørslene har falt på SØREN RICHTER. Han har også daglig hjulpet instituttets egne medarbeidere med forskjellig referanse- og litteraturarbeid. Forespørsler angående Antarktis er i alt vesentlig blitt besvart av SIGURD HELLE, som også har tatt seg av bestillingene av karter og flytotografier.

NATASCHA HEINTZ og THOR SIGGERUD har skrevet et hefte om Svalbard som er blitt stensilert med tanke på å deles ut til assistenter og andre interesserte.

NATASCHA HEINTZ har gjennomgått den russiske litteraturen som har kommet inn og særlig konsentrert sin oppmerksomhet om artikler som vedrører aktiviteten i Dronning Maud Land. En stor artikkel om havisforskning i Nordpolbassenget er blitt oversatt for T. LUNDE og ellers har en rekke kortere artikler blitt oversatt for andre av instituttets medarbeidere. Under professor L. L. BALACSHINS besøk i Norge fungerte hun som tolk ved et foredrag som denne holdt for instituttets medarbeidere.

I forbindelse med at fredningsbestemmelsene for Antarktis nå blir utarbeidet, har en rekke spørsmål vedrørende fredning i dette området vært utredet.

Forelesning- og foredragsvirksomhet

TORE GJELSVIK holdt foredrag om «Svalbard i dagens situasjon» i Norsk-Svensk Forening i Stockholm og i Militære Samfunn i Bodø. I Rederforbundets studiegruppe snakket han om «Svalbard – Norge, aktuelle problemer» og i Larvik Handelstand holdt han et foredrag med samme tittel.

NATASCHA HEINTZ holdt foredrag om «Kjempeøglene på Svalbard – et tropisk dyr i Arktis» i Norsk Zoologisk Forening og i Polarklubben.

OLAV LIESTØL ledet vårsemesteret 1963 kollokvier i glasiologi, og i høstsemesteret holdt han forelesninger over samme emne. Han var eksaminator til hovedfag i fysisk geografi.

THOR SIGGERUD holdt foredrag om «På jakt etter faraoenes gruver» i Oslo og Gol folkeakademi.

TORGNY E. VINJE fortalte om forskningsarbeidet på Norway Station og viste filmen som var blitt tatt opp i Antarktis i Studentersamfunnet ved Landbrukshøgskolen på Ås og i Oslo Geofysikeres Forening.

Reiser, kongress- og møtevirksomhet

NATASCHA HEINTZ deltok i tiden 6–12/1 i «NATO Advanced Study Institute, Conference on Paleoclimate» i Newcastle-upon-Tyne, England.

KAARE Z. LUNDQUIST var i England i tiden 15–21/1 i forbindelse med kjøp av Hi-Fix anlegget og for å konferere med Hydrographic Departement om dettes erfaringer med bruk av systemet.

THOR SIGGERUD besøkte i tiden 20/3–6/4 Grønlands Geologiske Undersøgelse, København, British Antarctic Survey, Scott Polar Research Institute og Department of Geology, Cambridge University, alle England, for å sette seg inn i bruk av helikopter i arktiske strøk, og samle erfaringer for forskjellige typer feltutstyr.

EINAR NETELAND oppholdt seg i tiden 20/4–1/6 i England for å delta i et teknisk Hi-Fix kurs, arrangert av Decca Navigator Company.

AUDUN HJELLE besøkte i tiden 5–12/6 Sedgwick Museum, Cambridge, for å se på de bergartsprøvene de hadde der fra Ny Friesland og Olav V Land og diskutere geologien og petrografien i dette området med W. B. HARLAND og hans medarbeidere.

TORE GJELSVIK deltok i september i SCAR-møte i Johannesburg i Syd-Afrika.

NATASCHA HEINTZ var Norsk Polarinstitutts representant ved en naturvitenskapelig konferanse for Nordkalott-landene som ble holdt 14–15/9 i Rovaniemi, Finnland.

OLAV LIESTØL, VIDAR HISDAL og TORGNY VINJE deltok i «Polartagung» i Karlsruhe i Tyskland i tiden 6–10/10.

BJARNE EVENSEN besøkte i tiden 19–21/12 Sjøkartverket i Stavanger for å studere nyere tegnemetoder og få informasjoner om tegneteknikken ved bruk av radérmetoden på plast.

Besøk

Blant de som besøkte Norsk Polarinstitutt i det forløpne år var: Geograf WALLY HERBERT, New Zealand; Dr. JOHN R. WINCKLER, University of Minnesota, Minneapolis; Dr. JOHN C. BEHRENDT, Geophysical and Polar Research Centre, University of Wisconsin; Dr. JOHN HANESSIAN JR., American Universities Field Staff, New York; Dr. MARY C. LOBBAN, Division of Human Physiology, Medical Research Council Laboratories, England; sysselmann FINN B. MIDBØE, Svalbard; S. W. SIBBETTS, Department of Mines and Technical Surveys, Ottawa, Canada; Dr. MAX WUPPERMANN, Deutsche Gesellschaft für Polarforschung, Tyskland; professor dr. LEONID L. BALACSHIN, Arctic and Antarctic Research Institute, Leningrad, SSSR.

Dessuten har representanter for en rekke utenlandske ambassader i Oslo gjentatte ganger besøkt Polarinstituttet.

Publikasjoner

Skrifter:

Nr. 127 – DEREK JOHN GOBBETT – Carboniferous and Permian Brachiopods of Svalbard.
Nr. 128 – OVE WILSON – Cooling effect of an Antarctic climate on man.

Årbok:

Årbok 1962.

Norwegian-British-Swedish Antarctic Expedition 1949–52.
Scientific results:

Vol. I, Part 2 D – Surface observations:
VIDAR HISDAL – Visibility, cloudiness, humidity and precipitation.

Vol. I, Part 1 C – Aerology:
KÅRE HAGEN – The surface inversion.

Vol. VI, Part 3 –
JOHN GIÆVER and VALTER SCHYTT – General report of the expedition.

Instituttets medarbeidere har dessuten i andre serier publisert:

NATASCHA HEINTZ: Casting Dinosaur Footprints at Spitsbergen. Curator, VI, (3), 1963. New York.
VIDAR HISDAL og SØREN RICHTER: Polarlandene. Gyldendal Norsk Forlag.
SØREN RICHTER: Nordmenns ferder fra pol til pol i «Norge 1814–1964». Gyldendal Norsk Forlag.
SØREN RICHTER: Svalbard, Jan Mayen og bilandene i «Norge – Land og folk». J. W. Cappelens Forlag.

The activities of Norsk Polarinstitutt in 1963

Extract of the annual report

BY

TORE GJELSVIK

Staff

In 1963 the permanent staff of Norsk Polarinstitutt was increased by five positions, making the total number of the staff at the end of the year twenty-nine. Two of the permanent positions were vacant. Eleven persons were temporarily engaged, four of them for working only on the data collected by the Norwegian expeditions to Antarctica. Cand. real. AUDUN HJELLE and stud. real. JENÖ NAGY, geologists, JOHANNES HUS and EINAR OLSEN, topographers, MAGNE GALÅEN, draughtsman and EINAR NETELAND, technician, joined the staff in 1963.

Expeditions to Svalbard

The ice- and weather conditions in the Svalbard waters were generally fairly good during the summer 1963. However, drift ice in the Barents Sea south-east of Spitsbergen prevented the planned chartering of this area, and in July the helicopters, based in Billefjorden, were largely grounded because of fog and low clouds.

The expedition to Svalbard in 1963 was in many respects subjected to radical changes concerning working methods and logistic support. Norsk Polarinstitutt this year got opportunity to charter the modern research vessel "H. U. Sverdrup", that is built specially for oceanographic investigations, and equipped with electronic positioning system (Hi-Fix), the work could go on unhampered by fog or clouds, as often in the previous years. The logistic support of the landbased parties was undertaken by the expeditionship M/S "Signalhorn" and occasionally also by M/S "Nordsyssel". A helicopter base, leader T. SIGGERUD, was established in Ebbadalen, Billefjorden, and two topographical and three geological parties got logistic support from the helicopters. Although the weather was not particularly favourable, the helicopter-operations were very successfull and enabled the number of stations surveyed by the topographers to be increased more than tenfolds as compared to earlier seasons. Two of the geological parties used both snowscooter and helicopter for transport, and this combination proved to be very useful under most glacial conditions.

The expedition to Svalbard in the summer 1963 numbered 59 men and with the crews of the two vessels and two helicopters, the total number was 76 men. This is by far the largest expedition sent to Svalbard by Norsk Polarinstitutt, and it was made up of three hydrographical, three topographical, eight geological, one geochemical and three biological parties. The expedition left Norway in the beginning of July and returned early in September.

Hydrography

K. Z. LUNDQUIST assisted by F. BIE and E. NETELAND on M/S "H. U. Sverdrup" surveyed in the waters off the north-west coast of Vestspitsbergen. Even though the installation of the electronic positioning system (Hi-Fix) took more time than originally expected, the work proceeded fast when started and approximately 1350 nautical miles of echogrammes were obtained. In August LUNDQUIST took over M/S "Signalhorn" and the coastal navigation aids were controlled and overhauled as usual.

H. HORNBÆK, using the hydrographic surveying-boat "Svalis", just about finished the soundings of the inner part of Woodfjorden.

Topography

J. HUS and E. OLSEN with logistic support from the helicopters, carried out trigonometrical surveying in southern Ny Friesland and Olav V Land. Measurements were carried out from seventy stations. Twenty-four new cairns were built and ten old ones repaired. At the base in Billefjorden tidal observations were made regularly.

W. FLAATA took terrestrical photograms and made trachyometric measurements for producing maps in the scale of 1:1 000 and 1:10 000 of the Breinosa coal-field in Adventdalen. In late August, HUS and OLSEN carried out tellurometer measurements in Adventdalen.

Geology

H. MAJOR investigated the coal-bearing formations to the south-east of Adventdalen and examined stratigraphic profiles within the Adventdalen quadrangle. He also assisted the Mine Inspector of Svalbard during his visits to the various coal-mines.

T. S. WINSNES carried out palaeontological and stratigraphical investigations in the Permo-Carboniferous and Triassic formations in the areas north-east of Tempelfjorden.

A. HJELLE investigated the granite contacts and the Hecla Hoek sequences in the central part of Ny Friesland. He was particularly looking for mineralizations of possible economic importance. He also took up a detailed stratigraphic investigation of the more than 2 000 m mighty, Hecla Hoek series, which consists of greywacke, sandstone and carbonate rocks. The "granite" examined was in parts migmatic, while at other places it was massive. Dioritic and gabbroic intrusions were also observed.

D. L. J. NIEMANTSVERDRIET (Netherland) undertook detailed stratigraphic investigations in the area between Sassendalen and Agardhbukta.

J. NAGY first worked in the Grimfjell anticline in Torrell Land and investigated the coal-bearing formations in the Hornsund area. Later he moved to the east coast and continued the stratigraphical and palaeontological investigations that he had taken up the previous year on the Markhambreen quadrangle.

E. NYSÆTHER continued the sedimentological, stratigraphical and structural investigations of the Mezosoic beds at both sides of the inner part of van Keulenfjorden.

T. GJELSVIK undertook petrographical and structural investigations as well as prospecting for ore in the Hecla Hoek beds along the north coast of Vestspitsbergen, from Sørgattet to Raudfjorden, and later in the area between Bockfjorden and Liefdefjorden. A few days was spent studying the extinct Sverrefjellet volcano in Bockfjorden.

J. SZUPRYCZYŃSKI (Poland) investigated marginal moraines at various places in the same areas as was covered by GJELSVIK. Unfortunately, he had to interrupt his studies at an early stage, for returning to Poland.

W. INGEBRETSEN sampled river sediments for geochemical prospecting along the coast between Isfjorden and Bellsund. Heavy rainfall and bad weather hampered the work so that it could not be finished this summer.

Biology

At the request of the people living in Ny-Ålesund, it was planned to try to transfer eight to ten reindeers from the Liefdefjorden area to Brøggerhalvøya. A group of three students, headed by T. LARSEN, had taken upon themselves this task. It was originally planned to anaesthetize the reindeers with drugs from the curare-group. However, permission to use such drugs was not granted. It was therefore tried to use traps, but with no success, and the whole project had to be abandoned. The group later undertook ornithological investigations along the north coast of Vestspitsbergen and ringed about 1 000 birds, mainly little auks (*Plautus alle*).

M. NORDERHAUG continued this studies of the biology of little auks in the Hornsund area. His group also ringed about 2 700 birds, about 1 900 of these being little auks.

N. GULLESTAD undertook further investigations of the Spitsbergen char (*Salmo alpinus*) in Revvatnet and Revelva. He also collected water- and plancton samples.

One private Norwegian company undertook investigations for oil at Brøggerhalvøya and in Grønfjorden during the summer 1963.

Foreign expeditions

Five foreign scientific expeditions worked in Svalbard for longer or shorter periods during the summer 1963. In addition one private American firm and one Soviet-Russian expedition explored for oil. Besides this several climbing and touristic expeditions visited Svalbard.

Expeditions to Jan Mayen

Two Norwegian students C. BANG and S. SKRESLET spent the summer on Jan Mayen investigating the lake Nordlaguna and collecting zoological material.

Two British expeditions visited Jan Mayen.

Expeditions in Dronning Maud Land, Antarctica

South Africa and Soviet-Russia each maintained one scientific station in Dronning Maud Land.

Glaciology in Norway

In april O. LIESTØL started an investigation of Rembesdalsskåki and in May he visited Storbreen for continuing the study of this glacier. O. LIESTØL and partly also O. DYBVADSKOG visited Storbreen, Hardangerjøkulen and Nigardsbreen several times later in the summer and the autumn.

Preparations of data from Svalbard

Hydrography

The work with the new chart covering the north-west corner of Svalbard and a new edition of chart No. 503 was continued. Preparations were made for using the new electronical positioning system (Hi-Fix) and in this connection the base map for the chartering of the Bjørnøya–Sørkapp–Hopen area was prepared.

Topography-geodesy

The two western sheets of the new Svalbard map in the scale of 1:500 000 were made ready to printing. Trigonometrical calculations were accomplished for the following regions: Raudfjorden, Woodfjorden, Olav V Land, Ny Friesland, Bolterdalen and Foxdalen, and coast-lines in Bockfjorden and Woodfjorden were constructed.

Geology

H. MAJOR continued the preparation for publication of the geological map of Adventdalen (scale 1:100 000). He was in charge of putting the Spitsbergen coal-fields on a map giving all the coal-fields in Europe. MAJOR also worked on the plans for the new coal mine (Gruve VII) in Adventdalen and studied samples of the coal, that will be used by Norsk Koksverk A/S.

T. S. WINSNES worked on fossils from the Permo-Carboniferous beds and he compiled a review on these two periods from Svalbard. He also studied the Carboniferous beds from Greenland in order to make comparison with the same layers at Svalbard.

T. SIGGERUD worked on the geological material from the Kongsfjorden and St. Jonsfjorden areas and published a short paper on the marbles at Blomstrandhalvøya.

A. HJELLE undertook microscopial investigations of rocks from the northern part of Vestspitsbergen and worked on material he collected in Olav V Land and Ny Friesland in the summer 1963.

J. NAGY correlated his geological observations from the quadrangle Markhambreen with the one done by K. BIRKENMAJER and prepared a geological map of this area. He also worked on a structural map of the area around Grimfjellet in Torell Land.

N. HEINTZ published a paper on the Dinosaurs found in Createaceous beds at Svalbard and continued the work on the Devonian fish-faunas.

Geophysics

O. LIESTØL assisted by O. DYBVADSKOG analysed the collected glaciological data from Svalbard and Norway. A map of Finsterwalderbreen, Vestspitsbergen, was constructed. T. LUNDE continued his studies of sea ice in the Arctic regions and constructed mean ice-boundaries for the months February to September for the period 1946–63.

Biology

N. HEINTZ also this year prepared a form for observations of fauna and flora in Svalbard, that was sent with all the parties working in the field in Svalbard during the summer. The data thus obtained was made ready for publication.

Preparation of data from Antarctica

Map construction

Two maps in the series "Dronning Maud Land, scale 1:250 000" were made ready for publication and work on two other maps in the same series was initiated. In addition the map Kronprinsesse Märtha Kyst, scale 1:100 000 and Maudheimvidda aust, scale 1:500 000 were made ready for publication.

Meteorology

V. HISDAL finished a study on the tidal observations from Polarsirkelbukta in Dronning Maud Land. He has also edited the four new papers published in a series of papers from "The Norwegian-British-Swedish Antarctic Expedition, 1949–52".

T. E. VINJE made ready for publication a paper on the radiation balance and micro-meteorological observations from Norway Station.

Glaciology

T. LUNDE accomplished his paper on the firn temperature and glacier flow in Dronning Maud Land.

Notiser

A note on the stratigraphy of Goldschmidtfjella, Oscar II Land

Abstract. Goldschmidtfjella has on earlier geological maps been plotted as "Devonian ?". According to fossils found during a visit to Goldschmidtfjella the authors have reached to the conclution that this mountain is of Triassic age.

On the geological map of Svalbard (ORVIN 1940), an area NNE of the head of St. Jonsfjorden, Oscar II Land, is plotted as "Devonian ?". In the description ORVIN (1940 p. 18) discusses the occurrence of the Devonian deposits on Brøggerhalvøya and near St. Jonsfjorden. Regarding the latter area he says i. a.: "It may also be assumed that there is a branch fault from Isfjorden, running some distance inland from St. Jonsfjorden and across Brøggerhalvøya, on the east side of which the Devonian occurs between the Carboniferous and the Hecla Hoek, but is absent on the west side. If this fault does exist, Devonian should be expected to occur next to the Hecla Hoek north-east of St. Jonsfjorden and east of the fault but be absent west of it, as the Devonian here was denuded before the Culm strata were deposited. Judging from the aerial photographs Goldschmidtfjella consists of a dark rock, the colour and type of weathering of which resemble those of the Devonian. On the map I have plotted it as Devonian ?, as it has been impossible to find any information about the rocks of this mountain."

FRIEND (1961) mentions the same "Devonian" occurrence. "An area of " ?Devonian" sediments is shown on ORVIN's (1940) map, just to the north-east of St. Jonsfjorden. A mountain seen from the fjord by the C.S.E. would certainly appear to belong lithologically to the Wood Bay Series, and the moraine material confirms this similarity."

DINELEY (1958) gives a sketch map of the geology of Western Vestspitsbergen which somewhat differs from ORVIN's map regarding the area east of St. Jonsfjorden. The area which ORVIN marked as "Devonian ?" is in this map marked as "Formations above the Brachiopod Cherts ?". DINELEY calls these layers the "Wittenburg Facies" of Lower Permian–Triassic age. However, he does not go into further detail as to the area NE of St. Jonsfjorden and does not give his opinion on the age of Goldschmidtfjella. Presumably he has not visited any locality north of Wittenburgfjella. Goldschmidtfjella thus does not seem to have been visited by any geologists. The mountain lies as a nunatak on Osbornbreen, a large glacier reaching St. Jonsfjorden from NE. Goldschmidtfjella has the shape of a narrow steep ridge running N–S. It is about 6 km long and 500 m wide and the highest point is 560 m above sea level. The southernmost part is about 10 km NNE of St. Jonsfjorden. Owing to crevasses in Osbornbreen, Goldschmidtfjella is difficult to reach overland.

Using a helicopter the authors of this paper in August 1964 visited Goldschmidtfjella with the intention of attempting to determine the age of its rocks.

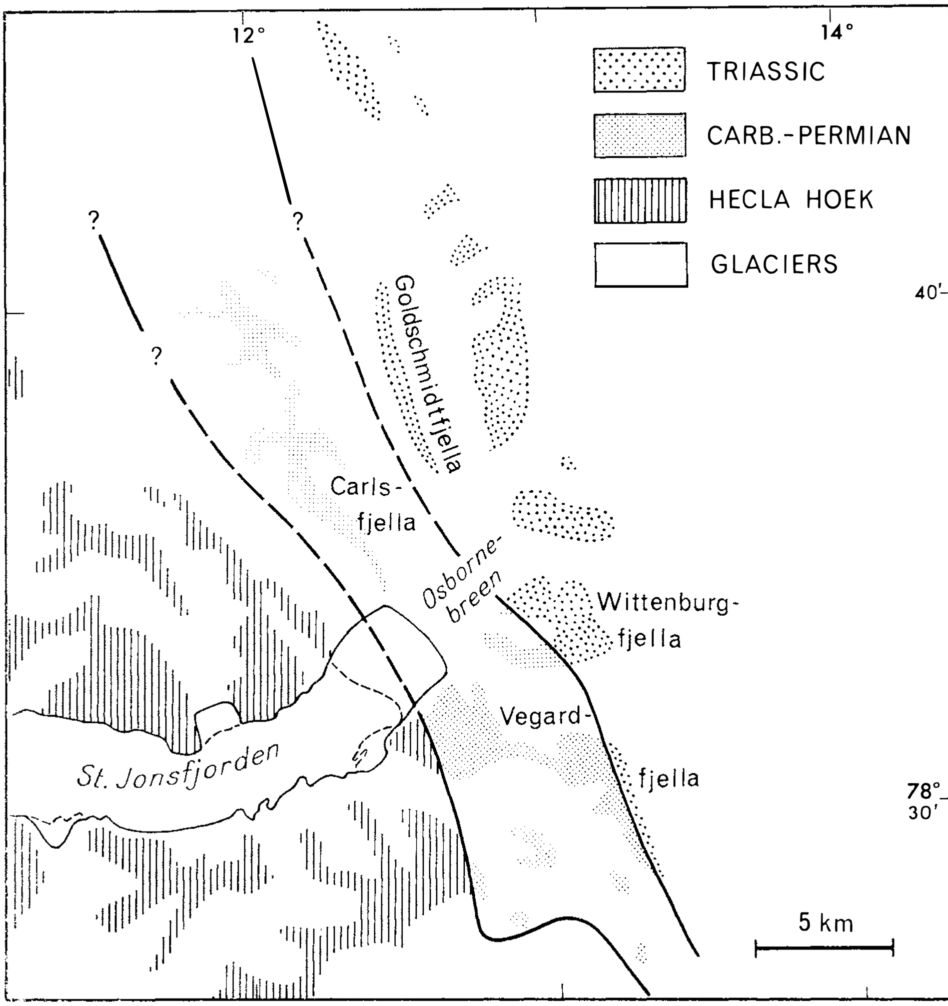

Fig. 1. *The map shows the general geological features in the area at the head of St. Jonsfjorden, indicating the stratigraphical position of Goldschmidtfjella.*

The helicopter landed on the more or less horizontal but very narrow plateau close to the northernmost tip of the ridge, and we spent about two hours investigated the mountain.

Goldschmidtfjella is built up of grey, yellowish and nearly black shales, slates and siltstones with layers of more silicified rocks, all somewhat metamorphosed. Practically the entire ridge is covered by débris, moving downwards with the solifluxtion.

After a short search T. SIGGERUD discovered some blue, badly preserved fossil bone-fragments. Further investigations resulted in a collection of about a dozen fragments – all typical bluish-white pieces of vertebrate bones. All the bone-fragments are preserved in a metamorphosed, grey, fine-bedded sandy slate with a yellow weathered surface. The bones are black in fresh fracture – bluish when weathered. The preliminary examination of the fossils has shown that they are partly massive and thick (about 1–$1^1/_2$ cm). No pieces exhibit surface sculpture –

only one small fragment shows parallel low ridges, about 6–7 on 5 mm. The largest pieces are about 5–6 cm long and 3–4 cm broad. As far as can be seen, no fragments represent parts of the vertebra, ribs or extremity-bones. Most probably the bones are pieces of the head-roof of Stegocephalian. They resemble the fragments of Stegocephalian collected by A. HEINTZ in Triassic rocks in Hornsund in 1949. Some of the smaller and thinner bones may belongs to fishes.

One piece of rock contained some badly preserved Ammonites(?). These are, however, difficult to determine. They are small forms about 2.5–3 cm in diameter and about 0.5 cm thick, with partly preserved septa (?), but the surface sculpture or suture-lines cannot be seen. In another stone some thin fossil pieces show a certain resemblance to Pelycopod-fragments.

Thus the rocks as well as the fossils seem to indicate that the deposits belong to the Triassic. In any case it is certain that the fossils discovered do not represent fragments of Devonian fishes.

From the air the southernmost tip of the ridge appeared to consist of harder layers of rock, and this is confirmed by aerial photographs. It looks as if it might be the Brachiopod Cherts of the Upper Carboniferous–Lower Permian, but unfortunately there was no time to find a landing place for the helicopter so that this could be studied on the spot. The beds were almost vertical or with a westerly dip. The strike is about NW–SE, cutting the ridge at about 30°.

According to DINELEY (1958) the Brachiopod Cherts are overlaid by what he calls the Wittenburg facies, the type locality of this facies being established on Wittenburgfjella which lies about 6 km SSE of Goldschmidtfjella.

The fossils seem to indicate that Goldschmidtfjella does not consist of Devonian but probably of Triassic rocks. Neither do the layers of Goldschmidtfjella lithologically seem to be of the Wood Bay Series (Devonian) as presumed by FRIEND. His assumption, however, is based on what can be seen from St. Jonsfjorden, and he does not specifically say that he actually is referring to Goldschmidtfjella. If the C.S.E. expedition did see typically red sediments it could have been a different mountain in the same area where the Carboniferous red beds are exposed. According to SIGGERUD it is not uncommon to find reddish sand and siltstones with a varying content of clay material in the moraines along Osbornbreen below Vegardfjellet where the red beds also can be seen in outcrops. (Visited by SIGGERUD in 1960.)

From a distance Carlsfjellet to the west of Osbornbreen appears to consist of the same yellowish sand- and limestones which are found in Vegardfjellet where the Carboniferous deposits overlies the Hecla Hoek rocks.

Even if further fieldwork could establish the exact location of the boundaries between the various formations we do not believe in the existence of outcrops of possible Devonian sediments, as indicated on ORVIN's map. In our opinion the boundary to the Hecla Hoek rocks should be drawn slightly further to the west than previously presumed. The Triassic deposits also occur farther north than plotted on earlier maps.

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

Anatol Heintz and Thor Siggerud

Paleontologisk Museum, Oslo – Norsk Polarinstitutt, Oslo

The Cambridge Spitsbergen Expedition 1963

The field work in the summer of 1963 was organized as in 1962, except that geophysical work was intermitted. W. B. HARLAND directed the work, but Dr. A. H. NEILSON undertook the overall leadership in the field from the motorboat "Salterella". Conditions were the worst yet experienced by our expeditions, for extensive late sea ice eventually gave place to weather unusually rough for small boats through much of the summer.

The main parties of the expedition arrived at the beginning of July and left Longyearbyen again on 28 August. The expedition totalled 22 men, divided into six parties.

Party A (leader R. A. GAYER) made its way by small boat from Biskayerhuken to Bangenhuken in north west Ny Friesland where the hut was repaired for a base. The party divided for work into two geological units and one survey unit for the further investigation of the Lower Hecla Hoek rocks between Mosselbukta and Femmilsjøen. "Salterella" took the whole party south to Cookbreen, where brief traverses were made up the main glaciers to the south for correlation of northern structures and stratigraphy with those previously investigated by others. The party then crossed Mittag-Lefflerbreen via Ragnarbreen to Ebbadalen, whence "Salterella" eventually returned the party to Longyearbyen.

Party B (leader D. G. GEE) was based at Biskayerhuken and worked in three interchanging units. The investigations on the structure and stratigraphy of the Caledonian metamorphic rock between Biskayerhuken and Rabotdalen was continued and a detailed sedimentological study of the Wood Bay Series east of the Breibogen–Bockfjorden fault was undertaken by M. MOODY-STUART.

Party C (leader A. CHALLINOR) travelled by small motorboat "Lingulella" from Ny-Ålesund, but was held up by weather for a week at Kvadehuken before proceeding to a depot laid out by M/S "Nordsyssel" in St. Jonsfjorden. The Alpine structures and post-Caledonian stratigraphy of Oscar II Land were further investigated by sledge up Osbornebreen. The party then worked south to Trygghamna and completed this study. At the end a few days were spent in Grønfjorden before returning to Longyearbyen.

Party D (leader A. H. NEILSON). Because of adverse conditions, supply and transport of all other parties was the main preoccupation, but NEILSON had opportunities for some systematic botanical work on the east side of Woodfjorden and both sides of Wijdefjorden. Altogether "Salterella" covered 1212 nautical miles between Isfjorden and Ny Friesland, mostly in short coastal journeys at an average speed of 5.4 knots.

Party E (leader J. L. CUTBILL) set out from Longyearbyen in company with party F and made its way to Skottehytta at the head of Billefjorden. During the summer the structure and stratigraphy of Carboniferous and Permian rocks in Dickson Land (between Pyramiden, Triungen and Odellfjellet), around Ebbadalen, then Brucebyen and around northern Bünsowland and eventually to Tempelfjorden were studied. 48 sections were measured and the general stratigraphical and palaeontological correlation of the area was concluded. A detailed sedimentological study of the lower Gypsiferous Series (Moscovian) was initiated by D. HOLLIDAY.

On 16 July while returning with a survey unit of three from Faraofjellet, one of the members of party E. J. KNIGHT lost control and slid down a snow- and rockslope breaking a thigh as well as sustaining superficial injuries. Very fortunately a helicopter of the neighbouring Norsk Polarinstitutt party (leader T. SIGGERUD) was able to bring the doctor from Longyearbyen and, after a delay due to bad weather, return KNIGHT to hospital there. He later returned to hospital in Bodø, Norway and then on to England on 12 October. A tragedy was thus avoided by the presence of the Norsk Polarinstitutt party and the resolution and skill of the pilot R. MARTINSEN and Dr. A. ARFELDT and the many others who assisted. We express our gratitude.

Party F (leader J. R. PARKER) was based at Vindodden in Sassenfjorden for the study of Mesozoic stratigraphy and Alpine tectonics of the major fault belt. Detailed mapping of Flowerdalen was continued from 1962 and 9 further Triassic sections up Sassendalen were systematically measured and collected.

The expedition was part of the field work of an investigation of the stratigraphy and structure of Spitsbergen by W. B. Harland and supported by the Department of Scientific and Industrial Research.

Walter B. Harland
Departement of Geology, Sedgwick Museum, Cambridge, England

Observasjon av dvergfalk (*Falco columbarius*) i Hornsund sommeren 1963

Abstract. On 4 July 1963 a Merlin (*Falco columbarius*) was observed in Hornsund (77° N.), Vestspitsbergen. Previously the Merlin has only once been recorded from the area just south of Bjørnøya. It is possible that this very northern find of Merlin may have relation to the favourable climatic conditions during the spring migration in Scandinavia in 1963.

Under feltarbeidet i Hornsund (77° N. br.) skremte mine to assistenter K. HAGELUND og R. SYVERTSEN 4. juli 1963 opp en liten falk fra en knaus under Rotjesfjellet. Falken ble iakttatt i kikkert i godt sidelys i ca. 1 minutt på 30 m hold og HAGELUND og SYVERTSEN, som begge er dyktige feltkjennere, var ikke i tvil om at det var en dvergfalk (*Falco columbarius*). De mente at etter fargen å dømme var det en hunn.

Så vidt jeg kan bringe i erfaring er dette første gang dvergfalk er blitt påtruffet på Vestspitsbergen. Det er forøvrig et av de nordligste steder arten overhodet er registrert, og tidligere har vi fra Svalbard bare en sikker og en usikker observasjon, begge fra havområdene syd for Bjørnøya (mellom 73° og 74° N. br.) (LØVENSKIOLD 1964).

Det kan være av interesse å nevne at denne dvergfalken rimeligvis har havnet så langt nord, fordi våren 1963 over store deler av Skandinavia førte til gode trekkforhold og forlenget vårtrekk. Derfor kunne man også registrere at en del sørlige arter dro lengre nordover enn vanlig.

Magnar Norderhaug
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Geese studies in Vestspitsbergen 1963

Introduction

In the summer 1963, a group of three, sponsored by Norsk Polarinstitutt, carried out ornithological field work in the Hornsund area, Vestspitsbergen. The aim was to continue parts of the investigations started by the Norwegian Ornithological Spitsbergen Expedition (N.O.S.E.) in 1962.

The group arrived in Hornsund at July 2. and left the place at August 28. Severe climatic conditions caused a poor breeding season along the coast of Vestspitsbergen in 1962. In spite of snow in the first week of July and a rather rainy August, the breeding season in this area was good in 1963.

This paper only gives a short review of the work on the geese populations. Theese studies will be continued in the Hornsund–Bellsund area in 1964 by one British and one Norwegian expedition.

Estimation of the geese population and degree of non-breeding 1963

Both the Pinkfooted Goose (*Anser fabalis brachyrhynchus*), the Barnacle Goose (*Branta leucopsis*) and the Brent Goose (*Branta bernicla hrota*) were found breeding in the area.

The population of Pinkfeets on the north side of the fjord were of about the same size as in 1962. Breeding took place nearly to the same extent. This indicates that the Pinkfeets in 1962 must have been little influated by the conditions that caused poor breeding for many other species at Spitsbergen that year.

The population of Barnacles were remarkably smaller than observed here in 1962, when nearly the whole stock (about 1100 birds) were observed non-breeding. In 1963 a great part of the Barnacles were breeding. Observations of ringed birds at different localities (Isøyane, Hyttevika, Dunøyane) seems to indicate that the non-breeding stock of 1962, this year were spread and breeding over a greater area.

The population of Brents consisted of less than 150 birds and only 20–30 % seemed to breed. In 1962, less than 50 Brents, all non-breeding, were observed in the area.

The production of gooslings

One of the most important parts of the work consisted of collecting data concerning the production of gooslings. Especially for the Brents and the Barnacles this was of importance on the back ground of the poor breeding season of theese species in 1962. The mean brood sizes in July/August for Pinkfeets, Barnacles and Brents were 2.5 (28 clutches), 2.8 (35 clutches), and 2.6 (12 clutches) respectively.

Ringing of geese

A small family group of 46 Barnacles (22 ad. and 24 pull.) were caught. Five adult birds could fly and escaped, and of the 17 left, 15 had been ringed at Dunøyane in 1962 and one had also been recaptured in Scotland in February 1963. Other attempts of catching were not performed, partly because of unsufficient consentrations of geese, partly of lack of time.

The distribution of geese

Observations from 1962 and 1963 gives a picture of the different species, their distribution and breeding habits in the area.

The Pinkfeets are the typical inhabitants of the valleys and plains along the coast, both before and after hatching.

The Brents on the other side, lives around the islands and skerries during most of the summer. Considering the breeding grounds, the Barnacles in this area use the same type of biotope as the Brents, but are more bound to the shore and the coastal plains on the mainland after the hatching. The moving of Barnacle families away from the nesting ground should be regarded as a search for better feeding grounds for the gooslings.

Geese and predators

Only the severe damage that man indirectly can cause at the nesting grounds of Barnacles (and Brents and Eiders) should briefly be mentioned. Numbers of Glaucous gulls (*Larus hyperboreus*), which nearly always breed in the same areas

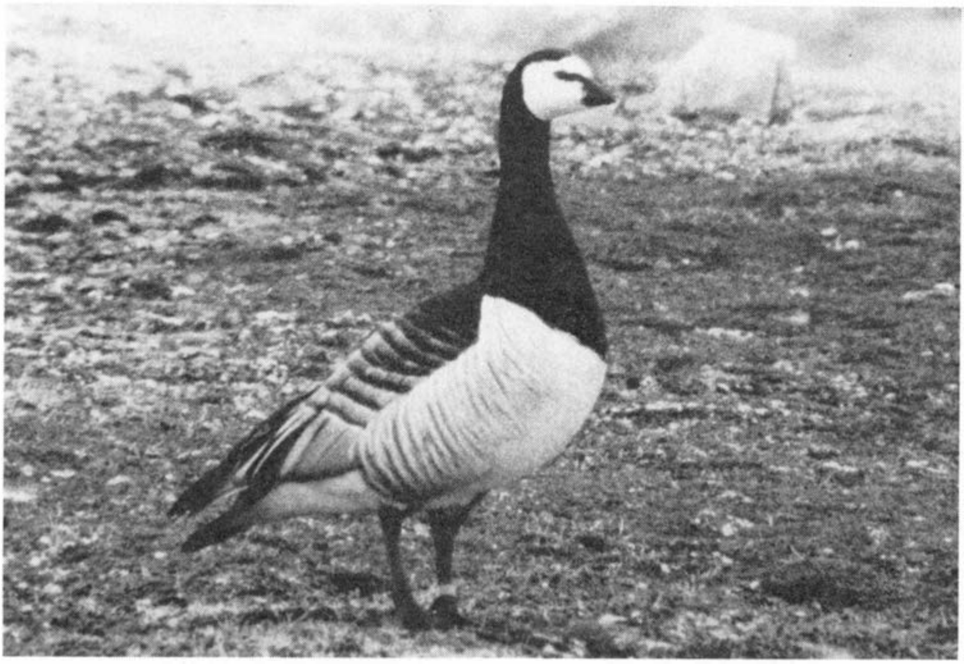

Fig. 1. *Barnacle goose (Branta leucopsis) on the breeding ground in Vestspitbergen. Note the ring on the left leg. This bird has been ringed in Hornsund in the summer 1962 and was photographed in the same area in July 1963.* Photo: M. NORDERHAUG

in this part of Vestspitsbergen, will immediately attack every goose nest that have been left, due to disturbance of man.

It is thus of great importance that every disturbance (men, helicopters, boats, etc.) causing indirectly predation by gulls, should be eliminated.

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Funn av to nye hekkplasser for ismåke (*Pagophila eburnea*) på østkysten av Vestspitsbergen

Abstract. On 12 August 1963 to Dutch students, E. FLIPSE and J. W. DE ROEVER, found to new colonies of Ivory gulls (*Pagophila eburnea*) in the area between Agardhbukta and Ulvebreen on the east coast of Vestspitsbergen. The first colony counted about 15 nests, the other about 20. It was, however, not possible to get the exact numbers, as it was very foggy and also because the finders did not want to disturb the birds.

Sommeren 1963 fant to hollandske studenter, E. FLIPSE og J. W. DE ROEVER, to nye hekkeplasser for ismåke (*Pagophila eburnea*) på østkysten av Vestspitsbergen. De fortalte meg at 12. august oppholdt de seg i området mellom Ulvebreen og Agardhbukta og her fant de like sør for Ulvebreen og vel 9,5 km fra kysten en koloni med ca. 15 reder. Noe senere fant de den andre kolonien på tilsammen ca. 20 reder, som lå omtrent halvvegs mellom Ulvebreen og Agardhbukta, ca. 2,5 km fra kysten. Det var tett tåke da funnene ble gjort, så derfor var det ikke mulig å

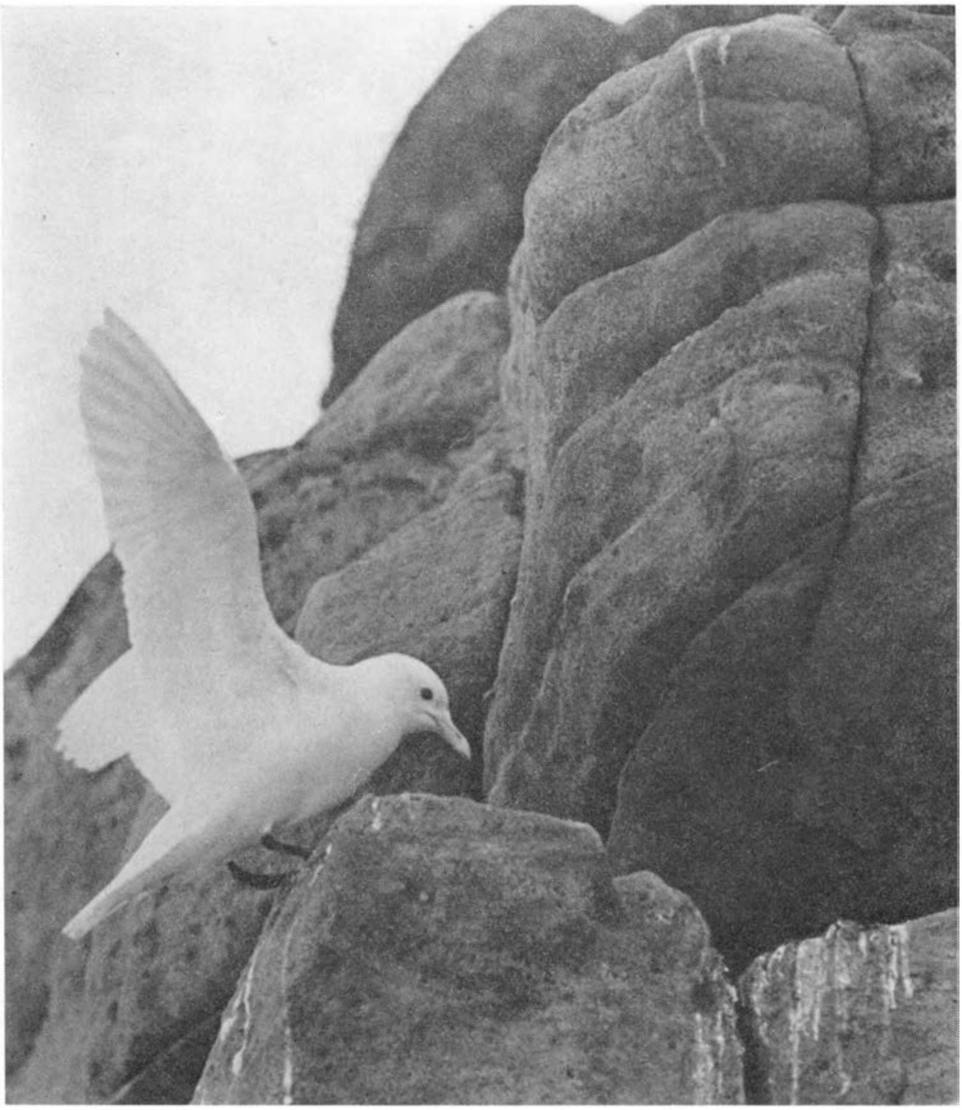

Fig. 1. *Ismåke (Pagophila eburnea) ved redet på østkysten av Vestspitsbergen.*
Foto: E. FLIPSE

telle nøyaktig hvor mange reder det var i hver koloni. Dessuten ble det også funnet et rede adskilt fra de to koloniene.

Finnerne ville ikke forstyrre fuglene mer enn høyst nødvendig og derfor ble bare ett rede undersøkt. Det inneholdt to halvvoksne unger, men av tydelig forskjellig alder.

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Ornitologiske undersøkelser fra den nordvestre del av Vestspitsbergen sommeren 1963

Abstract. In the period July 26 to August 14, ornithological investigations were undertaken in the area between Raudfjorden and Amsterdamøya. All birdcliffs which were found are given on Fig. 1 and Table 2. Some of the birdcliffs were rather large, thus at the southern end of Hamiltonbukta about 10–15 000 Brünnich's Guillemots were breeding. 64 Glaucous gulls were shot at different places, and the stomack content was examined (Table 1).

Innledning

I perioden 26. juli til 14. august ble det arbeidet i området mellom Raudfjorden og Amsterdamøya med følgende ornitologiske undersøkelser: 1. Generelle ornitologiske observasjoner. 2. Undersøkelser av ærfuglbestanden. 3. Lokalisering og taksering av fuglefjell. 4. Ringmerking. 5. Ernæringsundersøkelser hos polarmåke.

Jeg vil gjerne takke stud. real. ODDVAR BREKKE, stud. PER JOHNSEN og stud. real. EIGIL REIMERS for god hjelp under sommerens arbeid. Jeg vil også takke Mr. D. GRAHAM BELL, Mr. E. FLIPSE og direktør T. GJELSVIK for verdifulle opplysninger i forbindelse med våre oppgaver. Til slutt vil jeg takke Norsk Polarinstitutt som lot oss fortsette å arbeide ut sommeren med disse selvvalgte, alternative oppgavene.

Når det gjelder ringmerkingsresultatene og de generelle ornitologiske observasjonene, er disse overlatt til NATASCHA HEINTZ og vil bli publisert i en artikkel om dyrelivet på Svalbard i 1963 (Norsk Polarinstitutt Årbok 1963, p. 157). Resultatene av ærfugltakseringene, som ble foretatt i hele området mellom Bockfjorden og Danskøya, er foreløpig lagt til side.

Ernæringsundersøkelse hos polarmåke (Larus hyperboreus)

På bakgrunn av ernæringsundersøkelsen fra Hornsund sommeren 1962 (BANG *et al.* 1963), ble 64 polarmåker skutt på forskjellige steder, og mageinnholdet

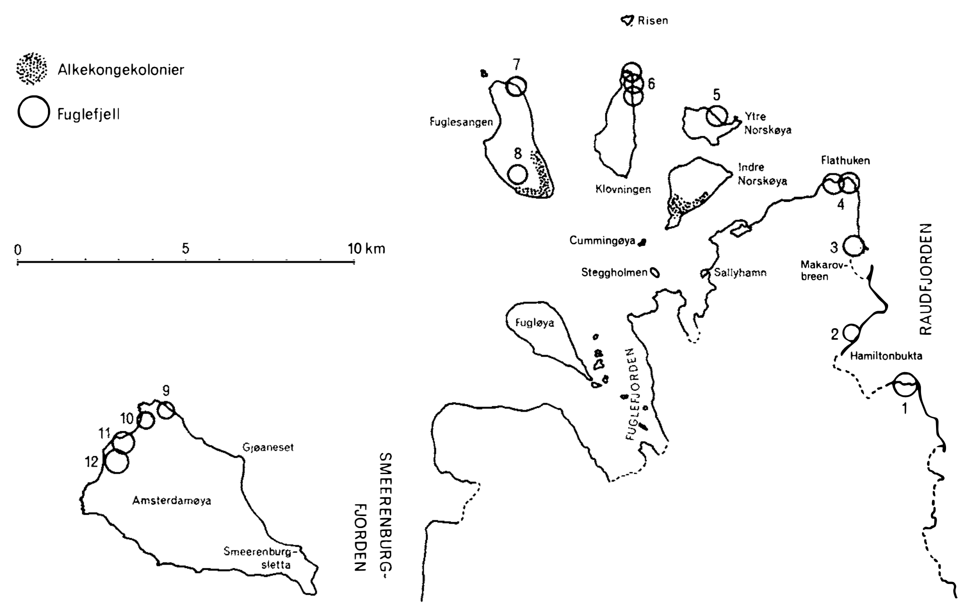

Fig. 1. Kartet viser plaseringen av de viktigste fuglefjellene i området mellom Raudfjorden og Amsterdamøya.

On the map is indicated the largest birdcliffs within the area between Raudfjorden and Amsterdamøya.

Tabell 1. *Mageinnhold hos polarmåke*

Lokalitet	Datum	Polar-måke, nr.	Mageinnhold	Lokalitet	Datum	Polar-måke, nr.	Mageinnhold
Liefdefjorden	$^{12}/_7$	1	Alkefugl	Fuglefjorden	$^{29}/_7$	33	Krepsdyr
»	»	2	Planterester, gruspartikler	»	»	34	Krepsdyr
»	»	3	Kjøtt fra snadd[1]	»	»	35	Pyntekrabbe
»	»	4	Fjærrester, antagelig krykkje	»	»	36	Intet mageinnhold
»	»	5	Kjøtt fra snadd	»	»	37	Alkefugl, antagelig alkekonge
»	»	6	Ærfuglegg, gruspartikler	»	»	38	Krepsdyr, fragmenter av musling
»	»	7	Fjærrester (alkefugl ?), gruspartikler	»	»	39	Pyntekrabbe
»	»	8	Innvollsrester fra snadd	»	»	40	Intet mageinnhold
»	»	9	Ærfuglegg, fjær av måkefugl	»	»	41	Fisk
»	»	10	Ærfuglegg, planterester	Cummingøya	$^{3}/_8$	42	Pyntekrabbe
»	»	11	Fjær av måkefugl	»	»	43	Pyntekrabbe
»	»	12	Alkefugl	»	»	44	Pyntekrabbe
Flathuken	$^{27}/_7$	13	Fjærrester, antagelig alkefugl	»	»	45	Krepsdyr
»	»	14	Pyntekrabbe	»	»	46	Pyntekrabbe
»	»	15	Rester av storkreps, ant. pyntekrabbe	»	»	47	Krepsdyr, antagelig pyntekrabbe
Risen	$^{28}/_7$	16	Ærfuglunge	»	»	48	Eggrester, antagelig ærfugl
»	»	17	Alkekonge (ad ?)	»	»	49	Intet mageinnhold
»	»	18	Gruspartikler, storkreps	Flathuken	$^{13}/_8$	50	Planterester
»	»	19	Sjøpiggsvin	»	»	51	Planterester, krepsdyr, ben av fugl
»	»	20	Fjær av måkefugl	»	»	52	Pyntekrabbe, rester av alkefugl
»	»	21	Storkreps, antagelig pyntekrabbe	»	»	53	Planterester, alkefugl
»	»	22	Planterester, ben av fugl	»	»	54	Ærfuglunge
»	»	23	Rester av fisk	»	»	55	Ærfuglunge, ærfuglegg
»	»	24	Alkefugl	»	»	56	Unge av lomvi
»	»	25	Ærfuglegg	»	»	57	Ærfuglegg, rester av fugl
»	»	26	Fisk	»	»	58	Ærfuglunge
Fuglefjorden	$^{29}/_7$	27	Sjøpiggsvin	»	»	59	Pyntekrabbe
»	»	28	Pyntekrabbe	»	»	60	Egg, antagelig lomvi
»	»	29	Fisk, krepsdyr	»	»	61	Ærfuglunge
»	»	30	Krepsdyr	»	»	62	Alkefugl
»	»	31	Gruspartikler	»	»	63	Gruspartikler, rester av alkefugl
»	»	32	Intet mageinnhold	Sallyhamna	$^{13}/_8$	64	Spekk, gruspartikler[2]

[1] En snadd ble skutt og flådd i leiren $^{12}/_7$.
[2] En snadd ble skutt og flådd i Sallyhamna $^{11}/_8$.

Fig. 2. A. Lomviene (*Uria lomvia*) er lite sky ved reiret og lar seg lett fange med hendene. *Brünnich's Guillemots are not easily frightened at the nest and may easily be taken by hand.*

B. Unge av ringgås (*Branta leucopsis*).
A Brent goose chicken.
Foto: T. LARSEN

undersøkt. Samtlige undersøkelser ble foretatt i felt. En nøyere undersøkelse kunne ofte vært ønskelig, f. eks. med hensyn til artsbestemmelse av funne benfragmenter og fjærrester. Resultatene av undersøkelsen er stilt opp i tabell 1.

Stiller vi sammen de enkelte data får vi: Snadd (*Phoca hispida*) 3; fugl (Aves) 3; måkefugl (*Larus* sp.) 3; krykkje (*Rissa tridactyla*) 1; ærfuglunge (*Somateria m. borealis*) 6; egg av ærfugl 6; alkefugl (*Alca* sp.) 8; alkekonge (Plautus alle) 1; lomvieunge (*Uria lomvia*) 1; egg av lomvie 1; fisk (Pisces) 4; storkreps (Malacostraca) 7; pyntekrabbe (Hyas sp.) 14; sjøpiggsvin (*Echinus*) 2; musling (Lamellibranchia) 1; planterester 5; gruspartikler 5.

I sammendraget er tvilstilfellene regnet som sikre. Sammenlignet med resultatene fra Hornsund sommeren 1962, ble det funnet forholdsvis meget storkreps, i det hele 21 individer fra området ved Norskøyane inneholdt disse dyrene. Forbausende mange pyntekrabber ble funnet absolutt hele, bortsett fra at et par av klørne kunne være brukket.

Lokalisering og taksering av fuglefjell

Under arbeidet med taksering av fuglebestanden i fuglefjellene benyttet vi følgende metode: Et mindre område av kolonien med normal tetthet av fugler for det fuglefjellet som skulle undersøkes, ble anslått i areal. Reir og fugler ble talt ved hjelp av en kikkert som forstørret 30 ganger. Det ble foretatt 4 uavhengige tellinger og resultatene ble deretter sammenlignet. Ved større uoverensstemmelser ble disse diskutert, og nye tellinger ble gjerne gjennomført. Vi forsøkte også å fotografere felter i fjellet med teleobjektiv på opptil 400 mm, for å telle fuglene på fotografiene som vi dermed fikk. Dette viste seg imidlertid ikke å være en brukbar metode, i det detaljene ikke ble særlig gode når bildene ble tilstrekkelig forstørret.

Resultatet av våre undersøkelser er satt opp i tabell 2. Det ble funnet to større alkekonge-kolonier, den ene på Indre Norskøya, den andre på Fuglesangen. Det var uråd å anslå bestandens størrelse, men begge koloniene er tegnet inn på kartet (Fig. 1) sammen med de øvrige fuglefjellene.

Det bør presiseres at det ofte var stor uoverensstemmelse mellom de resultatene vi fikk ved de forskjellige tellingene, hvilket skulle tyde på at metoden ikke er helt god.

Tabell 2. *Oversikt over fuglefjell i området Raudfjorden–Amsterdamøya*

Koloni nr. Lokalitet	Polarlomvi (*Uria lomvia*)	Krykkje (*Rissa tridactyla*)	Alkekonge (*Plautus alle*)	Lundefugl (*Fratercula arctica*)	Teist (*Cepphus grylle*)	Merknader
Nr. 1. Sørenden av Hamiltonbukta	10–15000	ca. 300	—	—	—	Absolutt det største fuglefjellet i hele det undersøkte området
Nr. 2. Nord for Hamiltonbukta	3–400	ca. 150	—	—	—	
Nr. 3. Nordsiden av Makarovbreen	3–400	ca. 150	—	—	—	
Nr. 4. Flathuken	4–6000	ca. 200	—	—	—	Besto av tre kolonier som lå meget tett sammen. Spredt hekking av lundefugler
Nr. 5. Nordsiden av Ytre Norskøya	3–400	—	500–1000	100–150	50–100	Liten men meget interessant koloni. Lett adkomst, lett å studere alle Svalbards alkefugler
Nr. 6. NØ Klovningen	1500–2000	3–400	—	—	—	Fire kolonier som lå tett sammen
Nr. 7. Nordsiden av Fuglesangen	ca. 200	—	—	—	—	
Nr. 8. SV Fuglesangen	2–300	ca. 100	—	—	—	
Nr. 9. Nordsiden av Amsterdamøya	ca. 500	800–1000	—	—	—	
Nr. 10. NV Amsterdamøya	ca. 100	1000–1500	—	—	—	
Nr. 11. NV Amsterdamøya	700–1000	2–300	—	—	—	
Nr. 12. NV Amsterdamøya	3–400	1500–2000	—	—	—	Områdets største krykkjekoloni

Fenomenet "non-breeding" som ble observert i Hornsund i 1962 (Bang *et al.* 1963), ble ikke konstatert på den nordlige del av Vestspitsbergen sommeren 1963. Samtlige fuglearter vi kom i kontakt med syntes å hekke normalt.

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Litteratur

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Løvenskiold H. L., 1964: Avifauna Svalbardensis. *Norsk Polarinstitutt Skr.* Nr. 129. Oslo.

Ornithologische Notizen von Spitsbergen

Anlässlich einer Spitsbergen-Expedition, die vor allem Fragen des Tagesrhytmus in arktischen Breiten und der Ökologie der Meeresküste klären sollte, konnten im Sommer 1963 einige ornithologische Beobachtungen in Vestspitsbergen gemacht werden. Sie bringen gegenüber Løvenskiolds «Avifauna Svalbardensis» (1964) keine prinzipiell neuen Ergebnisse, sind aber geeignet, einige bestätigende Ergänzungen zu geben.

Ringelgans (*Branta bernicla hrota*). Vier Exemplare fliegen am 1.7 bei Fuglesangen am Schiff vorbei. Sonst wurden Ringelgänse oder Nonnengänse (*Branta leucopsis*) nicht beobachtet.

Alpenstrandläufer (*Calidris alpina* subsp.) Ein Exemplar im Brutkleid hielt sich mindestens vom 15.7 bis zum 27.7 am Ortsrand von Ny-Ålesund auf, wo es mehrfach von Ornithologen, die mit Touristenschiffen kamen, beobachtet wurde. Stets war nur ein Exemplar vorhanden, eine Brut dürfte also nicht in Frage kommen.

Rotschenkel (*Tringa totanus* subsp.). Ein Exemplar am 30.6 in Ny-Ålesund.

Steinwälzer (*Arenaria i. interpres*). Je ein Exemplar am 30.6 bei Ny-Ålesund und am 23.7. am Gråhuken.

Falkenraubmöwe (*Stercorarius longicaudus*). Je ein Exemplar am 29.6 bei Longyearbyen und am 30.7 am Kongsfjord (Blomstrandhalvøya).

Eismöwe (*Larus hyperboreus*). Nur zweimal wurden einjährige Tiere diesse so häufigen Vogels beobachtet: Am 29.6 im Grønfjorden 1 Exemplar, am 3.8 am Brandalpynten (Kongsfjorden) zwei Exemplare. (Vgl. dazu Løvenskiold l. c. S. 236 f, der über ähnliche Erfahrungen berichtet).

Schwalbenmöwe (*Xema sabini*). Je ein Exemplar am Gråhuken (23.7) und am Kongsfjorden (29.7). Beide Tiere wurden in Gesellschaft von Dreizehenmöwen (*Rissa tridactyla*) beobachtet, nicht aber zusammen mit Küstenseeschwalben (*Sterna macrura*), wie das offenbar meist der Fall ist. Das Tier am Gråhuken sass in einem Schwarm rastender Dreizehenmöwen und flog bei meiner Annäherung mit ihnen ab; am Kongsfjorden hielt sich die Schwalbenmöwe in

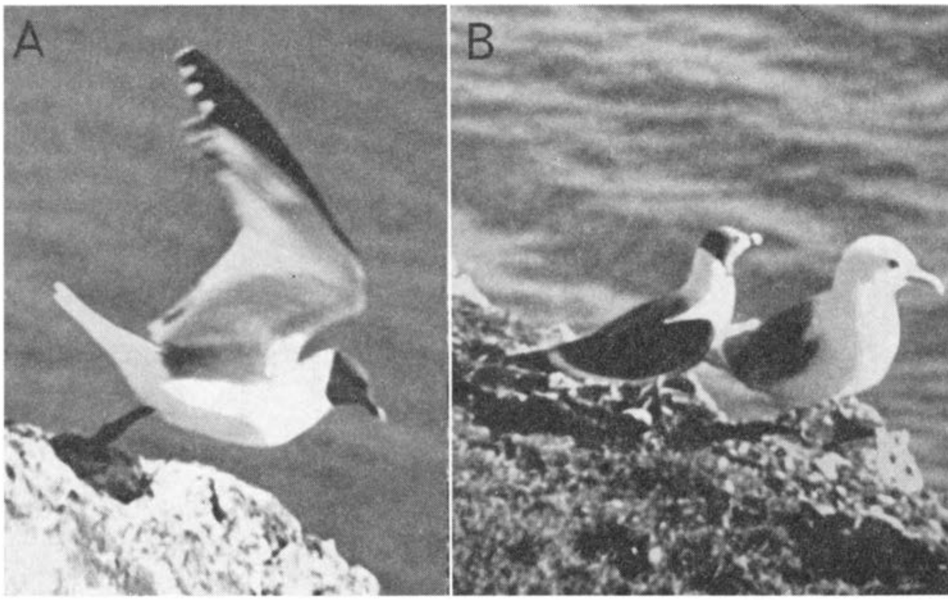

Fig. 1. Schwalbenmöve (*Xema sabini*) am Kongsfjorden. A: das Tier beim Abflug. B: zusammen mit einer Dreizehenmöve (*Rissa tridactyla*).
Photo: H. REMMERT

einer Dreizehenmöwenkolonie auf und zeigte gegenüber der fremden Art öfter Balzverhalten. Da offenbar bisher kaum Photos von *Xema sabini* existieren, seien einige der bei dieser Gelegenheit gemachten (nach Farbdiapositiven) wiedergegeben. (Eine weitere *Xema* soll im Sommer 1963 bei Longyearbyen geschossen worden sein). Ich möchte hier die Ansicht LØVENSKIOLDS (l. c. S. 48) unterstützen, dass der Abschuss dieser so extrem selten gewordenen Art auf alle Fälle unterbleiben muss! Der wissenschaftliche Wert eines weiteres Balges der Art von Spitsbergen ist sowieso äusserst fragwürdig.

Schneeammer (*Plectrophenax n. nivalis*). Wie auch LØVENSKIOLD angibt, ist die Brutzeit und Jungenaufzucht dieser Art von Paar zu Paar offenbar sehr verschieden. Ich beobachtete bei Ny-Ålesund die ersten flügen Jungvögel am 2.7, aber an anderen Nestern noch Fütterungen am 30.7. Daher erscheint es mir möglich, dass die Schneeammer gelegentlich auf Spitsbergen zwei Bruten aufzieht. Hier erscheinen zusätzliche Beobachtungen angezeigt.

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Hydrobiologisk studentekspedisjon til Jan Mayen sommeren 1963

Abstract. Two students during the summer 1963 carried out zoological investigation at Jan Mayen. The building up of fat and organic materials in marine zooplankton was studied. The lake Nordlaguna was examined and 166 Arctic chars (*Salmo alpinus*) were collected, all being in poor conditions. Samples of the sublitoral fauna and flora were collected.

Ekspedisjonen til Jan Mayen sommeren 1963 bestod av stud. real. CHRISTOFER BANG og stud. real. STIG SKRESLET og planen var å samle materiale til hovedoppgaver i marin zoologi. Oppgavene var satt opp i samarbeid med Institutt for marin biologi, avd. A, ved Universitetet i Oslo.

CHRISTOFER BANG skulle samle marint zooplankton, hovedsakelig for å bestemme oppbygningen av fett i løpet av den korte tiden planktonet blomstrer opp på slike høye breddegrader. Videre skulle han foreta morfologiske studier av den nyopprettete arten *Calanus glacialis* og om mulig beskrive dens utviklingsfaser. Endelig skulle BANG ved å samle plankton med tre forskjellige nett-typer og ved å ta vannprøver fra samme tid og sted, forsøke å bringe klarhet angående den relative betydningen av organismer av forskjellig størrelsesorden.

STIG SKRESLET skulle undersøke Nordlaguna på øya. Beretninger tydet nemlig på at Nordlaguna var av samme type som den berømte Mogilnoje innsjøen på Kildin på Murmankysten, som ble beskrevet av DERJUGIN og KNIPOWITCH i slutten av forrige århundre. Vannmassene i denne innsjøen er delt i to adskilte sikt med ferskvann over saltvann og byr på meget interessante biologiske forhold. Nordlaguna ble loddet opp og kartlagt i 1930 av ingeniør KJØLLESDAL i Havnedirektoratet i forbindelse med en prosjektert havn. I 1934 fanget ornitologene BIRD en del røye (*Salmo alpinus*) og disse funnene ble publisert i "The Salmon and Trout Magazine" i juni 1935.

De slutninger man kan trekke av de tilgjengelige kildene er at røyen i Nordlaguna har slike livsbetingelser, at den nærmest må sies å leve ved eksistensminimum. Da det alltid er av stor interesse å studere ekstreme livsforhold, ble det planlagt å foreta en så grundig undersøkelse som mulig av røyen i Nordlaguna og dens miljø.

Vi tok kontakt med "The 1963 Beerenberg Expedition, Imperial College, London" og tilbød oss å samarbeide med britene. Vi var interessert i de opplysningene som britene kunne gi om avsmeltningen i området rundt Nordlaguna, og videre hadde de sagt seg villige til å hjelpe til med å artsbestemme de plantene vi fant i Nordlaguna og nærmeste omegn. Britene på sin side var interessert i våre temperaturmålinger i havet og i å få bli fraktet rundt langs kysten med vår båt.

Til slutt hadde vi også planer om å foreta en preliminær undersøkelse over sublittoralfaunaen på Jan Mayen.

Vi reiste fra Oslo 5. juni, videre med fangstskuten M/S «Polarhav» fra Bodø 15. juni og kom til Jan Mayen 17. juni med avreise derfra igjen 23. august.

Hovedbasen ble etablert i Hvalrossbukta og vi begynte arbeidet med planktoninnsamlingen. Båten vår var en 22 fots sjark, som vi hadde planlagt å trekke på land mellom hvert tokt. Dette viste seg imidlertid å være umulig slik at vi ble nødt til å legge båten på svai i en moring. Under en sterk storm fra vest til sørvest 27. juni strandet båten og planktonoppgaven med den.

Vi fikk bare foretatt to tokt før havariet, nemlig 21. og 24. juni. Hver gang ble det benyttet tre forskjellige nett-typer som ble slept på 5 og 25 m dyp over en strekning av ca. 1 km. Planktonfangstene ble fiksert på formalin. Temperaturen i dyp fra 1 m til 90 m ble målt med vendetermometer og hastigheten og retningen av strømmen ble registrert ved hjelp av strømkors. Dessuten ble siktedybden målt med Secchiskive og phytoplanktonprøver ble tatt fra overflaten.

Da båten gikk tapt, kunne vi ikke samle mer planktonmateriale.

Vi hadde håpet at vi kanskje kunne få blitt med en av de mange småhvalfangerne som vanligvis fangster på Jan Mayen feltet, men i 1963 var forekomstene av hval i dette området minimale og ingen hvalfangere fangstet her. Videre forsøkte vi forskjellige innretninger til fangst fra land, men ingen av disse lot seg gjennomføre i praksis dels på grunn av de langgrunne kystområdene, og dels på grunn av den lave strømhastigheten våre målinger viste.

I Nordlaguna ble følgende feltarbeid utført:

1. *Hydrografi.* Det ble i løpet av sommeren arbeidet med tre hydrografiserier og på stedet ble bestemt O_2, PO_4–P, pH, ledningsevne, temperatur og siktedyp.

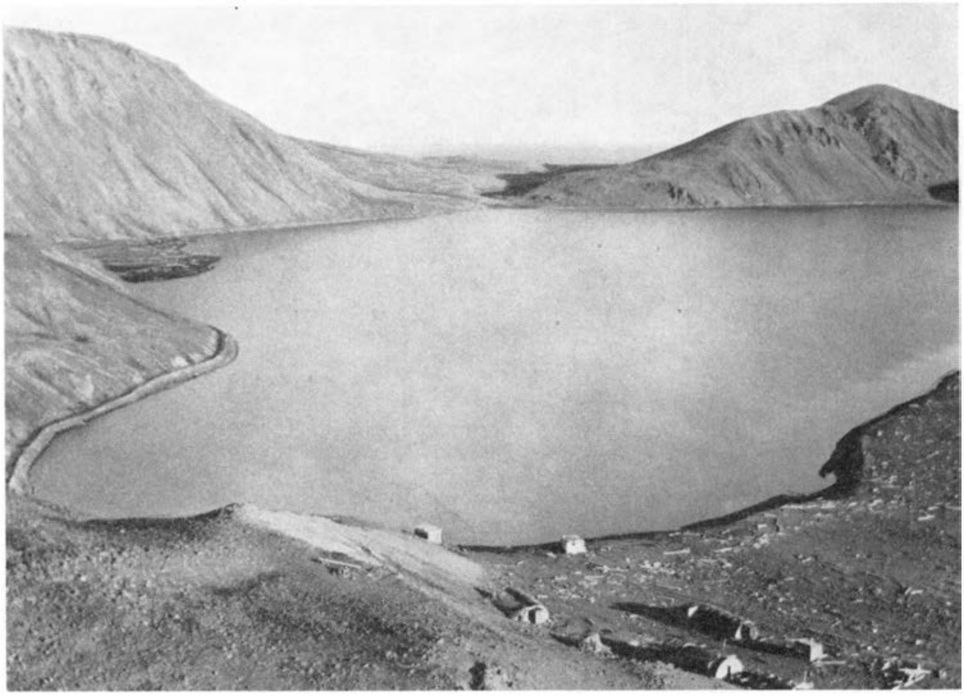

Fig. 1. *Nordlaguna på Jan Mayen med utsikt sørover mot Rekvedbukta.* Foto: C. BANG

Det ble også ført kontroll med vannstanden og vannprøver for senere bestemmelse av salinitet ble tatt. Som vannhenter ble benyttet planktonfelle.

2. *Plankton.* Parallelt med og fra samme dyp som vannprøvene ble det samlet inn planktonprøver med felle. Vertikaltrekk med nett ble også foretatt.

3. *Bunnprøver.* Til innsamling av bunnfauna og -flora hadde vi planlagt å benytte dykkerutstyr. Etter flere dykk ble det imidlertid klart at bunnfaunaen og -floraen var meget fattig. Vi tok en serie med en Ekmann grabb for å prøve å få tak i det som måtte finnes. Men det var vanskelig å bruke grabben da det var mye sand i prøvene.

4. *Fisk.* I løpet av sommeren ble det med garn av forskjellig maskevidder i alt fanget 166 røyer (*Salmo alpinus*). Vi noterte fiskens lengde, vekt, kjønn og modningsstadium, samt hvor i lagunen, på hvilket dyp og med hvilket garn fisken var tatt. Videre tok vi vare på skjell, otolitter og mageinnhold. Vi undersøkte også hvorvidt fisken hadde parasitter. All fisken ble fiksert på formalin og tatt med til Norge.

Våre feltundersøkelser gav følgende data om Nordlaguna: Den er ca. 1,5 km lang og ca. 1 km bred og er avstengt fra havet med en sandbarriere. I 1930 var den 39,3 m dyp, men i følge våre loddinger viste den seg å være 35,5 m. Trolig skyldes det sandstormene som sikkert legger igjen mye sand i denne innsjøen. En del kan muligens også skyldes brenningene, som under kraftige stormer bryter over barrieren som er 150–200 m bred og ca. 5 m høy. Vannstanden lå omtrent på havets nivå da vi kom, men sank i løpet av ca. 1 måned 12 cm. Vi registrerte ingen fluktuasjoner i forbindelse med tidevannsforskjellen i havet. Heller ikke observerte vi noen elver eller bekker som løp ut i Nordlaguna mens vi var på Jan Mayen, så antagelig fører elveleiene bare vann under den sterkeste vårsmeltningen. Den eneste tenkelige ferskvannstilførselen må være tilsig av direkte nedbør gjennom sandgrunnen og eventuelle underjordiske vannårer.

Vannet i lagunen er svakt brakt og noenlunde homogent fra overflaten til bunnen, både med hensyn til temperatur og salinitet.

Nordlaguna virker ganske produktiv med hensyn til phytoplankton, men vi fant lite zooplankton i prøvene. Et krepsdyr tilhørende underorden Cladocera, muligens slekten *Macrothrix* ble funnet i mindre antall.

Bunnen besto for det meste av sand og et tynt lag slam. I bunnprøvene fant vi en del oligochaeter, en tardigrad, samt noen insektlarver. Den eneste form for litt større planter var en mose og en liten grønnalge, trolig *Ulothrix*, som vokste på steiner i 0–1 m sonen.

Stammen av *Salmo alpinus* består for det meste av mager småfisk, men med en og annen stor, velnæret kannibal. Den største veide 3,6 kg. Den minste fisken ernærte seg ved å ta til seg sand og fordøye det som måtte følge med av leddmark og protozooer. Gytingen later til å skje sent på høsten og synes å foregå i brakkvann, dersom ikke tilstrømmingen av ferskvann gjennom sand- eller steingrunnen skaper egnete gyteplasser.

Under oppholdet på Jan Mayen dykket vi ned til ca. 5 m dyp i sublittoralsonen utenfor øya. Her samlet vi inn en del materiale fra den forholdsvis rike faunaen og floraen, og dette materiale befinner seg nå i Tromsø Museum.

Det øvrige innsamlete materiale vil bli bearbeidet senere.

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