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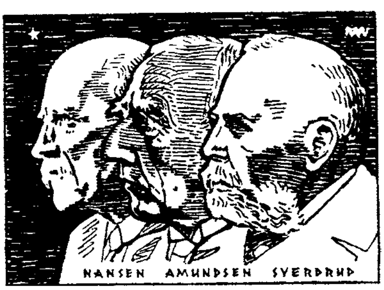

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Leiren til den Den Norske Antarktisekspedisjonen, 1968–69 in Vestfjella, Dronning Maud Land.
«Skyen» i bakgrunnen er kondensasjonsstripen fra et Herculesfly.

*The camp of The Norwegian Antarctic Expedition, 1968–69 in Vestfjella, Dronning Maud Land.
The "cloud" in the background is the contrail from a Hercules aircraft.*

Photo: K. BRATLIEN

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Structure of the Norwegian Basin

BY

G. L. JOHNSON,[1] J. S. FREITAG,[1] J. A. PEW[1]

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Abstract

During the summer of 1969 the USNS «Keathley» conducted a reconnaissance survey of the Norwegian Sea. Sediment thickness of over two km is present in the northern basin with somewhat less in the southern basin.

The history of the Norwegian Sea has been dominated by axial growth of the Mid-Oceanic Ridge. The Mohns Ridge axis has apparently remained stable; however, farther south the ridge axis has shifted at least once to the west.

Introduction

During the summer of 1969 the USNS «KEATHLEY» conducted a reconnaissance survey of the Norwegian Basin. Parameters measures were magnetics, bathymetry and seismic reflection. A Proton precession magnetometer (Varian 4931 D R) was employed to measure the absolute value of the earths' magnetic field. Magnetic tapes were scaled at 50 gamma intervals and at all magnetic highs and lows. Soundings were obtained with a 12 kHz towed transducer in conjunction with an Ocean Sonics Precision Recorder. The echo distances measure in units of 1/400 sec travel time are probably accurate to at least 1 part in 3000. Seismic reflection data were collected with a Bolt Associates air gun, Teledyne hydrophone streamer and two Raytheon PSR recorders. The air gun was fired at about 1800 lbs. pressure every 8 seconds using a 120 cubic inch chamber. The incoming signal was band pass filtered from 40 to 76 Hertz. Navigation was by LORAN and

[1] U.S. Naval Oceanographic Office.

satellite and was extremely accurate with excellent agreement between intersecting lines.

Until recently knowledge of the bottom configuration of the Norwegian-Greenland Sea was meager. NANSEN's (1904) bathymetric chart was revised by later expeditions, but still remained schematic. The first systematic echo-sounding profiles of the Greenland and Norwegian Seas were made by S. S. «Veslekari» in 1937–38 under the leadership of Miss LOUISE A. BOYD (BOYD 1948). STOCKS (1950) produced a bathymetric chart on the basis of pre-World War II soundings. LITVIN (1964) incorporating about a decade's accumulation of Soviet data produced an excellent chart of the Norwegian Sea. The general physiography of the entire Norwegian-Greenland Sea was reported by JOHNSON and HEEZEN 1967 (Figs. 1 and 2).

Basic to the interpretation of data presented in this report is the recently discovered concept that the Mid-Oceanic Ridge is a continuous generator of new sea floor. This sea floor can be dated by its imprinted linear magnetic anomalies which reflect ridge orientation and the orientation and polarity of the geomagnetic dipole field at the time of emplacement. A detailed review of this process is found in VOGT et *al.* (1969).

The Norwegian Basin

The Norwegian Basin actually consists of two basins separated by the Jan Mayen Fracture Zone (Fig. 1). The north-western boundary of the northern basin is delineated by the crest of Mohns Ridge; the southern boundary is the Jan Mayen Fracture Zone. The basin is floored by the well developed 11 000 mile^2 Dumshaf Abyssal Plain which lies in approximately 1 740 fms (3 200 m).

Seismic reflection data across the Dumshaf Plain (Fig. 3) show a sequence of flat turbidites approximately 200 m thick overlying one km of acoustically transparent layers. These deeper layers are distorted by either tectonism or differential compaction over the rough basement. The transparent sediment on the western end of Fig. 3 is apparently totally pelagic and one is tempted to infer that it is simply an elevated portion of the acoustically transparent sedimentary sequence found beneath the plain's turbidites. The rough basement presumably represents the buried Mid-Oceanic Ridge flanks.

Fig. 4 illustrates four seismic reflection lines from the Norwegian Continental Shelf westward across the northern basin. All profiles show a prominent reflector, herein designated Layer N, at approximately 600 m shoaling toward both the east and west. Layer N probably crops out in the rough topography on the western end of profiles 1, 3 and 4 (Fig. 4). It also nears the surface of the sea floor at base of the continental slope. Layer N may represent a series of turbidites emplaced in response to either sea level or tectonic changes along the Norwegian Continental Margin. Approximately one km of transparent sediment with only occasional layering lies beneath Layer N. All profiles show rough basement topography on

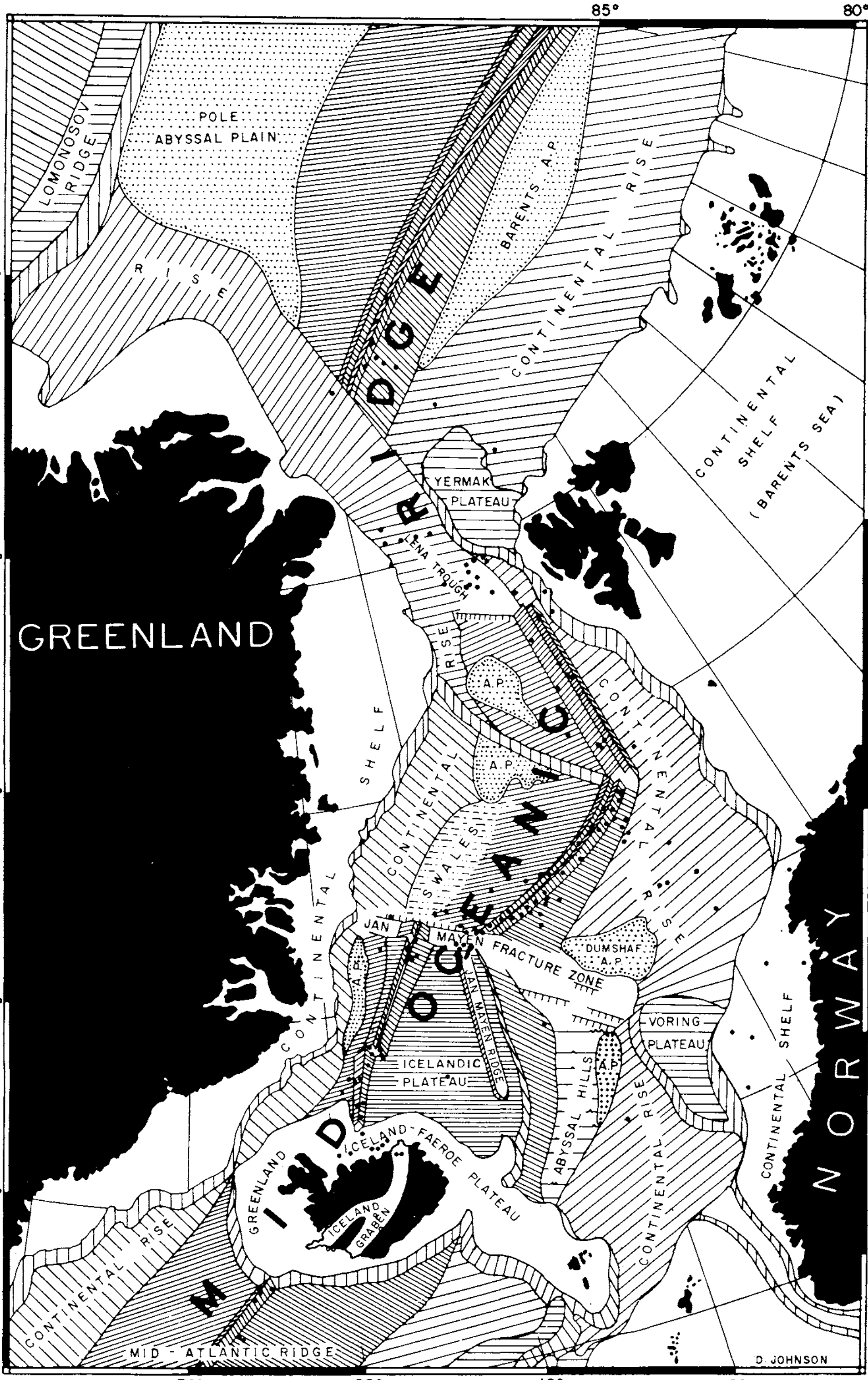

Fig. 1. *Physiographic provinces of the Norwegian-Greenland Sea.*
(From JOHNSON and HEEZEN 1967).

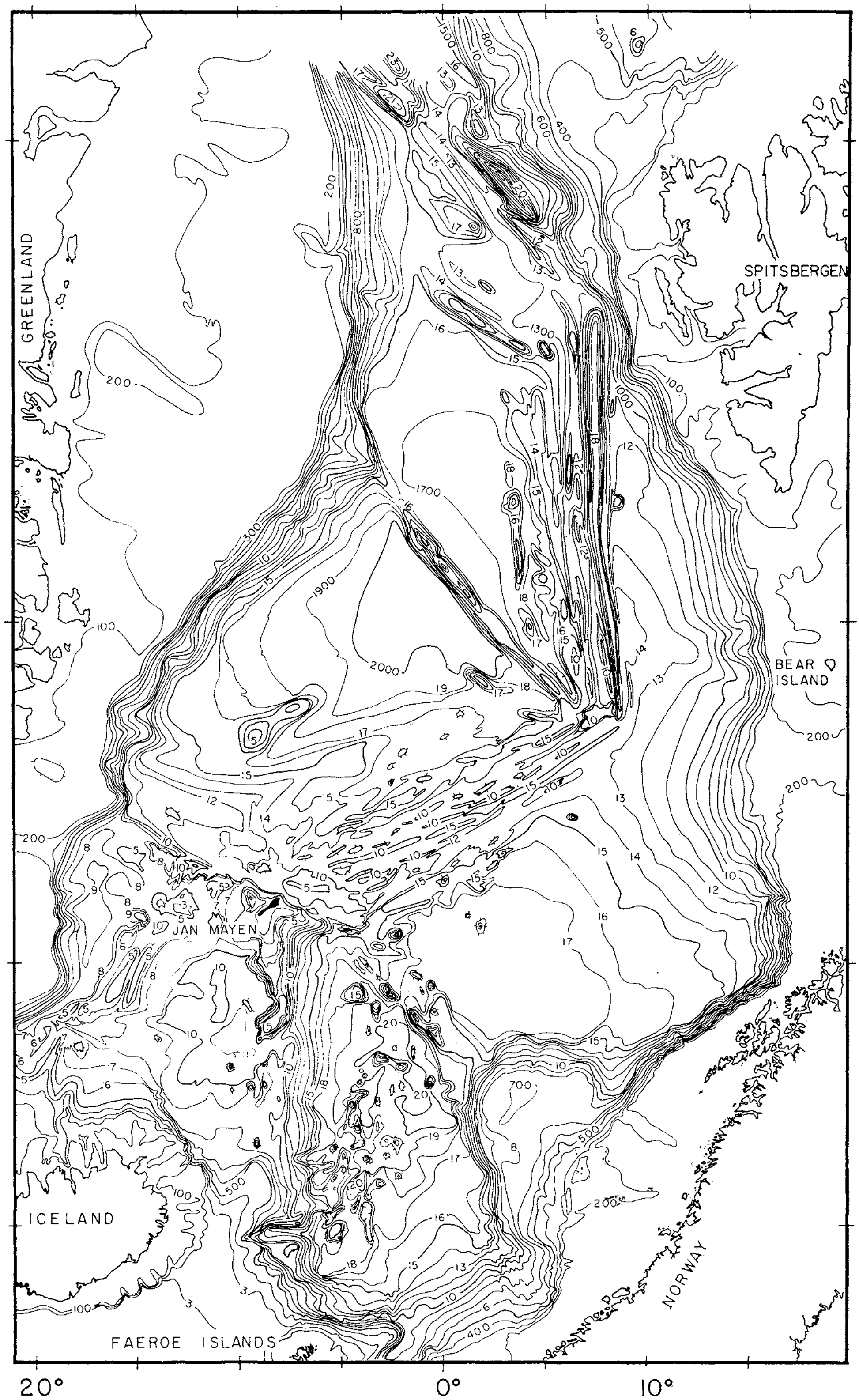

Fig. 2. *Bathymetric sketch map of the Norwegian-Greenland Sea. Contours are in units of 1/400 second travel time (nominal fathoms). For details of Mohns Ridge, see* JOHNSON *and* HEEZEN *(1967).* From JOHNSON and HEEZEN (1967).

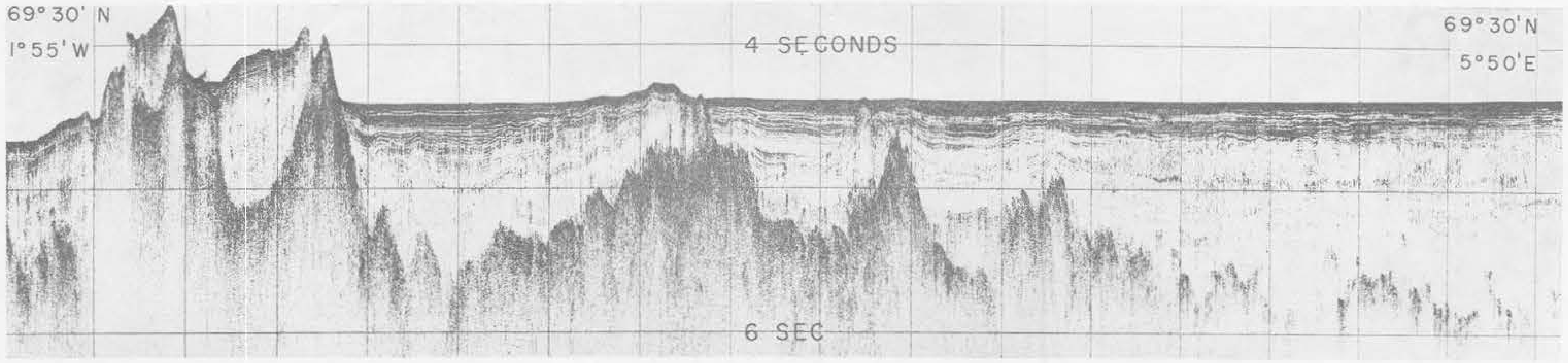

Fig. 3. *Seismic reflection record across a small portion of the Dumshaf Abyssal Plain. One second of travel time is equal to approximately one km. The flat-lying turbidites overlie a rather contorted sequence of relatively transparent sedimentary horizons. The Jan Mayen Fracture Zone is represented by the rough topography at the western end of this profile. Record length is about 170 miles (320 km).*

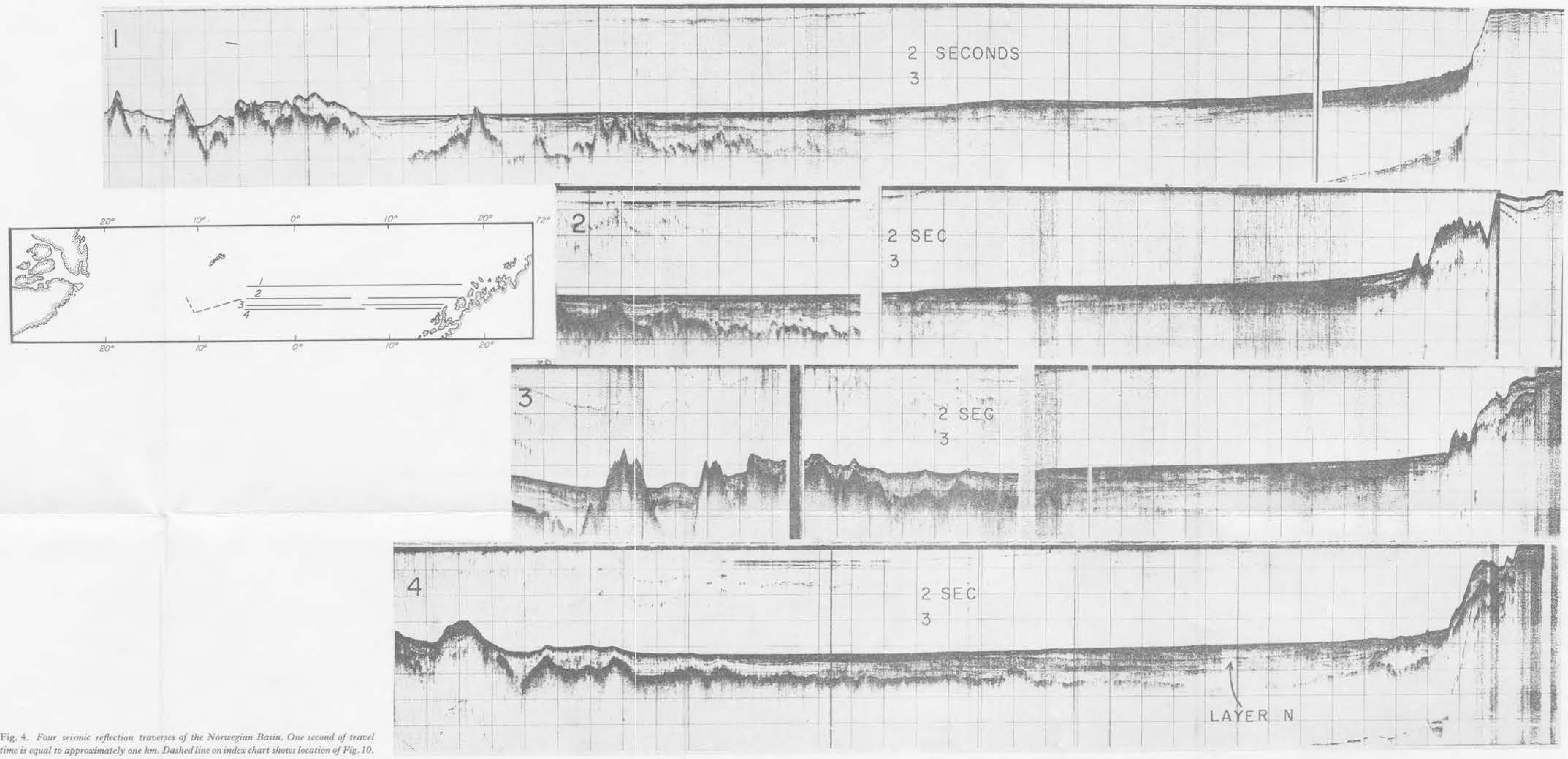

Fig. 4. *Four seismic reflection traverses of the Norwegian Basin. One second of travel time is equal to approximately one km. Dashed line on index chart shows location of Fig. 10.*

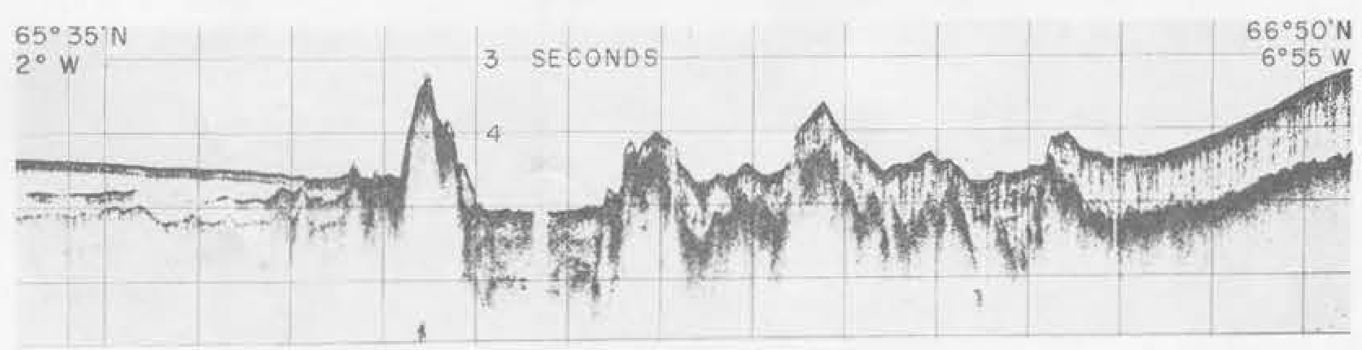

Fig. 5. *Seismic reflection record across the buried seamount chain in the southern Norwegian Basin. One second of travel time is equal to approximately one km.*

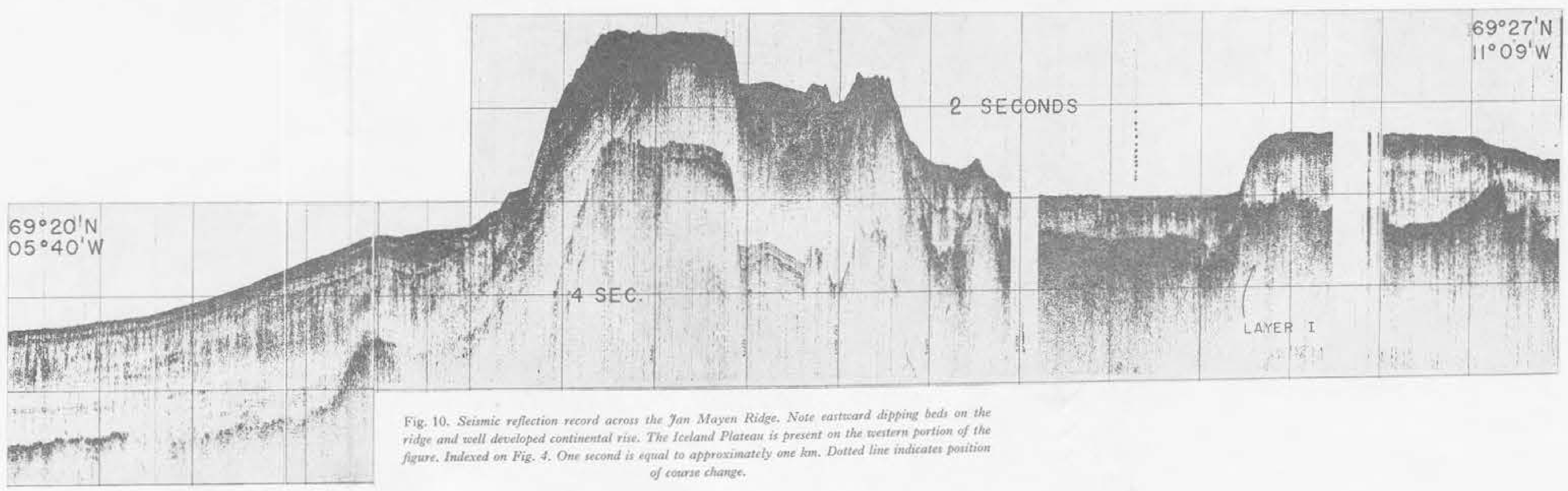

Fig. 10. *Seismic reflection record across the Jan Mayen Ridge. Note eastward dipping beds on the ridge and well developed continental rise. The Iceland Plateau is present on the western portion of the figure. Indexed on Fig. 4. One second is equal to approximately one km. Dotted line indicates position of course change.*

the western extremity which is partially buried Mid-Oceanic Ridge. In Fig. 4, profile 4, the basement appears to have less relief; however, the authors believe the true relief is masked by a strong reflecting layer through which the higher peaks of the basement are barely discernible. This deep layer is clearly seen at depths of two km on profile 3 although it does not appear so opaque. The apparent abrupt termination of the basement peaks in this profile perhaps suggests tectonic control. In profiles 1, 2 and 4 (Fig. 4) basement can be seen gradually becoming indistinct on the seismic record beneath the thickening wedge of sediments. The outer shelf of the Norwegian continental block consists of at least 800 m of prograded and somewhat distorted sedimentary horizons (Fig. 4, profiles 2–4).

The southern basin of the Norwegian Sea is occupied by a partially buried seamount chain with only local abyssal plain development (Figs. 1 and 2). The sea floor is about 300 fms deeper than the maximum depths of Dumshaf Abyssal Plain to the north. Sediment cover averages from 500–800 m (Fig. 5) over a rough basement with the exception of one smoothish area in the central portion where sediment thickness is over one km. This basement dip might represent an ancient fracture zone or rift valley. The western portion of Fig. 5 shows almost one km of sediment overlying a rather smooth, highly reflective layer. This sediment represents a continental rise associated with the Jan Mayen Ridge. The southern end of Fig. 5 illustrates a dual opaque reflector which may be synchronous to Layer N north of the Jan Mayen Fracture Zone.

The Jan Mayen Fracture Zone

The Jan Mayen Fracture Zone is an en échelon series of troughs and elongated highs which, striking south-east, bisect the Norwegian Basin (Figs. 1 and 2). Its topographic, magnetic, and structural character was surveyed in detail between 69° and 70°30′N and 5°W to 1°E by the USNS «Keathley» (Figs. 6, 7, and 8). Sediment fill of over two km is apparent in the axis of the fracture zone. Magnetic lineations parallel the fracture along its axis. To the east of the fracture and perpendicular to it normal Raff-Mason spreading lineations are apparent over the Dumshaf Abyssal Plain. Evidence of recent deformation along the axis of the Jan Mayen Fracture Zone can be seen in Fig. 9 along the wall of the bordering escarpment. The changing character of the fracture zone is illustrated by Fig. 3 in which the zone appears to be an elevated portion of basement rather than a deep trough. The large pile of sediment on the left hand portion of Fig. 3 appears similar to the buried transparent, convoluted sediment of the Dumshaf Abyssal Plain, suggesting uplift. The fracture zone orientation is N 45°W. This reflects the Mid-Oceanic Ridge spreading direction that prevailed when this fracture zone was active; since fracture zones are always very nearly perpendicular to the ridge axis, the strike of the fracture zone implies that the Mid-Oceanic Ridge strike was N 45°E. The lack of seismicity along the eastern end of the fracture zone attests to its present inactive status.

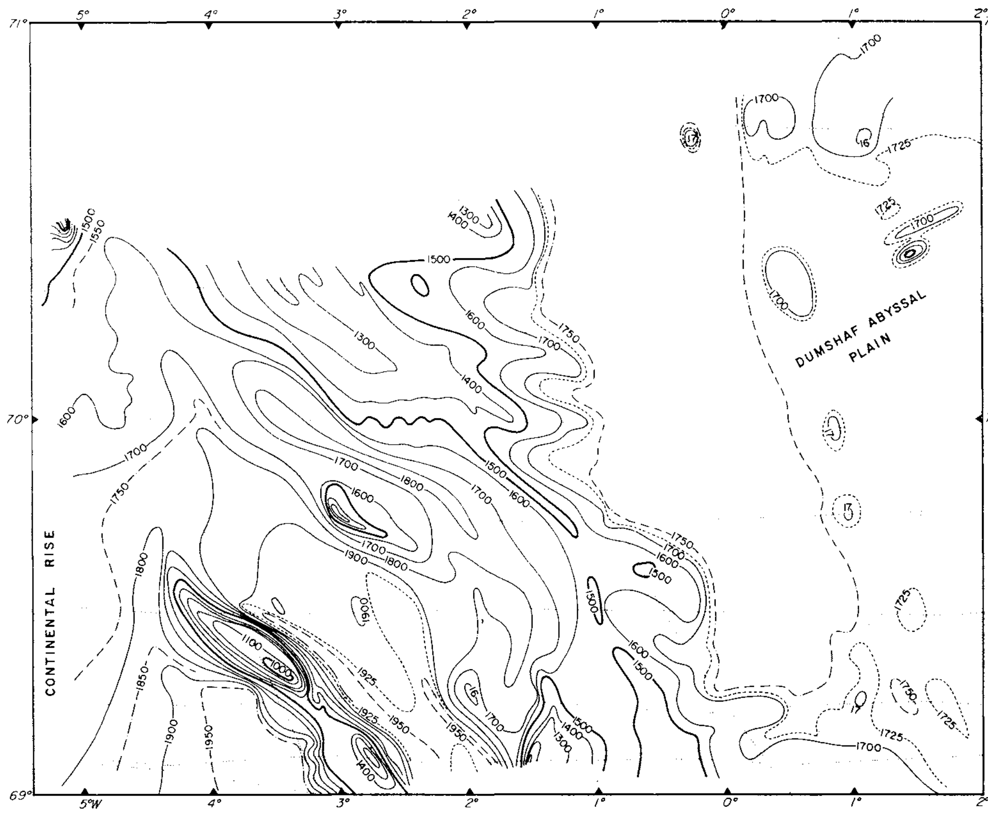

Fig. 6. *Bathymetric sketch map of a portion of the Jan Mayen Fracture Zone. Control is shown by dotted lines. Isobaths are in units of 1/400 sec. travel time (nominal fathoms).*

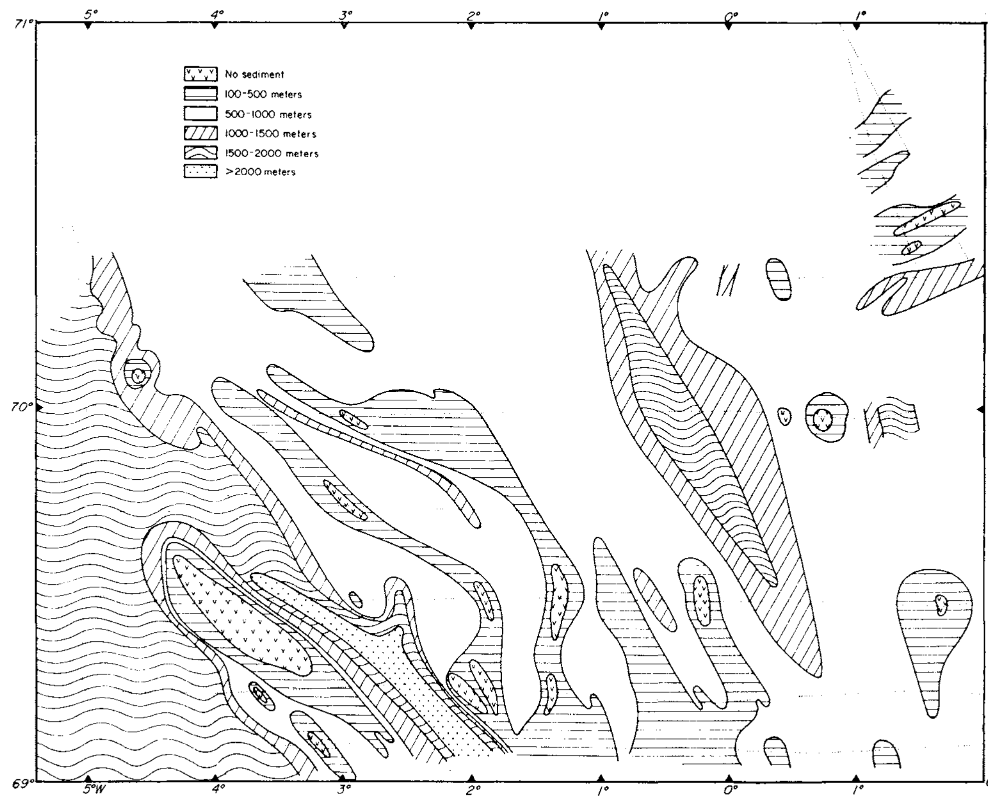

Fig. 7. *Isopach chart of a portion of the Jan Mayen Fracture Zone. Depths are in meters as determined from the seismic reflection data.*

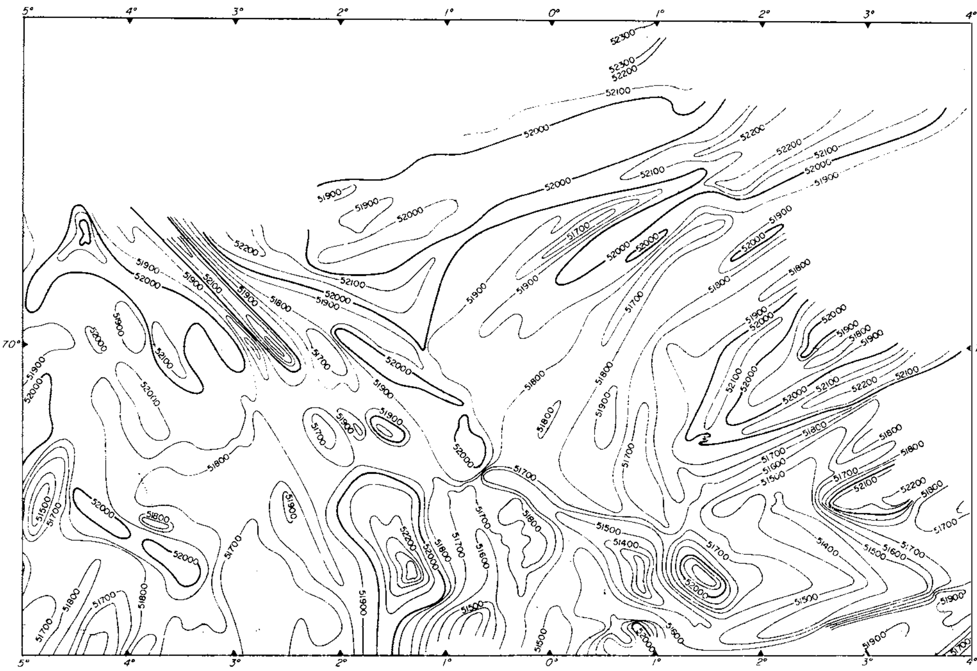

Fig. 8. *Total field magnetic chart of a portion of the Jan Mayen Fracture Zone. Note the parallelism with Fig. 6. The north-eastern portion of this illustration is dominated by typical Raff-Mason magnetic lineations parallel to Mohns Ridge.*

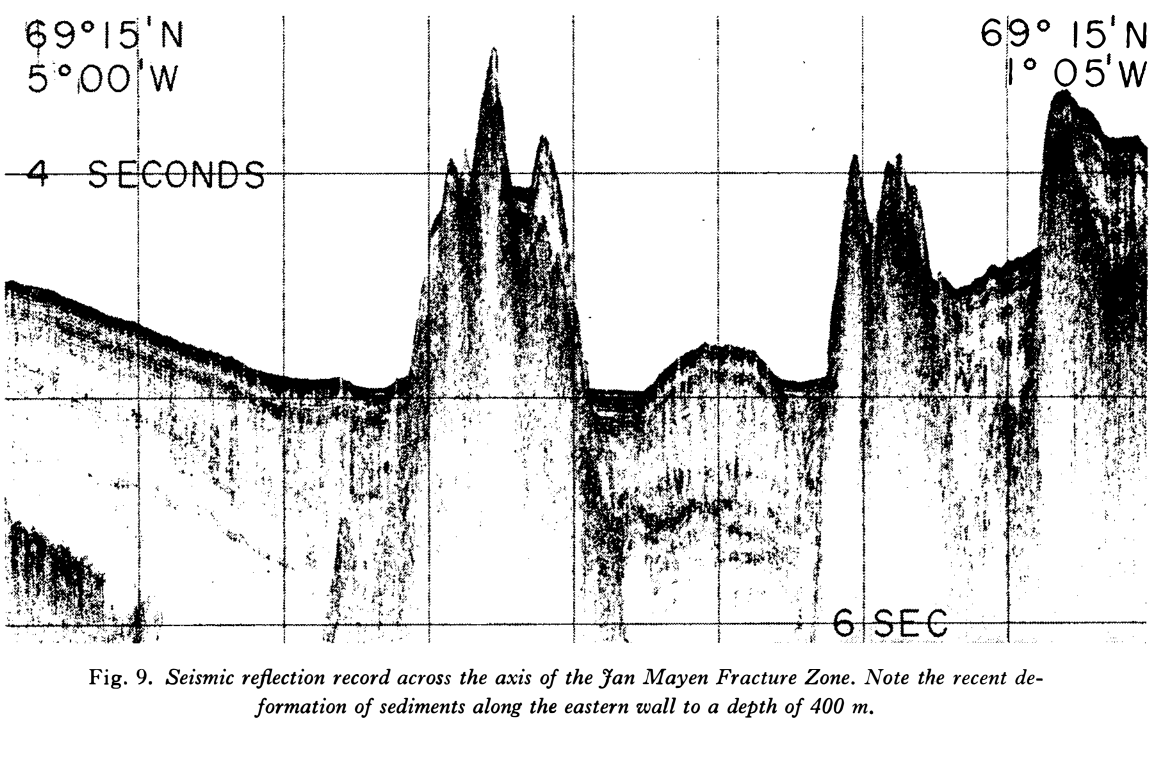

Fig. 9. *Seismic reflection record across the axis of the Jan Mayen Fracture Zone. Note the recent deformation of sediments along the eastern wall to a depth of 400 m.*

Origin

Within the last few years WEGENER's concept of continental drift (WEGENER 1924) has progressed from heresy to become virtually unanimously accepted by the scientific community. The central hypothesis is that oceanic crust is created by dike injection with some vulcanism and normal faulting at the axis of the Mid-Oceanic Ridge (DIETZ 1961, HESS 1962, HEEZEN 1960). VINE and MATTHEWS (1963) noted the fairly symmetric anomalous magnetic profiles across the Mid-Oceanic Ridge, and assumed that as the mantle derivatives cool in the axial zone, they must acquire a magnetization dependent upon the ambient strength and direction of the geomagnetic field. Utilizing known polarity reversals on land, they were able to construct a "magnetic tape recorder" model of the Mid-Oceanic Ridge. VOGT et al. (1969) gives a complete review of the processes involved.

Throughout the history of the Norwegian Basin the active Mid-Oceanic Ridge has always been the dominant and controlling feature (Fig. 1). Between Iceland and Jan Mayen the Mid-Oceanic Ridge is a relatively small arch marked by rough topography and a large axial magnetic anomaly. This section of the ridge is offset to the east by the Jan Mayen Fracture Zone. The Mid-Oceanic Ridge thence strikes north-east from Jan Mayen toward Bjørnøya (Bear Island) and is commonly known as Mohns Ridge. At its intersection with the Greenland Fracture Zone (Fig. 1) the Mid-Oceanic Ridge turns sharply to the north.

AVERY et al. (1968) have determined that Norway and Greenland began to separate about 60–70 mybp approximately along what are now the edges of their continental shelves (VOGT et al. 1970). The median location of Mohns Ridge between Greenland and Norway suggests spreading has always proceeded from a single axis in the northern Norwegian Sea.

To the south of the Jan Mayen Fracture Zone (Fig. 1) the history of the sea floor is more complex. The present Mid-Oceanic Ridge is assymmetrically located between the Jan Mayen Ridge and Greenland. JOHNSON and HEEZEN (1967) proposed that the Jan Mayen Ridge was split off from the Greenland shelf during a recent relocation of the rift axis, and that the partially buried chain of seamounts in the Norwegian Basin (Fig. 5) delineate the extinct rift axis. On the Reykjanes Ridge (AVERY et al. 1969) between 60 to 42 mybp about 400 km of crust was generated. This is approximately the total width of crust created by Mohns Ridge within this time span as well as being approximately the distance between the Jan Mayen Ridge and the edge of the Norwegian Continental Shelf (including the Vøring Plateau as continental), indicating that the spreading rates north and south of Iceland were about equal. It therefore seems reasonable that spreading on the old axis ended before 30 mybp (VOGT et al. 1970).

The rift axis later shifted westward and possibly split off the Jan Mayen Ridge as a continental fragment. Seismic reflection records across this feature show eastward dipping beds truncated near the surface and covered by 100–300 m of flat-lying sediments (Fig. 10, and JOHNSON and HEEZEN 1967). Seaward of the Jan Mayen Ridge a well developed continental rise is present (Figs. 5 and 10), which may be a relic of an earlier Greenland Continental Rise. The deepest reflector at approximately one km (Fig. 10, eastern end) can be traced up onto the crest of the Jan Mayen Ridge. The layers appear similar to the prograded beds of European continental margins as described by CURRAY et al. (1966). However, if flat-lying beds were elevated some three km by an intrusive mass, one would expect prominent slump features to be apparent. The authors, therefore, favor a progradation origin for the eastward dipping beds on the eastern side of the Jan Mayen Ridge. The magnetic field has been shown by JOHNSON et al. (1970) to be rather subdued across the Ridge.

The assymmetric location of the present Iceland–Jan Mayen Ridge between the Jan Mayen Ridge and the Greenland Shelf (Fig. 1) suggests that another axis may lie somewhat west of the Jan Mayen Ridge. This second hypothesis is that the entire Iceland Plateau (Figs. 1 and 10) is oceanic in nature, having been created approximately between 30 mybp and 10 mybp. Volcanic Jan Mayen, which was probably constructed in Mid-Tertiary to early Pleistocene times (JOHNSON 1968), may then represent an emerged portion of Mid to Upper Tertiary Iceland. The flattopped Jan Mayen Ridge would be the highest remanent of a northern extension of Iceland which has foundered with time. The sediment unconformity on the crest of the Jan Mayen Ridge then represents a former sea level erosion surface dating from the time of initial subsidence. This hypothesis is attractive because the Iceland style of sea floor spreading would have occurred during the period of known slow spreading on the Reykjanes Ridge. This suggests that complex Iceland style sea-floor spreading in part requires slow spreading rates.

Up to one km of sediment is present on the Iceland Plateau (Fig. 10, western end). The sediment is transparent, indicating it is probably primarily pelagic in nature. Beneath this transparent sediment a smoothish, highly reflective layer is present, herein designated Layer I. Layer I is gently convoluted, perhaps indicating it is conformable to an irregular igneous basement. The opaque nature of Layer I suggests it may be composed at least in part of volcanic debris. In Fig. 10 in the vicinity of the course change (dotted line) the transparent sediment is only 400 m thick. A possible explanation is non or a reduced rate of deposition due to the action of bottom currents.

The present day evidence does, however, point toward an extinct axis in the Norwegian Basin caused when the center of rifting shifted westward during Mid-Tertiary times.

Acknowledgements

The authors wish to thank the U. S. Naval Oceanographic Office scientists as well as the officers and crew of the USNS «Keathley» who participated in the survey of the Norwegian Sea.

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Radiocarbon dating of raised marine terraces at Hornsund, Spitsbergen, and the problem of land uplift

BY

KRZYSZTOF BIRKENMAJER[1] and INGRID U. OLSSON[2]

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Abstract

Six samples of shells, whale bones, and driftwood from raised marine terraces at Hornsund, southern Spitsbergen, have been dated, using the radiocarbon method. The higher *Saxicava-Mya* terraces (7.5–8.8 m alt.) are about 9000 years old, and the lower *Mya* terraces (5.5–7.5 m alt.) are some 400 years younger. The periods of formation of both the *Saxicava-Mya* and *Mya* assemblage-bearing deposits are referred to as the Pre-Boreal and Boreal climatic intervals of the Holocene, respectively.

The whale bones at 8 m alt. are about 9000 years old, and those at 5.5 m alt. about 700 years old. Neither of them matched the age of the great hunting period on Svalbard, some 350 years ago,

[1] Norsk Polarinstitutt, Oslo, Postboks 5054, Majorstua, Norway (on leave from the Polish Academy of Sciences, Geological Laboratory, Kraków, Senacka 3, Poland).
[2] University of Uppsala, Institute of Physics, Box 530, S-751 21 Uppsala 1, Sweden.

and hence the criticism of the "whale method" of calculating the land uplift in Svalbard expressed by various authors was justified.

The rates of land uplift at Hornsund are discussed in relation to similar data from other parts of Svalbard. New tentative curves of relative land uplift and subsidence during the Holocene for central and southern Spitsbergen are drawn, and coordinated with new evidences of marine transgressions in Svalbard during the mid-late Holocene times, as presented by FEYLING-HANSSEN and HYVÄRINEN.

Introduction

From 1956 to 1960 raised marine features were studied along the coasts of Hornsund, Spitsbergen, by members of the Polish Spitsbergen Expeditions in the Third International Geophysical Year (I.G.Y.), particularly by A. JAHN (1958, 1959a, b, 1968; JAHN & SZCZEPANKIEWICZ 1958) and K. BIRKENMAJER (1958a, b, c, 1959, 1960a, b). BIRKENMAJER presented detailed descriptions, maps and geological cross-sections of raised storm ridges, terraces and cliffs, laying particular stress on the character of the sediments and their organogenic compounds (shells, whale bones, driftwood). He assumed that the whale bones found on the surface of raised marine terraces between 5 and 8 (8.5) m above sea-level, especially those of the now nearly extinct Greenland Whale (*Balaena mysticetus* L.), had resulted from the widespread hunting which started in Spitsbergen in 1611 but declined rapidly in the middle of the 17th century. The figure of 8 m, at which level numerous whale bones were concentrated, was chosen, and this gave an extremely rapid rate of uplift of 2.3 m per century for the last 350 years (1611—1957). It should also be noted that the value of whale bones as indicators of the rate of land uplift on Svalbard was independently advocated by CORBEL (1960; see also critical review by FEYLING-HANSSEN 1965a) but was abandoned shortly afterwards (CORBEL 1965, p. 63).

The "whale method" was applied by BIRKENMAJER not only to Hornsund but also to the Svalbard archipelago as a whole, and tentative isobases of the present land uplift were drawn (BIRKENMAJER 1958c, 1960a), using data from various sources. The method met with some support from KUC (1964, 1968) but was energetically opposed by JAHN (1959a, b, 1968) and by the majority of those who have studied the subject of land upheaval in Spitsbergen (cf. review by BIRKENMAJER 1968). JAHN concluded that within the last 50 years any negative shift of the shoreline has been negligible, and the land uplift of the Hornsund area, if it had occurred at all, would probably have been matched by a simultaneous eustatic rise of the sea-level. Also the results of studies of old hunting settlements situated close to the shore (BLAKE 1961b; CHRISTIANSSON 1961) and the radiocarbon ages of mollusc shells, whale bones and driftwood from the raised beaches elsewhere in Svalbard (for instance OLSSON 1959, 1960; FEYLING-HANSSEN & OLSSON 1959—1960; OLSSON et al. 1961; BLAKE 1961a; OLSSON & BLAKE 1962; OLSSON & PIYANUJ 1965; FEYLING-HANSSEN 1965b) were generally in disagreement with the rapid rates of the present uplift postulated by BIRKENMAJER.

The first radiocarbon dating of the raised terraces at Hornsund (Rålstranda)

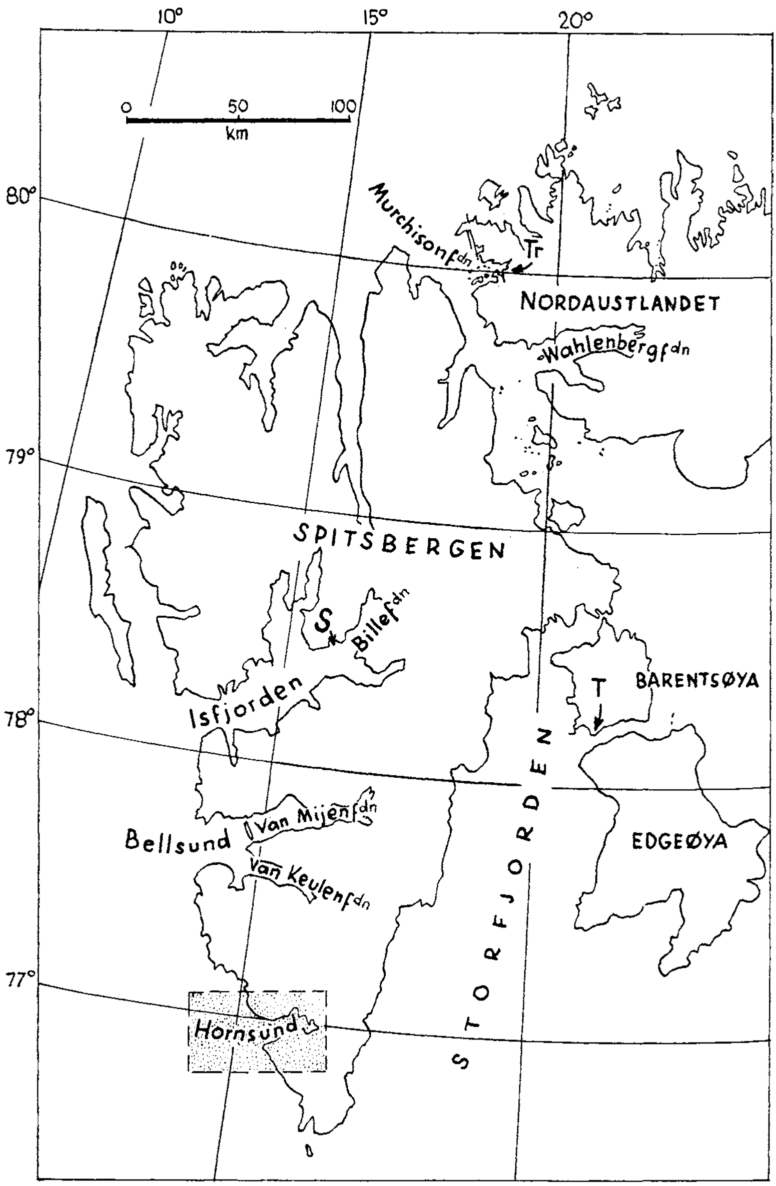

Fig. 1. *Key map to show the location of Hornsund (stippled) within the Svalbard archipelago.* S – Skansbukta; T – Talaveraflya; Tr – Trullvatnet.

was performed (Blake et al. 1965; Olsson & Kilicci 1964) on a thin layer of peat, the top surface of which was approximately 12 m above the sea. The bottom part of the peat (some 55–60 cm below the surface) was dated 1390 ± 70 years B.P., while a slightly higher layer (54–55 cm below the surface) gave two dates of 260±110 and 620±80 years B.P. (in years before 1950) respectively. Blake et al. (1965, p. 179) concluded that the dates obtained, and especially that of 1390±70 years for basal peat approximately 11.5 m above sea-level, lent support to the arguments of JAHN in favour of a relatively slow uplift in the Hornsund area during the last few centuries. However, as no radiocarbon dating was applied to bones on which the "whale method" was founded by BIRKENMAJER, and as the three ages from the peat were partly in disagreement with each other, the solution of the problem had to wait until a proper collection of bones from critical sites had been made. This was made possible in 1966, when K. BIRKENMAJER revisited the Hornsund sites in the course of his geological investigations carried out for Norsk Polarinstitutt in Torell Land (Spitsbergen). The samples of whale bones, driftwood, and shells from the raised terraces were subsequently submitted to the Institute of Physics at the University of Uppsala, where I. U. OLSSON took care of the data-processing (OLSSON et al. 1969).

Description of sites

GENERAL

The samples of marine shells, whale bones, and driftwood used for radiocarbon dating were collected on the northern shore of Hornsund between Hansbreen and Revdalen, on a coastal plain known as Fuglebergsletta (Figs. 1 and 2). A more detailed description of the locality is given in Figs. 3–6 and in the description under headings *Shells*, *Whale bones*, and *Driftwood*. As a detailed survey of the raised marine features of Fuglebergsletta has already been published by BIRKEN-

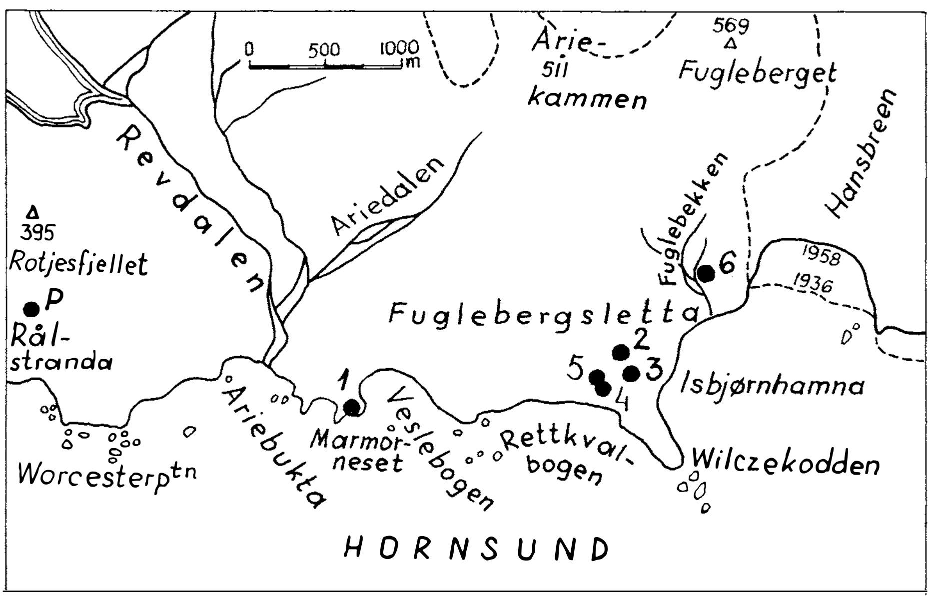

Fig. 2. *Key map for radiocarbon-dated samples from the northern coast of Hornsund. 1–6 samples described in the present paper as* Q1*a* – Q6*a*; *P - peat locality at Rålstranda, described by* BLAKE *et al. (1965).*

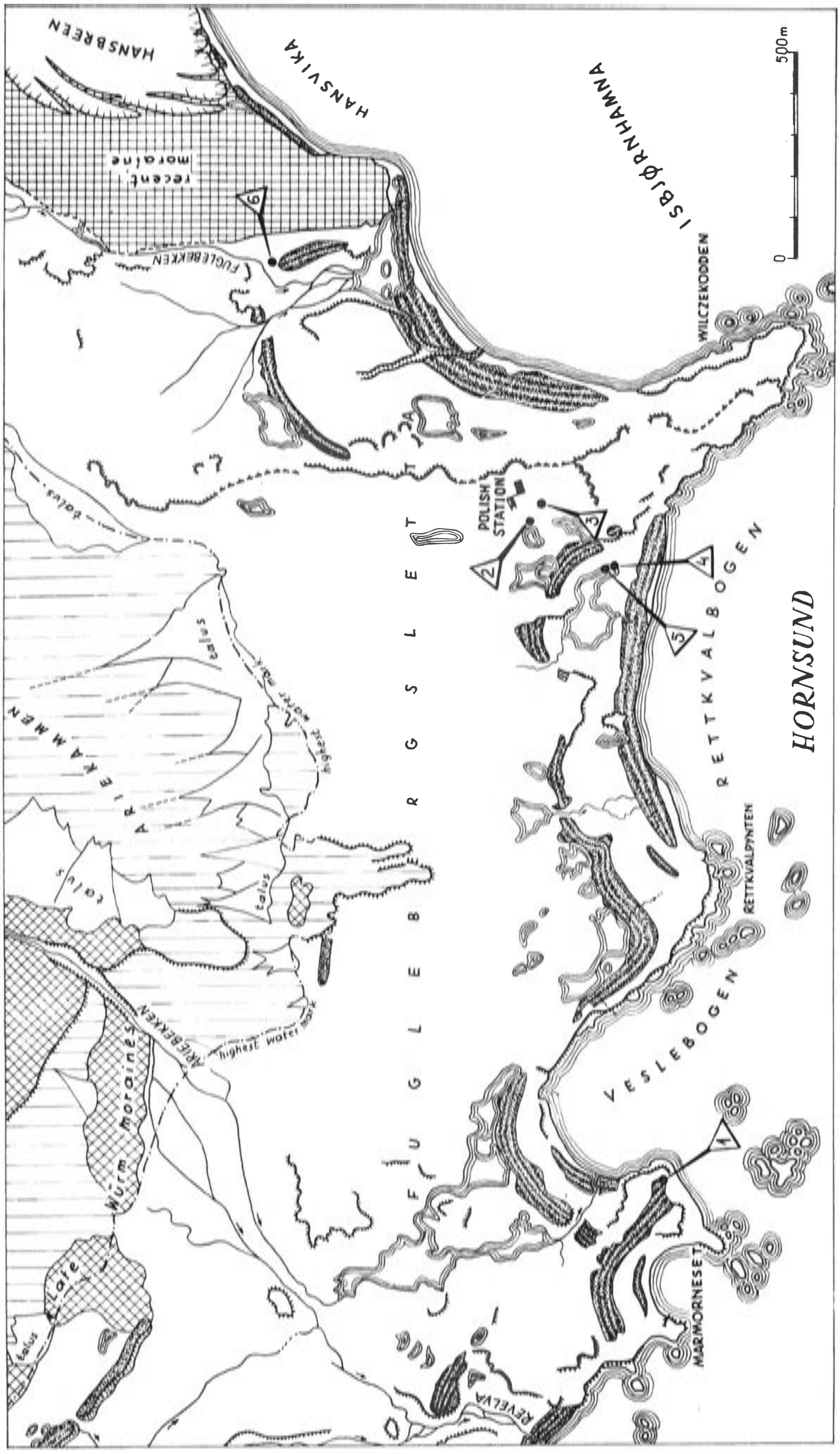

Fig. 3. *Localization of radiocarbon-dated samples 1–6 (=Q1a–Q6a) on the northern coast of Hornsund. Geomorphological features adapted from* Birkenmajer *(1960b,* Pl. XII). *Stippled – raised storm ridges; blank – raised marine terraces (partly also talus and alluvial cones included); obliquely cross-hatched – late Würm moraines; vertically cross-hatched – Recent moraines; vertically hatched – pre-Quaternary substratum above the highest water mark. Erosional escarpments (raised cliffs etc.) and terrace pools also shown.*

MAJER (1960b, pp. 13–40, Pl. XII: map), no more than an outline will be given here. This area (between Rotjesfjellet–Revdalen and Hansbreen) was chosen to establish a standard sequence of the raised marine terraces of Hornsund (Table 1).

The terraces are nearly flat, rocky plains gently tilted seaward. They are partly or entirely covered with a thin layer of marine gravel and sand (locally also with fresh-water accumulation), and are separated from each other by steep cliffs and raised storm ridges. The highest, the 4th and 3rd terraces, yielded no shells, as was also the case with the two higher levels (*2c*, *2b*) of the 2nd terrace system, the latter being the best-developed terrace sequence. The only sediments which contained marine shells corresponded with the $2a_2$, $2a_1$ (*Saxicava-Mya* and *Mya* respectively), and the 1st (*Balanus*) terraces.

In general, the mollusc assemblages of the Hornsund terraces were meagre. Nevertheless, as characteristic species occurred, a comparison with central Spitsbergen was drawn up, and this indicated a much smaller total Holocene uplift for Hornsund (Table 2).

The risk of vertical movements of shells due to frost action, as envisaged by OLSSON et al. (1967, pp. 456–457), is ruled out here for these particular samples (the details are given under heading *Shells* and in Fig. 5A–C).

SHELLS

Sample Q1*a*. *Marmorneset* (western part), Hornsund, Spitsbergen (77°00′–15°29′). $2a_2$ terrace (=*Saxicava-Mya* terrace), altitude of the surface 8.5 m above mean sea-level. Sample of shell detritus, mostly *Balanus* sp., taken from gravel layer 0.2 m thick and 0.4 m below the terrace surface; altitude of sample about

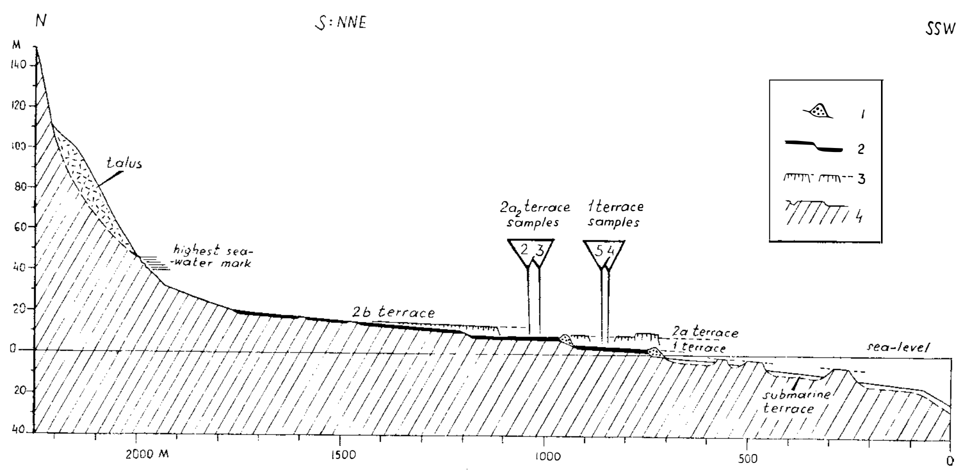

Fig. 4. *Transverse cross-section of the northern coast of Hornsund at Isbjørnhamna to show the position of the most important radiocarbon-dated samples, 2, 3, 4, and 5, corresponding* to Q2*a*, Q3*a*, Q4*a*, *and* Q5*a respectively. Cross-section roughly along the "F" profile line in* BIRKENMAJER's *map (1960b, Pl. XII)*. 1 – *Recent and raised storm ridges*; 2 – *raised marine-terrace accumulation*; 3 – *raised cliffs*; 4 – *bedrock.*

Table 1

Raised marine terraces north of Hornsund; standard sequence (after BIRKENMAJER *1960b, Table 1, simplified)*

Terrace		Faunal assemblage	Altitudes in metres above mean sea-level	
			Front edge	Rear edge
4th terrace		—	c. 40	—
3rd terrace		—	25–27	—
2nd terrace system	*c*	—	13–16	25
	b	—	10–15	18.5–30
	a_2	*Saxicava* and *Mya*	7.5–8.8	10
	a_1	*Mya*	5.5–7.5	8–10
1st terrace		*Balanus*	2–5.5	—

Table 2

Comparison of raised marine terraces of Billefjorden and Hornsund (adapted from BIRKENMAJER *1960, Table 17). Altitudes in metres above sea-level.*

		Billefjorden, central Spitsbergen (FEYLING-HANSSEN 1955)	Hornsund, southern Spitsbergen (BIRKENMAJER 1960b)
Late Glacial cold period	*Saxicava-Mya* terraces	90(96)–84.5 (deposits without fauna)	40(45)–10 (deposits without fauna)
		84.5–60 (deposits with fauna)	8.8–7.5 (deposits with fauna)
Post-Glacial temperate period	*Mya* terraces	60–38(40)	7.5–5.5
Post-Glacial warm period	*Astarte* terraces	38(40)–17 17–6	(Below sea-level and in shelly push moraines)
	Mytilus terraces	6–3	(Unknown)

8 m (see Fig. 5A). Gravel consists of gneiss, quartz and quartzite pebbles predominantly 0.5–3 cm in diameter, well-rounded to rounded (70%), sub-rounded to angular (20%), with admixture of shell detritus and sand (10%). Reference: BIRKENMAJER (1960b, pp. 18–19, Text-fig. 4; horizon "f"; Pl. I, Fig. 2, Pl. XII).

Radiocarbon dating:	$T_{\frac{1}{2}}$ 5570 years	5730 years
U-682 (inner)	7410 ± 90 B.P. $\delta C^{13} = +0.3‰$ *Comment*: Inner 55% was used.	7630 ± 90 B.P.
U-2065 (outer)	7620 ± 130 B.P. $\delta C^{13} = +0.2‰$ Shell layer surrounding the part used for U-682. *Comment*: Layer corresponds to 20% of the shells; 25% was removed by washing.	7840 ± 140 B.P.

Sample Q3*a*. *Isbjørnhamna*, Fuglebergsletta, Hornsund, Spitsbergen (77°00′ – 15°33′30″). $2a_2$ terrace (*Saxicava-Mya* terrace), altitude of the surface 8 m above mean sea-level. Sample of shell fragments (0.2–3 cm long) of *Mya truncata* and *Saxicava arctica* (and of *Balanus* sp., not taken into consideration) from gravel layer (poorly rounded or angular rock fragments) 0.5 m below the terrace surface; altitude of sample 7.5 m (see Fig. 5B). Reference: BIRKENMAJER (1960b, pp. 17–18, Text-fig. 3; horizon "d"; Pl. XII).

Radiocarbon dating:	$T_{\frac{1}{2}}$ 5570 years	$T_{\frac{1}{2}}$ 5730 years
U-665 (inner)	9620 ± 110 B.P. $\delta C^{13} = 0.2‰$ *Comment*: Inner 50% was used.	9890 ± 120 B.P.
U-666 (outer)	9560 ± 140 B.P. δC^{13} assumed 0.2‰ Shell layer surrounding the part used for U-665. *Comment*: Layer corresponds to 30% of the shells; 20% was removed by washing.	9840 ± 150 B.P.

Sample Q6*a*. *Fuglebekken,* Hornsund, Spitsbergen (77°00′30″–15°34′). $2a_1$ terrace (=*Mya* terrace), altitude of the surface from 5.5 to 6 m above mean sea-level. Sample of shell fragments and unbroken valves of *Mya truncata, Astarte borealis* and *Chlamys islandica* (also *Balanus* sp., not taken into consideration)

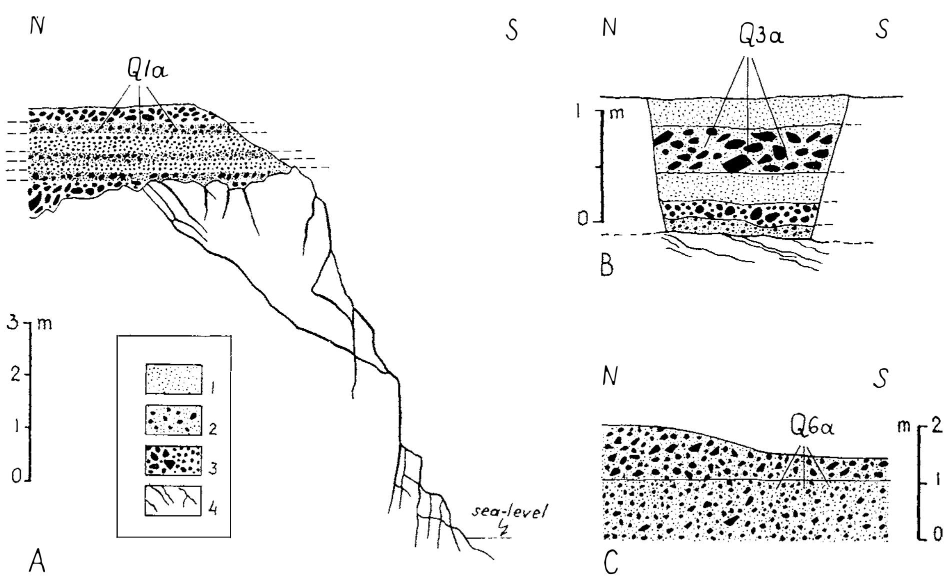

Fig. 5. *Position of the radiocarbon-dated shell samples within the sediments of the raised marine terraces, northern coast of Hornsund. A – Marmorneset,* $2a_2$ *terrace; B – Isbjørnhamna, Fuglebergsletta,* $2a_2$ *terrace; C – Fuglebekken (Isbjørnhamna),* $2a_1$ *terrace; 1 – sand; 2 – sandy gravel; 3 – gravel; 4 – bedrock. (A and B adapted from* BIRKENMAJER *1960b, Fig. 4 and Fig. 3 respectively.)*

taken from sandy gravel 0.5 m below the terrace surface; altitude of sample about 5.5 m (see Fig. 5C). Gravel consists of sub-rounded and sub-angular pebbles usually 1–5 cm (sometimes up to 10–20 cm) in diameter, with a 10–15% admixture of brownish sand with shells. Reference: BIRKENMAJER (1960b, p. 20, text-locality No. 1; horizon "a"; Pl. XII).

Radiocarbon dating:	$T_{\frac{1}{2}}$ 5570 years	$T_{\frac{1}{2}}$ 5730 years
U-2079 (inner)	9210 ± 180 B.P. $\delta C^{13} = -2.1‰$ assumed *Comment*: Inner 33% was used.	9470 ± 180 B.P.
U-2069 (outer)	9150 ± 160 B.P. $\delta C^{13} = -2.1‰$ *Comment*: Layer corresponds to 37% of the shells; 30% was removed by washing.	9410 ± 170 B.P.

WHALE BONES

Sample Q2*a*. *Isbjørnhamna*, Fuglebergsletta, 82 m SW of the Polish Station, Hornsund, Spitsbergen (77°00'–15°33'30"). Surface of the $2a_2$ terrace (=*Saxicava-Mya* terrace), altitude 8 m above mean sea-level. Whale bone, probably *Balaena mysticetus* L. Sample taken from lower jaw 1.9 m long and 17 cm in diameter, damaged in its apical and rear parts, two-thirds buried in tundra (layer of mosses, lichens, *Saxifraga, Salix polaris,* grass with humus admixture, 2–3 cm thick) and in underlying fine-grained pure sand devoid of humus (see Fig. 6A and Pl. I). Reference: BIRKENMAJER (1960b, pp. 77 et seq.: upper whale level; Pl. XII: "very old bones").

Radiocarbon dating:	$T_{\frac{1}{2}}$ 5570 years	$T_{\frac{1}{2}}$ 5730 years
U-703 (R_1)	9380 ± 140 B.P. $\delta C^{13} = -17.1‰$ *Comment*: Bone EDTA treated after extraction with acetone.	9650 ± 150 B.P.
U-2130 (R_2)	9840 ± 230 B.P. $\delta C^{13} = -18.2‰$ *Comment*: Another portion of the pre-treated bone used for U-703.	10,130 ± 230 B.P.
U-2131 (W)	8610 ± 170 B.P. $\delta C^{13} = -19.4‰$ *Comment*: Wrong fraction received in the EDTA treatment, giving U-703 and U-2130.	8860 ± 180 B.P.

Sample Q5*a*. *Rettkvalbogen* (eastern part), Hornsund, Spitsbergen (77°00'–15°32'30"). Surface of the 1st terrace (*Balanus* terrace), altitude 5.5 m above mean sea-level. Whale bone, *Balaena mysticetus* L. Sample taken from an almost com-

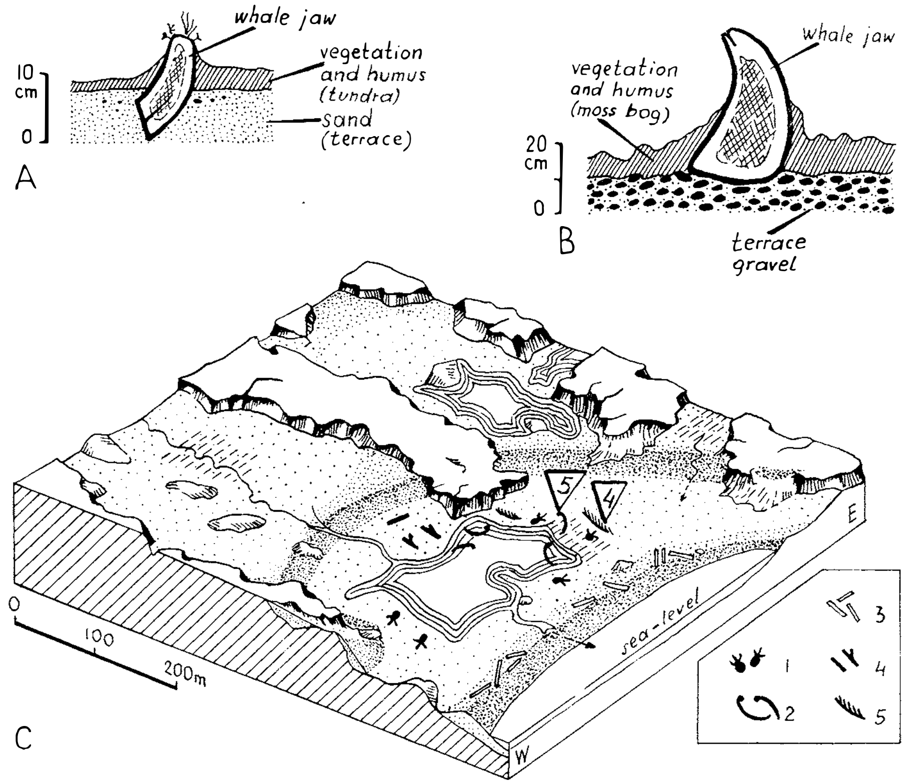

Fig. 6. *A – position of the dated whale jawbone (transverse section) from Isbjørnhamna, Fugleberg-sletta* (Q2*a*) *in relation to the sediment and vegetation cover of the* $2a_2$ *terrace*; *B – position of the dated whale jawbone (transverse section) from Rettkvalbogen, eastern part* (Q5*a*) *in relation to the sediment and vegetation cover of the 1st terrace*; *C – block diagram to show the position of dated samples* (4 = Q4*a and* 5 = Q5*a*) *with respect to the Recent and raised storm ridges and cliffs.* 1 – *"old" and "very old" whale vertebrae*; 2 – *"old" and "very old" whale jaws*; 3 – *recent driftwood (on the crest of the recent storm ridge)*; 4 – *"old" and "very old" driftwood*; 5 – *"very old" frost-split driftwood.* (*Fig. 6C adapted from* BIRKENMAJER *1960b, Fig. 10.*)

plete and very fresh-looking upper left jaw 5.6 m long and 0.45 m broad at its rear edge. Rear edge half buried in moss vegetation, front edge resting on terrace gravel, partly surrounded by moss bog (see Fig. 6B,C and Pl. II). Reference: BIRKENMAJER (1960b, pp. 77–78; Pl. VIII, Fig. 2: incorrectly described as "lower right jaw"; Pl. XII: "old bones"; Text-fig. 10).

Radiocarbon dating:	$T_{\frac{1}{2}}$ 5570 years	$T_{\frac{1}{2}}$ 5730 years
U-2048 (R)	1120 ± 80 B.P. $\delta C^{13} = -19.5‰$ *Comment*: Sample was treated with acetone before the EDTA extraction.	1160 ± 80 B.P.
U-620 (A)	770 ± 70 B.P. $\delta C^{13} = -24.3‰$ *Comment*: Acetone extract from the sample used for U-2048.	800 ± 70 B.P.

DRIFTWOOD

Sample Q4*a*. *Rettkvalbogen* (eastern part), Hornsund, Spitsbergen (77°00′–15°32′30″). Surface of the 1st terrace (*Balanus* terrace), the same locality as for sample Q5*a*, altitude 5.5 m above mean sea-level. Sample taken from log 10 m long, 40 cm in diameter, frost split, half buried in moss vegetation, resting directly upon the sand and fine gravel of the terrace (no humus or dead vegetation under the log) (see Fig. 6C and Pl. II). Reference: BIRKENMAJER (1960b, p. 86; Pl. X, Fig. 1: "very old driftwood"; Pl. XII; Text-fig. 10).

Radiocarbon dating:	$T_{\frac{1}{2}}$ 5570 years	$T_{\frac{1}{2}}$ 5730 years
U-619	1080 ± 70 B.P. $\delta C^{13} = -23.7‰$	1110 ± 80 B.P.

Processing of samples

The only wood sample dated in this series was not supposed to cause any complication and it was simply treated with HCl, NaOH and HCl again, as wood samples usually are treated after the outer parts have been cut away.

The shell samples were first ultrasonically washed several times with distilled water, which was also boiled for sample Q6*a*, so that it contained little dissolved carbon dioxide. Since the shell samples consisted of rather small pieces, fractionation was necessary to get information concerning the risk of contamination. The first 20–30% was removed by leaching with HCl and then the remainder was fractionated into one outer and one inner fraction. All samples originally contained *Balanus*, but *Balanus* was rejected from the dated parts of Q6*a* and Q3*a*, due to the fact that the surface of *Balanus* is so large that there was a greater risk that the *Balanus* fragments could have been contaminated rather than the other fragments.

The collagen fraction of the bones was used in the dating. Although it is very laborious to extract the organic fraction by the EDTA method, this method was chosen, since it has yielded more reliable results for old bones from Spitsbergen than the simple, commonly used method of treating the bone with HCl. All the experience gained in Uppsala in dating bones, using different methods, is discussed in a paper now in preparation (by OLSSON et al. 1970). When the samples were submitted to Uppsala, it was suggested by K. BIRKENMAJER that the "fat" of the bones should be recovered from sample Q5*a*. The pretreatment of the bones was initiated by normal washing and scraping of the samples. The samples were cut into pieces a few centimetres long and less than 2 cm² in cross-section. An acetone extraction in a Soxhlet apparatus was performed. The sample Q5*a* yielded so much extract that it could be dated. Similar extractions have been tried on old and young bones and it has not affected the age of the final collagen fraction. Only young bones have yielded enough extract for a meaningful dating. The extraction has been followed by a careful washing of the bones with boiled distilled water and by an EDTA treatment in which the bones are decalcified. After about six washings in EDTA, the gelatinous remains were washed several times in distilled water and then treated with HCl to remove the carbonate and dried. The sample was finally treated with boiled distilled water and the dissolved part dried and used as the collagen fraction. The undissolved fraction (the "wrong fraction") can also be dated but it has always yielded a slightly lower age than the collagen fraction (the "right fraction").

Results of radiocarbon dating

AGES OF RAISED MARINE TERRACES

The results of the C^{14} datings are summarized in Table 3 and the results are plotted in a diagram (Fig. 7), but here only the unrejected dates are included and the correction for the apparent age of the sea-water is applied. As the "age" of the surface water of the sea close to Spitsbergen is considered to be about 400 years (see FEYLING-HANSSEN & OLSSON 1959–1960, p. 126; OLSSON 1960), the latter figure was subtracted from the shell and whale-bone dates.

The ages are expressed in years before 1950 (B.P.) and the value of 5570 years has been used for the half-life of C^{14}.

Due to the great age of most of the samples, no correction for previous variations of the C^{14}/C^{12} ratio has been applied. The ages used in the following discussions are corrected for the apparent age of the surface water.

No correction for the specific age of the wood by counting tree rings was possible, due to the very poor state of preservation of the frost-split log. However, as the dated sample came from the inner part of the log, the error anticipated would not be more than some scores of years. Another error is introduced by the drifting time, which for logs of Siberian provenance amounts to a minimum of 4–5 years before they reach Spitsbergen (see CHARLESWORTH 1957, p. 196; BIRKENMAJER 1960b, p. 87). For the logs brought by the Gulf Stream, the drifting time could be even longer.

Both whale bones dealt with in the present paper were jaws of *Mysticeti*, which feed on surface and sub-surface plankton. Hence the correction (minus) for the age of the surface water is sufficient. However, with other bones of the whale skeleton (ribs, vertebrae), the problem could be more complicated, as it is usually impossible to distinguish from them not only the species, but also the genera and higher systematic units of *Mysticeti* from *Odontoceti*. And in the case of the Sperm Whale, one of the most common and biggest whales of the *Odontoceti* group, a correction for the apparent age of deep water is recommended, as this whale feeds mainly on deep-water cephalopods (see TOMILIN 1957).

Another error is represented by the specific age of the individual whale, which, for the bones older than the great whaling period, may amount to many scores

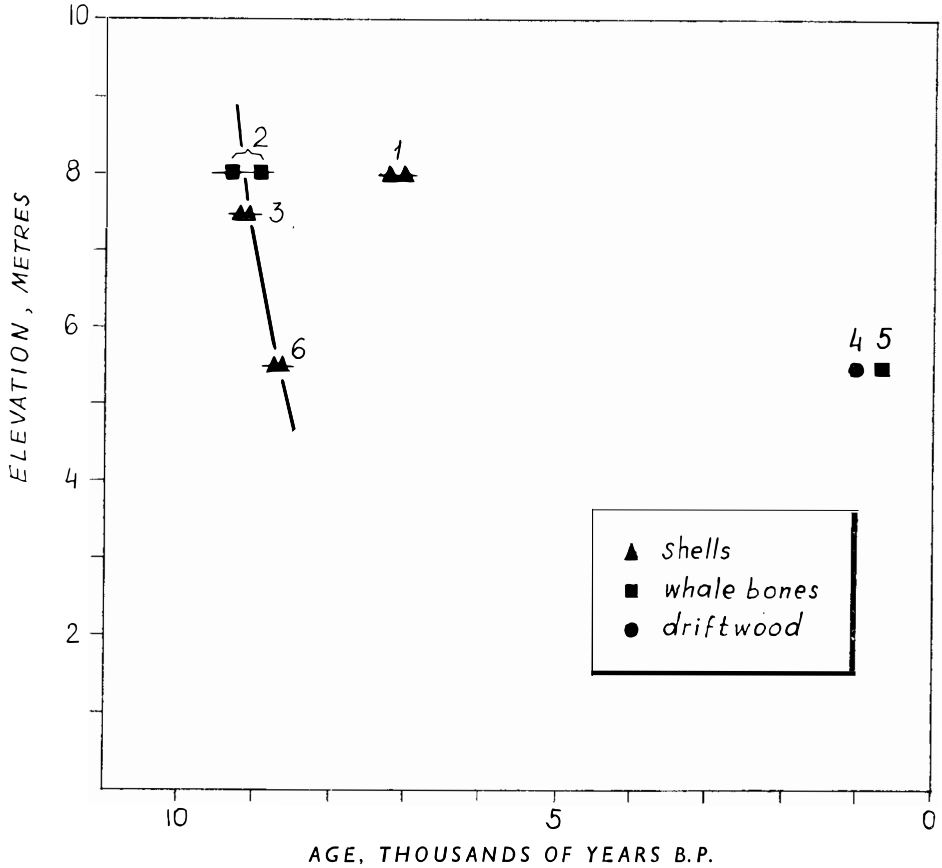

Fig. 7. *Diagram for radiocarbon-dated samples* 1–6 (=Q1*a*–Q6*a*). *Correction for apparent age of the sea-water was applied to shell and whale-bone samples. Curve of negative shift of the shoreline drawn only for samples* 2, 3, *and* 6. *The conventional half-life of* 5570 *years was used. No correction for previous variations in the* C^{14}/C^{12} *ratio was applied.*

of years. Unfortunately, as the specific age determination is possible in only a very few cases and needs a trained expert biologist, this error can only exceptionally be determined.

1st terrace. It can be seen that both whale bone and driftwood from the 1st-terrace surface are about 1000 years old. The acetone extract yielded a significantly lower age than the collagen fraction of the bone. It is believed that the whale (*Balaena mysticetus*) should show an apparent age of about 400 years, as previously determined for shell samples from the Spitsbergen area (see FEYLING-HANSSEN & OLSSON 1959–1960; OLSSON 1960). After subtraction of this apparent age the bone will appear somewhat younger than the driftwood.

The bone and the wood reflect the age of the whale and the tree rings respectively when the specimens were living. The undeterminable error with respect to the specific age (whale and driftwood, see above) and to the drifting time (wood,

Table 3

Radiocarbon dates of the Hornsund samples.

Stratigraphic position			Sample material	Sample No.	Elevation above mean sea-level (metres)	Uppsala dating number	Remarks	Age in years B. P. (before 1950) $T_{\frac{1}{2}}=5570$ years: Not corrected	Corrected for the age of sea water (400 years)
2nd terrace system	a_2	Surface	Whale bone	Q2*a*	8.0	U-703	Right fraction (R_1)	9380 ± 140	8980 ± 140
						U-2130	Right fraction (R_2)	9840 ± 230	9440 ± 230
						U-2131	Wrong fraction (W)	8610 ± 170	—
		Sediment cover	Shells	Q1*a*	8.0	U-682	Inner fraction	7410 ± 90	7010 ± 90
						U-2065	Outer fraction	7620 ± 130	7220 ± 130
			Shells	Q3*a*	7.5	U-665	Inner fraction	9620 ± 110	9220 ± 110
						U-666	Outer fraction	9560 ± 140	9160 ± 140
	a_1	Sediment cover	Shells	Q6*a*	5.5	U-2079	Inner fraction	9210 ± 180	8810 ± 180
						U-2069	Outer fraction	9150 ± 160	8750 ± 160
1st terrace		Surface	Whale bone	Q5*a*	5.5	U-2048	Right fraction (R)	1120 ± 80	720 ± 80
						U-620	Acetone extract (A)	770 ± 70	—
			Driftwood	Q4*a*	5.5	U-619		1080 ± 70	

see above) may account for some of the differences in age. However, the samples are supposed to give an indication of the time (B.P.) when the 1st terrace surface emerged from the sea.

2nd terrace. All samples from the $2a_1$ and $2a_2$ terraces are much older than those from the 1st terrace. The shell samples (Q3*a*, Q6*a*) both gave slightly lower ages for the outer fraction than for the inner fraction, but the difference was much lower than 1σ and there is thus no indication of contaminated shells. The difference between the two "right" fractions of the bone (Q2*a*) from the $2a_2$ terrace is not significant ($<2\sigma$), but the "wrong" fraction is here, as usual, significantly younger than the right fraction and, as usual, has been rejected.

Two dates for the $2a_2$ terrace at Isbjørnhamna, Fuglebergsletta (samples from the same terrace, horizontal distance between the sites about 50 m; see Fig. 3) coincide rather well with each other. The terrace sediment (sample Q3*a*: shells) 0.5 m below the surface is about 9200 years old (U-665: 9220 ± 110 years B.P.). The age of the $2a_2$ terrace-surface sediment is indicated by the whale bone. The weighed mean value of the two bone dates is slightly, but not significantly, lower than the age of the shells, as could be expected from the geological point of view.

The $2a_1$ terrace sediment from Fuglebekken at Isbjørnhamna (shells: sample Q6*a*, about 900 m north-east of the former sites; see Fig. 3) is some 400 years younger (U-2079: 8810 ± 180 years B.P.) than that of the higher terrace ($2a_2$), as is fully understandable.

The formation of the shell-bearing marine gravels of the $2a_2$–$2a_1$ terraces at Isbjørnhamna, about 9000 years ago, corresponds therefore with the Boreal stage (early Holocene) of Blytt-Sernander's scheme, for which stage the conventional age limits are 8500 and 9400 years B.P. (Fig. 8). On both the mollusc assemblage and radiocarbon-age evidence, it seems now justified to correlate the $2a_2$–$2a_1$ terrace sediments (*Saxicava-Mya* and *Mya* terraces) of Hornsund with the *Mya* terraces (pre-Boreal to Boreal stages) of the Billefjorden area, central Spitsbergen, in Feyling-Hanssen's scheme (1965b, Fig. 2).

The third sample from the $2a_2$ terrace sediment (shells: sample Q1*a*) from Marmorneset, some 1.7 km west of the Isbjørnhamna sites (see Fig. 3) is significantly younger than the other samples: U-682 (inner) 7010 ± 90 years B.P., U-2065 (outer) 7220 ± 130 years B.P. The two fractions agree rather well, although the difference between the inner and outer fractions is 210 ± 160, that is, slightly higher than 1σ but well below 2σ. This was the only shell sample from which *Balanus* was not rejected.

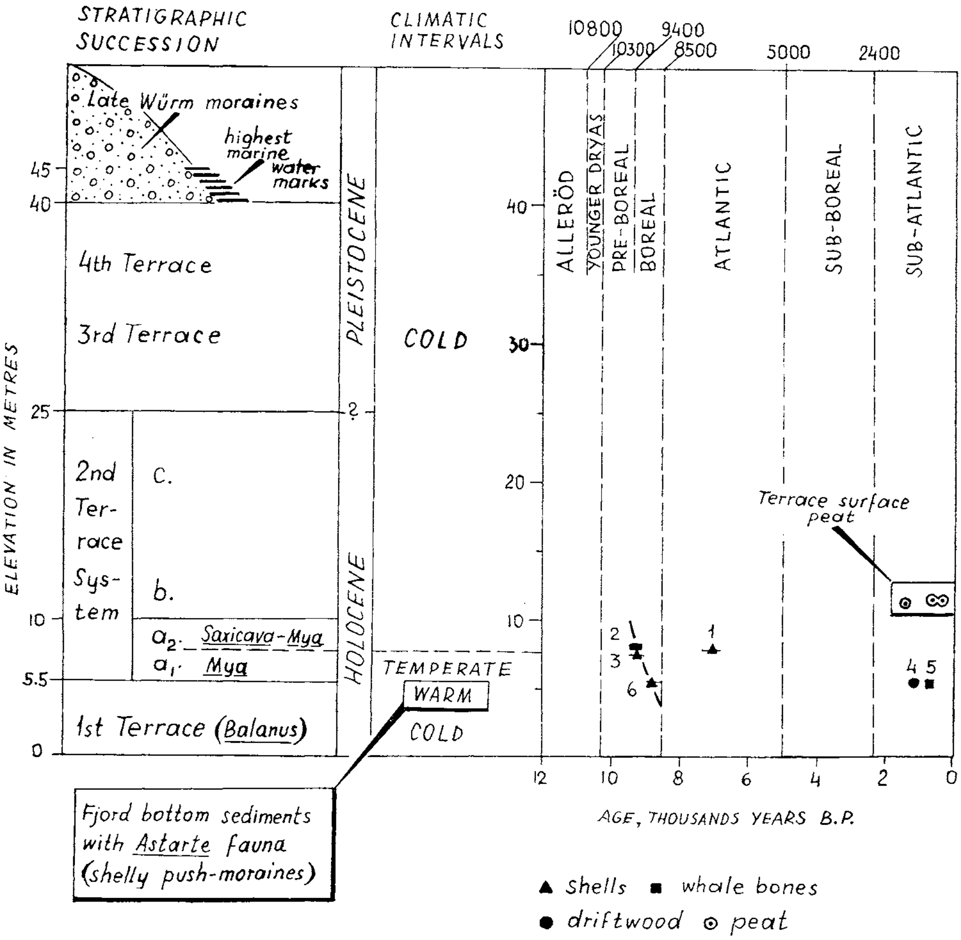

Fig. 8. *Position of radiocarbon-dated samples from the Hornsund area with regard to the local stratigraphical scheme and to the chronostratigraphical scale.* 1–6 – *numbers of samples* Q1*a*–Q6*a*. *Dates of shells and whale bones corrected for the apparent age of the sea-water. The conventional half-life of 5570 years was used. No correction for previous variations in the* C^{14}/C^{12} *ratio was applied.*

RATES OF LAND UPLIFT AT HORNSUND

It is evident from the age of the whale bones (Table 3) that neither of the two samples matched the age of the great hunting period in Svalbard, i.e. about 350 years ago, as assumed for BIRKENMAJER's "whale method". As the "very old bones" (BIRKENMAJER 1960b) at 8 m altitude are about 9000 years old, and as the "old" ones at 5.5 m are some 700 years old, it is evident that the altitudes of the bones of the Greenland Whale (*Balaena mysticetus* L.) on the raised terraces at Hornsund, and probably elsewhere in Svalbard as well, *cannot be directly used in determining the rates of the present land uplift.* Hence the criticism with regard to the "whale method" expressed by various authors (see Introduction) is justified.

The radiocarbon dates for samples Q2*a*, Q3*a* and Q6*a* give a relatively steep curve (Fig. 7) from about 8800 to about 9200 years B.P. (for shell samples). As the difference in altitude for the samples Q3*a* ($2a_2$ terrace) and Q6*a* ($2a_1$ terrace) is 2 m, the rate of land uplift in relation to the sea-level was about 0.5 m per century (2 m in about 400 years), provided that both shell-bearing deposits had formed at a similar depth, not very far from the shoreline. This is evidenced by the character of the sediments, which consist of gravel and sand (sub-littoral deposits), and by the presence of a raised cliff separating the terraces from each other, which is an obvious evidence of a shoreline.

No shoreline samples of driftwood were available from the surfaces of these terraces. The age of the whale bone (sample Q2*a*) lying on the top of the higher terrace sediments (see Figs. 4 and 6A), possibly itself an indication of a shoreline, is very near to that of the underlying sediment (shells), some 0.5 m below (sample Q3*a*), both about 9000 years B.P.

In discussing the above problems at the Winter Conference of Nordic Geologists in Copenhagen (Jan. 1970), Dr. R. W. FEYLING-HANSSEN raised two questions of importance. The first question is that the life environment of *Saxicava* and *Mya*, which is a silty bottom, is different from that of the Hornsund terraces, which is gravel and sand. This may call for a redeposition of shells from some higher levels, now destroyed, during the negative shift of the shoreline. The second question, which arises from the first, is that the shell-bearing gravels and sands of the $2a_2$ and $2a_1$ terraces could both correspond to the 40–45 m water mark. If so, the $2a_2$ terrace sediment would form at a depth of about 35 m (32 to 37 m) below sea-level.

If we accepted this explanation, the curve of uplift with a rate of 0.5 m per century would remain unchanged for the $2a_2$ and $2a_1$ terrace sediment samples, but the total uplift of the Hornsund terraces during the last 9000 years would be much higher, amounting to 40–45 m in relation to the present sea-level. The mean rate of uplift relative to the present sea-level would average 0.47 m per century (42.5 m per 9000 years), a rate strikingly similar to all the rates calculated for Hornsund in the present paper, indicating a stable land rise, irrespective of positive shifts of the shoreline, during the past 9000 years.

In the authors' opinion it does not seem necessary to assume that the shells contained in gravelly-sandy deposits of the $2a_2$ and $2a_1$ terraces are a secondary deposit derived from higher terraces, now destroyed. In fact, the sediments of the terraces higher than the $2a_2$ terrace are completely devoid of shells, and raised marine silts with shells are nowhere found. The alternation of shell-bearing gravel and sand layers in vertical cross-sections of the terrace sediments (see Fig. 5A–C), together with some other features of a near-shore environment (raised cliffs, storm ridges, as well as the fragmentation of most shells), would rather suggest that the shells had been washed out from a deeper silty bottom and pushed upwards by agitated waters, finally fragmented and deposited (re-deposited) in a sub-littoral zone, together with sand and gravel. This re-deposition would have been contemporaneous or penecontemporaneous with the formation of the primary shell-bearing bottom silt, as is expressed by the consistency of radiocarbon data of shells. The present thanatocoenoses of *Saxicava-Mya* and *Mya* on raised marine terraces at Hornsund could therefore be regarded as representing the age of the sub-littoral coarse sediment and of the primary silt as well, within rather narrow limits of error.

The samples from the surface of the 1st terrace at Hornsund give the age of the shoreline at an altitude of 5.5 m as 1080 $\pm$ 70 years B.P. and 720 $\pm$ 80 years B.P. respectively. These data allow us to determine the rates of the land uplift within the last millennium (Table 4). The rates were calculated with respect to the present mean sea-level, and with respect to a storm wave-mark, which, at present, in the eastern part of Rettkvalbogen is expressed by the first storm ridge elevated about 3 m above the mean sea-level (see BIRKENMAJER 1960b, Pl. XII).

As follows from Table 4, during the last millennium the negative shift of the shoreline at Hornsund amounted to a minimum of 0.2–0.3 m per century (or a maximum of 0.6–0.7 m per century), a value only slightly lower than that for the Boreal stage (0.5 m per century) for the period 8800 to 9200 years B.P. The statistical uncertainty of the figure 0.5 is indeed $^{+0.3}_{-0.15}$.

Caution is needed in calculating the rates of uplift for the lowest raised terraces (beaches), as the displacement by storm waves of movable shoreline indicators may vary greatly from place to place, depending mostly on the direction of the prevailing storm winds, longshore drifting, configuration of the coast and tides (see BIRKENMAJER 1960b, p. 90). At Hornsund the present storm wave-mark is expressed best by the altitudes of the 1st storm ridge, which is only about 1.6 m high in the inner part of the fjord (Treskelen) but rises quickly to 3–4 m in its middle part and to 4–5 m near the mouths of the fjord. Similar values would also be subtracted from altitudes of higher shorelines, and thus the curve of land uplift would start not with the nominal mean sea-level but with an appropriate storm wave-mark line (see Figs. 8 and 9).

Table 4

Rates of the present land uplift at Hornsund (Isbjørnhamna)

1st terrace surface, sample	Uppsala dating number	Real age years B.P.	Rate of uplift in metres per century (with respect to the present mean sea-level)	Rate of uplift in metres per century (with respect to the present storm wave-mark = 3 m)
Driftwood (Q4*a*) altitude 5.5 m	U-619	1080 ± 70	$\frac{5.5\text{ m}}{1080\text{yr}} \times 100 = \text{c. } 0.51$	$\frac{(5.5-3)\text{ m}}{1080\text{ yr}} \times 100 = 0.23$
Whale bone (Q5*a*) altitude 5.5 m right fraction	U-2048	720 ± 80	$\frac{5.5\text{ m}}{720\text{ yr}} \times 100 = \text{c. } 0.76$	$\frac{(5.5-3)\text{ m}}{720\text{ yr}} \times 100 = 0.35$
Mean rate			c. 0.6	c. 0.3

Discussion

HOLOCENE MARINE TRANSGRESSIONS IN SVALBARD

The results of the radiocarbon dating of the Hornsund samples do not fit into a single curve of continuous relative land uplift and a continuous negative shift of the shoreline. Caution is needed in reconstructing the curve for the geologically younger samples, as there is evidence, provided as early as 1961 by FEYLING-HANSSEN (1965b, c), of a marine transgression in Svalbard during the Holocene "Warm Interval". This evidence will be discussed below.

At *Talavera*[1] (Barentsøya) a thin peat layer (altitude 12.6 m above sea) is covered by about 1.2 m of marine deposits with mollusc shells (*Astarte* type assemblage) and *Balanus*. The insoluble fraction of the peat was first dated as 6000 ± 400 years B.P. (FEYLING-HANSSEN 1965b, c; OLSSON et al. 1961: U-186), but a later dating of the humus extracted from the peat gave a much lower age: 3030 ± 290 years B.P. (OLSSON & KILICCI, 1964: U-205).

At *Skansbukta* (Billefjorden, central Spitsbergen) a thin peat layer (altitude 16.2 m above the mean sea-level) is covered by about 1.5 m of marine beach gravel with shells (*Astarte* assemblage). The age of the insoluble fraction of the peat was established as 4800 ± 120 years B.P. (FEYLING-HANSSEN 1965c; OLSSON et al. 1961: U-185) but later dating of the humus fraction of the same peat again gave a much lower age: 3410 ± 230 years B.P. (OLSSON & KILICCI 1964: U-206).

FEYLING-HANSSEN (1965c, pp. 46–47) concluded that the Skansbukta transgression could correspond with the late Atlantic to early Sub-Boreal marine transgression of northern Europe (about 5000 years B.P.), and the Talavera transgression either to a very early stage of this transgression, or to a late stage of the Boreal to early Atlantic transgression, or to another positive shift of the shoreline. In the light of the last datings of the peats from Skansbukta and Talavera (OLSSON & KILICCI 1964, see above), both events appear to have been

[1] The name "Talavera" has been used by previous authors, while the right place-name is Talaveraflya. (Editor's note.)

more or less simultaneous and had occurred some 3000 years ago, during the mid-Sub-Boreal stage.

Further evidence of a marine transgression was provided by HYVÄRINEN (1969) from sediment cores of the Trullvatnet lake deposits, Murchisonfjorden (Nordaustlandet). The sediment succession starts there with marine-lagoonal deposits, followed by fresh-water lake sediments (Stockholm radiocarbon dates of lake isolation 7240 ± 200 to 6485 ± 100 years B.P.), and these again by lagoonal deposits, showing that the lake was reconnected with the fjord waters between 5550 ± 140 and 4745 ± 120 years B.P. (Stockholm radiocarbon dates). Still later the lagoon was transformed into the present fresh-water lake. The fjord-connected lagoonal deposits, some 4.7 to 5.5 thousand years old, lie at a depth of 3.5 to 3.8 m below sea-level.

Coming back again to Hornsund, a long age gap between the successive $2a_1$ terrace (about 8800 years B.P.) and the 1st terrace (about 1000 years B.P.) may account for a submergence of the southern Spitsbergen coasts some 3000 years ago (as seen at Talavera and Skansbukta), respectively, in the period from about 3000 to about 5500 years ago (when the Trullvatnet transgression is also taken into account). So far no transgressive marine deposits have been recorded from the Hornsund area comparable with those of Talavera and Skansbukta. The satisfactory coincidence of the ages of both the sediment (shells) and the surface deposits (whale bone) upon the $2a_2$ terrace precludes the possibility that this terrace was invaded by the sea during this mid-Holocene transgression. However, well-developed raised cliffs and storm ridges separating the 2nd terrace system from the 1st terrace (BIRKENMAJER 1960b, Pl. XII) would fit in well with the period (periods) of relative stagnation of the coastal line at a level higher than the present sea-level but not exceeding the altitude of the $2a_2$ terrace margin.

THE HOLOCENE WARM INTERVAL AT HORNSUND

During the "Warm Interval" in Spitsbergen the conditions of life of the littoral mollusc fauna at Hornsund were much worse than those in the Isfjorden area. BIRKENMAJER (1960b, pp. 89–90) assumed that during this interval (mainly the Atlantic and Sub-Boreal stages, 8500 to 2400 conventional years B.P.; cf. FEYLING-HANSSEN 1965b) only the deeper waters of the Hornsund fjord were inhabited by *Astarte* assemblages. The latter are known so far only from shelly moraines superimposed upon all the raised terraces, including the 1st terrace, exposed on rocky thresholds in inner Hornsund (see HEINTZ 1953; BIRKENMAJER 1958b, 1964). Neither *Cyprina islandica* nor *Mytilus edulis*, both indicators of relatively warmer waters, lived at that time in Hornsund (BIRKENMAJER 1958b, p. 155), and the present conditions here are as severe as at the beginning of the Holocene, the sub-littoral zone and the shore being practically devoid of shells.

THE HOLOCENE LAND UPLIFT OF SPITSBERGEN

Much more data are needed before final curves for shoreline displacement (both positive and negative) and relative uplift of the land during the Holocene can be drawn for different parts of the Svalbard archipelago. Our present knowledge, derived from the Billefjorden and Hornsund areas respectively, was summarized in Fig. 9. This is a new interpretation, which suggests that the curves are

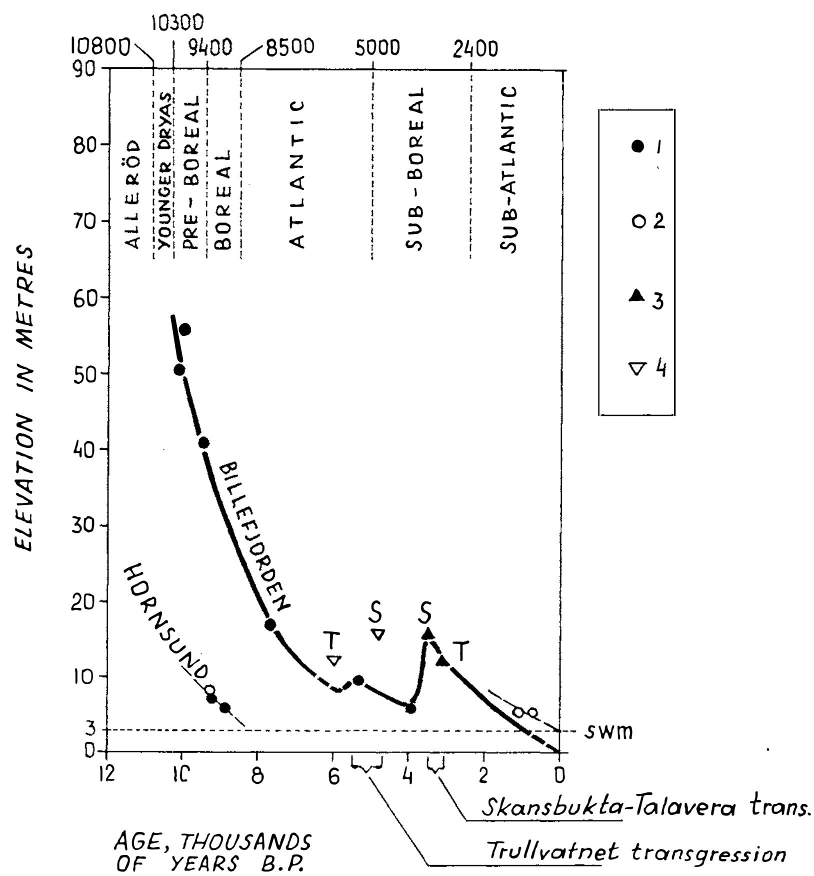

Fig. 9. *Tentative curve of relative land uplift and subsidence for central and southern Spitsbergen respectively. New interpretation of the radiocarbon dates from Billefjorden, as given by* FEYLING-HANSSEN & OLSSON (*1959–1960*) *and* FEYLING-HANSSEN (*1965b*), *also with the shell sample from 9.7 m altitude displaced according to the new determination by* OLSSON & KILICCI (*1964*: *U-279*). *The Billefjorden curve* (*solid line*) *consists of three descending segments, separated by two transgressions* (*indicated by ascending segments*). (*The approximate ages for the Skansbukta-Talavera transgression are maximum ages.*) *The Hornsund data are grouped along two separate descending segments of dashed curve*; *the gap between these segments corresponds to a period of transgression* (*transgressions?*) *of unknown duration.* 1 – *Shells*; 2 – *movable shoreline indicators* (*driftwood, whale bones*); 3 – *peat, humus fraction*; 4 – *peat, insoluble fraction*; *S* – *Skansbukta*; *T* – *Talavera*; *swm* – *storm wave-mark for Hornsund sites* (*movable shoreline indicators*). *Shell and whale-bone data corrected to the apparent age of the sea-water.*

not smooth but form peaks, which correspond to at least two marine transgressions, the older Trullvatnet transgression (5550 ± 140 to 4745 ± 120 years B.P.) and the younger Skansbukta-Talavera transgression (maximum age 3410 ± 230 years B.P. for Skansbukta and 3030 ± 290 years B.P. for Talavera). The interpretation of the Billefjorden curve would also lead to the conclusion that the absolute land uplift, irrespective of the eustatic rise of the sea-level, proceeded at a rate decreasing much more slowly than was indicated by previous diagrams (see, for example, FEYLING-HANSSEN & OLSSON 1959–1960, Fig. 1).

The picture presented in Fig. 9 is preliminary. There are many more indications, especially in the detailed morphology of the coast, of alternating quicker and slower relative uplifts (see BIRKENMAJER 1960b; FEYLING-HANSSEN 1965b). The picture may serve for the comparison of different rates of land uplift for the central (Billefjorden) and southern (Hornsund) parts of the same Spitsbergen island during the periods pre-dating and post-dating the above-mentioned transgressions.

The older branch of the Billefjorden curve, corresponding to ages from more than 10,000 to about 9,400 years B.P. (Pre-Boreal stage), indicates that in central Spitsbergen the land rose at a rate of about 2 m per century (FEYLING-HANSSEN & OLSSON 1959–1960, p. 127). The corresponding data are not available from Hornsund so far, but for Nordaustlandet the inclination of the curve (BLAKE 1961a, Fig. 9; OLSSON & BLAKE 1962, Fig. 9) is as steep as for Billefjorden.

During the Boreal and early Atlantic stages (from 9400 to about 7500 years B.P.) the mean rates of land uplift for Billefjorden, as deduced from the ages and altitudes of samples Nos. 326*a*, *b* (U-123, 124) and 350*a*, *b* (U-129, 130) presented by FEYLING-HANSSEN and OLSSON (1959–1960), would average about 1.5 m per century. The appropriate data from Hornsund relating to the Boreal stage (9200 to 8800 years B.P., see above) gave a much slower rate of uplift of the order of 0.5 m per century. This difference in the rates of uplift between the central and southern parts of the main Spitsbergen island resulted in the much smaller total uplift of the early Holocene terraces in Hornsund, as has already been pointed out by BIRKENMAJER (for example, 1958a, b, 1960b; see also Table 2).

The reconstruction of the younger segments of the uplift curve is more difficult, as only few datings are available (Fig. 9). From the Talavera cross-section it appears that the top of the younger marine sequence post-dating the peat (hence not older than U-205 = 3030 ± 290 years B.P.) lies at about 13.8 m above the sea and is represented by coarse sand with mollusc shells and *Balanus* (FEYLING-HANSSEN 1965c). It is not known what ages should be applied to the youngest marine layer in the sequence, as no radiocarbon determinations on shells were made. If we choose the maximum date, which is given by the minimum age of the underlying peat, and assume that the top marine layer formed close to the sea-level, then the rate of land uplift for Talavera would be 0.46 m per century (a 13.8-m rise in 3030 years). A slightly lower rate of land uplift, 0.34 m per century (a 11-m rise in 3190 years), may be obtained from the vicinity of Talavera on data presented by GROSSWALD et al. (1967): Mo-420 (driftwood), 3190 ± 130 years B.P., 11 m altitude. Unfortunately, no detailed information was given by the Russian authors (GROSSWALD et al. 1967; SEMEVSKIJ 1967) as to the geological position of the radiocarbon-dated driftwood from Barentsøya with respect to the raised terrace deposit. Hence we cannot exclude some errors which usually affect the calculations of land uplift on such movable shoreline indicators. For instance, if we subtract 3 m for a minimum vertical displacement of this driftwood by storm waves (cf. Table 4), we will get $\frac{(11-3)\,\mathrm{m}}{3190\ \mathrm{yr}} \times 100 = 0.25$ m per century, i.e. the value very similar to that for the last millennium at Hornsund (Table 4).

In the Skansbukta section the radiocarbon-dated peat (ages: U-185, 4800 $\pm$ 120 years B.P. (insoluble fraction), and U-206, 3410 $\pm$ 230 years B.P. (soluble fraction)) is overlain by 1.5 m of beach gravel deposits with shells (FEYLING-HANSSEN 1965b, p. 46), the top of which is about 19.2 m above the sea. Assuming again that the highest stratum of these deposits had formed close to the sea-level, we would obtain a 0.56 m per century rate of uplift for Skansbukta (a 19.2-m rise in 3410 years).

The above rates for Talavera and Skansbukta are of the same order of about 0.5 m per century (0.46 and 0.56 m per century respectively) and should be regarded as *minimum* mean rates of negative shift of shoreline during the last 3000 years, as, undoubtedly, some time elapsed between the formation of the dated peats (taking into account only their minimum age dates) and the top strata of the marine gravel and sand (1.2 to 1.5 m thick) overlying the peats.

The middle segment of the Billefjorden curve of land uplift is based on dated shell samples from the lower *Astarte* terraces (FEYLING-HANSSEN & OLSSON 1959–1960; OLSSON & KILICCI 1964: U–279). The relation of these shells to the transgressive deposits of Skansbukta has not been given in the accounts published. The youngest segment of the curve is based on the Skansbukta peat site pre-dating the transgression. Fig. 9 shows, therefore, a short, moderately inclined curve of relative land rise, separated from the older and younger segments by two transgressions. It is also evident that the *Skansbukta–Talavera transgression was a very important event,* which resulted in a rapid positive shift of the shoreline and the related submergence of the Billefjorden coasts down to about 8–10 m.

Here we come again to the problem of land uplift in the Hornsund area during the last 1000 years. The mean minimum rate of rise of about 0.3 m per century (Table 4: corrected to the storm wave-mark) is lower than those for Talavera (*c.* 0.5 m per century) and, especially, for Skansbukta (*c.* 0.6 m per century). The latter two values relate, however, to a much longer period of time, of the order of about 3000 years.

The land rise of the Talavera area relative to the present sea-level, calculated on driftwood data presented by GROSSWALD et al. (1967), for the same period of time is 0.34 m per century (not corrected to the storm wave-mark) and 0.25 m per century (if corrected to a 3-m storm wave-mark) – see above. The data for the last millennium are not available so far for Talavera, but another driftwood sample from a 5.5-m level (GROSSWALD et al., op. cit.: Mo-419) dated as 2400 $\pm$ 120 years B.P., will give 0.23 m per century (not corrected to the storm wave-mark) and 0.10 m per century (if corrected to a 3-m storm wave-mark). The above rates fall within the range, or are slightly lower than, the present land uplift at Hornsund (see Table 4).

The above considerations indicate that a special study of land rise and subsidence in Spitsbergen, with reference to the period of the mid- and late-Holocene transgressions and regressions, and the corresponding marine deposits would be of great value, as it would help us to understand the youngest stages of the geological and geomorphological history of the Svalbard archipelago.

THE HOLOCENE LAND-UPLIFT PATTERN OF SVALBARD

In a preliminary report on the results of the Stockholm University Svalbard Expedition of 1966, SCHYTT et al. (1967) presented a number of new curves of land upilft for the Svalbard archipelago. The curves were based on both the already known and the new radiocarbon dates, and also included those presented by GROSSWALD et al. (1967), and were drawn separately for Kong Karls Land, Hopen, Edgeøya, Wilhelmøya (and its surroundings), Kapp Linné, and Murchisonfjorden (SCHYTT et al. 1967, Fig. 2). These curves served, moreover, as a basis on which the isobase map for Svalbard was reconstructed, which included also some results from Franz Josef Land (SCHYTT et al. 1967, Fig. 3). The map shows the present elevation of shore features developed approximately 6500 years ago, and differs in details (especially in the values of relative land uplift) from an earlier published map of the land uplift of Svalbard during the last 5000 years by GROSSWALD et al. (1967, Fig. 2).

A conclusion was adopted by SCHYTT et al. (1967) that the land uplift relative to the present sea-level during the past 6500 years was small near the edge of the continental shelf, i.e. along the western and northern coasts of Svalbard, and considerably larger eastwards and south-eastwards, towards the Barents Sea. An isobase corresponding to a 15-m uplift was drawn across Hornsund. This does not agree, however, with the evidence provided by the present paper. As was shown in Figs. 7–9, the total uplift of the Hornsund area relative to the present sea-level did not exceed 8 m during the last 9000 years, provided that the gravelly-sandy deposits of the $2a_2$–$2a_1$ terraces formed close to the shore at small depths. A corresponding value of the uplift for a 6500-year-old shoreline is not represented in our samples but, obviously, it would be still lower.

Only if we accepted Dr. R. W. FEYLING-HANSSEN's suggestion (see the preceding section), that the gravelly-sandy deposits of the $2a_2$–$2a_1$ terraces formed at a depth of about 35 m below sea-level (with the corresponding shoreline mark at 40–45 m above the present mean sea-level), could the corresponding land uplift for the 6500-year-shoreline be of the order of about 15–20 m (Fig. 10). However, we rejected this explanation in Figs. 7–9 due to the fact that the deposits and raised shore features discussed, all indicate much more shallow sedimentary conditions, even within the range of tides.

Of the three shell samples from Hornsund, the one from Marmorneset (Q1*a*) has yielded a significantly lower age of about 7000 years B.P. versus about 8800

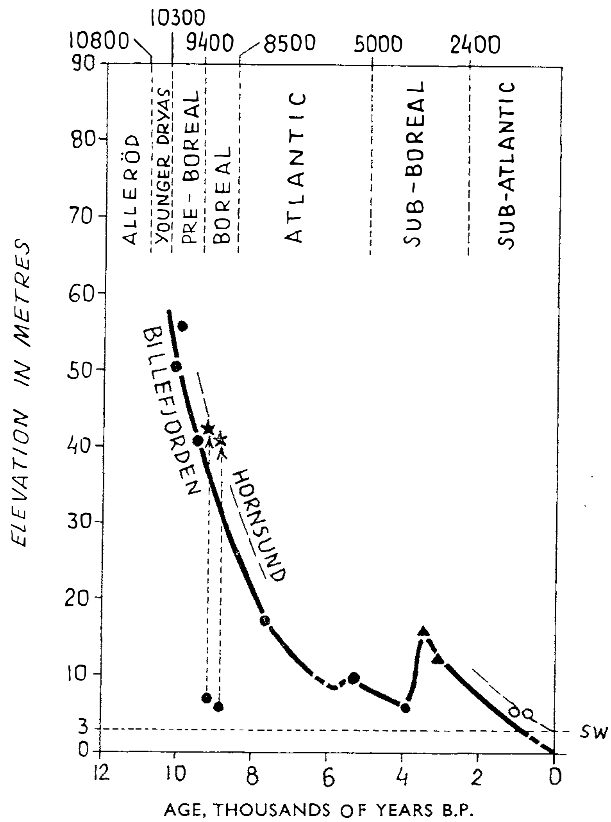

Fig. 10. *Position of the oldest shell samples from Hornsund in relation to the Billefjorden curve (see Fig. 9), provided that the shell-bearing sediments correspond to a 40–45-m water mark (asterisks), as suggested by* Dr. R. W. FEYLING-HANSSEN. *For explanations, see Fig. 9.*

and about 9200 years B.P. respectively for the remaining two. The altitude of the Marmorneset sample was 8 m, the same as that of the Isbjørnhamna sample (Q2*a*), which is about 9200 years old (see Table 3). Taking this into account, one could expect a higher land uplift relative to the present sea-level in the west (Marmorneset: an 8-m rise in about 7000 years) than in the east (Isbjørnhamna: an 8-m rise in about 9200 years). With a horizontal distance between the sites of barely 1.7 km (see Fig. 3), this would indicate either a tilt of the 2nd-terrace surface towards the east, i.e. in a direction quite opposite to that found by BIRKENMAJER (1960b, Figs. 15, 16), and also accepted by GROSSWALD et al. (1967, Fig. 2) and by SCHYTT et al. (1967, Fig. 3), or local neotectonic block-fault movements. The other possible explanation is that the Marmorneset sample (*Saxicava-Mya* assemblage) was contaminated by younger shells and/or *Balanus* during the supposed 8–10-m submergence of the Spitsbergen coasts some 3000 years ago. Such contamination would be expected along the margins of the 2nd-terrace deposits protruding into the fjord on promontories, as is the case with the Marmorneset sample, from which *Balanus* has not been rejected.

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Note added in proof

Fragments of *Balanus* shells from sample Q3*a* and the "wrong" fraction of Q5*a* were dated as:

	$T_{\frac{1}{2}}$ 5570 years	$T_{\frac{1}{2}}$ 5730 years
U-2228 (inner fraction of Q3*a*)	9480 ± 180 B.P. $\delta C^{13} = 2.8\ ^0/_{00}$ (assumed) *Comment:* Inner 55% was used.	9760 ± 180 B.P.
U-727 (outer fraction of Q3*a*)	$9470\ ^{+210}_{-220}$ B.P. $\delta C^{13} = 2.8\ ^0/_{00}$ Shell layer surronding the fraction used for U-2228. *Comment:* Layer corresponds to 25% of the shells; 25% was removed by washing.	$9470\ ^{+220}_{-210}$ B.P.
U-2229 ("wrong" fraction after EDTA-treatment of Q5*a*)	910 ± 110 B.P. $\delta C^{13} = -20.7\ ^0/_{00}$	940 ± 110 B.P.

The two shell fractions agree very well but have been dated at a lower C^{14} age than the other species from the same sample Q3*a*. The difference, however, is not significant. The "wrong" fraction of the bone sample was dated at an age slightly lower, although not significant lower, than that of the right fraction.

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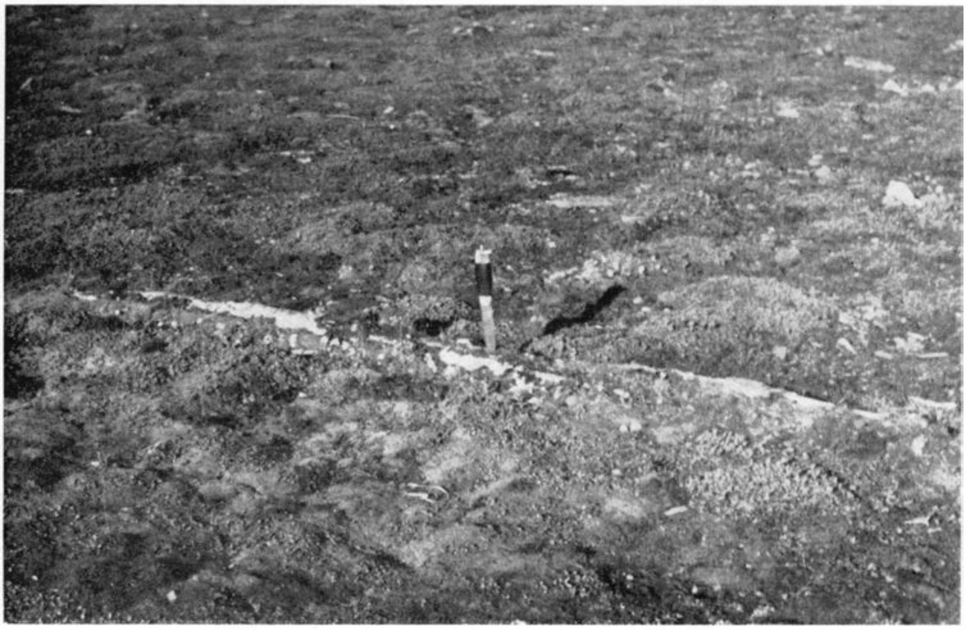

Fig. 1. *Whale jaw* (Q2*a*) *at Isbjørnhamna* (*Fuglebergsletta*), *Hornsund, 8 m alt.*
Photo: K. B. 1966.

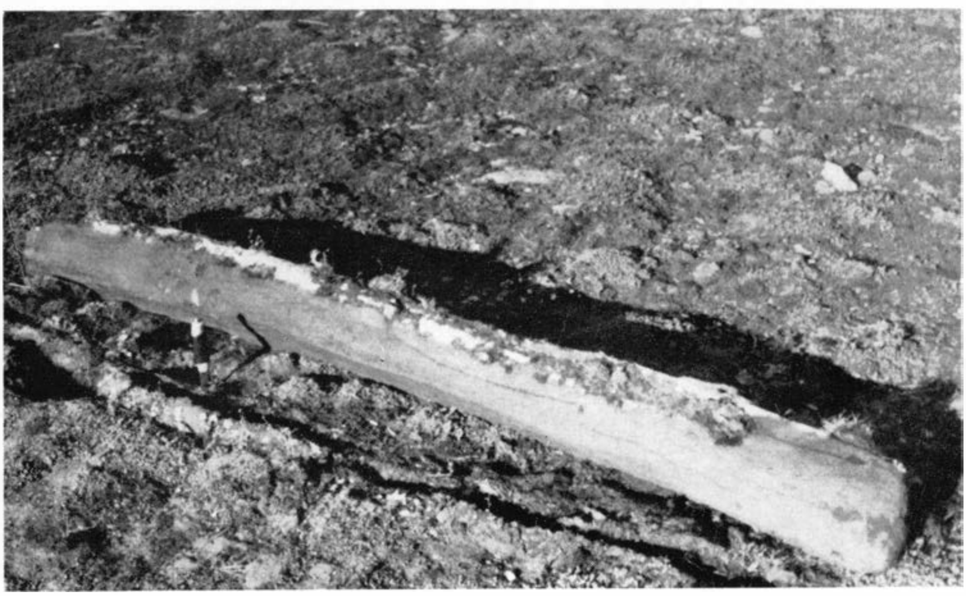

Fig. 2. *Whale jaw, as above, after excavation from tundra cover.*
Photo: K. B. 1966.

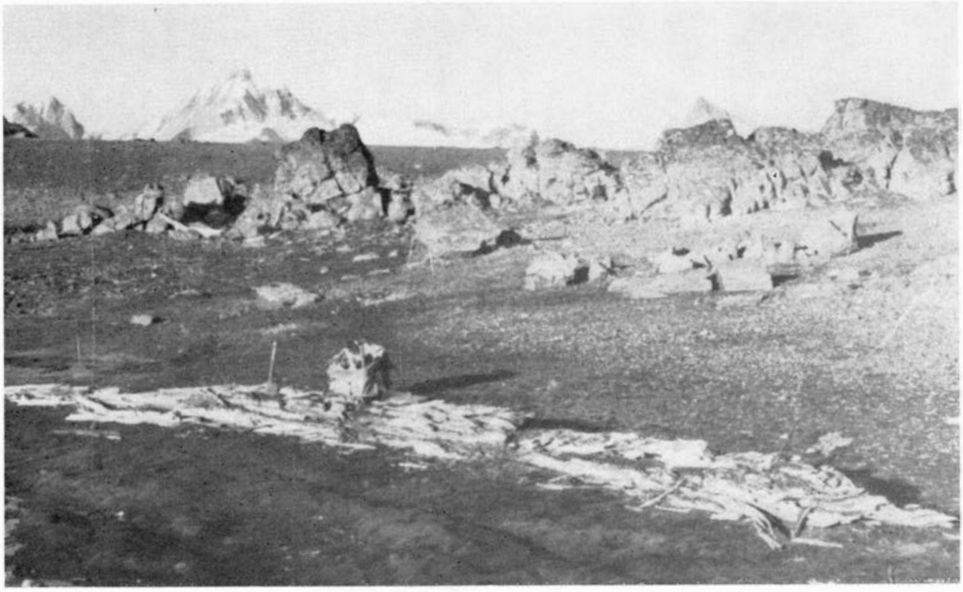

Fig. 1. *Driftwood* (Q4*a*) *at Rettkvalbogen* (*eastern part*), *Hornsund, 5.5 m alt.*
Photo: K. B. 1966.

Fig. 2. *Whale jaw* (Q5*a*) *at Rettkvalbogen* (*eastern part*), *Hornsund, 5.5 m alt.*
Photo: K. B. 1966.

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Zn-enriched whale bones on raised marine terraces at Hornsund, Spitsbergen

BY

KRZYSZTOF BIRKENMAJER[1] AND BAHNGRELL W. BROWN[2]

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Abstract

Carbon-14 ages from whale bone, shells, and driftwood offer means of dating the first and second terraces at Hornsund, Spitsbergen (Svalbard). The indicated age of the second terrace is c. 9200 years B.P., and of the first c. 700 years B.P. Zinc values for permineralized whale bones from the respective terrace surfaces were 290 and 285 ppm, indicating a near equilibrium after less than 1000 years and a time-dependent zinc partitioning.

Introduction

In 1966 two samples of whale bones were collected from raised marine terraces on the north coast of Hornsund, Spitsbergen, in the course of geological investigations led by K. BIRKENMAJER on behalf of Norsk Polarinstitutt. The samples were split into three parts. Those for radiocarbon dating were given numbers Q2*a* and Q5*a* and, together with the samples of shells and driftwood, were submitted to the Institute of Physics, University of Uppsala, where Dr. I. U. Olsson took care of the data processing (OLSSON et al. 1969; BIRKENMAJER & OLSSON this vol.). The corresponding parts of the samples for geochemical investigations were

[1] Norsk Polarinstitutt, Oslo, Postboks 5054, Majorstua, Norway (on leave from the Polish Academy of Sciences, Geological Laboratory, Kraków, Senacka 3, Poland).

[2] University of Southern Mississippi, Department of Geology, Southern Station, Box 166, Hattiesburg, Mississippi 39401, USA.

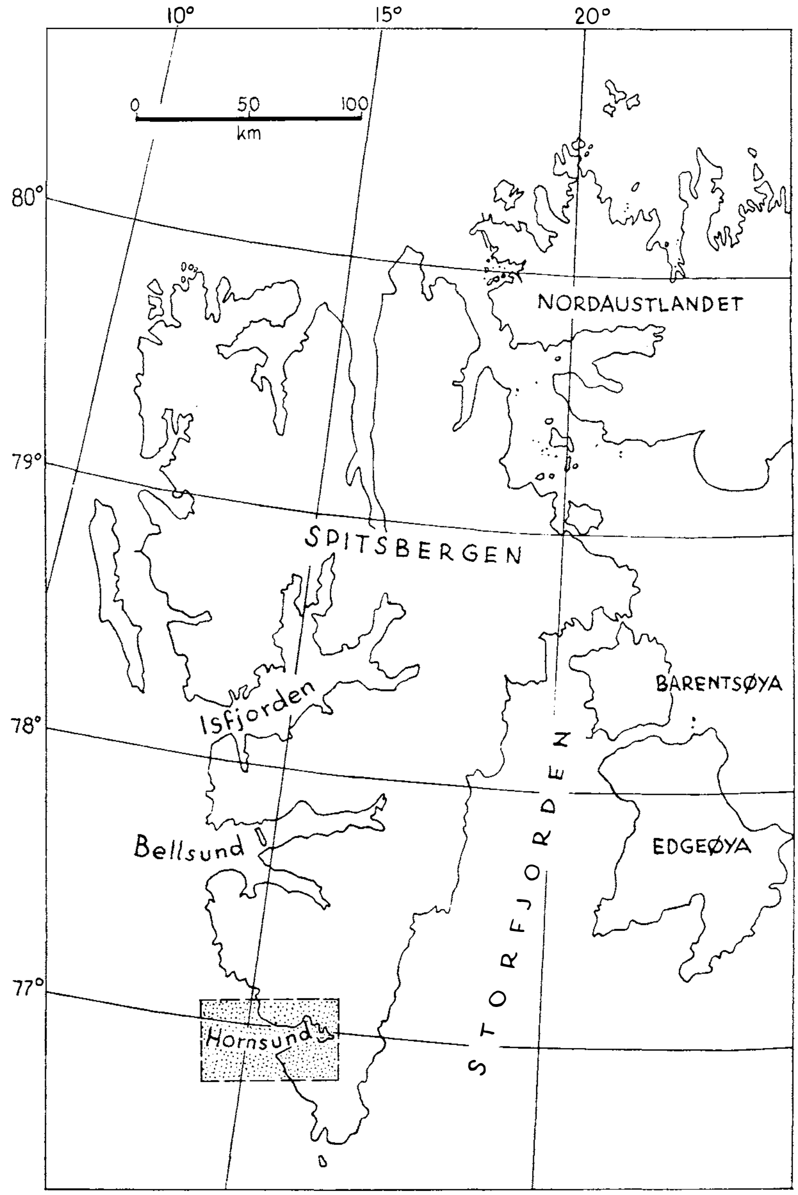

Fig. 1. *Key map to show the location of Hornsund (stippled) within the Svalbard archipelago.*

given Q2*b* and Q5*b* numbers respectively, and were analysed with respect to their enrichment in Zn by Dr. DWIGHT TALBURT at the Department of Microbiology, University of Southwest Louisiana. The third group of samples numbered Q2*c* and Q5*c* respectively were submitted to the Laboratory of Quaternary Geology, Polish Academy of Sciences in Warsaw, where Dr. T. WYSOCZAŃSKI-MINKOWICZ will undertake investigation of their collagen content and the fluorine-chlorine-apatite index.

At the present stage of investigations, it was possible to determine the radiocarbon age of the bones (op. cit.) with respect to their geological position on the coast, and the grade of secondary mineralization they acquired due to circulation of terrace waters (this paper).

For the most part of the year the polar tundra zone of Spitsbergen is covered by snow and ice. The surface layer of the permafrost zone, which reaches here down to about 300 m, thaws only for 2–3 months of the polar summer (Polar Day) to a depth of barely 0.5 to 2 metres. This allows only a very restricted and often incomplete circulation of water in loose terrace deposits and in the solid bedrock. The surface outflow is strongest at the beginning of the summer and gradually diminishes or even completely disappears along with the deepening of the active layer in the ground. The decline of the Polar Day sees most of the terrace deposits above the temporary ground water level as containing very little moisture, the terrace pools strongly reduced or even completely dry, and only part of moss bogs close to the streams still containing water enough for richer development of moss-bog vegetation. The then prevailing cold desert conditions cause intense evaporation of moisture from the terrace deposits. The ascending, slightly mineralized capillary waters bring zinc and other elements from the substratum to porous inner parts of the bones lying on the terrace surface. Here they are being kept, eventually changing the colouration of the inner, "rotten" part of the bone into yellow or brown (due to iron hydroxides), while the exposed, harder outer parts of the bones are bleaching and drying quickly due to insolation and wind. Plant rootlets often interwoven with the porous bone tissue contribute to the mineralization of the bone.

The processes of bone mineralization on the terrace surface are similar to the formation of the well known desert glazes, also known from the periglacial zone of Spitsbergen.

Site description

As a detailed survey of raised marine features and the position of whale bones with respect to the raised terraces has already been published by BIRKENMAJER (1960b) and is also treated separately (BIRKENMAJER & OLSSON this vol.), no more than an outline will be given here.

The samples were collected on the northern coast of Hornsund, close to the Polish Station (Figs. 1 and 2). A standard sequence of raised marine terraces established for this area is shown in Table 1. The whale bones are here most frequent on the surface of the lowest terraces (see BIRKENMAJER 1960b) and, consequently, our samples Q2*b* and Q5*b* refer to the $2a_2$ (*Saxicava-Mya*) and the 1st (*Balanus*) terraces respectively (Figs. 2 and 3). No whale bones are known from the terraces higher than the $2a_2$ terrace and from the present shore of the Hornsund fjord close to the Polish Station.

Sample Q2*b*. *Isbjørnhamna*, Fuglebergsletta, 82 m SW. of the Polish Station, Hornsund, Spitsbergen (77°00′N–15°33′30″E). Surface of the $2a_2$ terrace (=*Saxicava-Mya* terrace), altitude 8 m above mean sea-level. Whale bone, probably

Table 1.
Raised marine terraces north of Hornsund – standard sequence (after BIRKENMAJER, *1960b, Table 1, – simplified)*

Terrace		Faunal assemblage	Altitudes in metres above mean sea level: Front edge	Altitudes in metres above mean sea level: Rear edge
4th terrace		—	c. 40	—
3rd terrace		—	25–27	—
2nd terrace system	*c*	—	13–16	25
	b	—	10–15	18.5–30
	a_2	*Saxicava* and *Mya*	7.5–8.8	10
	a_1	*Mya*	5.5–7.5	8–10
1st terrace		*Balanus*	2–5.5	—

Balaena mysticetus L. Sample taken from lower jaw 1.9 m long and 17 cm in diameter, damaged in its apical and rear parts, two-thirds buried in tundra (layer of mosses, lichens, *Saxifraga, Salix polaris,* grass with humus admixture, 2–3 cm thick) and in underlying fine-grained pure sand devoid of humus (see Figs. 4A and 5A). Part of the bone exposed to the surface whitish or grey, that covered with vegetation – yellow-brown or dark brown. The porous inner part of the bone

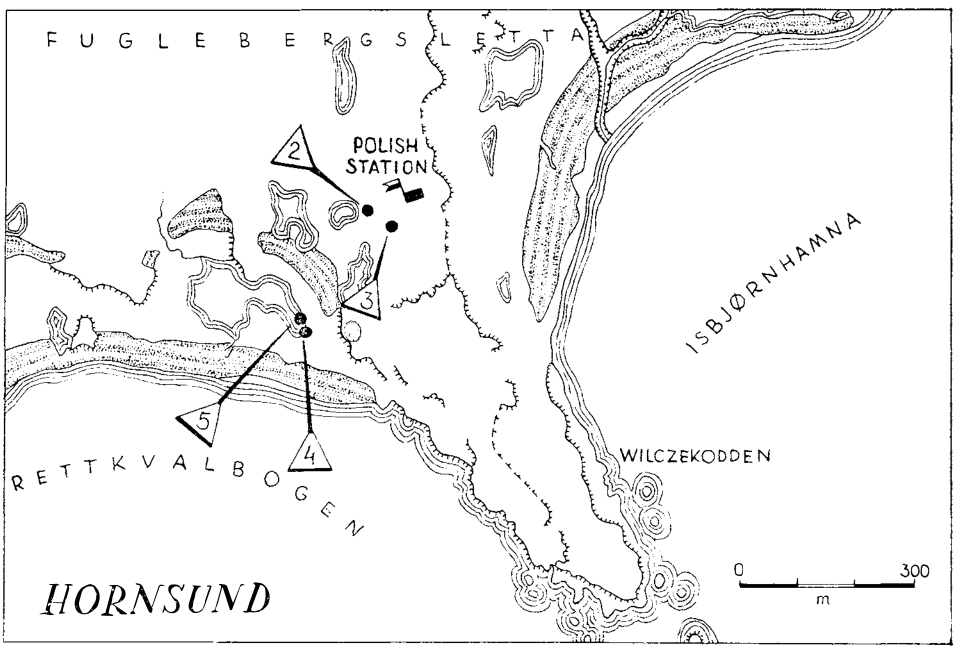

Fig. 2. *Localization of investigated samples at Hornsund. Numbers refer to samples as in Table 2* (2 = Q2*a*+*b*; 3 = Q3a, etc.). *Geomorphological features adapted from* BIRKENMAJER (*1960b, Pl. XII*). *Stippled - recent and raised storm ridges*; *blank - raised marine terraces. Erosional escarpments (raised cliffs etc.) and terrace pools shown in a conventional manner.*

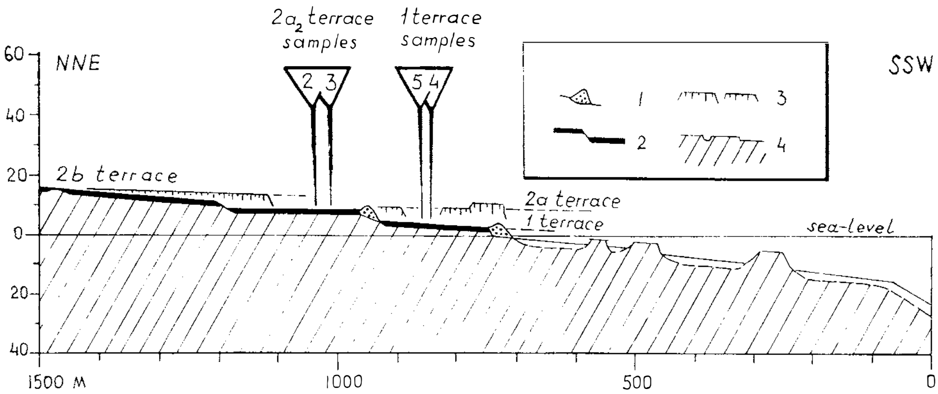

Fig. 3. *Transverse cross-section of the northern coast of Hornsund at Isbjørnhamna showing the position of investigated samples (see Table 2).* 1 – *recent and raised storm ridges*; 2 – *raised marine terrace accumulation*; 3 – *raised cliffs*; 4 – *bedrock (adapted from* Birkenmajer & Olsson *this vol., Fig. 4).*

brown or dark brown, interwoven with plant rootlets. Reference: Birkenmajer (1960b, pp. 17 et seq.: upper whale level; Pl. XII: "very old bones"). Radiocarbon dating: Olsson et al. (1969) and Birkenmajer & Olsson (this vol.); also Table 2 (this paper).

Sample Q5*b*. *Rettkvalbogen* (eastern part), Hornsund, Spitsbergen (77°00′N–15°32′30″E). Surface of the 1st terrace (*Balanus* terrace), altitude 5.5 m above mean sea-level. Whale bone, *Balaena mysticetus* L. Sample taken from an almost complete and very fresh-looking upper left jaw 5.6 m long and 0.45 m broad at its rear edge. Rear edge half buried in moss vegetation, front edge resting on terrace gravel, partly surrounded by moss bog (see Figs. 4B and 5B). Bone whitish or yellowish at the surface, slightly darker yellow in the inner, porous part, where it was rich in "fat". Reference: Birkenmajer (1960b, pp. 77–78; Pl. VIII, Fig. 2, incorrectly described as "lower right law"; Pl. XII: "old bones", Text-fig. 10). Radiocarbon dating: Olsson et al. (1969), Birkenmajer & Olsson (this vol.); also Table 2 (this paper).

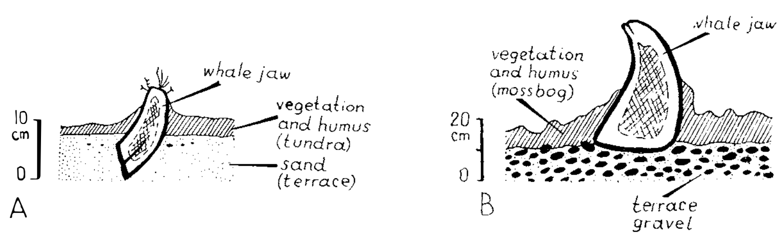

Fig. 4. *A. Position of the whale jawbone (transverse section) from Isbjørnhamna, Fuglebergsletta* (Q2*a*+*b*) *in relation to the sediment and vegetation cover of the* $2a_2$ *terrace.*

B. *Position of the whale jawbone (transverse section) from Rettkvalbogen, eastern part* (Q5*a*+*b*) *in relation to the sediment and vegetation of the 1st terrace (after* Birkenmajer & Olsson *this vol., Fig. 6).*

Fig. 5. *A. Whale jaw* (Q2*a*+*b*) *at Isbjørnhamna* (*Fuglebergsletta*), *Hornsund, 8 m alt.*
(Photo: K. B. 1966).
B. Whale jaw (Q5*a*+*b*) *at Rettkvalbogen* (*eastern part*), *Hornsund, 5.5 m alt.*
(Photo: K. B. 1966).

Results of Zn determination

The two whale bone samples Q2*b* and Q5*b* have been determined for zinc on a model 303 Perkin Elmer atomic absorption spectrometer using acetylene air flame, wave length of 214 mμ and a Boling burner. The chemical work was done by D. TALBURT on a dry whole sample. The results are 290 and 285 ppm for the Q2*b* and Q5*b* samples respectively (Table 2).

A dithizone test made by B. W. BROWN in 1966 at Hornsund has given about 100 ppm zinc. However, he used a volume of bone and not a weight, and the bone was quite porous and not dry weight calibrated, also, the field analytical procedure was one of cold acid (1 : 1 HNO_3) extraction. Zinc field tests by cold extraction made by B. W. BROWN at other sites in Spitsbergen (previously Vestspitsbergen) called attention to the zinc anomaly of bone and bone-associated regolith. The anomalous extractable zinc values of sediment immediately in contact with buried permineralized bone is not only a point for precaution in the interpretation of sediments in a zinc exploration program, but, as it relates to this study, helped clarify the direction of partitioning equilibria in the system: rock → Zn^{++} → water → bone.

Discussion

PROVENANCE OF ZINC IN WHALE BONES

The area of the northern coast of Hornsund close to the Polish Station shows the presence of Precambrian metamorphic rocks which belong to the Hecla Hoek Succession. The bedrock of the thin, generally gravelly-sandy, cover of the raised marine terraces consists here of garnetiferous-mica paragneisses and schists with carbonate (marble) intercalations, both distinguished by BIRKENMAJER (1958, 1960a) as the Ariekammen Series. This is the middle unit of his tripartite Isbjørnhamna Formation.

The metamorphic rocks are crossed by quartz-, ankerite-, and ankerite-quartz veins (BIRKENMAJER 1958, WOJCIECHOWSKI 1964) which often contain gangue minerals. In the area under discussion these are mainly pyrite, chalcopyrite and pyrrhotite, but also galena and sphalerite have been found in a close vicinity (WOJCIECHOWSKI 1964, FLOOD 1969).

The veins are cutting through most of the rocks of the Hecla Hoek Succession which range in age from the late Precambrian up to the Cambrian and possibly also Lower Ordovician inclusively. They have not been found at Hornsund to cut the post-Caledonian, i.e. Devonian to Tertiary sedimentary sequence. On the other hand, pebbles of vein quartz similar to that of the veins cutting through the Hecla Hoek rocks have been reported from the Lower Devonian and younger sediments of the area. Hence BIRKENMAJER and WOJCIECHOWSKI (1964) concluded that the veins are pre-Devonian and post-Hecla Hoek (post-Lower Ordovician), probably Silurian in age, and regarded them as evidence of late orogenic hydrothermal (mesothermal) activity of the main Caledonian orogeny in Svalbard. A similar view was also shared by FLOOD (1969) who assumed a pre-Devonian and post-Middle Ordovician age for most of the ore-bearing veins on a wide evidence from Spitsbergen and Bjørnøya.

The above data indicate the source of zinc to be the bedrock of the terraces and also pebbles within the terrace deposits.

ZINC MINERALIZATION VERSUS RADIOCARBON AGE OF WHALE BONES

The radiocarbon ages (see BIRKENMAJER & OLSSON this vol.) of whale bones, shells and driftwood from the $2a_2$ and the 1st terraces respectively are shown in Table 2. The ages are expressed in years before 1950 (B.P.) and the value of 5570 years has been used for the half-life of C^{14}. Due to the great age of most of the samples, no correction for previous variations of the C^{14}/C^{12} ratio has been applied.

The collagen fraction of the bones was used in the dating, and this is indicated in Table 2 as the "right fraction". Also the acetone extract from one of the bones, and the undissolved fraction, the "wrong fraction", from the other one were dated. The difference between the two right fractions of the bone from the $2a_2$ terrace is not significant ($<2\ \sigma$) but the wrong fraction is here, as usual, significantly younger than the right fraction and, as usual, has been rejected. Also the

Table 2.

Radiocarbon dates and Zn mineralization of whale bones at Hornsund

Stratigraphic position		Sample material	Elevation in metres above mean sea level	Radiocarbon dating (Birkenmajer & Olsson this vol.)			Age in years B. P. (before 1950) ($T_{\frac{1}{2}}=5570$ years)		Geochemical data	
				Sam-ple no.	Uppsala dating number	Remarks	not corrected	corrected for the age of sea water (400 years)	Sample no.	Zn (ppm)
$2a_2$ terrace	Surface	Whale bone	8.0	Q2*a*	U-703	Right fraction (R_1)	9380 ± 140	8980 ± 140	Q2*b*	290
					U-2130	Right fraction (R_2)	9840 ± 230	9440 ± 230		
					U-2131	Wrong fraction (W)	8610 ± 170	—		
	Sediment cover	Shells	7.5	Q3*a*	U-655	Inner fraction	9620 ± 110	9220 ± 110	—	—
					U-666	Outer fraction	9560 ± 140	9160 ± 140		
1st terrace	Surface	Whale bone	5.5	Q5*a*	U-2048	Right fraction (R)	1120 ± 80	720 ± 80	Q5*b*	285
					U-620	Acetone extract (A)	770 ± 70	—		
		Driftwood	5.5	Q4*a*	U-619	—	1080 ± 70		—	—

acetone extract date for the bone from the 1st terrace has been rejected on similar grounds.

As the "age" of the surface water of the sea close to Spitsbergen is considered to be about 400 years (see FEYLING-HANSSEN & OLSSON 1959–1960, p. 126; OLSSON 1960) the latter figure was subtracted from whale bone and shell dates to get the "real" age of the dated samples.

Both whale bones dated were jaws of *Mysticeti* which feed on surface and sub-surface plankton. Also the shells represent a shallow-water assemblage. Hence it was not necessary to apply corrections for the apparent age of deeper sea waters. No correction has been applied for the specific age of whales, as this was not possible to determine without special biological measurements. Also no correction for the specific age of the wood by counting tree rings was possible, due to a very poor state of preservation of the frost-split log. However, as the dated sample came from the inner part of the log, the error anticipated would not be more than some scores of years. There is also a possibility of error as regards the drifting time but this is considered a minor one, as it seldom exceeds the specific age of the wood: 4—5 years (minimum) for the logs of Siberian provenance, much longer time for those brought by the Gulf Stream.

It can be seen that both the whale bone and driftwood from the 1st terrace are about 1000 years old. After subtraction of the apparent age of the sea-water (400 years) the bone will appear somewhat younger than the driftwood, but we should remember the possible additional errors in age determination (see above), and also the unknown time span for shoreline stabilization. Both the samples are then supposed to give an indication of the time (B.P.) when the 1st terrace surface emerged from the sea.

All samples from the $2a_2$ terrace are much older than those from the 1st terrace. The shell sample gave slightly lower age for the outer fraction than the inner fraction (which is considered to represent the correct value), but the difference was much lower than 1σ and there is thus no indication of contaminated shells. Hence the terrace sediment (sample Q3*a*: shells) 0.5 m below the surface is about 9200 years old (U-655: 9220$\pm$110 years B.P.). The age of the terrace surface is indicated by the right fraction dates of whale bone. The weighed mean value of these two bone dates (U-703: 8980$\pm$140 years B.P., U-2130: 9440$\pm$230 years B.P.) is slightly, but not significantly, lower than the age of the shells, as could be expected from the geological point of view.

The results of the Zn-content determination in the bones are 285 ppm for the lower 1st terrace, and 290 ppm for the higher $2a_2$ terrace. The difference between these two values is slight when compared with great difference in radiocarbon ages of the same bones but, nevertheless, the geologically older bone contains more zinc than the younger one.

The corresponding values of zinc-content (in ppm) and "real" radiocarbon ages (in thousands of years B.P.) for the whale bones investigated were plotted in a diagram (Fig. 6). It indicates a very low rate of Zn increase in the bones from 285 to 290 ppm, barely 0.6 ppm per millennium (5 ppm in about 8200 years). This could indicate that both Zn values are in fact close to an equilibrium, and

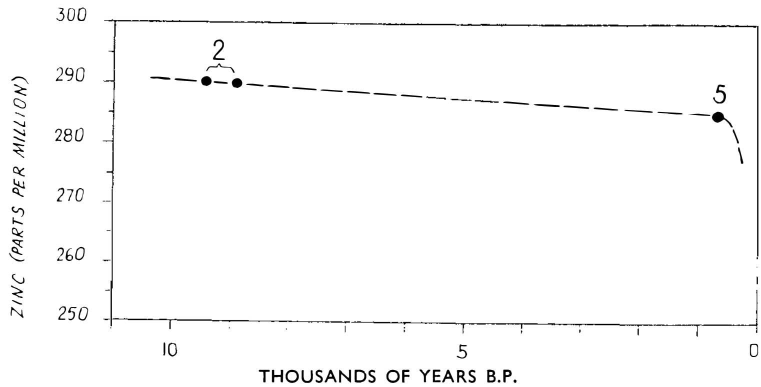

Fig. 6. *Diagram of Zn-content increase with the age of radiocarbon-dated whale bone samples 2 and 5(compare Table 2) from Hornsund, Sptisbergen.*

that less than a millennium is needed under given conditions for the bones exposed to soil-forming processes on the emerged terrace surface to reach this equilibrium.

Unfortunately, as neither were whale bones available from any such animals living at present in Spitsbergen waters, nor radiocarbon dated bones from the same Hornsund area pertaining to ages intermediate between the present and about 1000 years B.P., the reconstruction of the youngest segment of the Zn-mineralization curve would await a better opportunity.

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The present status of the Pink-footed Goose *(Anser fabalis brachyrhynchus)* in Svalbard

(Настоящее состояние короткоклювого гуменника *(Anser fabalis brachyrhynchus)* на Свальбарде)

BY

MAGNAR NORDERHAUG

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Abstract

The distribution of Pink-footed Geese in Svalbard is reviewed, based on observations from the 1960's. The main breeding areas are Prins Karls Forland and Spitsbergen (Fig. 1).

The population size in the 1960's is discussed. Based on density studies in the breeding areas (Table 1) and the available maximum counts from Denmark, Germany, and the Netherlands during the winter (Table 2), a population of the order of 12 000–14 000 is indicated. From the available data no marked population changes are indicated in the 1960's. However, increased human activity during the breeding and moulting periods, and increased hunting in Svalbard, in addition to the different negative factors in the wintering areas, calls for more attention and co-operation among research and administrative agencies in the countries involved.

Аннотация

Рассмотрено распространение короткоклювых гуменников на Свальбарде на основании материалов наблюдений, произведенных в 1960-ых годах. Главными гнездовыми районами этих птиц являются Земля Принца Карла (Prins Karls Forland) и Шпицберген (Spitsbergen) (рис. 1).

Обсуждается число популяции в 1960-ых годах. На основе плотностных исследований в гнездовых районах (табл. 1) и доступных максимальных подсчетов, произведенных в Дании, Германии и Нидерландах в зинмее время (табл. 2), указывается на наличие 12—14 тысяч особей

этого вида. Никакие доступные данные не свидетельствуют о значительных изменениях популяции, происходивших в 1960-ых годах. Однако нарастающая человеческая деятельность во время гнездования и линьки и более интенсивная охота на этих гусей на Свальбарде, как и разные отрицательные факторы на зимовках делают нужным больше внимания и координации со стороны исследовательских и административных органов затронутых стран.

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Introduction

The present paper is the last one of three, dealing with the status of the Svalbard geese in the 1960's. The first two papers (status of the Brent Goose and status of the Barnacle Goose) were published in Norsk Polarinstitutt Årbok 1968 (printed 1970).

The Pink-footed Geese are the most numerous of the three geese species breeding in Svalbard, occupying a more wide range of habitats than the two other species.

The paper deals with the distribution of the Pink-footed Goose in Svalbard, discusses the present population size, and mentions some environmental factors influencing the population.

Observations of Pink-footed Geese in Svalbard 1958–1969

The information presented in this chapter is mainly based on papers published in the period 1958–1969, personal information, and the author's own unpublished material from the years 1962–1969. A few data from 1956–1957 have also been included.

Published data have been taken from: BANG et al. (1963), BATESON and CUTBILL (1960), BURTON et al. (1960), DHONT et al. (1969), EHRENROTH and LOHM (1967),

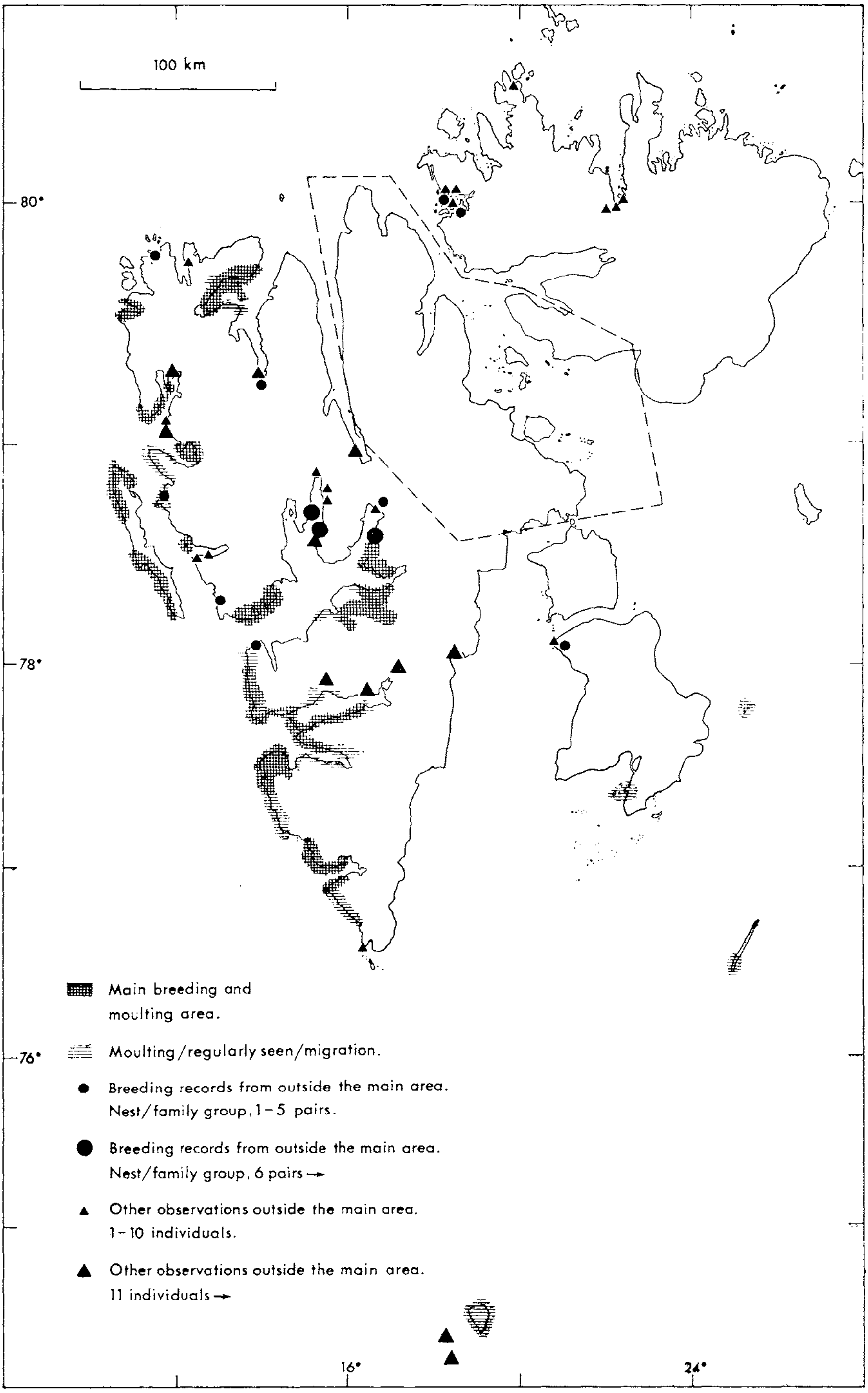

Fig. 1. *Distribution of Pink-footed Geese (Anser fabalis brachyrhynchus) in Svalbard according to observations in the period 1957–1969. From the area within the broken line reports are few or negative, or data are lacking.*

Ehrström (1958), Ferens (1960), Ford and Vaughton (1969), Frei and Teichmann (1965), Heintz (1963, 1965), Heintz and Norderhaug (1966a, 1966b), De Korte (1970), Norderhaug (1965, 1968, 1969, 1970), Norderhaug et al. (1965), Nyholm (1965), Ogilvie and Taylor (1967), Schweitzer (1966), Strijbos (1957), Tollén (1960), Voisin (this vol.), Vreugdenhil and Regensburg (1970), Wallers (1966), and Österholm (1966).

The total material includes about 290 observations. The observations have been geographically grouped in the same areas as used by Løvenskiold (1964) with a few modifications.

AREA I. BJØRNØYA

Breeding records

Pink-footed Geese have never been found breeding on Bjørnøya.

Other observations

On spring migration 1965, Pink-footed Geese were seen from May 23 to June 15. The species was observed on migration in August/September 1966. On spring migration 1967, the first individuals arrived on May 23. On May 24, two groups, one of 50–60 birds and one of 10–15 birds, were seen on migration 80 nautical miles south-west of Bjørnøya.

AREA II. HORNSUND

Breeding records

There are no breeding records or information from the southernmost part (the Sørkapp area). Between Stormbukta and Hornsund only a few are breeding. In 1964, 4 pairs with 10 goslings were seen in the area out of a total of 288 Pink-feet observed.

Between Hornsund and Torellbreen, Pink-feet are breeding regularly. In 1963 and 1964, respectively 28 and 15 breeding pairs were observed in this area.

Other observations

Observations in the years 1962–1964 from the area south of Hornsund indicate that this area is mainly a moulting area (see above). Most breeding takes place north of the fjord. The total population observed between Stormbukta and Torellbreen in 1964 counted 472 individuals.

AREA IIIa. SOUTH OF BELLSUND

Breeding records

The species has been found breeding between Kapp Borthen and Recherchefjorden, including Dunderdalen and Chamberlindalen. In the southern part (south of Thunaodden) breeding is more scarce. The total population observed between Kapp Lyell and Kapp Borthen in the summer 1964 counted 487 individuals, including 61 breeding pairs. In Ulladalen, on the northern coast of Van Keulenfjorden, a group of 3–4 adults with 7–10 goslings were observed in 1967.

Other observations

From Recherchefjorden and eastwards, along the southern coast of Van Keulenfjorden, there are only reports of non-breeding and moulting birds. Groups numbering up to 150 individuals have been observed in this area (1964). The same year, about 50 adults were observed near Svendsenhamna on the northern coast of Van Keulenfjorden.

AREA IIIb. NORTH OF BELLSUND

Breeding records

On Akseløya, family groups were seen in 1965 (3 adults, 9 goslings) and 1969 (25 adults, 7 goslings). At Conwentzodden on the southern shore of Van Mijenfjorden, 40 adults and 25 goslings were seen in August 1969. On the coast between Bellsund and Isfjorden, nests and family groups have been found in many localities: Kaldbukta, Camp Morton, Vårsolbukta, Ingeborgfjellet, Van Muydenbukta, Diabaspynten, Eungane, Ytterdalssåta, Gravsjøen, St. Hansholmane, Andungen, Osodden, Lisettholmane, Holmungen, Orustdalen, Vassiget, Strokdammane, Tunsjøen, and Kapp Starostin.

Other observations

Groups of non-breeding birds have been found in Kjellströmdalen (30 individuals, August 1965), Reindalen (60 individuals, August 1969), Liljevalchneset (30 individuals, August 1965), Berzeliusdalen (16 individuals, August 1969), Vårsolbukta (20 individuals, August 1965 and 50, June 1969), Marvågen (about 250, August 1965), Gravsjøen (about 150, July 1964), Osodden (40–50, July 1964), and Båtodden (about 200 individuals, July 1957).

At Kapp Linné, individuals or smaller groups are seen occasionally during the whole summer.

AREA IV. ISFJORDEN

Breeding records

Pink-feet were found breeding in Adventdalen, Sassendalen, and the area between these valleys (De Geerdalen, Janssonhaugen, Lusitaniadalen, Deltadalen, and Eskerdalen). Some pairs with goslings were seen on Gåsøyane in 1957. In Billefjorden nests or observation of family groups were recorded near Ebbaelva, in Petuniabukta and near Brucebyen. In Dicksonfjorden there are breeding records from Kapp Smith and Kapp Wijk. Furthermore, there are breeding records from Erdmannflya (15–20 adults with 25–30 goslings, July 1967) and Ymerbukta (about 10 nests, July 1962). At Alkhornet 16 nests were found in July 1965. In Teistlaguna, south of Marstrandodden, 3 nests were found in 1965. On Hermansenøya 7 pairs with 14 goslings were seen in July 1968.

Fig. 2. *Breeding Pink-footed Goose in camouflage posture.*
Photo: M. NORDERHAUG

Other observations

In addition to various observations of smaller groups, non-breeding birds in groups numbering 32–100 individuals have been observed in Sassendalen, Gipsdalen and Erdmannflya. During migration, groups of 59–150 birds were recorded from Adventdalen, Sassendalen, and Agardhbukta in August/September.

AREA V. PRINS KARLS FORLAND

Breeding records

The southern part of the island was visited in 1968 and the following nesting localities recorded: Nordøya (1 pair), Midtøya (7 pairs), Lortholmen (1 pair). Furthermore, Pink-feet were probably breeding on Salfjellsletta (probably 3 pairs observed) and south of Tvihyrningen (probably 2 pairs observed).

On the northern part of the island, the most important breeding area is around Fuglehuken. In 1963, 20 nests were found there and in 1964, 15 nests. In 1966 family groups were seen on Horneflya, Stormneset, Fuglehuken, Aberdeenflya, and Langflya, numbering a total of 450–500 individuals.

Other observations

A moulting area was found in the south-western part of the island. In 1968 about 200 moulting birds were seen around Forlandsøyane in the first week of July.

AREA VI. KONGSFJORDEN

Breeding records

Two pairs were breeding on the northern part of Sarsøyra in 1967. In general, Brøggerhalvøya is not a very important breeding area (but is regularly visited by Pink-feet during the summer). Close to Ny-Ålesund a pair with 5 goslings was seen in 1964. Pink-feet are probably regular breeders on Ossian Sarsfjellet according to observations from 1956 (2 adults with 3 goslings) and 1962 (5 adults with 12–13 goslings). On Gerdøya, a nest was found in 1956. Two pairs with 4 goslings were recorded on Sigridholmen in 1968, and 8 adults with 10 goslings on the same island in July 1969. At Blomstrandhalvøya, 6 adults with 6 goslings were seen in July 1969.

In Krossfjorden Pink-feet have been found breeding at Kongshamaren (1956, 1968) and Ebeltoftlaguna (1965, 1966).

Other observations

On Brøggerhalvøya's western coast there were regular observations of 1–35 individuals in the period 8–22 August, 1968. At Kapp Guissez 15 adults were seen in summer 1962, and 21 at Regnardneset the same year. At Ebeltoftlaguna about 70 moulting birds were seen on August 22, 1965. In Diesetvatnet more than 100 individuals were recorded on August 16, 1966.

On spring migration, 1969, first record from Kongsfjorden was May 26.

AREA VII. NW SPITSBERGEN

Breeding records

In Magdalenefjorden 4 nests were recorded on the northern coast in July 1960 and two pairs observed in July 1965. At the mouth of Fuglefjorden, a pair with 6 goslings was seen in August 1966. At Vestvallafjellet a nest with 4 eggs and two pairs with 6 goslings were seen in the second week of July 1969. On Reinsdyrflya Pink-feet were found breeding in 1964 (at least 5 pairs around Siktefjellet) and in 1965 (at least 2 pairs in the same area). In 1964, 10 adults and 3 goslings were seen on Lernerøyane and a nest (5 eggs) found close to Annabreen in 1963. At Sigurdfjellet in the inner part of Woodfjorden, a nest (4 eggs) was found in 1969.

Other observations

Droppings, tracks etc. from geese (probably Pink-feet) were seen close to Lilljeborgfjellet (Reinsdyrflya) in 1969. On Reinsdyrflya there are, furthermore, records of non-breeding Pink-feet (6–50) from Sørkollen and the south-western coast of the peninsula, from Andøyane, Måkeøyane, Lernerøyane, Erikbreen, Roosneset, and Sigurdfjellet (Woodfjorden).

AREA VIII. WIJDEFJORDEN

Breeding records

No observations.

Other observations

A group of 50 adults was seen in Austfjorden in August 1957.

AREA IX. HINLOPENSTRETET

No observations.

AREA X. NORDAUSTLANDET

Breeding records

In Murchisonfjorden two pairs were breeding in 1957.

Other observations

There are a few observations from Murchisonfjorden. Furthermore, in Dalvågen (near Beverlysundet) two Pink-feet were seen in the third week of July 1966. In the inner part of Rijpfjorden, 6 groups (1—3 individuals) were seen on migration August 19, 1965. In Rijpfjorden, south of Kræmerodden, one individual was seen August 16 the same year.

AREA XI. STORFJORDEN

Breeding records

A nest was found near Kapp Lee on July 1, 1969.

Other observations

Barentsøya was visited in August, 1969, but no Pink-feet were seen there. From Edgeøya the following records have been noted: In Tjuvfjorden (1964) the first record was May 30 (2 individuals). After that date, Pink-feet were regularly seen in the area. In 1966 one was heard on the SE coast of Tjuvfjorden on August 11, and 8 adults seen on Ytre Zieglerøya, August 7, the same year. In Negerdalen 4 adults were seen May 22, 1969 (first record). On the northern part of the island, the first one appeared on May 25 the same year. On Ryke Yseøyane two Pink-feet were seen on August 19, 1967. In 1968 the first record from these islands was May 24 (3 individuals), and 1—5 were seen from May 25 to June 24.

AREA XII. KVITØYA

No observations.

AREA XIII. KONG KARLS LAND

Svenskøya and the western part of Kongsøya were visited in August 1969. No Pink-feet were observed in the area.

AREA XIV. HOPEN

Breeding records

None.

Other observations

In 1964 one Pink-footed Goose was shot on May 28. Four individuals were seen at Bjørnstranda on September 11, 1965. In 1966 the first one arrived on May 27. Pink-feet (1—7) were seen from May 31 to June 23. In 1967 the first Pink-feet (4) were seen on June 12.

Estimates of the population size in the 1960's

Population density in the breeding area

In the summer 1964 two expeditions, one from The Wildfowl Trust, England, the other from Norsk Polarinstitutt, visited adjacent parts of Spitsbergen with the object of investigating the status and distribution of the Svalbard geese (Barnacle Goose, Brent Goose and Pink-footed Goose). The expeditions worked independently, but study methods had been co-ordinated beforehand.

These field studies gave fairly complete information on the population size between Kapp Lyell (Bellsund) and Olsokbreen (Stormbukta) (NORDERHAUG et al. 1965). A total of 959 Pink-feet were observed in this area (Fig. 3).

During the breeding period, the Pink-feet are to a great extent found in the lower parts of Svalbard (coastal plains and valleys rich in water and vegetation). In the investigated area, as well as in other parts of Svalbard where Pink-feet

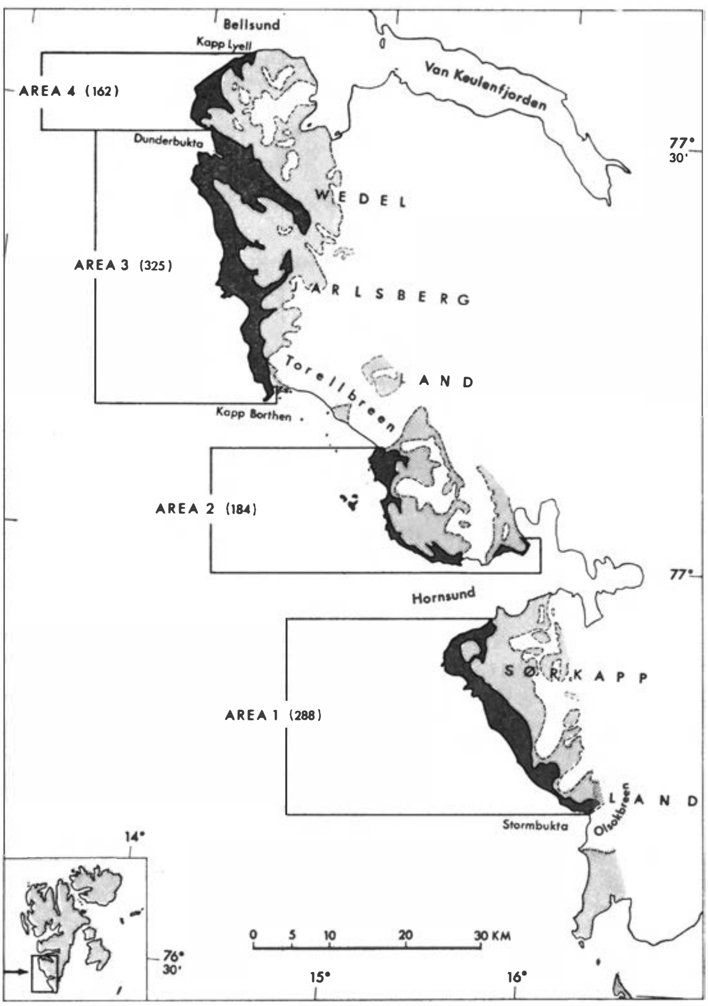

Fig. 3. *Goose survey in south-western Spitsbergen summer 1964. Black areas indicate potential habitats surveyed. Total number of Pink-footed Geese is given if brackets. See Table 1 nor further details.*

Table 1
Population size and density of Pink-feet in south-western Spitsbergen. Summer 1964

Area	Observed number of geese	Estimated size of productive habitat (km^2)	Estimated density (geese per km^2)
1. Olsokbreen-Hornsund	288	80	3.60
2. Horsund-Torellbreen	184	34	5.41
3. Torellbreen-Dunderbukta	325	171	1.90
4. Dunderbukta-Kapp Lyell	162	26	6.23
Total	959	311	3.08

habitats have been visited, the main part (if not all) of the Pink-feet are located in the lower parts of the islands, normally well below 100 m a.s.l.

The size of the areas where the geese counts were made in summer 1964 has been estimated (restricted to snow and ice free areas up to 100 m a.s.l. on maps 1:500 000, and not including moraine areas marked on the maps). In Table 1 the size of the habitat is compared with the population size in the respective areas.

As seen from the review of the distribution of the Pink-feet in Svalbard, nearly the whole population is probably found in Spitsbergen and Prins Karls Forland. Snow free areas up to 100 m a.s.l. in these two islands total about 4 417 square km (NORDERHAUG 1969). A total estimate of the population size of Pink-feet in Svalbard based on the observed, average density in the south-western Spitsbergen in 1964 (3.08 individuals per sq. km), indicates a population of the order of 13 600 individuals. In general the south-western parts of Spitsbergen must be regarded as optimum habitats in Svalbard. The observed density of Pink-feet in this part must therefore be somewhat higher than for the whole island. This factor is, however, to some extent reduced by the few Pink-feet inhabitating the eastern islands (Edgeøya, Nordaustlandet and others), which are not included in the estimate.

Based on the present material it seems reasonable to estimate a population of the order of 12–13 000 Pink-feet in Svalbard in the middle of the 1960's.

Population counts from the wintering grounds

Svalbard's Pink-foot population passes Denmark during the migration to and from the wintering quarters. These mainly include the areas: Föhr, Jadebusens, Friesland, Zeeland, and the goose reserve by Damme (Belgium) in the south (HOLGERSEN 1956, STICHMANN & TIMMERMANN 1965). Both from Denmark, Germany, and the Netherlands there are some Pink-foot counts (mainly from 1961 to 1968) from some frequently visited localities. The maximum figures give some indication of the population size (Table 2).

Table 2
Highest recorded numbers of Svalbard Pink-footed Goose in wintering quarters in recent years.

Area	Recorded numbers	Date	Reference
Föhr, Germany	8–10 000	Autumn 195 ?	HOLGERSEN 1956
Tipperne, Denmark	10 000	Spring 195 ?	LIND 1956
Workum, The Netherlands	11–12 000	20.12. 1960	STICHMAN & TIMMERMANN 1965
Jadebusen, Germany	c.10 000	14.2 1961	—»— —»—
The Netherlands and Belgium	c. 9 200	Dec. 1962	—»— —»—
The Netherlands	9 000	10.3. 1963	—»— —»—
Denmark	14 500	Oct. 1965	FOG 1966
—»—	15 000	Oct. 1966	–»– 1967
—»—	15 000	Oct. 1967	–»– 1968
—»—	12 200	Oct. 1968	–»– 1969
—»—	12 000	Oct. 1969	–»– 1970

Conclusion

Comparing the results from the density studies in Svalbard with the maximum counts of Pink-feet from Denmark, Germany, and the Netherlands during the autumn, winter, and spring gives a good correlation.

Regarding the lowest counts (8–9 000), these are probably not total counts. Furthermore, the highest estimates of 14–15 000 individuals seem rather high, indicating an average density in the breeding area higher than found in the optimum habitats in Spitsbergen. It is, however, necessary to note that the population may show some fluctuations in number from one season to another, caused by variations in breeding conditions, hunting pressures etc.

As an average order of size for the Pink-foot population in the 1960's 12–14 000 individuals seems reasonable, these figures being based on studies of the breeding grounds and the available maximum counts from the wintering areas.

Present factors influencing the Pink-foot population

As distinct from the Svalbard population of Barnacle and Brent Geese, where marked population changes have been observed during the last 20 years, few such changes have been observed in connection with the Pink-foot population. This could indicate that this population is relatively stable, but alternatively it may be connected with difficulties in the registration of population changes in the stock. It should in this connection be mentioned that TIMMERMANN (pers. comm. 1970) feels that the number of Pink-feet in the Netherlands now is decreasing.

As the present population trend is uncertain, some of the factors influencing the population and its productivity in Svalbard should, therefore, be considered.

As seen from Fig. 1, the main distribution of Pink-feet is found in Spitsbergen, the island where also most of the human activity takes place. At the end of the

1960's, about 1 800–1 900 Russians and 900–1 000 Norwegians are living in three mining towns in the Isfjorden area. Furthermore, reopening of another coal mine in Van Mijenfjorden is planned. Another 60–70 people occupy different winter stations. During the summer months an increasing scientific field activity takes place, mainly in Spitsbergen. In 1968, 28 different expeditions with 209 participants from 11 nations visited this archipelago. The increasing trend in Arctic tourism is also observed in Svalbard. At the end of the 1960's, no hotel was in operation, and there is no air connection during the summer, but this is now probably only a question of time. Svalbard is now visited regularly by an express shipping service from Norway during the summer; in addition a number of tourist-ships visit Svalbard. In summer 1969, probably more than 5 000 tourists visited the area from these ships. Nearly all this activity takes place in Spitsbergen, and all field activities are concentrated during the summer months, (i.e. the birds' productive season).

In Svalbard there is at present an open season for Pink-feet in the autumn from August 20, and in the spring to June 10. Up to recent years, the annual kill of Pink-feet in Svalbard was probably rather restricted, but there are indications of a marked change in the situation. At the moment there are no actual hunting statistics available. There is, however, an increasing trend in recreational hunting in Svalbard. Another factor is the increasing number of small speedboats, making

Fig. 4. *Typical coastal plain in south-western Spitsbergen. Used by Pink-feet for breeding and moulting, and for feeding during migration in spring and autumn.*

Photo: M. NORDERHAUG

Fig. 5. *Pink-feet on autumn migration, Hornsund, Spitsbergen.*
Photo: M. NORDERHAUG

goose-hunting in general more effective, and also possible in more distant areas where previously no hunting had taken place. In autumn 1969, two hunters operating from a small speedboat, returned from a weekend's hunting with 141 geese (about one per cent of the total population).

Considerable prospecting, mainly for oil has also taken place in the last years. The surprisingly few Pink-feet found in Reindalen (Nordenskiöld Land) in summer 1969 (FORD & VAUGHTON 1969), compared with the number observed there in the 1950's, may have been caused by oil prospecting and other human disturbances in the area.

The total effect of these factors in Svalbard is clearly negative, due to the increasing trend in human activity in the breeding and moulting areas. Further protective measures for the Pink-feet in Svalbard are rather difficult to implement. Distribution is wide and scattered and the establishment of reserves would therefore be difficult. However, a curtailment of the hunting season will be proposed in connection with the present revision of the hunting regulations in Svalbard.

In light of the changing situation in Svalbard, together with the present situation in the wintering grounds in Denmark, Germany and the Netherlands, and taking into account the increasing disturbance, pollution, and drainage of migration and wintering habitats (LEBRET 1965, and others), and the present hunting pressure, the future of the population should be watched with great care. In this connection, a more effective co-operation between research and administrative agencies in the countries involved should be developed for a rational management of the population.

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Investigation of the Svalbard reindeer (*Rangifer tarandus platyrhynchus*) in Barentsøya and Edgeøya, summer 1969

(Исследеования свальбардского северного оленя (*Rangifer tarandus platyrhynchus*) на островах Barentsøya (Баренца) и Edgeøya (Эдж) летом 1969 г.)

BY

MAGNAR NORDERHAUG

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Abstract

Studies of the reindeer population in Barentsøya (1300 sq.km) and Edgeøya (5150 sq.km) in eastern Svalbard summer 1969 are summarized.

Counts made from helicopters covered nearly all potential reindeer habitats on the two islands. The main part of the animals was located in the vegetation-rich coastal plains and lower valleys. A total of 484 reindeers (1.26 animals per sq. km habitat) and 1448 reindeers (0.96 animals per sq. km habitat) was found in Barentsøya and Edgeøya respectively (Tables 1 and 2). Observed calf crops were 17.8% (Barentsøya) and 20.0% (Edgeøya). Ground survey performed in south-eastern Barentsøya indicated a population composition of 28.4% females, 31.8% males, 18.9% calves, and 20.9% unidentified (mainly yearlings). Reindeer on these islands are normally found in small groups (1-9 animals) (Fig. 4).

Restoration of the Svalbard reindeer population continues and may result in a population comparable to that 300-350 years ago (before human exploitation started).

The need for further research on the ecology of the Svalbard reindeer is stressed.

Аннотация

Подводятся итоги исследований популяции северного оленя, проведенных летом 1969 г. на островах Barentsøya (1300 кв. км) и Edgeøya (5150 кв. км), расположенных в восточной части архипелага Свальбард.

Подсчетами, выполненными с вертолетов, охвачены почти все возможные места распространения северных оленей на этих двух островах. Основная часть животных находилась на богатых растительностью прибрежных равнинах и в низменных долинах. Общее число оленей оказалось на острове Barentsøya — 484 (1,26 головы на кв. км) и на острове Edgeøya — 1448 (0,96 головы на кв. км) (см. табл. 1 и 2). Отмеченное количество телят в стаде составляет 17,8% на Barentstøya и 20,0% на Edgeøya. Наземные подсчеты, произведенные на юго-западе острова Barentsøya, показывают следующий состав стада: самок — 28,4%, самцов — 31,8%, телят — 18,9% и неопределенных (гл. об. однолетних животных) — 20,9%. Олени этих островов, как правило, водятся небольшими группами (от 1 до 9 голов) (см. рис. 4).

Восстановление популяции свальбардского северного оленя продолжается и постоянный прирост ее может привести к числу животных, сравнимому с числом особей, живших на островах 300—350 лет тому назад (до вмешательства человека).

Подчеркивается необходимость в дальнейших исследованиях экологии свальбардского оленя.

Acknowledgements

I wish to express my gratitude to colleagues at Norsk Polarinstitutt's Svalbard expedition 1969, T. SIGGERUD (expedition leader), B. FLOOD, J. NAGY, T. WINSNES (geologists), D. NORBERG (topographer), the helicopter pilots, and my field assistant N. GULLESTAD for their assistance and keen interest in the work.

During a stay at Kapp Lee, Edgeøya, I also had valuable discussions with P. OSTERVELD, member of a Dutch biological expedition.

Introduction

Summer 1969, Norsk Polarinstitutt's expedition worked in the eastern parts of the Svalbard area, assisted by the expedition vessel M/S «Polarstar» and 4 helicopters. The activity included geological, topographical, and biological investigations.

The present paper summarizes results from the studies of the reindeer populations in Barentsøya and Edgeøya, conducted during the expedition. Information regarding population size, calf crop etc. from this part of Svalbard has previously been scarce, as these islands are not often visited.

Area description

Barentsøya and Edgeøya (77°10'N–78°40'N) are the two biggest islands in the south-eastern part of the Svalbard archipelago, covering an area of 1300 and 5150 sq.km respectively. A considerable part of both islands is glaciated.

The islands are dominated by the same geological structures: sandstone, silt stone, and schist of Triassic age. In certain areas dolerites dominate.

Both islands are relatively low, the main parts below 200 m a.s.l. and with maximum altitudes of 590 in Barentsøya and of 551 in Edgeøya. The rocks are only slightly folded, and rounded relief forms are characteristic (plateaus, wide valleys, coastal plains).

The ice conditions in these parts of Svalbard are influenced by winter temperatures lower than those of Spitsbergen, and a transport of cold water and sea ice from the north-east. The ice along the coasts of the islands may not break up before July (in some parts considerably later), and the influx of sea ice from the north-eastern waters may keep the coasts closed for nearly the whole summer in some years.

The northern strait between Barentsøya and Spitsbergen, Heleysundet, is free from ice for long periods, also during the cold season owing to the strong current between the islands. The strait between Barentsøya and Edgeøya, Freemansundet, is normally frozen during the winter, and contact between the reindeer herds of the two islands is then possible.

As usual in Svalbard, the precipitation in the eastern areas is scarce. The yearly mean is below 400 mm. The driest period is normally from April to June.

Vegetation is mainly of the type found in high Arctic tundra communities. Large areas are completely barren, and others have very sparse vegetation. Lichens do not dominate and are mainly found in some of the higher regions.

In Barentsøya the most important productive areas are found in the south-eastern corner and in the area from Talaveraflya to Rindedalen. In the northern part of the island the most important areas are found from Grimdalen to Sjodalsflya. In Edgeøya, large areas of rich vegetation are found in the north-eastern corner from Walter Thymensbukta to Blåfjorden, in Rosenbergdalen, the upper parts of Guldalen and Dyrdalen, and the coastal plains north of Kvalpynten.

Methods

Counts were made from small helicopters. Flying routes were worked out prior to starting on the basis of maps (1:100 000, 1:250 000) and air photographs. Flying altitude was about 300 ft above ground level and air speed 80–100 km per hour. The pilot assisted in the survey.

In Barentsøya the counts were performed 25–30 July; 388 km were flown. The south-eastern corner of the island (51 sq.km potential reindeer habitat) was covered by ground survey. In Edgeøya the counts were performed in the period 14–20 August; 1059 km were flown. In addition, some data were collected by

Fig 1. *Reindeer range in Barentsøya (photographed 190 m a.s.l.). In the background Freemansundet and the habitats in Edgeøya's north-eastern corner.*

Оленье пастбище на о. Barentsøya (снятое в 190 м над у. м. На фоне – залив Freemansundet и области распространения животных на крайнем северо-востоке о. Edgeøya.

Photo: M. NORDERHAUG

Fig 2. *Reindeer range (75 m a.s.l.) in the south-eastern corner of Barentsøya.*

Оленье пастбище (в 75 м над у. м.) на крайнем юго-востоке о. Barentsøya.

Photo: M. NORDERHAUG

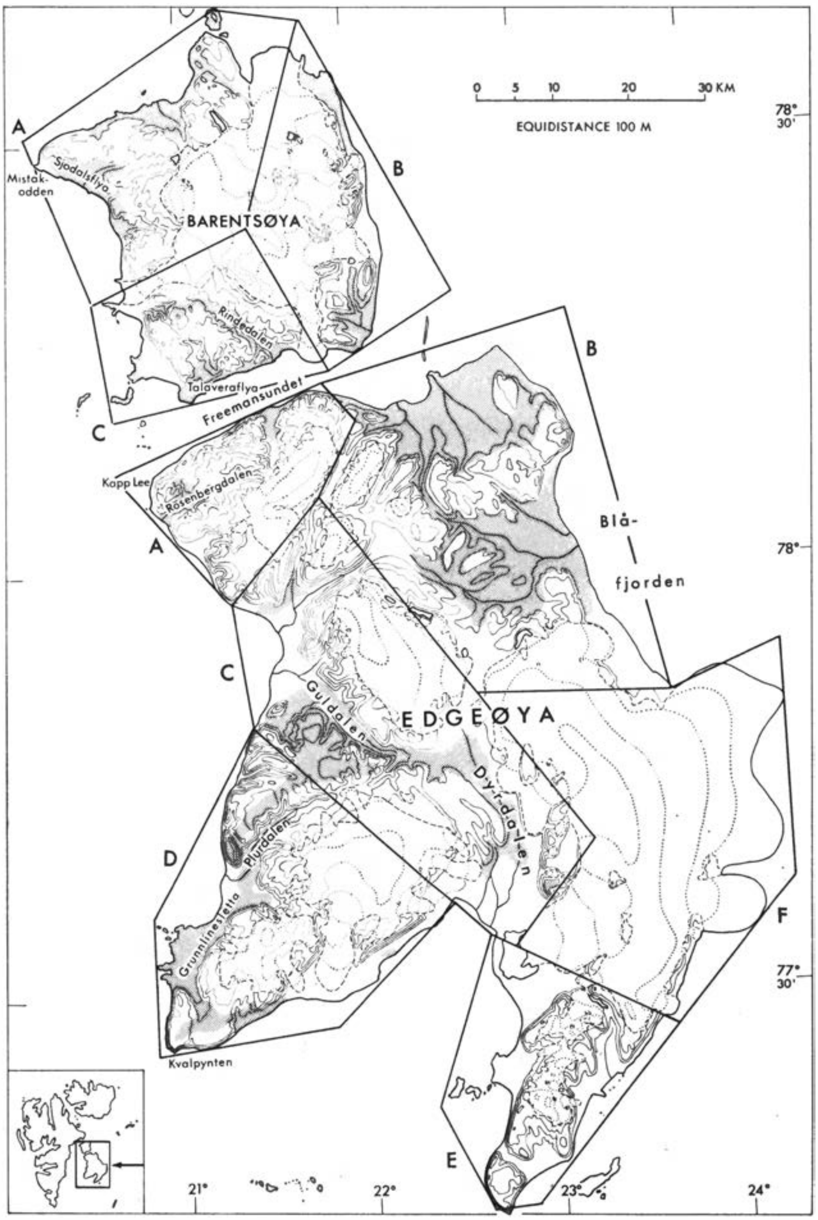

Fig 3. *Distribution of reindeer (grey) in Barentsøya and Edgeøya, July-August 1969. Survey areas are indicated.*

Распространение оленей на о-вах Barentsøya и Edgeøya в июле-августе 1969 г. Указны области охваченные подсчетами.

geologists and others on flights to some smaller, distant parts of the island (21 and 22 August). Totally, 17 flight hours were used for the survey of Barentsøya and Edgeøya, which are supposed to cover all potential reindeer habitats on the islands. The survey covered all lower parts of the islands where vegetation is found (below 200 m a.s.l.) and some higher, vegetation-covered plateaus. Ice-caps and barren mountain plateaus were omitted. The total productive area in Barentsøya and Edgeøya has been estimated at 383 and 1519 sq.km respectively (NORDERHAUG 1969).

Only the number of calves and number of adults were recorded during the air survey. A more differentiated classification of the population was not possible. However, the ground survey in the south-eastern part of Barentsøya gave more detailed information, partly about population composition in general, partly about calf crop (testing the results obtained from the air surveys).

Distribution and population size

The distribution of reindeer on the two islands was mainly restricted to areas with a well-developed vegetation cover. The main part was therefore found at the bottom of the valleys and on coastal plains (mainly below 200 m a.s.l.) In some areas, however, individuals or smaller groups were observed on vegetation-rich plateaus at considerably higher altitudes. This was mainly observed in Edgeøya, where smaller groups (including calves) were observed more than 400 m a.s.l. (on a mountain plateau east of Dyrdalen, near Karstenfjellet and Siegelfjellet).

As seen from Fig. 3, Barentsøya was divided into 3 areas. The main concentration was observed in area A. In area B nearly the whole population was found along the eastern coast. In area C the main part of reindeer was seen in the area Talaveraflya–Rindedalen.

Edgeøya was divided into 6 areas (A–F). In area E and F no reindeer were observed. In area A the main part was observed in Rosenbergdalen. Area B is the most important reindeer habitat in Edgeøya, and 51.2% of the population of this island was observed there. In area C the main part was seen in Guldalen and the upper part of Dyrdalen. In area D reindeer were mainly found in the southern part of Grunnlinesletta and in parts of Plurdalen. Fig. 3 indicates the distribution of reindeer in the survey period July/August 1969. Probably the distribution changes constantly during the year. This is partly a result of general movements in the terrain, partly of changes in population composition within a single area. The results of the surveys on the two islands are given in Table 1 and Table 2 together with figures of population density, based on the observed population size and estimated productive reindeer habitat (NORDERHAUG 1969).

Calf crop

In spite of the rapid growth in the first months of life, it was still easy in July/August to distinguish calves from adults and yearlings from a helicopter. Totally,

Table 1

Population size, calf crop, and density of reindeer in Barentsøya, 1969. Based on aerial survey (area A, area C) and ground survey (area B), July 25–30.

Area	Total number observed	Number of calves	Per cent calves of total	Estimated reindeer habitat* (sq. km)	Density. Animals/ sq. km habitat
A**	182	32	17.6	200	1.099
B	157	29	18.5	80	1.963
C	145	25	17.2	103	1.408
Total	484	86	17.8	383	1.264

* Preliminary data from NORDERHAUG (1969).
** Inclusive Kükenthaløya.

Table 2

Population size, calf crop, and density of reindeer in Edgeøya, 1969. Based on aerial survey, August 14–20.

Area	Total number observed	Number of calves	Per cent calves of total	Estimated reindeer habitat* (sq. km)	Density. Animals/ sq. km habitat
A	44	6	13.6	100	0.440
B	742	147	19.8	659	1.126
C	367	74	20.2	388	0.946
D	295	63	21.4	209	1.411
E	0	0	–	146	0
F	0**	0	–	8	0
Total	1448	290	20.0	1510	0.959

* Preliminary data from NORDERHAUG (1969).
** Small area between Pettersenbreen and Kong Karls Bre were not surveyed.

376 calves were observed in a population of 1932 reindeer found in Barentsøya and Edgeøya. The data are summarized in Table 1 and Table 2. The most important calf areas in Barentsøya were east of Mistakodden (area A), the south-eastern corner (area B), Rindedalen and Talaveraflya (area C). In Edgeøya the most important areas were area B, Guldalen (area C) and Grunnlinesletta (area D).

Population composition

The population composition was only studied from ground in one area, viz. the south-eastern corner of Barentsøya from Freemanbreen to Ritterflya. The population in this well-defined area is supposed to be representative for the population in Barentsøya as a whole. A slightly higher percentage of calves were, however, observed in this area (18.9% compared with 17.8% as an average for the whole island). This may in part be due to a slight difference in the identification possibilities between air and ground surveys. This slight difference between the two survey types may also indicate that the figures obtained from the air surveys are relatively close to the actual figures.

On July 25, 148 animals were observed in this area (30.6% of the total number observed in Barentsøya). Of the 148 individuals, 42 were females, 47 males, 28 calves, and 31 unidentified. The last group consisted mainly of yearlings, but also some adults that were seen at long distance.

Based on the data from the south-eastern corner of Barentsøya, the population composition was in July/August:

females:	28.4%	
males:	31.8%	
calves:	18.9%	
unidentified:	20.9%	(mainly yearlings)
	100.0%	

On both islands, some differences in the proportion of sexes in different areas were observed. In the northern part of Barentsøya males dominated south-west of Mistakodden and females with young north-east of this peninsula. Also in the south-eastern corner of the island, some grouping of the sexes could be observed, but not to the same extent as observed in the northern part. In Edgeøya a distinct concentration of females with young was observed in the upper part of Guldalen. In the lower part of the valley, males were more numerous. In Rosenbergdalen nearly all were males.

In Barentsøya (area B, July 25 and area C, July 28) and in Edgeøya (area C, August 14) group sizes of 134 and 167 animals respectively were noticed. Contrary to reindeer populations in many other areas, the high-Arctic populations seem to concentrate only in smaller groups, probably as a response to lower carrying capacity and the year-round use of these ranges. Herd sizes observed in Barentsøya and Edgeøya are shown in Fig. 4. A similar tendency was found to apply to the Peary caribou (*Rangifer tarandus peary*) on some of the Queen Elizabeth Islands in summer 1961 (TENER 1963).

Discussion

For reindeer surveys of this type the use of helicopters proved to be very satisfactory. It has a low air speed suitable for survey purposes, and can rapidly adapt to changes in altitude and direction in a changing terrain. The assistance of the pilots in the counts was important as it made possible a nearly complete coverage of the ground below and to both sides.

As previously mentioned, the main concentration of animals were found on or

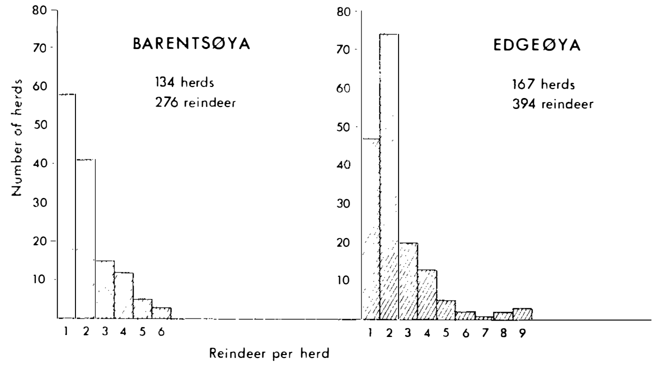

Fig 4. *Herd size frequency of reindeer in Barentsøya and Edgeøya, summer 1969.*

Частота величины оленьего стада на о-вах Barentsøya и Edgeøya, летом 1969 г.

near areas with well developed vegetation. In a few cases smaller groups of animals were found on higher, partly barren plateaus. It is possible that a few animals in this terrain have been missed. Their influence on the total population figure and the indicated population densities is, however, considered to be negligible.

The population density of 1.26 animals per sq.km potential habitat, found in Barentsøya, is the highest recorded from any main area in Svalbard. The density of 0.95 animals per sq.km observed in Edgeøya is furthermore comparable to observed densities in the best areas in Spitsbergen (NORDERHAUG 1969). A brief habitat-survey conducted during the field work in 1969 also supports the impression that these areas in eastern Svalbard should be classified as some of the best reindeer habitats in the archipelago. There is no evidence that the observed densities on the two islands are optimum densities. The relatively high calf crop found (17.8% in Barentsøya and 20.0% in Edgeøya) and the obviously good physical condition of the observed animals could indicate that a further population increase can occur in the 1970's. Further studies are, however, necessary to verify this point.

In general, the Svalbard reindeer population is one of the most unique in the world, living in the northernmost and most extreme part of the Arctic, without interference from any natural predators, and (during the last 45 years) with little or no disturbance by man. Its diet is probably only to a small extent lichen-based (from studies performed in Spitsbergen, Barentsøya, and Edgeøya in June–August 1969), and to a high degree based on the seasonal plant production of grass (*Alopecurus, Poa, Dupontia,* etc.) and other plants like *Equisetum, Salix, Oxyria, Ranunculus, Papaver, Saxifraga,* etc., combined with a well developed ability to accumulate fat.

The Svalbard reindeer must have become physically and ecologically well adapted to the extreme environment of these islands after a long period of isolation, and their population dynamics and possible self-regulatory mechanisms are well worth further studies.

Since the 17th century the population has been exploited by man, and over-exploitation reduced the herd probably to approximately 500 animals in the 1920's. Since the total protection enforced in 1925, the population has had a gradual but irregular increase. Illegal hunting and damage caused by wild dogs may still occur in some years (mainly in Spitsbergen). However, the general population dynamics are now only to a slight extent influenced by man. At present the restoration of the herd continues, and will probably, if no new negative factors occur, lead to a state comparable to the situation before man interfered some 300–350 years ago.

At present, the future management of the Svalbard reindeer is a question of additional preservation measures to make possible a continued population increase. Important fields for future research include repeated population surveys related to carrying capacity (herd size, distribution, calf crop) after 2–3 years in Barentsøya and Edgeøya, expanded population surveys in other parts of Svalbard, studies of reindeer expansion into unpopulated areas, and habitat studies from air photographs and field surveys.

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Synopsis of the flora of Svalbard

BY

OLAF I. RØNNING[1]

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Abstract

The flora of Svalbard, comprising 162 vascular species, has been arranged into high-, middle-, and low-arctic elements, and a widely distributed element. The amphi-atlantic species have been grouped in accordance with their main distribution. Special sections deal with relations to other arctic floras, as well as endemic and introduced species.

Preface

For several years I have collected data and have made as complete registration as possible of the flora of Svalbard. Prior to this, the curator of botany at the University of Oslo, JOHANNES LID, also systematically (up to 1934) collected data about that flora. All his notes have kindly been placed at my disposal.

As a result of these studies, Svalbards flora (RØNNING 1965a) was published. Distribution maps have been worked out and the first parts of these together with the text is to be published in the near future.

[1] Universitetet i Trondheim, Norges lærerhøgskole, Trondheim.

I am much indebted to curator LID, who for the past few years has given help and good advice which has been of great importance to me.
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Introduction

Svalbard comprises all the islands situated between long. 10° and 35°E, lat. 74° and 81°N. The total area of the archipelago is c. 62 100 sq. km.

Svalbard is the most northerly settlement in the world. In no other place is it possible to reach so far north by regular steamers. The Barents Sea is a shallow sea and the greater part of it is less than 200 m deep. From the west coast of Spitsbergen towards the north-west coast of Norway it slopes abruptly down to a depth of more than 2 000 m. This sea area in the Tertiary period probably constituted a land that more or less connected northern Scandinavia with Novaya Zemlya and Svalbard (NANSEN 1920, RØNNING 1959), and thus represented the northern continuation of the Eurasian continent.

Svalbard's landscape is dominated on the west coast by long and narrow east-west fjords, while on the east coast no major fjords occur. No belt of skerries surrounds Spitsbergen, but the strandflat is very pronounced. In many places it is up to 10–15 km wide. The fjords and the valleys were carved by the glaciers, and, thus, are U-shaped; they are filled at the bottoms with large deposits of river sand and loam.

CLIMATE

The climatic conditions in Spitsbergen are distinctly favourable taking into account the geographical latitude. A branch of the North Atlantic stream flows up the west coast, keeping it open and ice-free for a great part of the year. North of Spitsbergen the North Atlantic stream disappears under the cold arctic water. Cold arctic water streams down along the east coast of Spitsbergen, turns around Sørkapp, the southernmost point of Spitsbergen, and then flows north again along the west coast between the land and the Gulf Stream. This cold arctic stream can carry drift-ice, which during longer periods may block the west coast fjords with ice. As a result of this, there is often more severe conditions along the southern coast of Spitsbergen than on the north-western coast, which can be free of ice until late autumn. The heaviest drift-ice areas, however, are around the north-east and east coast of Spitsbergen, which are accessible by ordinary boats only under favourable conditions.

In wintertime the prevailing winds in the area are from the north-east. With airmasses of the cold and dry arctic type, the precipitation is consequently very small. In connection with a strong depression in the Norwegian Sea, warm and humid air from the south may, however, penetrate into the area.

In summertime the northward transport of warm and humid maritime air is frequent, more than 50% of all cases. This mild air is cooled in the lower layers by the cold arctic water. The result is a stable airmass. Mist and fog are thus common along the south and west coast as well as in the adjacent ocean areas.

Precipitation is generally small due to the frequent occurrence of dry arctic air and to the great stability of the mild and humid airmasses.

Most of the precipitation falls along the coasts. Several inland areas, situated in the rain shadow on the lee side of the mountains, get very little precipitation. Within the Svalbard area there are four meteorological stations, viz. Bjørnøya, Hopen, Isfjord Radio, and Longyearbyen. In Figs. 1, 2 and 3 temperatures and precipitation for two of these stations (Isfjord Radio and Longyearbyen) are compared. They are both situated in the Isfjorden area, but Isfjord Radio at Kapp Linné is a coastal station situated on the west coast. Longyearbyen lies in the central part of Isfjorden. Though situated near the fjord, it must be regarded as an inland station, however, it is not one of the most typical inland stations. The two other stations are located on rather isolated islands, and their importance as climatic stations for biological purposes are rather limited. Unfortunately, continuous meteorological observations have been made at Longyearbyen only since 1957, as well as for a short period between 1930 and 1934. As the observations for Isfjord Radio were interrupted during World War II, I have chosen the period 1947–1968.

Fig. 1 shows the annual average temperature for the two stations, and it appears that the annual mean temperature at Longyearbyen is about 1°C lower than the coastal station Isfjord Radio. Fig. 2 shows the mean temperatures for July. This reveals a similar state of affairs with warmer summers in Longyearbyen than at Isfjord Radio. Fig. 3 shows the annual precipitation at the two stations. The coastal station Isfjord Radio has a greater precipitation, varying from 276 to 544 mm in the period shown, while the inland station Longyearbyen has a precipitation varying from 130 to 305 mm for that shorter period. Among the scattered observations from previous years there is one reading of 103 mm in 1932. Because of the frequent occurrence of falling and drifting snow, the values of measured precipitation should, however, be treated with some reservation.

Both the temperature and the precipitation show a continental trend to the east and the inner parts of the island. There are reasons to believe that this trend is even more pronounced farther east towards the head of the fjords and the main inland area, as well as toward the north. The inland precipitation, often less than 200 mm for several years, is on a level with that of deserts and semi-deserts in tropical and subtropical parts of the world. But there are also striking differences. The temperatures are lower, and there is thus a lower rate of evaporation, and much of the precipitation falls as snow. Therefore most of it is preserved until spring and summer, i.e. the growing season when the melt water is available to plants. Finally the permafrost helps to keep the water at the upper or active layer where the main roots are found.

Situated north of the tree limit, with low yearly mean temperature, low precipitation, and the mean temperature in the warmest month lying between 0° and 10°C, the climate must be classified as arctic or as a tundra climate.

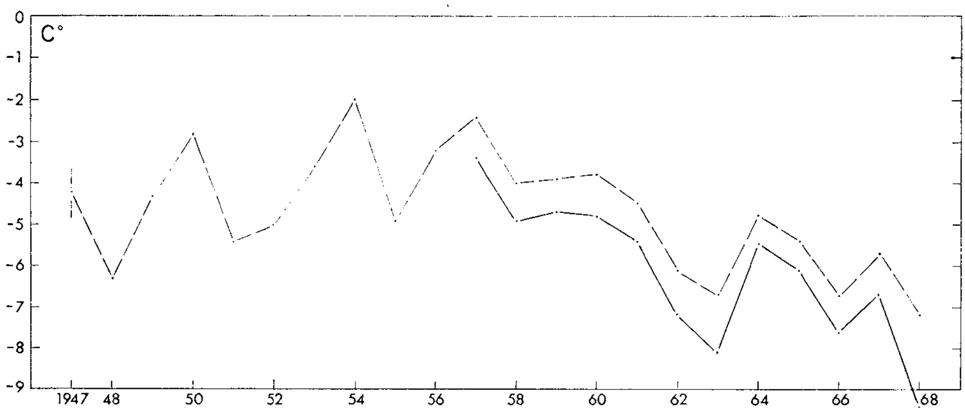

Fig 1. *Yearly mean temperatures 1947 (1957)-1968. Solid line Longyearbyen, broken line Isfjord Radio.*

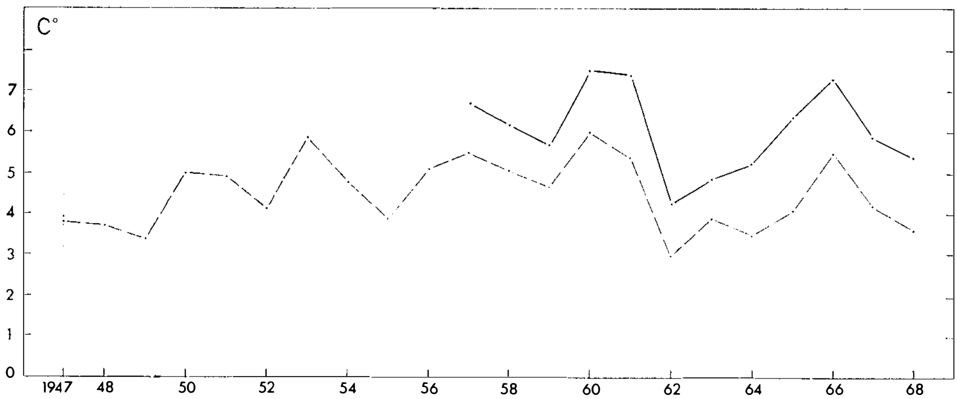

Fig 2. *Monthly mean temperatures July 1947 (1957)-1968. Solid line Longyearbyen, broken line Isfjord Radio.*

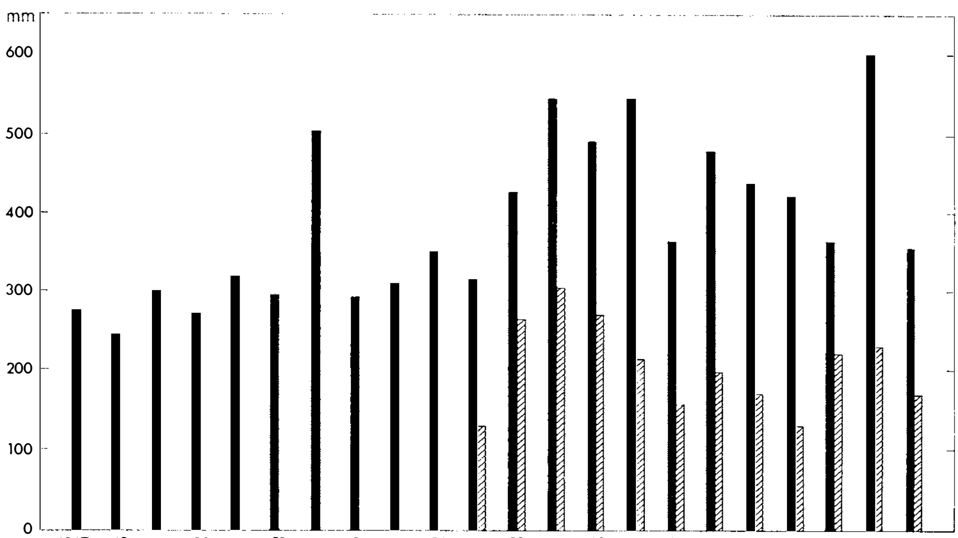

Fig 3. *Annual precipitation 1947 (1957)-1968. Black columns Longyearbyen, shaded columns Isfjord Radio.*

GEOLOGY

An outline of the geology of Svalbard is given in Fig. 4 (WINSNES, HEINTZ and HEINTZ 1961). All geological systems, from Precambrian to Tertiary, are represented in Svalbard, a fact that has made Svalbard well known to geologists. It appears from the map that the youngest beds of Tertiary age are found in the southern inland area, forming the upper part of a great syncline extending from Kongsfjorden south-eastwards to Storfjorden. Going outwards in the syncline from the Tertiary, successively older beds occur, from Cretaceous to Permian.

The peninsula between Woodfjorden and Wijdefjorden south to Nordfjorden and the areas around Raudfjorden are made up of Devonian sediments, mostly red sandstones. Barentsøya, Edgeøya, and the eastern part of Spitsbergen are composed of Mesozoic sediments. Along the coast to the west there is a zone of Hecla Hoek rocks, i.e. metamorphic rocks of Precambrian to Lower Palaeozoic age. Hecla Hoek rocks are also found in wide areas of north-east Spitsbergen. Throughout the Hecla Hoek areas in the north, granites and gneisses are found, of which the largest areas occur in the north-west.

Carboniferous and Permian beds constitute the southern part of the island Nordaustlandet. Extending into Spitsbergen, they form a cone between the Hecla Hoek and the mesozoic rock on the east coast; towards Isfjorden they again widen in the innermost part of the fjord. The features of the geology outlined above are of course more complicated than it appears from this introduction and the map, Fig. 4. There are several faults and foldings which complicate the geological conditions considerably.

Today about two-thirds of Svalbard are covered by glaciers. Branches from the greater inland glaciers flow down the valleys and reach the sea near the head of the fjords. The glaciers have eroded the landscape during the Pleistocene, and most of the fjords and valleys are characterized by glacial erosion. The bottoms of the big valleys are mostly flat and covered by large amounts of fluvial deposits from the rivers.

Because Svalbard is an arctic land, its subsoil is permanently frozen. This permafrost may reach to a depth of 300–350 m. Only the uppermost part of the soil thaws in the summer. This upper layer, or active layer, is where the plants take root, and is therefore of major importance to plant life. The permafrost layer impedes the water in percolating downward. In sloping terrain this layer causes severe solifluction phenomena.

Plant geographical elements

In Svalbard 162 native species of vascular plants are found. In RØNNING (1965a) 162 species are mentioned. In 1967 ENGELSKJØN, however, revised the Bear Island Taraxaca and found them to be *T. cymbifolium* H. LINDB. ex DT., thus increasing the number of species in Svalbard to 163. Further investigations, however, showed that the Bear Island plant named *Stellaria calcycantha* should be referred to as

Fig 4. *Outline of the geology of Svalbard.* (After WINSNES, HEINTZ AND HEINTZ 1961.)

S. humifusa. The number of species so far known from Svalbard should consequently be 162. In the following synopsis the taxonomy followed by RØNNING (op. cit.) is adopted.

Since the first survey of the flora of Svalbard, given by MALMGREN in 1862, the number has increased considerably. MALMGREN mentions 93 vascular plants found during the Swedish expeditions in 1858 and 1861. TH. FRIES later (1871) listed 112 species. After the expedition in 1882, NATHORST (1883) mentioned 123 species from Spitsbergen. RESVOLL HOLMSEN (1927) describes 133 vasculars in her flora, and HØEG (1956) mentiones 143 indigenous species, a number that the research in subsequent years has increased to 162, of which there are 6 pteridophytes, 101 dicotyledones and 55 monocotyledones. In addition to the indigenous flora, a number of introduced species has been found of which, however, only very few have survived more than their first growth season.

The flora of Svalbard consists of species with different geographical distribution. Considering the distribution in north-west Europe, especially Scandinavia, we may set up different groups of species.

GROUP OF HIGH-ARCTIC ELEMENT

This group consists of species inhabiting the high-arctic regions, i.e. areas with very low precipitation, low summer temperatures, and very long days during the growth season. In general these plants do not occur on the north-west European mainland; a few might, however, be represented there with special varieties or subspecies. In all, 36 species belong to this group, accounting for 22% of the total flora.

Alopecurus alpinus
Arctophila fulva
Carex ablyorhyncha
» *stans*
» *ursina*
Cerastium regelii
Colpodium vacillans
» *vahlianum*
Deschampsia brevifolia
Draba bellii
» *micropetala*
» *oblongata*
» *subcapitata*
Dupontia fisheri
» *psilosantha*
Eriophorum triste
Eutrema edwardsii
Festuca baffinensis
» *brachyphylla*
» *hyperborea*
Melandrium apetalum arcticum
Minuartia rossi
Pedicularis dasyantha
Pleuropogon sabinei
Poa abbreviata
» *hartzii*
Potentilla pulchella
» *rubricaulus*
Puccinellia angustata
» *svalbardensis*
Ranunculus pallasii
» *spitsbergensis*
Saxifraga flagellaris
» *hyperborea*
Sedum arcticum
Taraxacum arcticum

Salix glauca callicarpaea also belongs to this distribution pattern, but due to its rare occurrence in Svalbard and to the fact that it is not found in Scandinavia, it is referred to the low arctic group, mainly because of its distribution in Greenland.

GROUP OF MIDDLE-ARCTIC ELEMENT

The plants belonging to this group are common in Svalbard, and most of them have a rather wide distribution. With the probable exception of *Ranunculus pedatifidus*, all of them have a limited distribution in Scandinavia. They belong to the very interesting plant-geographical element, much dealt with in Scandinavian botanical literature, known as the "centric species". This means that their occurrence there is restricted to a limited area in northern Scandinavia or to a limited area in the mountains of southern Scandinavia. Some of them occur in both of these areas. There is, however, in most cases a considerable gap between them. It should be emphasized that some species belonging to the group in subarctic northern Norway are lowland or seashore plants. As such could be mentioned

Arctagrostis latifolia, *Carex subspathacea*,
Chrysosplenium tetrandum, *Papaver dahlianum*,
Polemonium boreale, *Puccinellia phryganodes*, and
Stellaria humifusa.

In all 34 species belong to this element, counting for 21% of the total flora.

Arctagrostis latifolia	*Luzula arctica*
Arnica alpina	*Melandrium affine*
Arenaria humifusa	*Papaver dahlianum*
» *pseudofrigida*	*Pedicularis hirsuta*
Braya purpurascens	*Phippsia algida*
Campanula uniflora	» *concinna*
Carex misandra	*Polemonium boreale*
» *nardina*	*Potentilla chamissonis*
» *subspathacea*	» *hyparctica*
Cassiope tetragona	» *nivea subquinata*
Cerastium arcticum	*Puccinellia phryganodes*
Chrysosplenium tetrandum	*Ranunculus pedatifidus*
Draba alpina	» *sulphureus*
» *cinerea*	*Saxifraga hieraciifolia*
» *gredinii*	*Stellaria crassipes*
Erigeron humile	» *humifusa*
Hierochloë alpina	*Taraxacum brachyceras*

GROUP OF LOW-ARCTIC ELEMENT

The low-arctic species are, with a few exceptions, commonly distributed in the Scandinavian mountains. Quite a few are, however, rather rare in Svalbard, but others, such as *Cardamine bellidifolia*, *C. nymanii*, *Minuartia stricta*, *Poa arctica* coll., and *Sagina intermedia*, are found all over the archipelago. In all 39 species or about 24% belong to this element.

Arabis alpina
Betula nana
Cardamine bellidifolia
» *nymanii*
Carex bigelowii
» *capillaris*
» *parallela*
Cassiope hypnoides
Cerastium cerastoides
Draba fladnizensis
» *lactea*
Empetrum hermaphroditum
Erigeron eriocephalum
Euphrasia arctica
Gentiana tenella
Hippuris vulgaris
Honckenya peploides diffusa
Juncus arcticus
» *castaneus*
» *triglumis*
Kobresia simpliciuscula
Luzula arcuata
» *wahlenbergii*
Minuartia rubella
» *stricta*
Poa arctica coll.
Potentilla crantzii
Ranunculus glacialis
» *hyperboreus*
» *nivalis*
Sagina caespitosa
» *intermedia*
Salix glauca callicarpaea
» *herbacea*
Sibbaldia procumbens
Taraxacum cymbifolium
Tofieldia pusilla
Vaccinium uliginosum
Woodsia glabella

GROUP OF WIDELY DISTRIBUTED ELEMENT

Among the flora of Svalbard are a number of species with a wide distribution both in Scandinavia and Svalbard. Most of them occur in Scandinavia both in the mountains and in the lowlands, especially in northern Scandinavia. The following 45 species or 28% belong to this group.

Calamagrostis neglecta
Carex glareosa
» *lachenalii*
» *maritima*
» *rupestris*
» *saxatilis*
Cochlearia officinalis
Cystopteris fragilis
Deschampsia alpina
Draba daurica
» *nivalis*
» *norvegica*
Dryas octopetala
Equisetum arvense
» *scirpoides*
» *variegatum*
Eriophorum scheuchzeri
Festuca rubra
» *vivipara*
Juncus biglumis
Koenigia islandica
Luzula confusa
Lycopodium selago
Minuartia biflora

Oxyria digyna	*Saxifraga aizoides*
Petasites frigidus	» *caespitosa*
Poa alpigena	» *cernua*
» *alpina*	» *foliolosa*
» *glauca*	» *hirculus*
Polygonum viviparum	» *nivalis*
Ranunculus lapponicus	» *oppositifolia*
» *pygmaeus*	» *rivularis*
Salix polaris	» *tenuis*
» *reticulata*	*Silene acaulis*
	Trisetum spicatum

Except for the species mentioned belonging to these four groups, there are a few species that are difficult to classify:

Alchemilla vulgaris	*Mertensia maritima*
Cakile maritima	*Ranunculus auricomus*
Campanula rotundifolia	*Rubus chamaemorus*
Cerastium alpinum	*Saussurea alpina*

Two of these are true sea-shore plants, viz., *Cakile maritima* and *Mertensia maritima.* The former has been found only once in the Isfjorden area in Spitsbergen. The latter is found in many localities in the same area. The species *Alchemilla vulgaris, Campanula rotundifolia, Rubus chamaemorus,* and *Saussurea alpina* could be of a possible anthropochorous origin. However, with the exception of *Campanula rotundifolia,* they have all been found in Svalbard for several years. The occurrence of the two species *Cerastium alpinum* s. str. and *Ranunculus auricomus* in Svalbard is rather doubtful. According to HULTÉN (1956), pure *C. alpinum* does not occur in Svalbard. It can be traced there only as a hybrid ("alpinum hairs") with the two other *Cerastium* species that occur there. It is also an open question whether the plants referred to as *Ranunculus auricomus* coll. should be named *R. auricomus* L. var. *glabrata* LYNGE, *R. pedatifidus* SM. var. *wilanderi* NATH., *R. amoenus* LED., or *R. wilanderi* (NATH.) SPACH. (ANDERSSON & HESSELMANN 1900). This problem needs further investigation.

AMPHI-ATLANTIC SPECIES

Only a few plant species have been studied with such a great plant-geographical interest as the so-called amphi-atlantic plants. These are plants which occur on both sides of the Atlantic Ocean, but are lacking on the Pacific side of the globe. The discussion about these plants has concentrated on the problem of how the plants crossed the North-Atlantic Ocean (DAHL 1958) or whether they in fact ever crossed the Atlantic, as emphasized by the theories of HULTÉN (1958). Therefore, this group of plants, with nearly similar distribution, has been regarded as having the same historical background. The species occurring in Svalbard with an amphi-atlantic distribution can be divided into three groups.

I. The plants in this group have their main distribution in Europe and a rather limited distribution in America and Greenland (eastern species). The following species belong to this group:

Arenaria pseudofrigida	*Deschampsia alpina*
Carex parallela	*Ranunculus glacialis*
Colpodium vacillans	*Taraxacum arcticum*

II. This group of plants has its main distribution in America and a more limited distribution in Europe (western species):

Arenaria humifusa	*Minuartia rossi*
Arnica alpina	*Poa arctica caespitans*
Campanula uniflora	» *hartzii*
Carex amblyorhyncha pseudolagopina	*Potentilla chamissonis*
	» *pulchella*
Carex nardina	*Puccinellia phryganodes groenlandica*
Erigeron humile	*Sagina caespitosa*
Festuca baffinensis	*Salix glauca callicarpaea*
» *hyperborea*	*Sibbaldia procumbens*
Kobresia simpliciuscula	*Silene acaulis*

The species *Carex amblyorhyncha* and *Puccinellia phryganodes* have a circumpolar distribution. However, the subspecies *pseudolagopina* of the former and the "Greenland type" of the latter have a western amphi-atlantic distribution.

III. The third group consists of plants of which the areas in America and Europe are of a comparable size:

Arabis alpina	*Pedicularis hirsuta*
Cassiope hypnoides	*Pleuropogon sabinei*
Cerastium arcticum	*Poa abbreviata*
» *cerastoides*	» *arctica* s.l.
» *regelii*	*Potentilla crantzii*
Draba norvegica	*Salix herbacea*
» *subcapitata*	*Saxifraga aizoides*
Euphrasia arctica	» *flagellaris platysepala*
Festuca vivipara	*Sedum arcticum*
Gentiana tenella	*Stellaria crassipes*
Papaver dahlianum	*Taraxacum cymbifolium*

As a whole, there occur 42 species and 5 taxa of lower rank than species, which have an amphi-atlantic distribution. Of these, 22 have an area of distribution of comparable size on each side of the Atlantic. Only 6 taxa have their main geographical area in Europe or towards the east, while 19 taxa have a pronounced distribution towards the west in America. *Saxifraga flagellaris* s.l. has a circumpolar distribution; however, ssp. *platysepala* (TRAUTV.) PORSILD is amphi-atlantic. Of the amphi-atlantic species known from Svalbard, 27 also occur on Novaya Zemlya.

Only three of these belong to the western (II) group and four to the eastern (I) group. In addition, Novaya Zemlya has 6 amphi-atlantic species with a more southern distribution, which therefore do not occur in Svalbard. They are: *Cerastium alpinum, Epilobium arcticum, Draba sibirica, Primula stricta, Ranunculus auricomus glabratus* and *Thalictrum alpinum.*

Relations with other arctic floras

BØCHER, HOLMEN and JACOBSEN (1957) mention 128 species for North-East Greenland (74°–79°N). Of these, 105 also occur in Svalbard. From Pearyland, North-East Greenland (80°–83°40'N) HOLMEN (1957) lists 96 species, and FREDSKILD (1966) adds seven more, making a total of 103 species represented there. Of these 79 also occur in Svalbard. This corresponds to 82% and 77% respectively, and it means that approximately 80% of the flora of North-East Greenland is common to both areas. From Novaya Zemlya, in the surroundings of Archangel Bay, (75°30'–77°N), a latitude comparable to southern Svalbard, LYNGE (1923) mentions 70 species of which 7 are not reported from Svalbard. It is apparent from the above that Svalbard has 105 species in common with North-East Greenland and 63 species in common with Novaya Zemlya in a comparable latitude. Also the amphi-atlantic plants show clearly the relationship between the floras of these areas and demonstrate a closer connection to the floras towards the west in North America and Greenland.

Endemic species

The number of endemic species occurring in Svalbard is rather low. Only two species, *Puccinellia svalbardensis* and *Ranunculus spitsbergensis,* can be regarded as endemic. But we might possibly add a few taxa of lower rank, such as *Puccinellia angustata* var. *decumbens* (JØRG.) SØRENSEN, *Colpodium vahlianum* var. *pallida* JØRG. (in shed.) and *Arctagrostis latifolia* var. *hirta* DAHL & HADAČ. It is also possible that *Luzula arctica* f. *nana* SCHOL. should be regarded as belonging to this element. There are reasons to think that Novaya Zemlya and Svalbard were once connected by dry land (RØNNING 1959). If we treat Novaya Zemlya and Svalbard together as one area, the number of endemics will increase with the inclusion of *Pedicularis dasyantha* and *Puccinellia phryganodes* (Spitsbergen type) (RØNNING 1962).

Introduced species

In an area regularly visited for more than 300 years and that has been settled for so long, there will always occur several introduced species. Many of them have been found as seedlings in the very same summer as the seeds germinated. Annual species so far north do not have enough time for the seeds to ripen for a new generation, unless they grow under exceptionally favourable conditions near houses or other warm places. Introduced perennial species may on some occasions reach such a degree of maturity that they are able to survive normal winters, and in favourable summers also produce ripe seeds. The introduced species are concentrated in localities near the old settlements. Nearly all plants listed below are confined to the old settlement Virgohamn on Danskøya, or to one or more of the villages Ny-Ålesund in Kongsfjorden, Pyramiden, Longyearbyen, and Barentsburg in Isfjorden.

Only a few species might be regarded as possible addition to the flora. Of these the following should be mentioned: *Capsella bursa-pastoris, Deschampsia caespitosa, Poa pratensis, Matricaria inodora, Ranunculus acris, Rumex acetosa,* and *Rumex acetosella.* Though the same species have been reported from different localities and by different botanists, it is still hard to say whether it has grown or will grow there for more than one season. The question of successive introductions of the same species is still there. To be certain the introduced plants, preferably, should be observed in the same locality several summers in a row, and by the same botanist.

The following is a list of anthropochous species known to the author in Svalbard:

Achillea millefolium L.
» *ptarmica* L.
Agrostemma githago L.
Alopecurus myosuroides HUDS.
» *pratensis* L.
Avena sativa L.
Barbarea vulgaris R. BR.
Capsella bursa-pastoris (L.) MED.
Carum carvi L.
Cerastium caespitosum GIL.
Chenopodium album L.
Conringia orientalis (L.) ANDRZ.
Deschampsia caespitosa (L.) P.B.
Erysimum cheiranthoides L.
» *hieraciifolium* L.
Fagopyrum esculentum MOENCH.
Festuca rubra L. coll.
Galeopsis tetrahit L.
Galium aparine L.
Hieracium L. sp.
Hordeum vulgare L.
Lappula myosotis MOENCH
Lapsana communis L.
Matricaria inodora L.
» *matricarioides* (DESS.) PORTER
Medicago hispida GAERTN.
Melilotus officinalis (L.) LAM.
Myosotis arvensis (L.) HILL.
Phleum pratense L.
Pisum sativum L.
Plantago major L.
Poa annua L.
» *pratensis* L.
» *trivialis* L.
Polygonum aviculare L.
» *convolvulus* L.
Ranunculus acris L.
Raphanus raphanistrum L.
Rumex acetosa L.
» *acetosella* L.
» *longifolius* DC.
Secale cereale L.
Senecio vulgaris L.
Sinapis arvensis L.
Sisymbrium altissimum L.
Sonchus oleraceus L.
Stellaria media (L.) VILL.
Taraxacum WEB. coll.
Thlaspi arvense L.
Trifolium arvense L.
» *hybridum* L.
» *pratense* L.
Vicia angustifolia (L.) REICH.

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Polar bear investigations in Svalbard 1968 to 1969

A progress report. III

BY

THOR LARSEN[1]

Abstract

Thirty-two polar bears were successfully trapped and marked during one month's summer expedition to Svalbard in August 1968. Bear studies continued from a station in Tjuvfjorden until August 1969. Bears were trapped in foot snares while roaming around the camps, or chased with ski-doo or dogs.

Of a total of 103 marked bears in Svalbard, there have been 32 confirmed recoveries, one control, and one resighting. Monel metal tags cause infections and will not be used in the future. Nylon rototags show almost no wear after two years.

Outside southern Edgeøya there is a westward migration of bears in the autumn, and an eastward migration in the spring. The bears seem to avoid the inland and frozen fjords. Only half a dozen denning females were registered. Two temporary dens were found.

There is need for additional marking of bears in Svalbard. Telemetry techniques should be introduced in the study.

Introduction

A planned winter expedition for continued research on polar bears (*Ursus maritimus*) in Svalbard 1968–69, was preceded by a summer expedition for trapping and handling bears. Prior to 1968, efforts had been made to develop safe methods for polar bear trapping in Svalbard. During the two summer expeditions, 1966 and 1967, a total of 55 bears had been successfully trapped and marked (LARSEN 1967, 1969).

Methods

Summer expedition 1969

The field research and bear trapping program followed the pattern developed the previous summers. A 90 ft., 430 h. p. commercial sealer, «Polstjerna», was chartered for one month's work in August. The ship carried a cage on deck and

[1] Institutt for Marin biologi avd. A, Universitetet i Oslo, Frederiksgt. 3, Oslo 1.

a laboratory on the upper aft deck. The laboratory facilities were the same as those of the previous summer expeditions. Dr. A. W. ERICKSON from the University of Minnesota and Dr. C. JONKEL from Canadian Wildlife Service participated in the field studies. Mr. E. FLIPSE from the Netherlands participated as observer. Mr. E. SCHUMACHER and Mr. H. BOPST from Germany participated as photographers for the World Wildlife Fund. On 14 August director T. GJELSVIK of Norsk Polarinstitutt followed the bear trapping from «Polstjerna».

Most of the bears were hunted when in the sea. A 14 ft. boat with a 9½ h.p. outboard motor was used for this purpose. They were stalked on foot only occasionally, and then with the help of a Siberian husky. This dog had been trained to chase bears, and could hold them until the hunter came close enough to fire the syringe gun. The dog was even able to keep family groups together.

All bears were immobilized with Sernylan (Parke Davis & Co., England), except in one case when Etorphine (Reckitt & Sons Ltd., England) was used. The marking and sampling program was as in 1967. In addition, a first premolar was pulled, on each subadult and adult bear trapped, for later sectioning and age determinations. The penis was extruded on male bears, and the length of the penisbone was measured in order to estimate age.

Winter expedition 1968–69

In early September 1968 a winter base was established in Tjuvfjorden on Edgeøya. Tjuvfjorden was chosen because polar bears are abundant outside southern Edgeøya in winter, and because there were several reports about polar bear denning on Negerpynten (LØNØ 1970). The trapping station on Halvmåneøya was used as a secondary station, and was manned by one or two men most of the winter. From the stations long field surveys could be performed with skidoo and dog teams. This fact made Tjuvfjorden more attractive than Kong Karls Land, which previously had been chosen for the winter study.

The winter party consisted of four members, namely the author with assistant KJELL REIDAR HOVELSRUD (ecological investigations) and cand. real. NILS ARE ØRITSLAND with assistant TOR ALF ANDERSEN (physiological investigations). A trappers cabin was rebuilt and insulated, and a prefabricated hut was erected beside it. The station was ready by late October 1968, and consisted of living-room, kitchen, laboratory/workshop and store-rooms in the old hut, and separate quarters, laboratory and store-room in the new building.

Trap lines of 23 foot snares were built in Tjuvfjorden/Halvmåneøya and run through the winter (Fig. 1). The traps were of a type developed by Dr. C. JONKEL for polar bear trapping in Hudson Bay (JONKEL 1967). But drifting snow filled the pens after only the slightest breeze, and the traps had to be modified. The new trap resembled the traditional Norwegian polar bear set-gun. The bait, a piece of seal blubber, was placed in a box on top of four logs. The snare was mounted between the two front logs underneath the bait, and marked with sticks (Fig. 2). This system operated even during storms, because the snow did not pack on or around the snare loop.

The traps in Bjørnbukta east of the station were connected to a wire warning

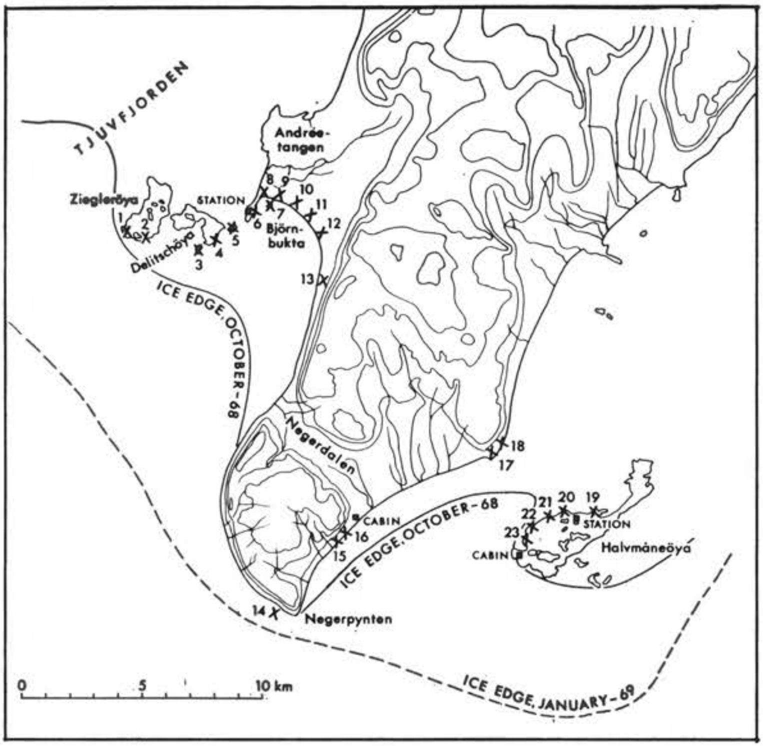

Fig. 1. *The southern part of Edgeøya where the winter base was established.*
x=*polar bear trapsites,* ——=*ide edge October 1968,* - - -=*ice edge January 1969.*

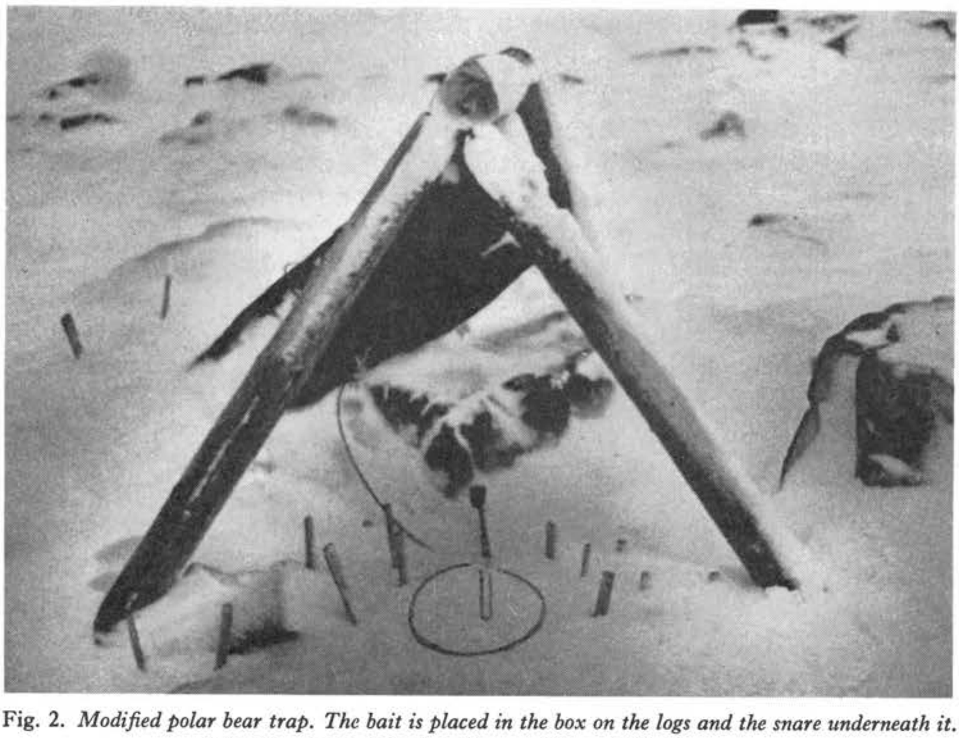

Fig. 2. *Modified polar bear trap. The bait is placed in the box on the logs and the snare underneath it. The sticks prevent the bear from stepping outside the snare.*

system, which would set an alarm in the station when one of the traps was triggered. But the wire was damaged by frequent storms, and had to be abandoned. Instead, the traps were checked daily on skis or with the dogs.

The ice came very early in 1968. Tjuvfjorden froze in early October, and it was possible to cross over to Halvmåneøya on 13 October. We travelled across Dyrdalen and Guldalen to Kapp Lee with ski-doo and a dog team in the last week of the month, when there was sufficient snow and good travel conditions. In midwinter, travelling was limited to eastern Tjuvfjorden, Negerdalen and the vicinity of Halvmåneøya and was often prevented by heavy storms. Travelling became more frequent from late February and onwards, when migratory studies and den surveys received high priority. From late March and onwards, a camp was erected on Negerpynten for the study of bear migration past the steep cliffs there and the open water less than five hundred meters to the south.

During the den surveys, hillsides, valleys and riverbanks were carefully surveyed. Some areas were searched by one man on skis and one or two dogs, and often several times. Others were surveyed regularly with binoculars, looking for openings or tracks.

Results and discussion

In August 1968, there were only 12 days of acceptable weather and ice conditions. A total of 32 bears were trapped and handled, of which one was a recovery of a bear marked the previous summer (No. 337). Best result was obtained on 20 August, when six bears were trapped in seven hours. No bears were killed due to handling.

In winter, a total of six bears were taken by means of the traps, and there were in addition eight visits. Why trapping efficiency was so low, is probably explained by the extreme ice conditions in 1968–69. The bears followed the edge of the ice further south, and avoided the frozen fjord and the inland areas. The traps were mainly visited from early February and onwards, when the bears started on their eastward migration. But between 26 February and 13 April the traps were demounted when the long sledge journeys began.

Six bears were trapped by means of a ski-doo, and another six were taken in the free in or around the camps. Previously we had found that polar bears in the pack can sometime be hunted down on foot in summer (LARSEN 1969). This was impossible in winter, and we even had difficulties in following the bears with the ski-doo. The polar bear's thermoregulation during exercise is probably better adapted to winter conditions, and excess heat produced does not present the same problem as in summer.

Observations outside Negerpynten and Kvalpynten show that the polar bears in this area migrate westwards in the autumn and eastwards in the spring. The eastward migration was very much in evidence in 1969. Tracks were very abundant outside Kvalpynten, and from our camp at Negerpynten we saw up to five bears pass by the cliffs every day, until the first week of May. Then the trek suddenly decreased. Afterwards, observations of bears passing by were only occasional. The observations of the migratory patterns were in agreement with aerial surveys performed over the eastern Svalbard waters in 1966 and 1967 (LARSEN 1966).

Signs of bears were less frequent inland after the sea had frozen in Tjuvfjorden and in Storfjorden. It seemed to us that the bears tended to follow the ice edge from Negerpynten to Kvalpynten and towards Sørkapp, and vice versa. Observations made on our sledge travels, as well as by the Dutch winter expedition on Kapp Lee, showed that some bears also pass through Freemansundet in winter.

Den surveys were concentrated on the western shorelines and valleys of Edgeøya and Barentsøya, between Kong Johans Bre in the south and Frankenhalvøya in the north. Parts of Storfjorden and Agardhbukta were also searched. Negerpynten, Kvalpynten, and Freemansundet were, in particular, carefully investigated.

Weather conditions in March, April, and May were generally good, and made spotting and track observations easy. But although a considerable effort was spent on locating denning sites in the spring 1969, only half a dozen denning females were registered. This was surprising, inasmuch as conditions were favourable for denning in the fall of 1968 on Edgeøya. The early winter ice and the abundance of snow early in winter should encourage denning. Some dens may certainly have been overlooked, as they are sometimes very difficult to observe. But even so, the scarcity of dens on Edgeøya is remarkable compared to the abundance of dens on Franz Josef Land further east. According to PAROVŠČIKOV (1964), dens are found on these islands with less than 2 km between them; totalling 150–200 dens on the archipelago. Aerial surveys over Kong Karls Land and the field investigations on Edgeøya and Barentsøya 1968–69 indicate that polar bear denning in the eastern Svalbard area is far less frequent.

LØNØ (1970) states that only pregnant polar bear females den in Svalbard. But in late winter, we found two temporary dens; one in Negerdalen and another at an iceberg in Tjuvfjorden. The first had been occupied by a young animal for several weeks at least. The other had been used a short time only, and probably by a male bear. The reasons for their denning is not known, but may have been caused by storms.

So far, a total of 103 polar bears have been successfully trapped and tagged in Svalbard. The mortality rate was less than 4%, and will probably be less in the future with the experience gained. (Two bears have been killed by syringe impact injuries, one has drowned, and one died from the secondary effects of Sernylan.) By August 1970, 32 recoveries, one control, and one observation of marked bears have been reported. One recovery is from Nanortalik in SW Greenland, the rest are from Svalbard. The control was made by the 1968 summer expedition and one marked bear was spotted by a helicopter pilot at Kong Karls Land.

The tags from the polar bears recovered were all in good shape, as far as we know. Some of the nylon rototags show no wear at all after two years' use, the monel metal tags, however, seem to cause infections; probably due to frost, irritation or a combination of both factors. The nylon tags seem to be of a better quality than those used in the Alaskan polar bear study, which often break or get lost (LENTFER 1970).

Final remarks

Although data obtained from the polar bear tagging program in Svalbard have been valuable, there is a need for more polar bear marking in the future. The best results would undoubtedly be obtained by a combination of boat and small helicopter, as previously outlined (LARSEN 1969).

Telemetry techniques should be introduced in the polar bear study in order to study bears' migration and activity. Radio collared bears can easily be spotted from the crows nest of a ship or from an aircraft. Spotting could also be done by the weather stations in Svalbard.

PAROVŠČIKOV (1964) states that there is a connection between the polar bears in Svalbard and those in the western Soviet Arctic. VIBE (1967) shows the correlation between seal and polar bear abundance and ice conditions, and states that ocean currents and ice drift are important factors in polar bear migration and abundance. The ice conditions between Svalbard and Franz Josef Land favour polar bear migration between these archipelagos, and it is reasonable to regard them as one geographical unit. The theory that polar bears in Svalbard, Franz Josef Land, and Novaya Zemlya belong to the same population, cannot be overlooked. But as the polar bear is protected in the Soviet Arctic, we cannot expect recoveries of marked bears there. On the other hand, marking, sampling, and telemetry studies in the Soviet Arctic may give us the answers we are looking for.

Acknowledgements

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Some observations on Coleoptera, Hymenoptera and Siphonaptera in Svalbard 1968

BY

SIGMUND HÅGVAR[1]

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Abstract

Coleoptera, Hymenoptera and Siphonaptera collected in Svalbard during 1968 are discussed here. New localities are given for the following Coleoptera: *Atheta graminicola* GRAV., *Atheta subplana* J. SAHLB., and *Rhynchaenus flagellum* ERICS. A larva of *Simplocaria* sp., found together with a dead specimen of *Simplocaria metallica* STURM, indicates that this species can perform its life cycle in Svalbard. Probably no Coleoptera exist that are typical inhabitants of the Svalbard tundra. On the contrary, there seems to be a strong correlation between the colonies of breeding birds, richly developed vegetation, and the occurrence of Coleoptera. Here also most of the Hymenoptera were found. One species of Siphonaptera, *Mioctenopsylla arctica* ROTHSCHILD, is mentioned.

Introduction

In connection with the activity of Norsk Polarinstitutt in Svalbard during the summer of 1968, I got the opportunity to study and collect some land arthropods on the west coast of Spitsbergen and on Prins Karls Forland. A part of this material will be discussed here.

[1] Zoological Laboratory, University of Oslo, Blindern, Oslo 3.

Coleoptera

The Coleopter fauna of Svalbard has earlier been studied by STRAND (1942), REMMERT (1966), and KANGAS (1967). During my own collecting work, four species were found of which *Simplocaria metallica* STURM was new to Svalbard.

Simplocaria metallica STURM

A dead specimen was found near the bird rock in Ossian Sarsfjellet, Kongsfjorden 23 July. The specimen and the habitat is described and discussed by STRAND (1969). At a later analysis of the collected material, a Coleopter larva, which might be a *Simplocaria* sp., was found. It had been collected in the same place as the imago and at the same date. The larva was sent to Fil. Dr. THURE PALM, Uppsala, who did not hesitate to place it in the genus of *Simplocaria*. As no other species in this genus, and even in the whole family of Byrrhidae, has been found in Svalbard, it is highly probable that it is the larva of *Simplocaria metallica*. This should mean that the species can perform its life cycle in Svalbard. Unfortunately the larva was destroyed when sent back from Uppsala.

Atheta graminicola GRAV.

The species has earlier been found numerous among leaves of *Betula nana* L. and also on snow in Colesbukta. One individual has been found among algae and the leaves of *Salix polaris* WAHLENB. etc. on the beach of Grønfjorden (STRAND 1942).

My own findings all represent new localities for the species:

Kongshamaren, Krossfjorden 13 July, 6 ind. under bird rock. Rich vegetation, dominated by *Cochlearia officinalis* L. Under stones.

Juttaholmen, Kongsfjorden 19 July, 1 ind. among nests of Eider (*Somateria mollissima* (L.)). Rich vegetation of grass. Under stone.

Gerdøyane, Kongsfjorden 20 July, 5 ind. near the beach. Humid, much moss. Under stones.

Irgensfjellet, Kongsfjorden 22 July, 2 ind. under bird rock. Rich vegetation. Under stones.

Ossian Sarsfjellet, Kongsfjorden 23 July, 3 ind. near bird rock. Rich vegetation. Under stones.

Atheta subplana J. SAHLB.

The species has earlier been found between leaves of *Betula nana* in Colesbukta. It has also been found in Adventfjorden (STRAND 1942).

My own findings all represent new localities for the species:

Signehamna, Lilliehöökfjorden, Krossfjorden 14 July, 4 ind. under bird rock. Rich vegetation; much *Cochlearia officinalis* and moss. Under stones.

Irgensfjellet, Kongsfjorden 22 July, 2 ind. under bird rock. Rich vegetation. Under stones.

Ossian Sarsfjellet, Kongsfjorden 23 July, 2 ind. near bird rock. Rich vegetation. Under stones.

Rhynchaenus flagellum ERICS.

Earlier records: Colesbukta (numerous among leaves of *Betula nana*); Gerdøyane, Kongsfjorden (numerous between leaves of *Salix reticulata* L.); Adventdalen and Moskushamn (numerous among moss and *Salix polaris*) (STRAND 1942). Also KANGAS (1967) mentions findings from Adventdalen.

Among the localities that I discovered, Gerdøyane is known from before. Seven ind. were found 20 July under stones in a dry place on the top of the island. The vegetation consisted of moss, lichens, grass, *Dryas octopetala* L. and *Salix* sp. The other two localities are new to the species:

Midtholmen, Kongsfjorden 19 July, 1 ind. under stone. Rich vegetation with much moss.

Ossian Sarsfjellet, Kongsfjorden 23 July, 2 ind. just above the bird rock, 1 ind. escaped. "Medium" humidity, richly developed moss and *Salix* sp. Under stones.

Discussion on habitat choice and occurrence of Coleoptera in Svalbard

It is improbable that species exist, which are specific for the typical tundra areas in Svalbard. Of the seven species which have been identified with certainty, *Atheta graminicola, Atheta subplana, Rhynchaenus flagellum* and *Simplocaria metallica* have been found only where the vegetation is especially well developed. *Micralymma marinum* STRØM, which is believed to have reached Svalbard by the Golf stream, is probably bound to the beach with its special conditions (upwelled algae, etc.). STRAND (1942) mentions the species from Isøyane, and REMMERT (1966) from the beach at Ny-Ålesund. The species cannot be said to belong to the typical tundra. KANGAS (1967) lists two more species, *Oryzaephilus mercator* FAUV. and *Atomaria lewisi* REITT. The first species was found in a packet of biscuits in a hut and is probably imported. The other species, however, was found on dry tundra, and the author says that the locality does not suggest importation. KANGAS points to the fact that the species in the last decades has had a great expansion in Europe. I think that there is a possibility that the species can survive on the Svalbard tundra. This type of habitat is, however, very special for *Atomaria lewisi.*

During the summer of 1968, I placed some pitfalls at four localities on the Svalbard tundra to collect possible Coleoptera. The traps had a diameter of about 7–10 cm. If we for each locality multiply the number of traps with the number of days each of them were working, we get the following number of "effective days": Isfjord Radio 14 days (23–27 June); Levinhamna, Prins Karls Forland 17 days (2–8 July); Signehamna, Krossfjorden 3 days (14–17 July), and Ny-Ålesund 13 days (18–31 July). Altogether this makes 47 days. No Coleoptera were caught.

At these localities a lot of stones were turned over and flowers and vegetation were examined, etc. This activity covered approximately the following hours: Isfjord Radio 3 hours (13–24 June); Levinhamna, Prins Karls Forland 4 hours (30 June–6 July); Signehamna, Krossfjorden 4 hours (11–16 July), and Ny-Ålesund 2 hours (10 and 18 July). This makes about 13 hours of thorough searching on the tundra, but no Coleoptera or Coleopter larvae were seen.

At Isfjord Radio I also examined (by flotation in water) a rotten Glaucous gull (*Larus hyperboreus* GUNN.), an old nest of Eider, ten dense tussocks of *Saxifraga oppositifolia* L., and excrements of reindeer. In addition bodies of polar bear and seals, which had been skinned and hung up, were examined, and also a dead White whale (*Delphinapterus leucas* (PALL)). No Coleoptera had been attracted to any of these "traps".

However, when examining habitats with a well-developed flora, the picture changed markedly. Especially the areas in the immediate vicinity of bird rocks, with their layers of guano, possessed a rich vegetation. Very often *Cochlearia officinalis* dominates in such places. Dense vegetation of grass, moss and *Salix* sp. is common. Even *Taraxacum* sp. may be present. In the distance the intense green slopes under the bird rocks can be seen. The humidity of the earth is high. As the rock is often very loose, a lot of small stones are present on the ground among the vegetation. This makes a good habitat for many Coleoptera.

Four big bird rocks were investigated and Coleoptera were found in the vicinity of all of them, mostly by turning stones. After a comparatively short time, I got the following good results:

Signehamna, Krossfjorden: 4 *Atheta* sp. during about 2 hours.
Kongshamaren, Krossfjorden: 6 *Atheta* sp. during about ½ hour.
Irgensfjellet, Kongsfjorden: 4 *Atheta* sp. during about ½ hour.
Ossian Sarsfjellet, Kongsfjorden: About 20 *Atheta* sp., 2 *Rhynchaenus flagellum* and 1 *Simplocaria metallica* during about 2 hours.

Some larvae of *Staphylinidae* (probably *Atheta* sp.) were also found. From Ossian Sarsfjellet only 5 *Atheta* sp. were taken care of. Under one stone (about $20 \times 10 \times 3$ cm) at the base of the bird rock, 7 *Atheta* sp. were seen.

The islands in Kongsfjorden also represent habitats with well developed vegetation because of the excrements from colonies of breeding Eiders. On these islands, 6 *Atheta* sp. and 8 *Rhynchaenus flagellum* were found after about 3½ hours of searching. Surprisingly no Coleoptera were found on Hermansenøya, Forlandsundet (about 2 hours) and Forlandsøyane (about 1 hour), although these islands have a well-developed vegetation as a result of guano deposits from Eiders and geese.

However, there seems to be a strong correlation between the concentrations of breeding birds and the occurrence of Coleoptera, and other insect groups (e. g. Hymenoptera). The birds' breeding colonies are the places where one should look for more species of Coleoptera in Svalbard. I think that new species will still be found.

Hymenoptera

Ichneumonidae

The following species were found: *Aclastus borealis* (BOHEMAN), *Stenomacrus pedestris* (HOLMGREN) ♀ and *Stenomacrus nigricornis* (BOHEMAN) ♀. Males of the genus *Stenomacrus* were also found, but it was not possible to identify these.

All three species have been found earlier near the beach at Ny-Ålesund (REMMERT 1966) in places where the vegetation was poor. However, I also found the species in habitats with richly developed vegetation. Generally the animals were taken under stones, but some were also found in flowers of *Dryas octopetala* and *Taraxacum* sp.

Most of the individuals were found at the base of bird rocks. Under the bird rock in Ossian Sarsfjellet, Kongsfjorden, the following species were found: *Aclastus borealis* (5♀♀), *Stenomacrus pedestris* (9♀♀) and *Stenomacrus* sp. (5♂♂). Under the bird rock in Signehamna, Krossfjorden, *Stenomacrus nigricornis* (1♀) and *Stenomacrus* sp. (1♂) were found.

On the islands in Kongsfjorden, with their well-developed vegetation (e.g. grass, *Salix* sp., and dense layers of moss), these species were collected: *Aclastus borealis* (Sigridholmen 1♂); *Stenomacrus pedestris*♀ (Midtholmen 1 ind., Sigridholmen 2 ind. and 1 ind. on an islet just outside Irgensfjellet); *Stenomacrus* sp.♂ (Sigridholmen 1 ind.).

Apart from the area of Ny-Ålesund and Kongsfjorden, Ichneumonidae were found at Signehamna, Krossfjorden. In addition to the individuals already mentioned from this locality, *Stenomacrus pedestris* (1♀) and *Stenomacrus* sp. (1♂) were found in flowers of *Dryas octopetala* on the tundra about 1 km from the bird rock.

All records of Ichneumonidae were made between 13 and 28 July.

Tenthredinidae

One individual of *Pristiphora frigida* BOHEMAN was found dead on the snow at Ny-Ålesund 10 July. REMMERT (1966) mentions the species from the same locality.

Siphonaptera

One specimen of *Mioctenopsylla arctica* ROTHSCHILD was taken on the wall of the bird rock in Signehamna, Krossfjorden 11 July. In the vicinity only Kittywakes (*Rissa tridactyla* (L.)) bred, but Brünnich's guillemot (*Uria lomvia* (L.)) also bred in the same bird rock. The species has been found earlier in Svalbard by Russian zoologists (REIDAR MEHL, pers. comm.). REIDAR MEHL will at a later date treat these findings more thoroughly.

Acknowledgements

I want to express my deepest gratitude to the following persons for identification of the material: Dr. phil. h.c. A. STRAND (Coleoptera, imagines), Fil. Dr. TH. PALM (Larva of *Simplocaria* sp.), Dr. KLAUS HORSTMANN (Ichneumonidae), Mag. E. LINDQVIST (Tenthredinidae), and Cand. real. REIDAR MEHL (Siphonaptera). I would also like to thank Dr. W. HELLÉN for helping me to find experts on the different Hymenoptera groups. And finally, biologist MAGNAR NORDERHAUG, Norsk Polarinstitutt, is heartily thanked for making it possible for me to carry out my collecting work.

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Some notes about birds and mammals in Svalbard, summer 1969

BY

JEAN-FRANÇOIS VOISIN[1]

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Abstract

The present paper summarizes fauna observations by the author, participant in the French Paleontological Expedition to Svalbard in summer 1969. The observations are mainly from the north-western part of Spitsbergen (Raudfjorden, Liefdefjorden, and Woodfjorden) and from Dicksonfjorden. Furthermore, some observations from Tjuvfjorden, Edgeøya, are mentioned.

Acknowledgements

I am greatly indebted to professor J. P. LEHMAN, the chief of our expedition, for being allowed to participate. I must also thank captain TRIGGER who had the command of M/S «Nordsel», and my comrades, especially those whose names appear in the text, for their collaboration and good fellowship.

I am very grateful to Mr. P. OSBORN who corrected my English.

Introduction

The present observations were made during the French Paleontological Expedition to Svalbard, summer 1969. As zoological work was only a secondary part of the expedition, my observations are not always so complete as could have been desired. Where common species are concerned, like the Kittiwake or the Glaucous Gull, only the most important of my observations are mentioned.

[1] 57 rue Cuvier, PARIS 5[0], France.

Mammals

Reindeer (*Rangifer tarandus platyrhynchus*)

On the slopes of Sigurdfjellet, Woodfjorden, numerous foot-prints, excrements, hairs, and horns were found (20–24 July). Five animals had gone along the strand at the foot of Sigurdfjellet only a few days before we came. Professor JARVIK told me he saw neither reindeer nor evidence of their existence when he stayed on Sigurdfjellet during the summer 1939. Neither LØNØ (1959), A. HEINTZ (1964), nor NORDERHAUG (1969) noted the presence of reindeer in this area.

No fresh evidence of the presence of reindeer was seen in Woodfjorddalen (24–28 July). Some bones and horns were discovered, but all of them were old; however, a party found one carcass with skin and flesh on Wagnerfjellet (FISCHER).

On the mountain Kronprinshøgda considerable evidence of reindeer activity was found (29–31 July). From the sea level to the ridge at the top at least four adults and a calf had gone a few days before my arrival. A herd of five adults was seen on 31 July at Kapp Kjeldsen (HEINTZ, FISCHER, CALLAS). There was probably another herd in the valley in front of Stjørdalen.

The party which worked on Roosfjella and Germaniahøgdene saw plenty of reindeer on 31 July. From helicopter observations the proportion of calves was estimated to be about 30% of the total population (DEFLANDRE).

The occurrence of reindeer between Jakobsenbukta and Sørlifjellet (31 july–9 Aug.) is confirmed by tracks, hairs, etc., at least as numerous as on Kronprinshøgda. A herd of seven animals, three of which were calves, was seen on 8 Sept. in Verdalen. Other reindeer were seen near the shore on the slopes of Sørlifjellet and of Prismefjellet (GINSBURG, FISCHER).

A herd was seen several times during our stay between Lilljeborgfjellet and Raudfjordbreen (Raudfjorden). There were one male and three females with young. Tracks were seen everywhere. Professor JARVIK (pers. comm.) had not seen any reindeer in this place during the summer 1939.

No reindeer were seen in the areas of Dicksonfjorden, Ekmanfjorden, and Billefjorden (12–19 Aug.). No tracks were found either, except a few old bones and horns, and the skull of a very young stag found on Borgen, dating back a few years ago.

Muskox (*Ovibos moschatus*)

On 25 Aug. a herd of 14 musk-oxen was observed in the delta of Ugledalen in Adventdalen. Four of these animals were calves.

Arctic fox (*Alopex lagopus*)

Some foxes were seen: 24–26 July at the foot of Wagnerfjellet (LEHMAN); 2 Aug. at the foot of Ben Nevis; 8 Sept. two young ones on Sørkollen (HEINTZ, FISCHER, CALLAS); 8 Sept. "about 15 individuals most of them young", near Camp Morton (RUSSEL, JANVIER).

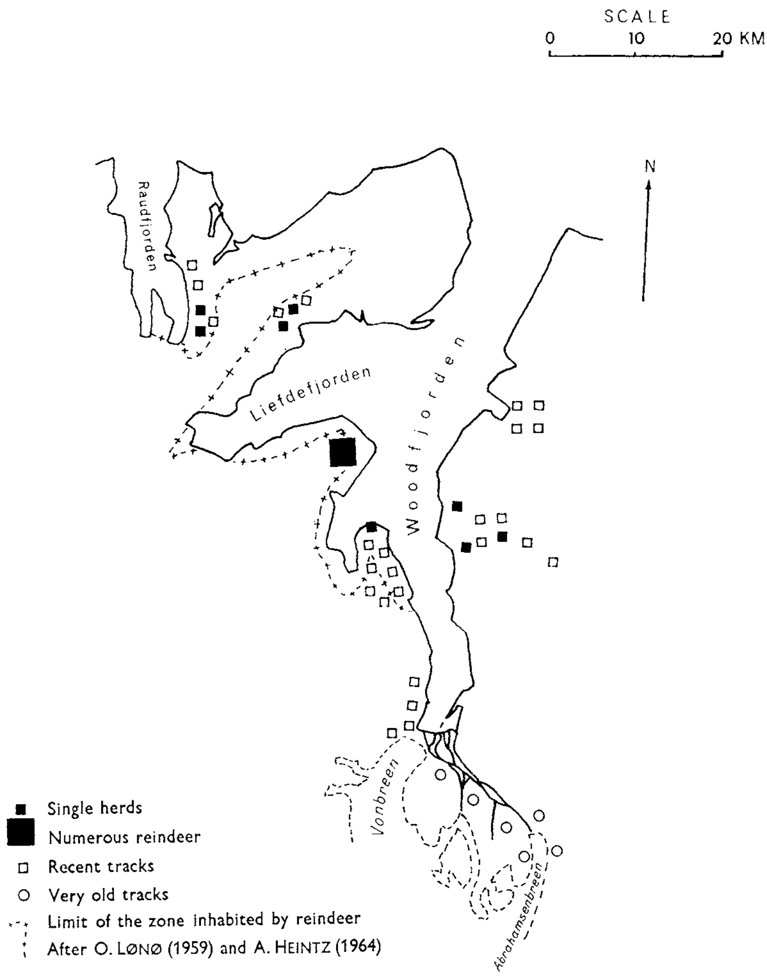

Fig. 1. *Observations of reindeer in NW Spitsbergen.*

Birds

Black-throated Diver (*Gavia arctica*)

Two Black-throated Divers were observed on 1 Sept. in the outer part of Tjuvfjorden.

Fulmar (*Fulmarus glacialis*)

A colony of Fulmars was seen in one of the mountains on the western side of the glacier Abrahamsenbreen, probably on the southern edge of Marinova, Woodfjorden. I saw from a helicopter two Fulmar nests on the western slope of that mountain about 600 m a.s.l.

A few nests, not more than half a dozen, of Fulmars were established on the upper ledges of the rock supporting the Kittiwake colony on Kronprinshøgda (see below).

In the Dicksonfjorden area I saw two colonies of Fulmars. The first one was established on Borgen at about 650 m a.s.l. There were nests almost everywhere in the chalky rocks lying at the top, but their greatest concentration was on the southern edge of the mountain. I counted about one hundred nests there.

I found the second colony much more important. It was situated on the eastern side of Dicksonfjorden at the top of Tåkefjellet and of Gangerolvfjella. The nests were most numerous in the small valley between these mountains. Several hundred Fulmars might have been nesting there.

Eider (*Somateria mollissima*)

Eiders were abundant at the bottom of Woodfjorden (20–29 July). The drakes in particular used to gather in big flocks of 51 (22 July) to 60 (23 July) birds, flying from the sea to the middle of Poninskiøyra. On 27 July two nests, each containing 4 eggs, were found on the little island off Poninskiøyra. About 30 ducklings were seen at the same place.

Curiously enough, at least two ducks resided up in Woodfjorddalen 14 km from the sea (27–28 July).

In Raudfjorden the ducks were numerous in the river deltas from Raudfjordbreen to Lilljeborgfjellet (1–6 Aug.). I counted up to twenty in the delta of the river which flows between Frænkelryggen and Ben Nevis. I found only one nest (4 Aug.) with four eggs in it. It was located more than 1 km from the sea in a little bog formed by the river. Shells of two emptied eggs were found at a short distance from it (4–5 Aug.).

No ducklings were seen in Raudfjorden.

King Eider (*Somateria spectabilis*)

On 10 Aug. a drake was observed in Zeppelinhamna, Ny-Ålesund.

Barrow's Goldeneye (*Bucephala islandica*)

Although I have not seen this bird in Spitsbergen during the summer 1969, I find it of interest to mention here an observation from 13 July 1963. At this date I saw a pair of Barrow's Goldeneyes resting on the sea off Revneset (Isfjorden). Before this observation the species was recorded only once from Spitsbergen, viz. by Schweitzer (1966) in Tempelfjorden in July 1961. Another *Bucephala,* without species determination, was seen in July 1965 at Nordre Dunøya (N. HEINTZ and NORDERHAUG 1967).

Pink-footed Goose (*Anser fabalis brachyrhynchus*)

Fourteen geese were seen standing near the shore at the foot of Sigurdfjellet, Woodfjorden (21 July). A goose, lying on four eggs, was found on a grassy slope of that mountain (FISCHER).

I found abundant evidence of geese activity (excrements, foot-prints, feathers) in the bogs at the foot of Sørkollen, Liefdefjorden (7 Aug.). A flock of about 15 Pink-footed Geese was seen there.

Also in Raudfjorden evidence of geese activity was found in the boggy area at the foot of Lilljeborgfjellet (7 Aug.).

Though I saw none, there was evidence that geese lived in the mud-flats at the mouth of Dicksondalen (visited 12–19 Aug.).

In Nathorstdalen, at the foot of Citadellet, I found a place where geese had stayed for a long while and had possibly bred (18 Aug.).

Brent Goose (*Branta bernicla hrota*)

On 31 Aug. I observed three Pale-breasted Brent Geese from a helicopter. They were flying above Zieglerøyane (Tjuvfjorden).

Ptarmigan (*Lagopus mutus hyperboreus*)

I found evidence of the presence of the Ptarmigan (excrements, feathers, dust-baths) on the slopes of Sigurdfjellet, of Marinova, and of Kulissene, Woodfjorden (20–28 July). Most of it was found between 200 and 500 m a.s.l.

Plenty of tracks of Ptarmigan were found on Kronprinshøgda 29–31 July. A hen with a clutch of 9 chicks was seen by a party on Kapp Kjeldsen (FISCHER).

A lot of tracks of this species was found on Sørkollen and on Siktefjellet, Liefdefjorden, 1–7 Aug. A hen with a clutch of 7 chicks was seen on 7 Aug. on the slopes of Sørkollen and another with at least 8 chicks was seen on 8 Aug. on the top of this mountain (HEINTZ, FISCHER, CALLAS).

In Andrée Land, between Jakobsenbukta and Sørlifjellet, no Ptarmigans were seen, only tracks were found (31 July–8 Aug.).

Tracks of Ptarmigans were to be found everywhere between Lilljeborgfjellet and Raudfjorden (Raudfjorden 1–6 Aug.). A hen with a clutch of 7 chicks resided at the foot of Ben Nevis (CALLAS).

I found plenty of Ptarmigan tracks on both sides of Dicksonfjorden (12–19 Aug.). I discovered two nests from last spring on the western slope of Borgen. On the east side of the mountain, at about 500 m a.s.l., I observed a hen with 5 chicks and, a few minutes later, a cock. In Nathorstdalen, on 18 Aug., I encountered a hen with only two chicks at the foot of Sophus Liefjellet, and heard another bird in the vicinity.

The members of the party which stayed in the Van Mijenfjorden area (19 July–18 Aug.) found numerous Ptarmigans on Rypefjellet and on Kolfjellet. There were many chicks (RUSSEL, JANVIER, MICHAUD).

Ringed Plover (*Charadrius hiaticula*)

Three or possibly four pairs of Ringed Plovers had settled quite near a colony of Arctic Terns at the eastern edge of Ny-Ålesund. I found neither young nor eggs, but at least one pair showed a territorial behaviour.

In Longyeardalen a Ringed Plover used to stay in the small river-arm close to Sverdrupbyen. I saw another Ringed Plover (22 Aug.) on the river banks near Gamlebyen.

Turnstone (*Arenaria interpres*)

On 10 Aug. I observed an immature Turnstone on the shore near Ny-Ålesund.

Purple Sandpiper (*Calidris maritima*)

On Sigurdfjellet, Woodfjorden, this bird was as common as in Isfjorden. In Woodfjorddalen it became less and less frequent as the distance from the sea increased. Nevertheless, I saw three of them on the slopes of Marinova and Kulissene, quite near the moraines of Abrahamsenbreen. I found an old nest at the foot of Marinova.

The Purple Sandpiper was common on Kronprinshøgda, where I found a recently used nest on 29 July. It was also common on Roosfjellet (LEHMAN), on Sørkollen, and on Siktefjellet (FISCHER).

In Andrée Land, between Jakobsenbukta and Sørlifjellet, the Purple Sandpiper was common too. I found a chick in Verdalen on 9 Aug.

The species was commonly seen in Raudfjorden, and a newly hatched chick was found at the foot of Ben Nevis on 5 Aug.

The purple Sandpiper was not common in Borgdalen, Dicksonfjorden, where I saw only half a dozen of them. On the contrary, they were common on both sides of Dicksonfjorden and in Nathorstdalen, where I observed a young not fully fledged (18 Aug.).

Dunlin (*Calidris alpina*)

I saw with certitude only one pair of Dunlins (17 Aug.), viz. at the foot of Brenna, Dicksondalen.

Grey Phalarope (*Phalaropus fulicarius*)

A male of this species was observed on 10 Aug. at Ny-Ålesund.

Pomatorhine Skua (*Stercorarius pomarinus*)

Only once did I see the Pomatorhine Skua in Spitsbergen in 1969, viz. at the entrance of Isfjorden on 18 July. On the contrary, this bird seemed to be fairly numerous in Storfjorden during August 1969. During the afternoon of 31 Aug. I saw 41 of them in seven passages: 1, 11, 6, 1, 5, 14, and 3 birds respectively. Among them I noticed 12 juveniles, about 1/3 of the total number.

All these Pomatorhine Skuas followed the northern shore of Tjuvfjorden, to the east, and were surely on migration.

Arctic Skua (*Stercorarius parasiticus*)

All the birds I observed were in pale phase.

I observed three birds of the species at the foot of Sigurdfjellet, Woodfjorden, on 22 July.

A pair of Arctic Skuas was seen near the Kittiwake colony at the top of Kronprinshøgda 30 July (GOUJET). I observed another pair in the delta in front of Stjørdalen 31 July.

In Dicksonfjorden I saw only one Arctic Skua, flying along the foot of Borgen on 16 Aug.

In the end of August I saw 15 Arctic Skuas north of Zieglerøyane, Tjuvfjorden.

In the afternoon the same day I counted 19 of these birds following the same route as the Pomatorhine Skuas. They went in four passages: 15, 2, 2, and 1 bird respectively.

Glaucous Gull (*Larus hyperboreus*)

At the bottom of Woodfjorden there were always Glaucous Gulls to be seen in the deltas, but I never counted more than 25 at one time.

In Woodfjorddalen I found two nests of this species on the slopes of Marinova.

In Dicksonfjorden a pair of Glaucous Gulls had settled in the vicinity of the colony of Fulmars on Borgen.

Black-backed Gull (*Larus marinus*)

On 28 July a Black-backed Gull was observed above Poninskiøyra, Woodfjorden (CORNET).

Ivory Gull (*Pagophila eburnea*)

Two Ivory Gulls were seen on 29 July at the bottom of Woodfjorden. On 23–24 July both professor LEHMAN's camp and mine were visited by Ivory Gulls. On 28 July three of them were flying around our boat, near Sigurdfjellet.

In Raudfjorden an Ivory Gull was seen on 2 Aug. at the foot of Ben Nevis.

Kittiwake (*Rissa tridactyla*)

A colony of Kittiwakes was discovered at the top of Kronprinshøgda (LEHMAN, GOUJET). It was situated 900 m a.s.l. at the very end of a valley which opens in front of Stjørdalen. This colony is very conspicuous because it is established on a dyke protuding about 50 m above the slope of the valley. On 31 July I counted about 500 nests on its NW and NE sides. High up in the dyke there were some nests of Fulmars, as mentioned above.

The members of a party (FISCHER) estimated the number of birds present in the colony on Siktefjellet, Liefdefjorden, at about 4000.

In Dicksonfjorden 12–19 Aug. no colony was found.

Arctic Tern (*Sterna macrura*)

This bird is not common at the bottom of Woodfjorden, and the number of nests between the river of Woodfjorddalen and Sigurdfjellet was less than ten.

Four pairs had settled on a sand bank about 10 km from Kapp Kjeldsen. Five others were established on a bank in front of Stjørdalen. I saw no chicks but I found old nests.

Three or four Arctic Terns were established in the small delta at the foot of Ben Nevis, Raudfjorden (1–6 Aug.). These birds seemed to have a territory. Also the Arctic Terns probably had chicks at the foot of Lilljeborgfjellet.

On 31 Aug. I saw from a helicopter hundreds of Arctic Terns above Zieglerøyane in Tjuvfjorden.

Little Auk (*Plautus alle*)

A few Little Auks were seen in the water at the bottom of Woodfjorden 20–29 July. I observed large numbers of them flying along the western side of the fjord toward Grevefjellet and Svartpiggen. There is probably a colony in that direction.

Little Auks might breed in Andrée Land between Jakobsenbukta and Siktefjellet. A dead, fully fledged juvenile was found at the foot of Sørlifjellet 8–9 Aug. (GINSBURG).

In Raudfjorden flocks of Little Auks were often seen along Frænkelryggen and Ben Nevis (1–6 Aug.). A colony was found on the eastern slope of the latter (LEHMAN). It was occupied by about four hundred birds.

On 1 Sept. I saw nearly 200 Little Auks at the mouth of Tjuvfjorden. Two swam alone, the others were in groups of 6–40 birds. As far as I could see, these birds were on migration.

Brünnich's Guillemot (*Uria lomvia*)

Brünnich's Guillemot was not common in the middle of Woodfjorden; I saw only half a dozen of them on 29 and 31 July.

In Sørdalsbukta, Liefdefjorden, this species was not very common either. I noted about 15 on 7 Aug. On the contrary, Brünnich's Guillemots were abundant in outer Liefdefjorden and in outer Woodfjorden as well as in the open sea along the coast.

On 10 Aug. in Kongsfjorden I saw for the first time juveniles on the water.

On 11 Aug. I estimated that about 3000 birds were present at the colony on Kongressfjellet in Isfjorden.

Black Guillemot (*Cepphus grylle mandtii*)

Black Guillemots were fairly common in the inner part of Woodfjorden, but I could not find any evidence of nesting.

There were plenty of Black Guillemots in Bockfjorden and in Woodfjorden along Kronprinshøgda. I discovered a small colony about 700 m a.s.l. on the eastern slope of Kronprinshøgda and at about 10 km from Kapp Kjeldsen. There were between 10 and 15 nests.

At this place I measured 10 specimens killed in the fjord by sailors. The results were:

Dimension of	Maximum	Minimum	Average
Exposed culmen	34 mm	30 mm	32.44 mm
Tarsus	41 »	37 »	38.75 »
Wing	175 »	163 »	170.25 »

On 10 Aug. in Kongsfjorden I saw for the first time juveniles on the water.

Puffin (*Fratercula arctica*)

In Woodfjorden, Liefdefjorden, and Raudfjorden I saw no Puffins except at the entrance of the fjords. On the other hand, Puffins were numerous off Reinsdyrflya from Worsleyneset toward Raudfjorden, in Breibogen, and off Jermaktangen (19 July to 9 Aug.). From Raudfjorden to Krossfjorden they were less abundant (19 July and 8 Aug.).

In Billefjorden and Sassenfjorden Puffins were numerous (17 July to 20 Aug.) and also at the entrance of Isfjorden (17 July to 26 Aug.).

At sea, off Bellsund, I observed 14 Puffins on 26 Aug. Four of them were escorted by one juvenile each.

White Wagtail (*Motacilla alba*)

Norwegian seamen told me that they had seen a White Wagtail on the inlet at the bottom of Woodfjorden on 25 July.

Snow Bunting (*Plectrophenax nivalis*)

This species was common on the slopes of Sigurdfjellet, Woodfjorden. I noted about a dozen pairs in the vicinity of our camp, and at least one nest.

The species was less abundant in Woodfjorddalen with increasing distance from the sea. I observed two pairs on the slopes of Marinova, and I found a nest on the slopes of Kulissene. A pair was seen at 900 m a.s.l. on Wagnerfjellet (DEFLANDRE).

On Kronprinshøgda the snow Bunting was numerous. Two pairs lived at 900 m altitude near the Kittiwake colony described above.

In Verdalen, Andrée Land, I saw at least two families of Snow Buntings on 9 Aug.

In Raudfjorden there were about 10 families of the species at the foot of Ben Nevis and Frænkelryggen. On 4 Aug. I saw for the first time completely fledged young.

In Dicksonfjorden there were plenty of Snow Buntings on both sides of the fjord. At that time of the year, 12–19 Aug., all young were fully fledged.

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Glaciological work in 1969

(Гляциологическая работа в 1969-ом году)

BY

OLAV LIESTØL

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Abstract

Norsk Polarinstitutt carried out mass balance measurements on five glaciers in the budget year 1968–69: on Storbreen, Hardangerjøkulen, and Omnsbreen in South-Norway, and on Austre Brøggerbreen and Midre Lovénbreen in Spitsbergen. The results are shown in Table 4 together with the results of measurements carried out by NVE (The Norwegian Water Resources and Electricity Board). Some special investigations of the energy balance on Omnsbreen are shown in Table 3 and Figs. 5 and 6.

Length variation measurements were carried out on ten glaciers. Only Briksdalsbreen in South-Norway and Engabreen in North-Norway advanced, the other ones regressed (see Table 5).

Аннотация

В балансовом году 1968-1969 сотрудниками Норвежского Полярного Института (Norsk Polarinstututt) был измерен вещественный баланс пяти ледников: Storbreen, Hardangerjøkulen, Omnsbreen (в южной Норвегии), Austre Brøggerbreen и Midre Lovénbreen (на Шпицбергене). Результаты измерений сопоставлены в табл. 4 с соответстующими результатами измерений других ледников, проведенных сотрудниками учреждения Norges Vassdrags- og Elektrisitetsvesen (управление гидрологической службы). Приведены результаты нескольких специальных исследований энергобаланса ледника Omnsbreen в табл. 3 и на рисунках 5 и 6.

Измерены колебания длины десяти ледников, из которых наступили только ледники Briksdalsbreen в южной и Engabreen в северной Норвегии, в то время как отступили остальные (см. табл. 5).

Storbreen in Jotunheimen

The accumulation was measured on Storbreen on 22 May. On this occasion a plane was used to and from Oslo. Due to the small precipitation in the winter season, the sounding of the snow depth was relatively simple. The last year's summer surface was quite marked. In contrast to the previous year, almost all the ablation stakes were visible. In the past few years measuring of the accumulation has been restricted to performing soundings in two representative areas, one at c. 1630 m and another at c. 1850 m a.s.l. Based on the previous years' comprehensive and exact measurements, a very good correlation has been found between these areas and the total accumulation on the whole glacier. As the measurements were done relatively late, some melting had already occurred, and the mean specific weight of the snow was as high as 0.46. The calculated value of the accumulation, plus snow fallen after the measurements were done, amounted to 1.22 m. This is somewhat below normal; for the last twenty years this has averaged 1.36 m.

The ablation measurements were carried out during four periods, viz.: 27–29 June, 5–8 August, 15–17 August, and lastly 19–21 September. On account of this summer's great ablation it was necessary to re-bore the stakes several times.

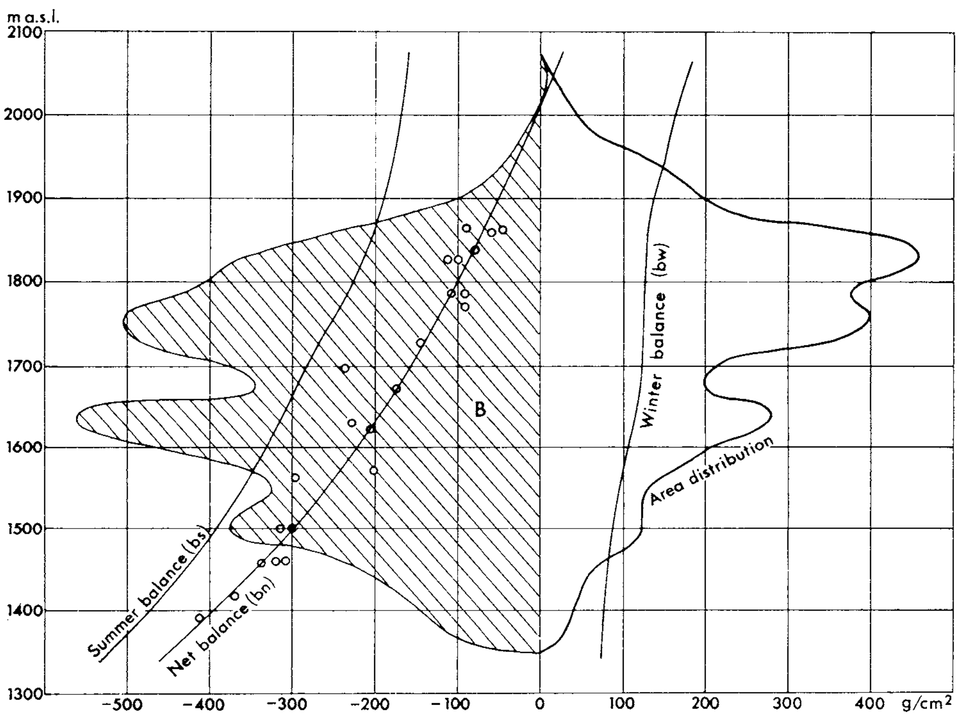

Fig. 1. *Variation in accumulation, ablation, and balance on Storbreen 1968–69 in relation to height above sea level.*

Вариация аккумуляции, абляции и баланса ледника Storbreen в 1968-69 гг. по отношению к высоте над уровнем моря.

The calculations of the ablation this summer show it to be the greatest one recorded since measurements were started on Storbreen in 1949, viz. –2.64 m. This, together with the fact that the accumulation was somewhat below normal, caused the balance to have nearly a record in high negative value, viz. 1.42 m. This is 14 cm over the previously highest value from 1959. The explanation is, as mentioned, the unusual high summer temperature. At Fannaråki the temperature for the months May to October was 2.6°C above normal. In addition, the snow disappeared very early from the glacier on account of the sparse accumulation. This resulted in a very low mean albedo and caused the sun energy to be absorbed in a higher degree than usual. In Fig. 1, where the mass balance measurements on Storbreen in 1969 are shown graphically, has been drawn a new hypsographic curve calculated on the basis of the map that has been plotted from air photographs taken in 1969. This hypsographic curve differs somewhat from the previous, which was based on maps from 1951. The accuracy of the older map may vary a little as it is based partly on terrestrial photogrammetry and partly on tachymetry. For this reason the maps are not suitable for calculation of the volume changes everywhere on the glacier. In comparing those areas where the older map is assumed to be exact, it appears that the glacier on the whole has decreased below c. 1650 m a.s.l. but increased above this height. On the lowest part of the glacier tongue the decrease is c. 40 m vertically, while the change in the area around 1850 m a.s.l. may be an increase of c. 5–8 m.

Hardangerjøkulen

The accumulation on Hardangerjøkulen was measured during a visit to the glacier in the first days of May. Precipitation during the winter had been below normal. The nearest meteorological stations in West-Norway showed a precipitation that was 80% of the normal in the accumulation period. The measurements of the accumulation was therefore relatively simple, and as all the stakes were found intact, the reliability was also quite good. The ablation season started on the lowest part of the glacier around 20 May, but frequent snowfalls on the glacier above c. 1500 m prolonged the winter season here to around 5 June. The result of the accumulation measurements shows a total of c. 18.7 mill. cubic metres of water or 1.07 m water evenly distributed over the glacier. This is the smallest value measured on Hardangerjøkulen since the mass balance measurements started in 1963. In 1967 and 1968 the accumulation was c. 2½ times higher. As shown in Fig. 2, it was especially in the lower areas that the accumulation was small. Thus on the lower part of Rembesdalsskåki blue ice was visible during the whole winter. The mean temperature at Reimegrend, one of the nearest meteorological stations, was in June 2.2°C and in August as much as 3.5°C above normal. In July, however, the temperature was 1.5° below normal. For the five summer months the mean temperature was c. 1°C above normal. The ablation stakes were inspected and measured on 21 June, 25–26 July, 24–25 August, and 7–12 September. During the three last-mentioned visits it was necessary to re-bore

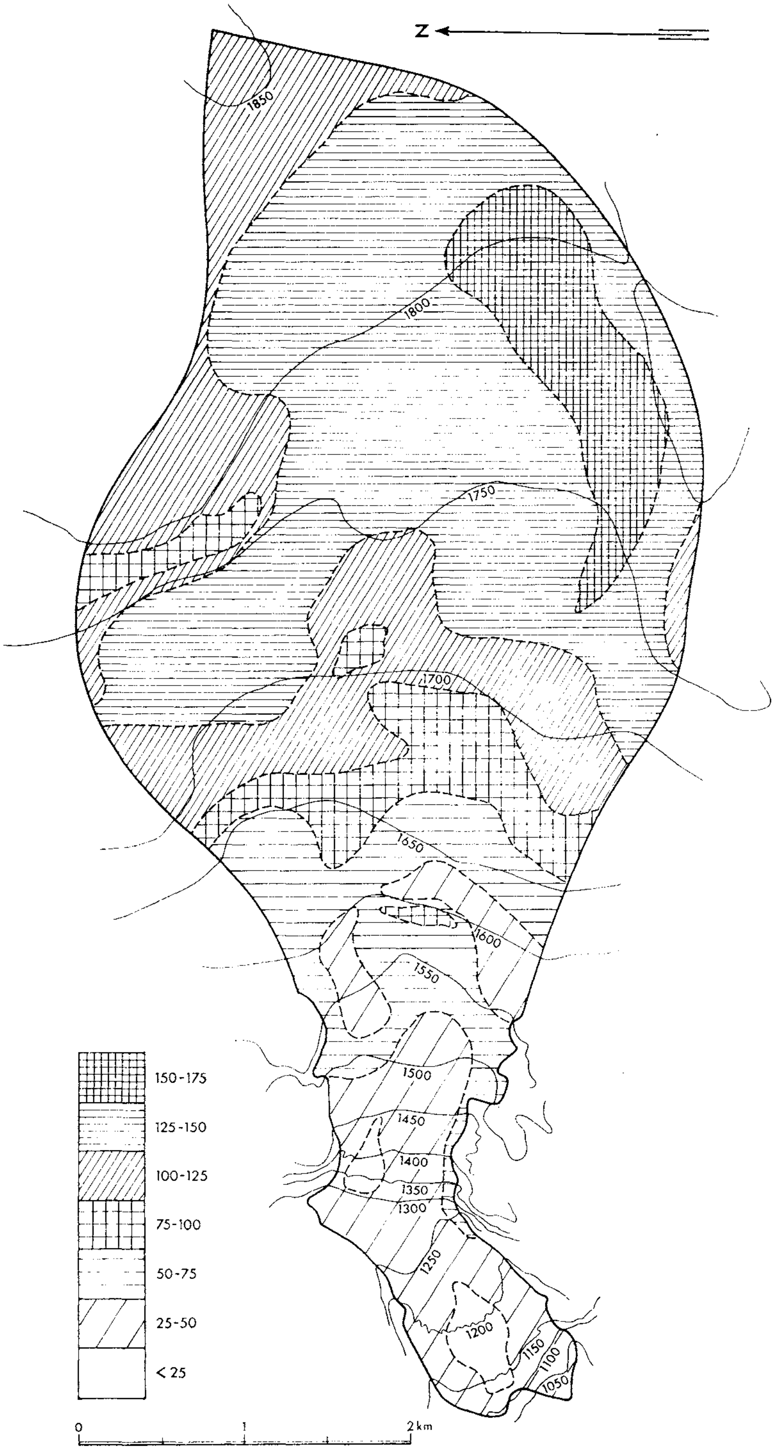

Fig. 2. *Map showing the distribution of accumulation in the part of Hardangerjøkulen that flows to the outlet glacier Rembesdalsskåki.*

На карте показано распределение аккумуляции части ледника Hardangerjøkulen текущей на выводной ледник Rembesdalsskåki.

some of the stakes because of the heavy melting. The first snowfall occurred on 22 September, when c. 50 cm snow fell in the Finse area, and still more on the top of Hardangerjøkulen. The middle part of October was, however, unusually warm. Below c. 1600 m the snow disappeared relatively quickly, while it remained on the upper parts of Hardangerjøkulen. This snow mass, which came and disappeared so quickly, ought to have been included in the table for the winter and the summer balance. This, however, was not done since one had no direct measurements of the snow mass. As can be seen from Table 1, the summer balance was c. 3 m, i.e. nearly 52 mill. cubic m water flowed away from this part of Hardangerjøkulen.

As a consequence of the sparse accumulation and the extraordinary large ablation, an unusually high negative balance was obtained, viz. –1.90 m. Even in the highest areas near the summit of Hardangerjøkulen the glacier decreased c. 2 m in thickness in relation to the previous year. This corresponds to c. 1 m of water equivalent. Lowermost on the glacier tongue the decrease was as much as 8 m. See Fig. 3.

In front of the glacier in Rembesdalen two sets of cairns, c. 1 m high, were built and painted white during the summer 1969. The distances between the cairns and the glacier front were measured so that variations of the glacier front can be measured easily in years to come.

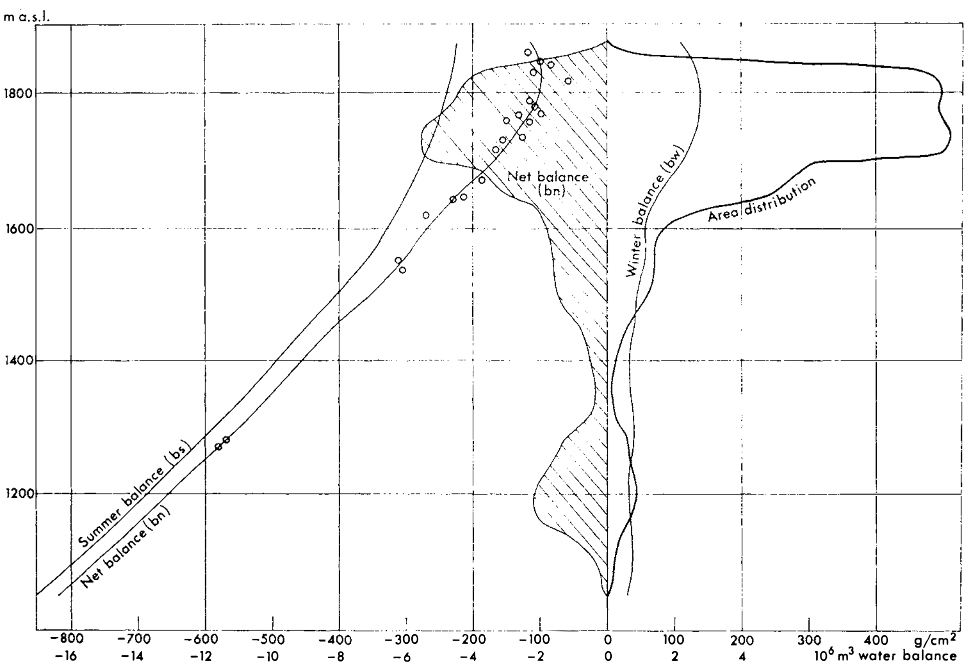

Fig. 3. *Variation in accumulation, ablation, and balance on Hardangerjøkulen (Rembesdalsskåki) 1968–69 in relation to height above sea level.*

Вариация аккумуляции, абляции и баланса ледника Hardangerjøkulen (Rembesdalsskåki) в 1968-69 гг. по отношению к высоте над уровнем моря.

Table 1
Hardangerjøkulen 1968-69.

Height interval m a.s.l.	Area km^2	Winter balance		Summer balance		Net balance	
		10^6m^3	m	10^6m^3	m	10^6m^3	m
1850–1900	0.070	0.075	1.07	0.154	2.21	–0.079	–1.14
1800–1850	3.375	4.781	1.28	8.441	2.26	–3.660	–0.97
1750–1800	3.866	5.258	1.36	9.542	2.47	–4.291	–1.11
1700–1750	3.910	4.770	1.22	10.401	2.66	–5.631	–1.44
1650–1700	2.084	2.000	0 96	6.002	2.88	–4.002	–1.92
1600–1650	0.936	0.571	0.61	2.930	3.13	–2.359	–2.52
1550–1600	0.640	0.333	0.52	2.189	3.42	–1.856	–2.90
1500–1550	0.542	0.287	0.53	2.060	3.80	–1.772	–3.27
1450–1500	0.319	0.140	0.44	1.360	4.26	–1.218	–3.82
1400–1450	0.196	0.073	0.37	0.921	4.70	–0.849	–4.33
1350–1400	0.112	0.034	0.31	0.377	5.15	–0.542	–4.81
1300–1350	0.084	0.032	0.38	0.473	5.63	–0.441	–5.25
1250–1300	0.270	0.108	0.40	1.647	6.10	–1.539	–5.70
1200–1250	0.315	0.107	0.34	2.076	6.59	–1.969	–6.25
1150–1200	0.321	0.093	0.29	2.285	7.12	–2.192	–6.83
1100–1150	0.115	0.038	0.33	0.879	7.65	–0.842	–7.32
1050–1100	0.022	0.007	0.34	0.180	8.20	–0.173	–7.86
1050–1900	17.53	18.71	1.07	52.12	2.97	–33.41	–1.90

Omnsbreen

(BY SIGMUND MESSEL)

Mass balance measurement, which was initiated in 1966, has also been carried out in 1969. In the period 3 June–8 September continuous glacio-meteorological recordings have been carried out, and the meteorological factors' contribution to the ablation in the mentioned period have been calculated.

Mass balance

Winter balance. – On Omnsbreen an essential part of the accumulation is supplied by wind transport from the neighbouring higher areas. In 1969 the wind transported snow mass amounted to c. 30% of the winter balance, which was calculated to $1.62 \cdot 10^6 m^3$ or 1.09 m water evenly distributed on the glacier. The map Fig. 4 shows the winter balance. The prevailing south-western wind is reflected in the distribution pattern.

Summer balance. – The 16 stakes on the glacier were measured about every sixth day during the summer season. The ablation was extraordinary strong in August, with a daily mean of 0.038 m. The mean temperature in August was c. 3.7°C above normal. Heavy snowfall occurred in the Omnsbreen area on 21 September, but due to an extraordinary warm period in October all the snow plus 6 cm of ice melted before the winter really started on 21 October.

Owing to both high summer temperature (c. 1.5°C above normal) and a very

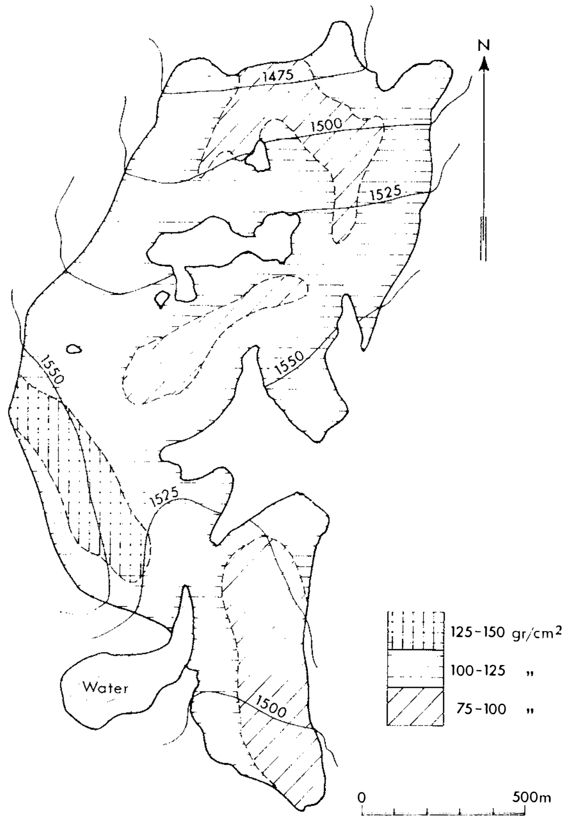

Fig. 4. *Map showing the distribution of accumulation on Omnsbreen.*
На карте показано распределение аккумуляции ледника Omnsbreen.

early exposure of the glacier surface (around 1 July), the summer balance was $5.52 \cdot 10^6 m^3$ or 3.68 m in average, which is $2.28 \cdot 10^6 m^3$ (1.55 m) higher than the mean summer balance for the last three years.

Net balance. – In the balance year 1969 Omnsbreen decreased $3.88 \cdot 10^6 m^3$ or 2.59 m. The mean decrease of Omnsbreen during the last three years has been $0.28 \cdot 10^6 m^3$ or 0.18 m.

Winter, summer, and net balance are shown in Table 2 and Fig. 5.

Glacio-meteorological investigations

As in 1968 the glacio-meteorological station on Omnsbreen was in operation from 3 June to 8 September. Measurements of temperature gradients, wind, and

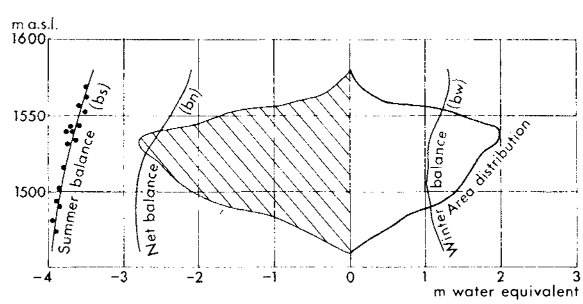

Fig. 5. *Accumulation, ablation, and balance on Omnsbreen in relation to height above sea level.*
Аккумуляция, абляция и баланс ледника Omnsbreen по отношению к высоте над уровнем моря.

Table 2
Omnsbreen 1969

Height interval m a.s.l.	Area km^2	Winter balance $10^6 m^3$	Winter balance m	Summer balance $10^6 m^3$	Summer balance m	Net balance $10^6 m^3$	Net balance m
1560–1580	0.036	0.046	1.28	0.121	2.36	–0.075	–2.08
1540–1560	0.313	0.379	1.21	1.093	3.49	–0.714	–2.28
1520–1540	0.446	0.468	1.05	1.619	3.63	–1.151	–2.58
1500–1520	0.385	0.397	1.03	1.444	3.75	–1.047	–2.72
1480–1500	0.254	0.275	1.07	0.992	3.86	–0.717	–2.79
1460–1480	0.063	0.072	1.15	0.249	3.96	–0.177	–2.81
1440–1460	0.000	—	—	—	—	—	—
1460–1580	1.497	1.647	1.09	5.518	3.68	–3.881	–2.59

relative humidity were carried out daily together with recordings of radiation, snow density, free amount of water, and the subsidence of the glacier surface (ablatograph measurements). The main meteorological data are shown in Fig. 6. The distribution of the different meteorological factors in the ablation pattern for periods of one week are presented in Table 3 and in the diagram Fig. 7. For the whole period 3 June–8 September, radiation contributed to the ablation with 54 per cent. Convection and condensation contributed 31 and 14 per cent respectively. Rain and sublimation caused scarcely ½% of the ablation in the mentioned period – a relative amount which is in accordance with the result of 1968.

Table 3
Omnsbreen. Relative importance of heat sources. Weekly accounts during the summer season.

Period	Radiation		Convection		Condensation		Sublimation		Rain		Relative importance in percent of				
	cal/ cm^2	g/ cm^2	cal/ cm^2	g/ cm^2	cal/ cm^2	g/ cm^2	cal/ cm^2	g/ cm^2	cal/ cm^2	g/ cm^2	Radiation	Convection	Condensation	Sublimation	Rain
3/6– 9/6	901	11.26	294	3.68	121	1.51	55	0.08			68.1	22.3	9.1	0.50	0
10/6–16/6	999	12.49	508	6.35	196	2.45	12	0.02			58.6	29.8	11.5	0.10	0
17/6–23/6	765	9.56	733	9.16	405	5.06			22	0.28	38.8	38.1	21.0	0	1.10
24/6–30/6	750	9.38	627	7.84	364	4.55			5	0.06	43.0	35.9	20.8	0	0.30
1/7– 7/7	916	11.45	207	2.59	80	1.00			2	0.03	76.0	17.2	6.6	0	0.20
8/7–14/7	944	11.80	257	3.21	120	1.50			4	0.05	71.3	19.4	9.0	0	0.30
15/7–21/7	1005	12.56	421	5.26	173	2.16			4	0.05	62.7	26.3	10.8	0	0.20
22/7–28/7	1005	12.56	489	6.11	250	3.13			9	0.11	57.3	27.9	14.3	0	0.50
29/7– 4/8	1279	15.99	1032	12.90	313	3.91			16	0.20	48.5	39.1	11.8	0	0.60
5/8–11/8	1483	18.54	707	8.84	204	2.55			1	0.01	61.9	29.5	8.5	0	0.10
12/8–18/8	1210	15.13	852	10.65	280	3.50					51.6	36.4	12.0	0	0
19/8–25/8	577	7.21	583	7.29	392	4.90			8	0.10	37.0	37.4	25.1	0	0.50
26/8– 1/9	897	11.21	516	6.45	332	4.15			3	0.04	51.3	29.5	19.0	0	0.20
2/9– 8/9	836	10.45	475	5.94	244	3.05	35	0.05	12	0.15	53.2		15.5	0.30	0.70
3/6– 8/9	13567	169.60	7701	96.30	3474	43.40	102	0.20	86	1.10	54.6	31.5	14.0	0.05	0.35

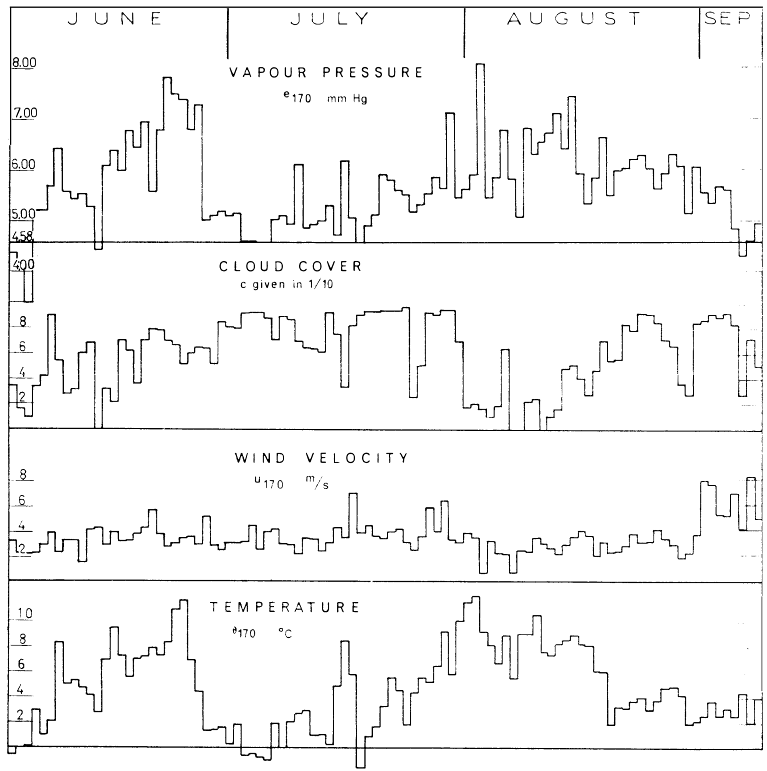

Fig. 6. *Daily mean values of measured meteorological parameters at 170 cm height above glacier surface on Omnsbreen.*

Средние суточные значения измеренных метеорологических параметров в 170 см над поверхностью ледника Omnsbreen.

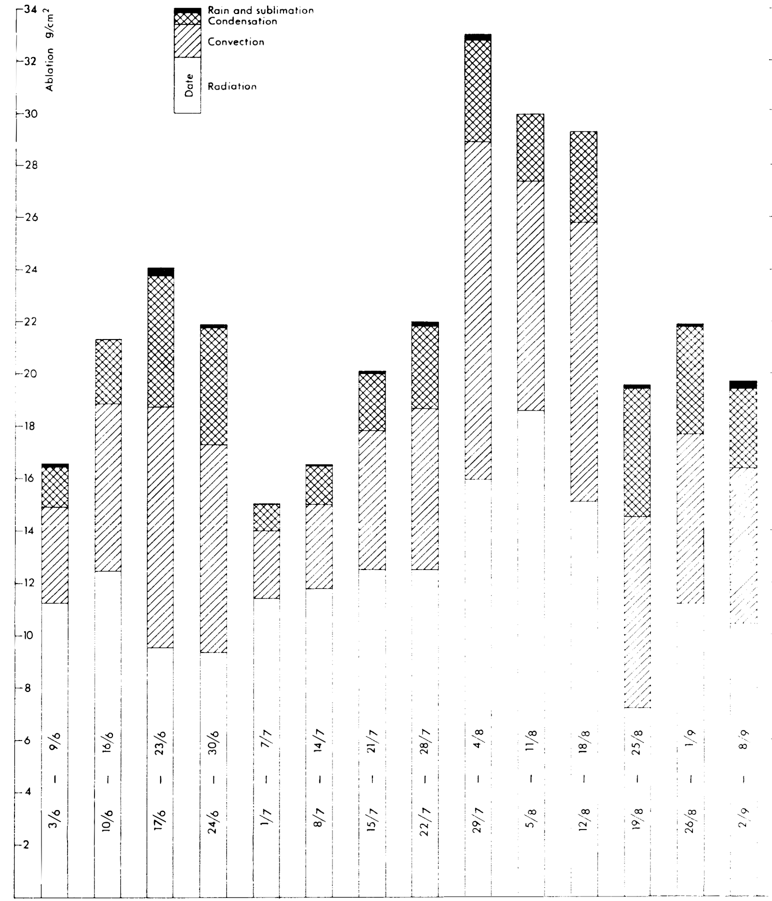

Fig. 7. *Weekly mean ablation values due to different meteorological factors at 1540 m a.s.l. on Omnsbreen.*

Средние еженедельные значения абляции ледника Omnsbreen на высоте 1540 м над уровнем моря, причиненной различными метеорологическими факторами.

Glaciers in Spitsbergen

The all-year-round measurements on Austre Brøggerbreen and Midre Lovénbreen, south of Ny-Ålesund, were continued in 1968–69 in the same way as the previous year. Accumulation and ablation measurements were carried out by JENS ANGARD at 'Forskningsstasjonen på Svalbard', Ny-Ålesund. Both glaciers were visited several times in the course of the year. The ablation was measured by direct readings on the stakes. As to accumulation, the stakes were read too, but this gives a somewhat weak basis for a judgement of the accumulation over the whole glacier. To obtain more accurate findings, soundings were carried out along lines across the central line of the glacier with intervals of 100 m. The result of the measurements in 1968–69 are shown in Figs. 8 and 9. Like the glaciers in Norway, the two Spitsbergen glaciers show a great deficit this year. To a great extent this is due to the long ablation season. Until the beginning of November no snow fell on the glaciers. As yet we have no statistics concerning 'normal accumulation' on these glaciers; it must, however, be assumed that ac-

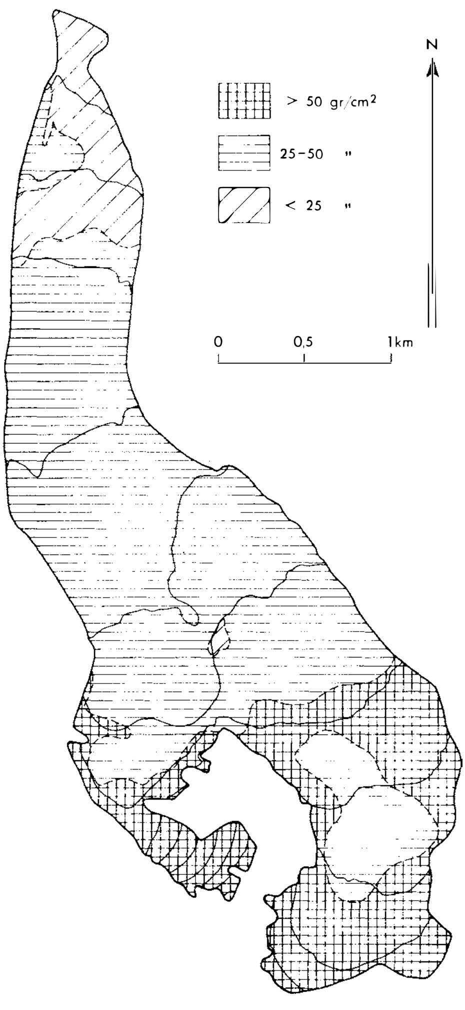

Fig. 8. *Distribution of accumulation on Austre Brøggerbreen.*
Распределение аккумуляции ледника Austre Brøggerbreen.

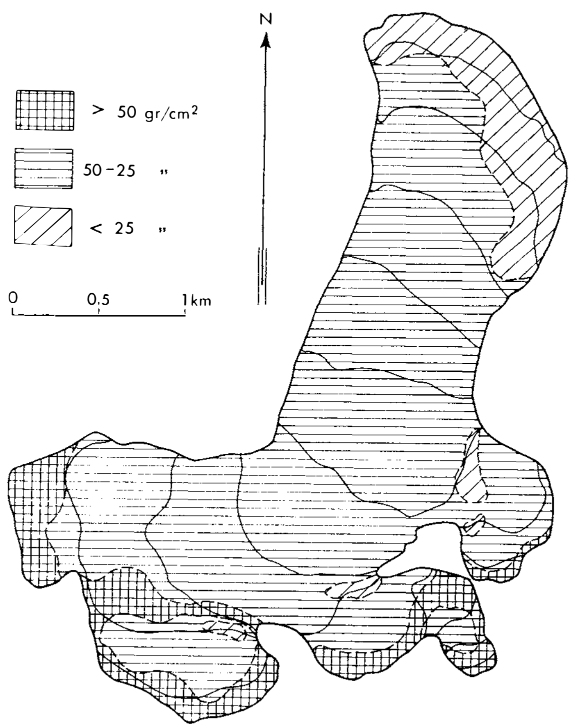

Fig. 9. *Distribution of accumulation on Midre Lovénbreen.*
Распределение аккумуляции леднипа Midre Lovénbreen.

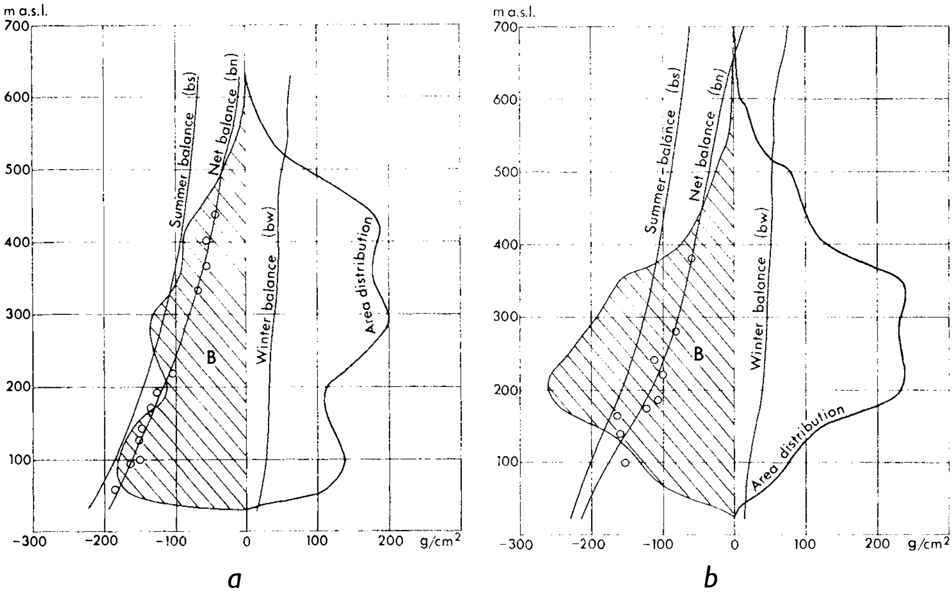

Fig. 10. *Accumulation, ablation, and balance in relation to height a.s.l. on Austre Brøggerbreen and Midre Lovénbreen.*

Аккумуляция, абляция и баланс ледников Austre Brøggerbreen и Midre Lovénbreen по отношению к высоте над уровнем моря.

cumulation this year has been below normal. On Brøggerbreen the accumulation was on an average 0.40 m, the ablation –1.33 m, and the net balance –0.93 m. The corresponding figures for Lovénbreen was 0.41 m, –1.25 m, and –0.84 m. See Fig. 10.

Based on aerial photography in the summer 1969, maps have been drawn of a considerable number of glacier fronts in Spitsbergen. All of them show a retreat from the previous time that such mapping was carried out.

Other investigations

In addition to the investigations carried out by Norsk Polarinstitutt on Storbreen, Hardangerjøkulen, Omnsbreen, Austre Brøggerbreen, and Midre Lovénbreen NVE (The Norwegian Water Resources and Electricity Board) carried out measurements on seven glaciers in South-Norway. These measurements are shown in Table 4 and in the diagram Fig. 11. In the diagram is also shown, for comparison, the mean for the six previous years and a calculated normal equilibrium.

Calculations of advance and retreat in metres were carried out for in all ten glaciers, and the result is presented in Table 5. Only Engabreen, an outlet glacier of Svartisen and Briksdalsbreen, an outlet glacier of Jostedalsbreen have advanced, while all the other glaciers in Norway retreated in 1969.

Table 4

Mass balance measurements.

Glacier	Area km²	Accumulation m	Ablation m	Balance m	Equilibrium line m a.s.l.
Southern Norway					
Ålfotbreen	4.82	2.66	4.83	−2.17	(1550)*
Vesledalsbreen	4.22	1.26	3.44	−2.18	(1850)
Tunsbergdalsbreen	50.11	1.53	3.22	−1.69	1700
Nigardsbreen	47.03	1.95	3.26	−1.31	1850
Hardangerjøkulen	17.53	1.07	2.97	−1.90	(1950)
Omnsbreen	1.50	1.09	3.68	−2.59	?
Storbreen	5.36	1.22	2.64	−1.42	(2020)
Hellstugubreen	3.33	0.95	2.23	−1.28	2130
Vestre Memurubre	9.05	1.05	2.11	−1.06	2170
Austre Memurubre	8.86	0.99	2.45	−1.46	2130
Gråsubreen	2.53	0.74	2.04	−1.37	(2350)
Spitsbergen					
Midre Lovénbreen	6.03	0.41	1.25	−0.84	(650)
Austre Brøggerbreen	6.08	0.40	1.33	−0.93	(650)

* Figures in parentheses represent a theoretical line above the highest point of the glacier.

Table 5

Variation in the position of some glacier fronts.

Jotunheimen		*Folgefonni*	
Storbreen	− 14m	Bondhusbreen	− 3 m
Styggedalsbreen	− 16 »		
		Møre	
Jostedalsbreen		Trollkyrkjebreen	−15 »
Briksdalsbreen	+ 8 »		
Stegholtbreen	− 99 »	*Svatisen*	
Lodalsbreen	−127 »	Engabreen	+ 8 »
Fåbergstølbreen	−135 »		
Austerdalsbreen	− 35 »		

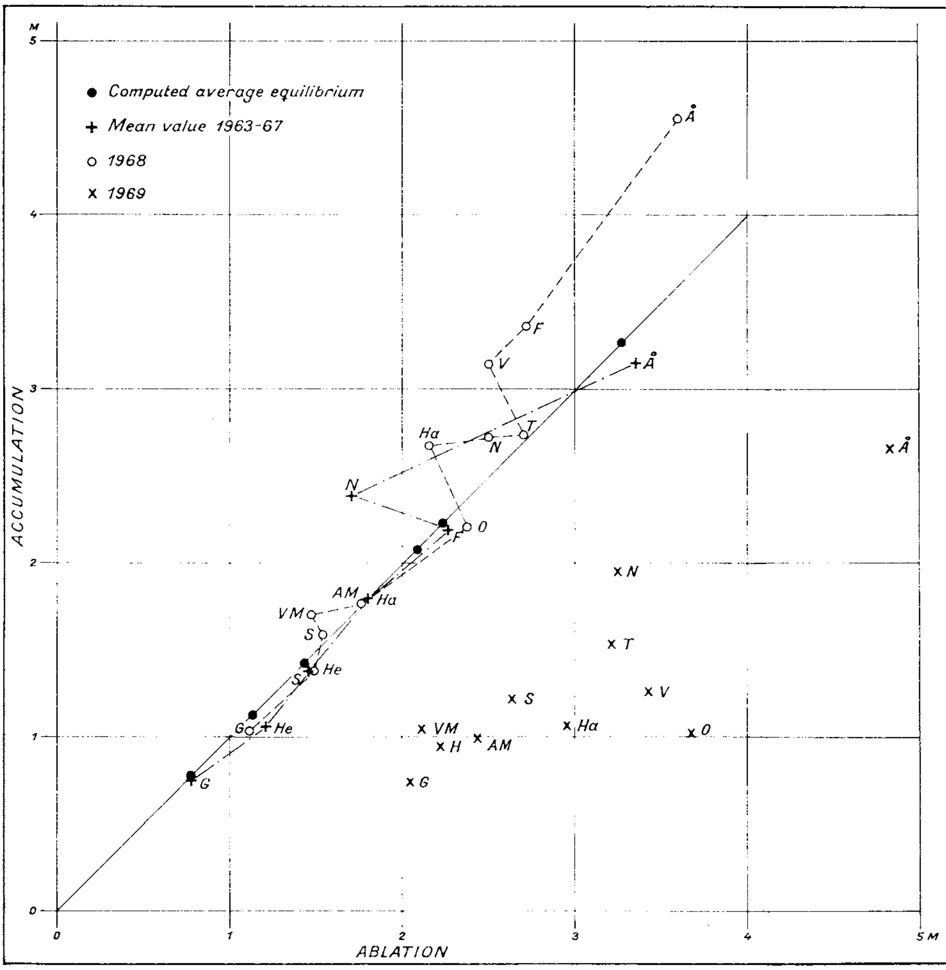

Fig. 11. *Relation between accumulation and ablation compared to the mean of the previous 6 years and also to that of a year with a computed balanced budget and a "normal" mass exchange.*

F = Folgefonni, Ha = Hardangerjøkulen, He = Hellstugubreen, G = Gråsubreen, N = Nigardsbreen, O = Omnsbreen, AM = Austre Memurubre, VM = Vestre Memurubre, S = Storbreen, T = Tunsbergdalsbreen, V = Vesledalsbreen og Å = Ålfotbreen.

Взаимоотношение между аккумуляцией и абляцией в сравнении с средними значениями предыдущих шести лет, так же как с значениями среднего рассчетного «нормального» года.

The weather in Svalbard in 1969

By
Vidar Hisdal

The diagram, Fig. 1, presents some important meteorological elements observed at Isfjord Radio during 1969: the daily maximum and minimum temperatures, the cloud amount, and the direction and the speed of the wind. The cloud and wind observations entered are those taken at 13 MET. The figure furthermore shows the average annual temperature variation for the period 1947–68. The symbols used are explained by examples in the diagram.

The table contains the monthly mean temperatures for Isfjord Radio, Hopen, and Bjørnøya for 1969 as well as their deviations from the monthly means based on the period 1947–68.

The diagram and the tabulated data show that the end of winter was especially cold in Svalbard. Thus, at Isfjord Radio the mean temperatures of March and April were nearly 7°C lower than the long-term average. The weather situations during this time of the year were generally characterized by high pressure areas over the Polar Basin or Greenland, with advection of cold, Arctic air in the Svalbard area, where cloudless or nearly cloudless skies lead to considerable radiative heat loss, which strengthened the advection effect. The ice conditions in the region, which were severe, due to the extremely low temperatures during the end of 1968, now grew still worse. In this connection it may be of interest to remind of the fact that there is a certain mutual interdependence between the extension of the sea-ice and the temperature conditions: a large extension of the sea-ice during winter time tends to create a cold, continental weather type in areas well north of the ice edge, the whole process forming a kind of "feedback system".

We note that while the mean temperature of February is about 3°C below "normal" at Isfjord Radio, it is 1°C and 2°C above "normal" at Hopen and Bjørnøya respectively. At least when comparing Isfjord Radio and Bjørnøya, a main reason for these differing temperature conditions seems to be that for relatively long periods a frontal zone is found in the Svalbard area, with Isfjord Radio to the north of the front, in the colder air mass. In addition, clear skies are likely to have been more frequent at Isfjord Radio. Unfortunately, adequate data are not yet available for a more conclusive discussion on this point.

Most of the autumn, as well as the month of December, are comparatively

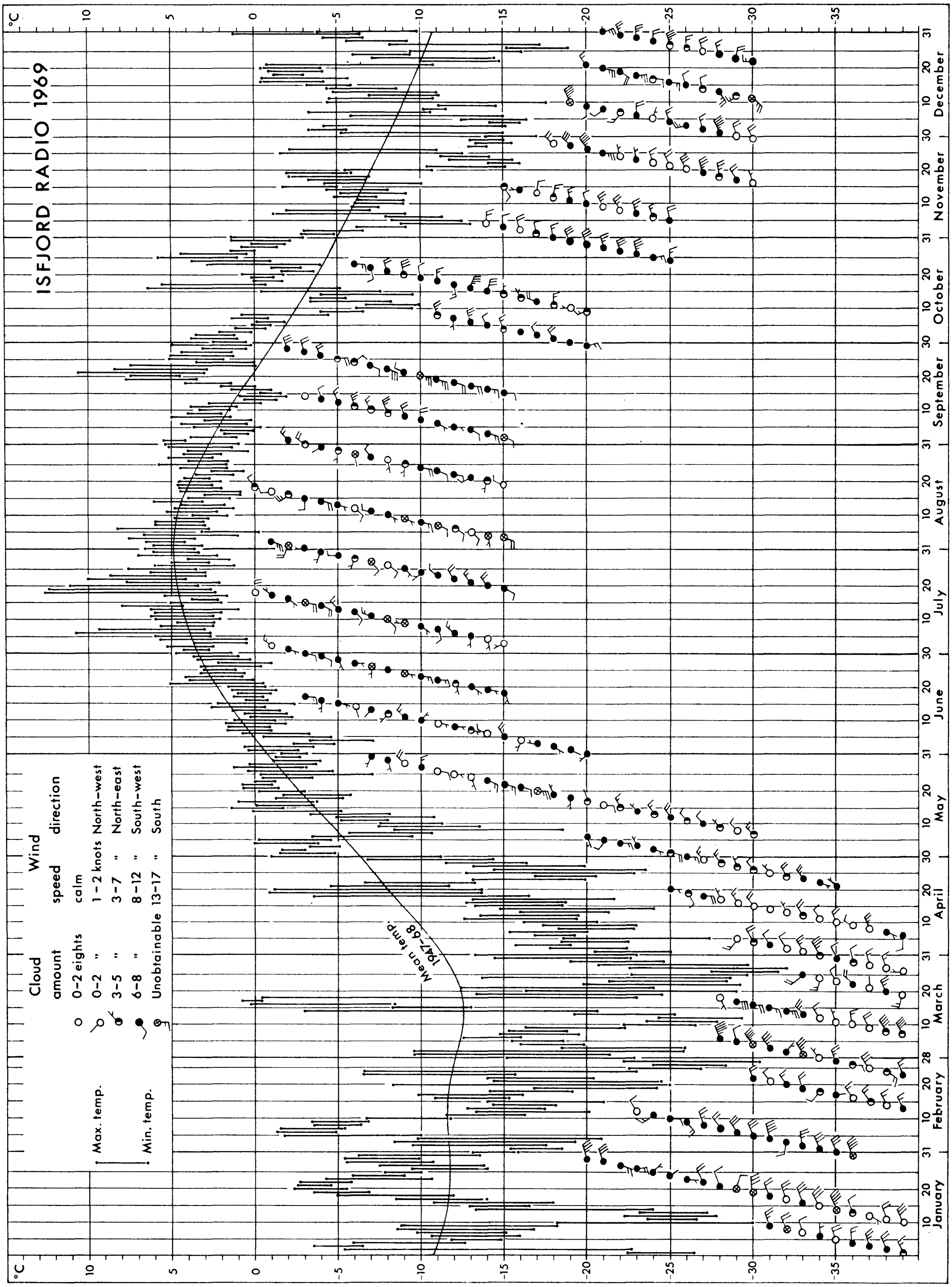
ISFJORD RADIO 1969
°C
10
5
0
-5
-10
-15
-20
-25
-30
-35
Cloud
amount
0-2 eights
0-2 "
3-5 "
6-8 "
Unobtainable
Wind
speed
calm
1-2 knots
3-7 "
8-12 "
13-17 "
direction
North-west
North-east
South-west
South
Max. temp.
Min. temp.
Mean temp.
1947-68
January
February
March
April
May
June
July
August
September
October
November
December

Fig. 1.

mild, which may be ascribed to advection of mild air from lower latitudes in connection with the passage of several strong cyclones during these periods.

The lowest temperature at Isfjord Radio, –32.0°C, was observed as late as on 27 March. The highest temperature, 12.7°C, occurred on 18 July.

Monthly mean temperatures for 1969 (T) and their deviations (d) from the means of the period 1947–68.

		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Isfjord Radio	T	–12.5	–14.7	–19.4	–15.7	–3.6	0.2	4.3	3.5	2.4	–1.1	–8.4	–8.4
	d	–0.8	–3.1	–6.9	–6.8	–0.1	–1.4	–0.2	–0.7	1.5	2.2	–1.8	1.1
Hopen	T	–14.2	–11.6	–18.9	–16.1	–4.7	–1.6	1.4	2.0	1.1	–0.2	–6.9	–7.3
	d	–0.9	1.1	–4.8	–5.8	0.3	–1.2	–0.5	–0.1	0.5	2.9	–0.3	3.3
Bjørnøya	T	–8.4	–5.2	–10.5	–8.6	–1.2	1.1	5.8	5.1	3.7	1.3	–3.4	–3.0
	d	–0.7	2.0	–2.5	–3.3	0.4	–0.7	1.7	0.9	1.0	1.1	–0.9	2.8

Sea ice observations in 1969

BY

TORGNY E. VINJE

The distribution of sea ice between Iceland and Novaja Zemlja is shown in Figs. 1–12. The main source of data is the pictures taken by the American weather satellites. The date of the different observations is noted in the figures. When the observations are taken from aircraft or from ships, the suffix 'air' or 'ship' has been noted. (Sources: U.S. Naval Oceanographic Office, The Royal Norwegian Airforce, and the monthly charts edited by the Meteorological Office in England.) Observations from infrared satellite pictures are marked with the letter N. For the Arctic stations Hopen, Bjørnøya, and Isfjord Radio the maximum and minimum concentration in oktas and type of ice is given for each month.

When comparing satellite pictures with surface observations, some inconsistencies can be seen. This is caused by the fact that a concentration of less than about 3/8 is not always registered by the satellite photographs. Observations indicate that when a satellite camera fails to register this smaller concentration, the drift ice consists of strips.

From February to the end of May the sea ice was found close to Iceland or at the north coast of Iceland. The sea ice disappeared from this area about one month earlier this year compared with 1968.

In Vesterisen (cf. Fig. 3), Odden and Nordbukta may be identified during February, March, April, and the first part of May. In 1968 these features were very well pronounced as late as medio July.

The temperature in the Svalbard area was well below normal during the winter 1968–69 and very thick bay or fiord ice was formed. In spite of this, the disintegration of the sea ice was near normal. The northern, western, and southern part of Spitsbergen (the main island) was free of ice from the end of July and the rest of the year. At the 24th of September the ice edge north of Svalbard had retreated to a rather high latitude.

In Østisen (cf. Fig. 3), Nordostodden is extraordinarily well pronounced during March and April. A main feature in the disintegration process during the summer, and which was also found during 1968, is the formation of an extensive opening from Franz Josef Land towards south-south-west. In the first part of October there is only a small amount of ice left at the north-eastern side of Svalbard.

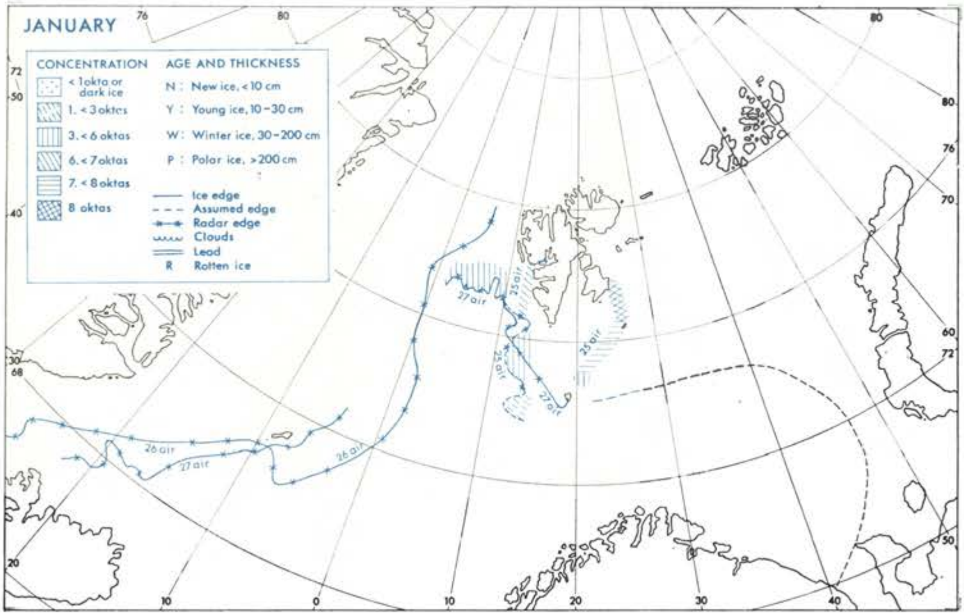
JANUARY
CONCENTRATION
< 1okta or dark ice
1. < 3 oktas
3. < 6 oktas
6. < 7 oktas
7. < 8 oktas
8 oktas
AGE AND THICKNESS
N : New ice, < 10 cm
Y : Young ice, 10 – 30 cm
W : Winter ice, 30 – 200 cm
P : Polar ice, > 200 cm
Ice edge
Assumed edge
Radar edge
Clouds
Lead
R Rotten ice
27 air
25 air
26 air

Fig. 1.

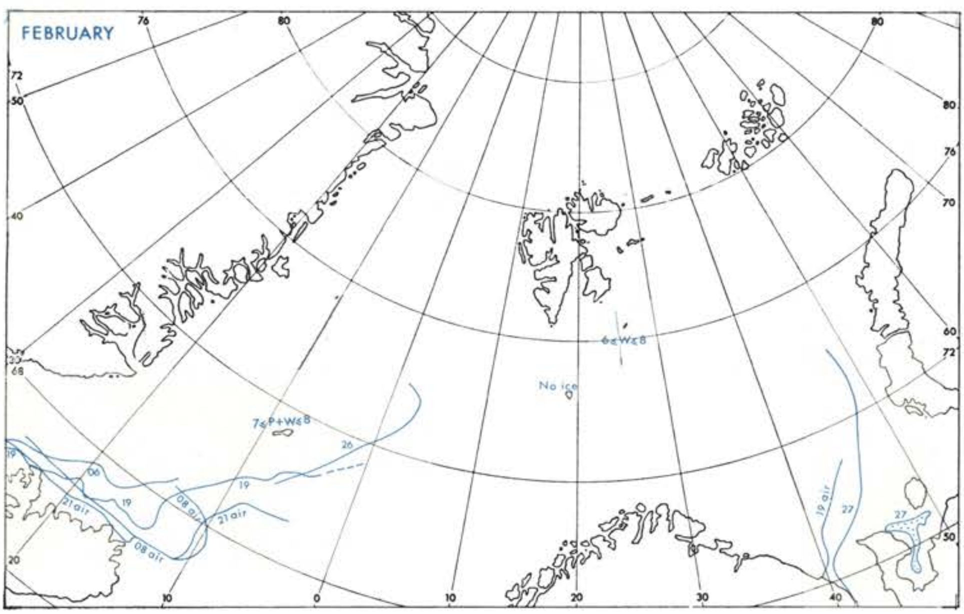
FEBRUARY
No ice
19 air
27

Fig. 2.

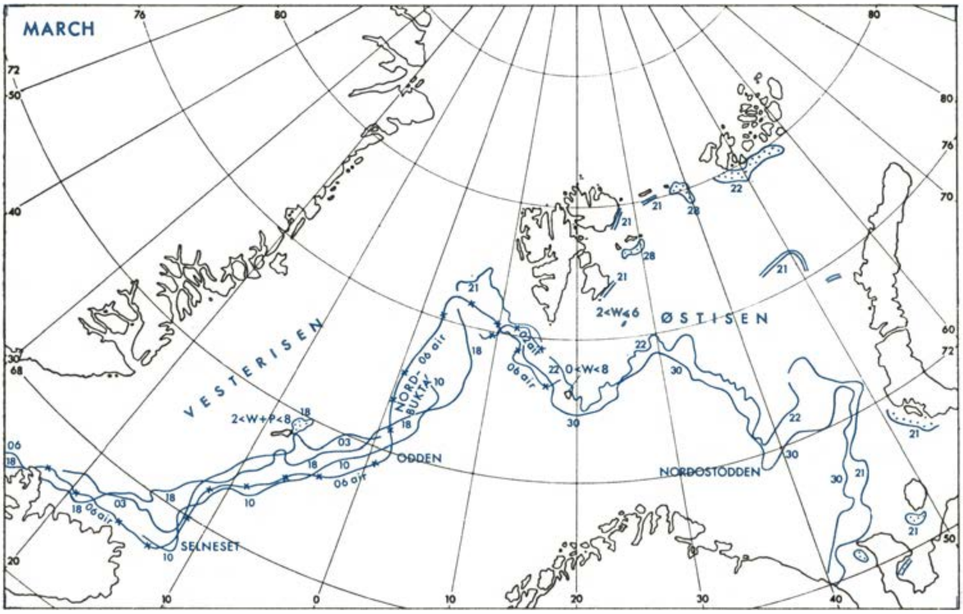
MARCH
VESTERISEN
ØSTISEN
NORD-
BUKTA
ODDEN
SELNESET
NORDOSTODDEN
2<W+P<8
2<W<6
0<W<8
06 air

Fig. 3.

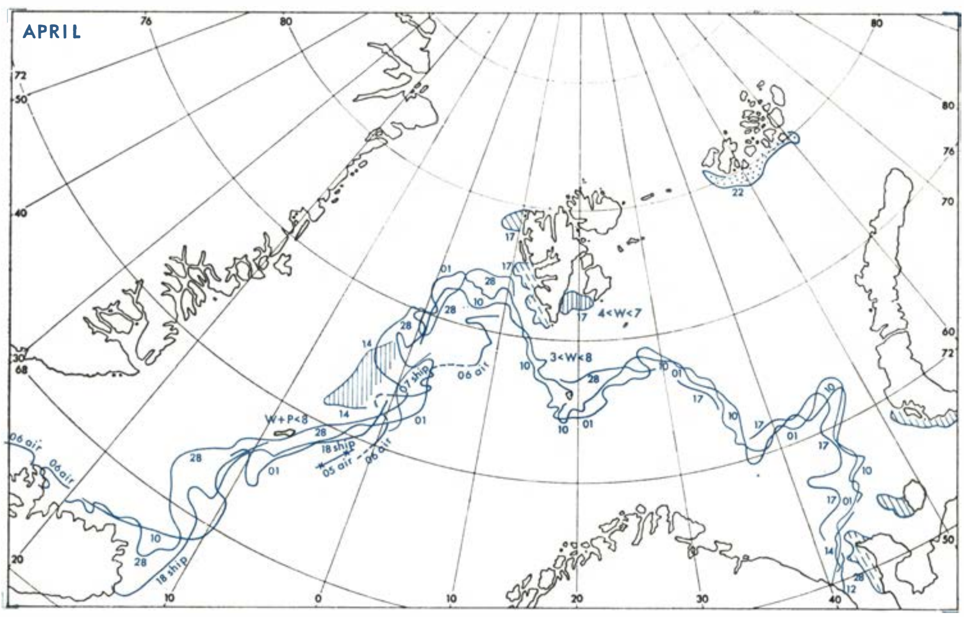
APRIL
W+P<8
4<W<7
3<W<8
18 ship
07 ship
06 air
05 air

Fig. 4.

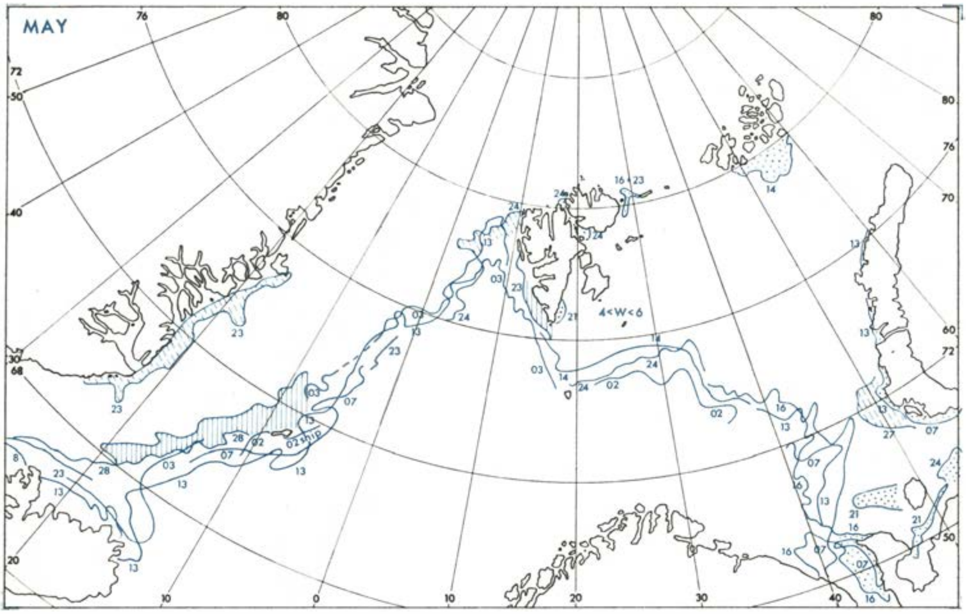

Fig. 5.

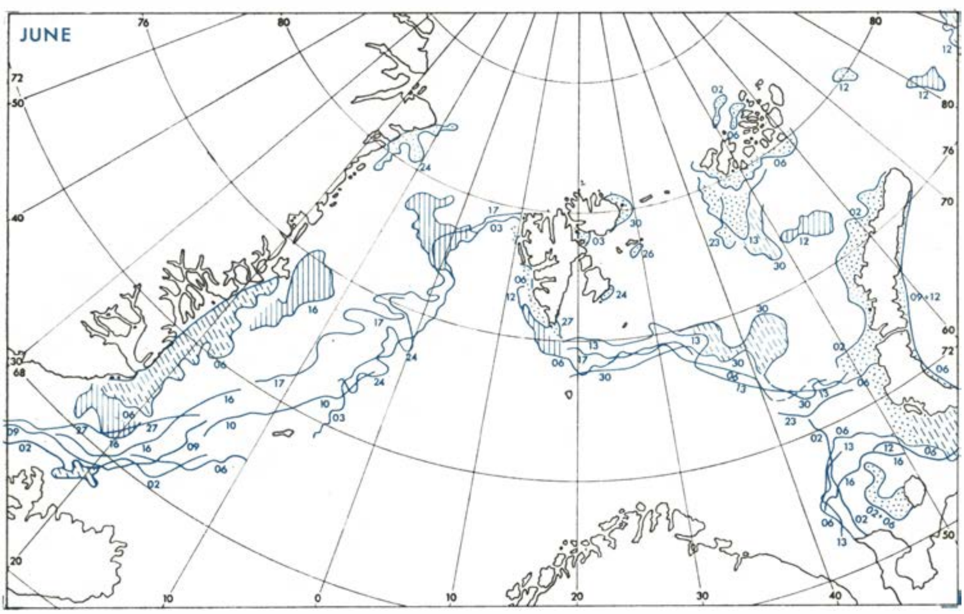

Fig. 6.

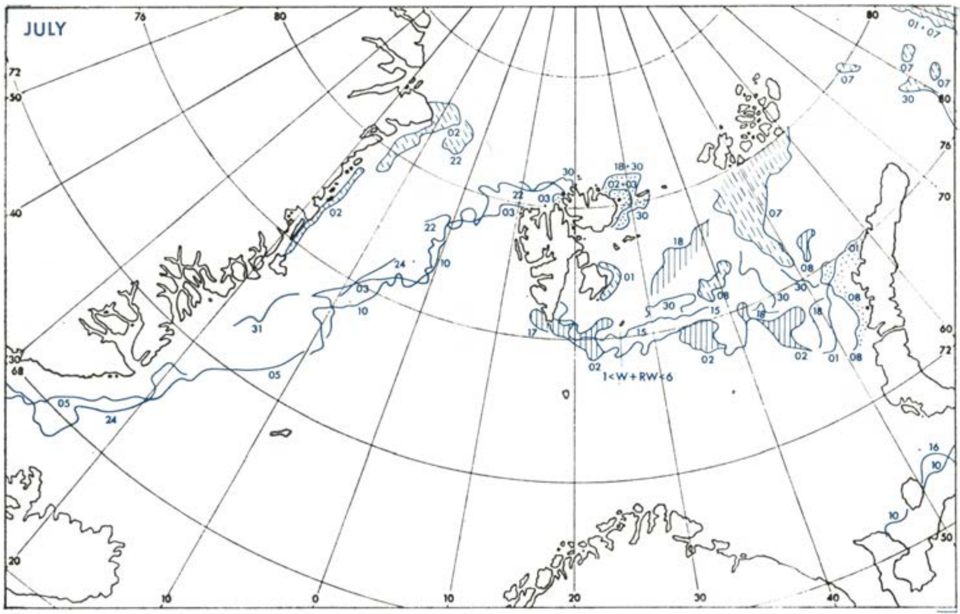

Fig. 7.

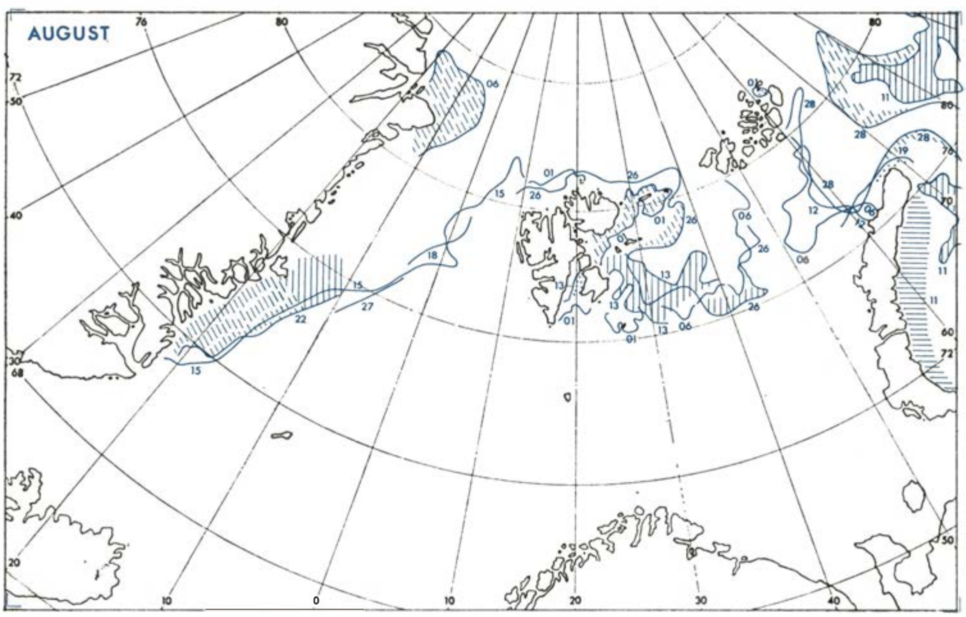

Fig. 8.

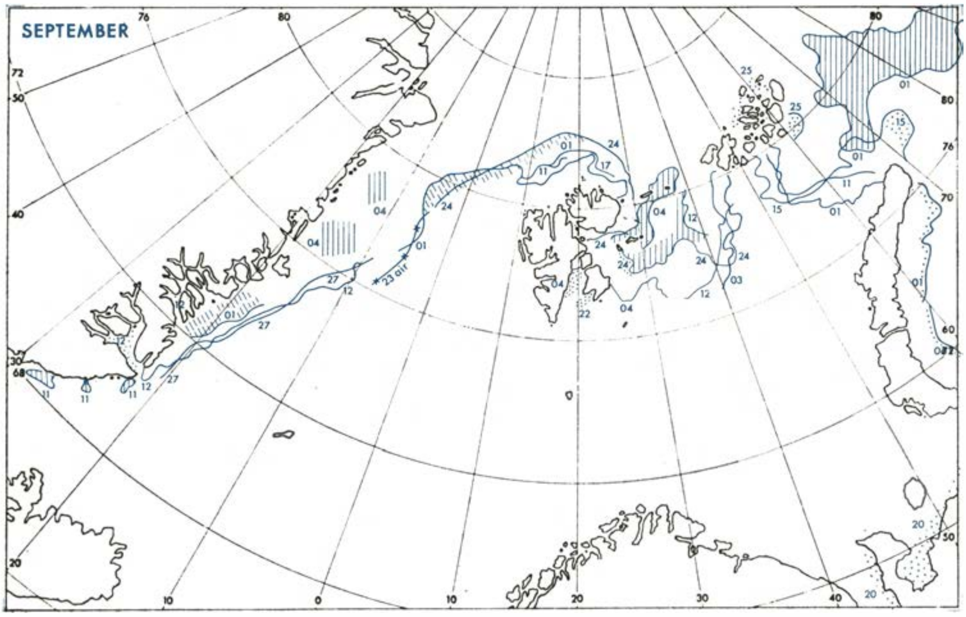

Fig. 9.

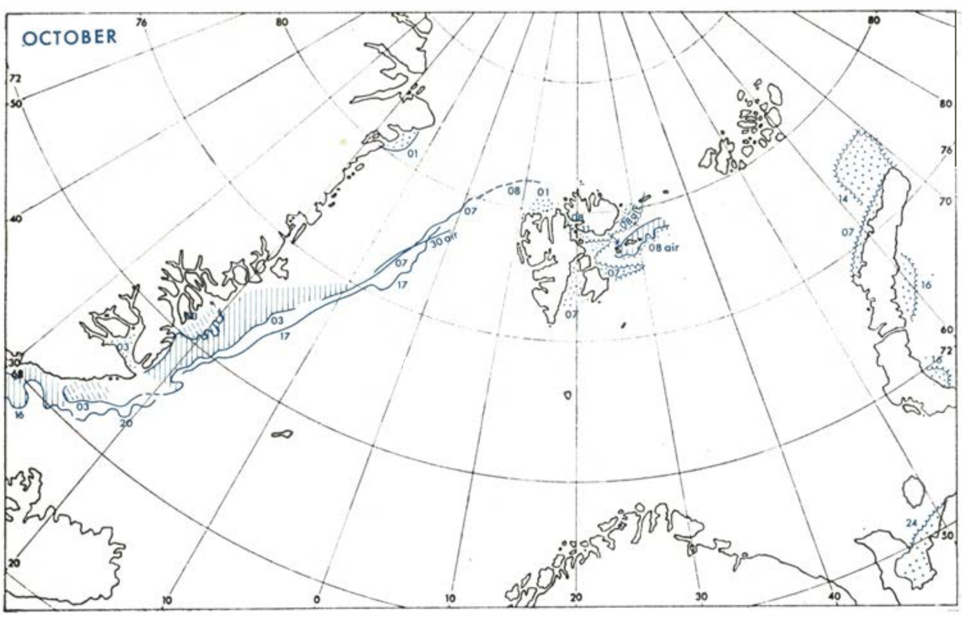

Fig. 10.

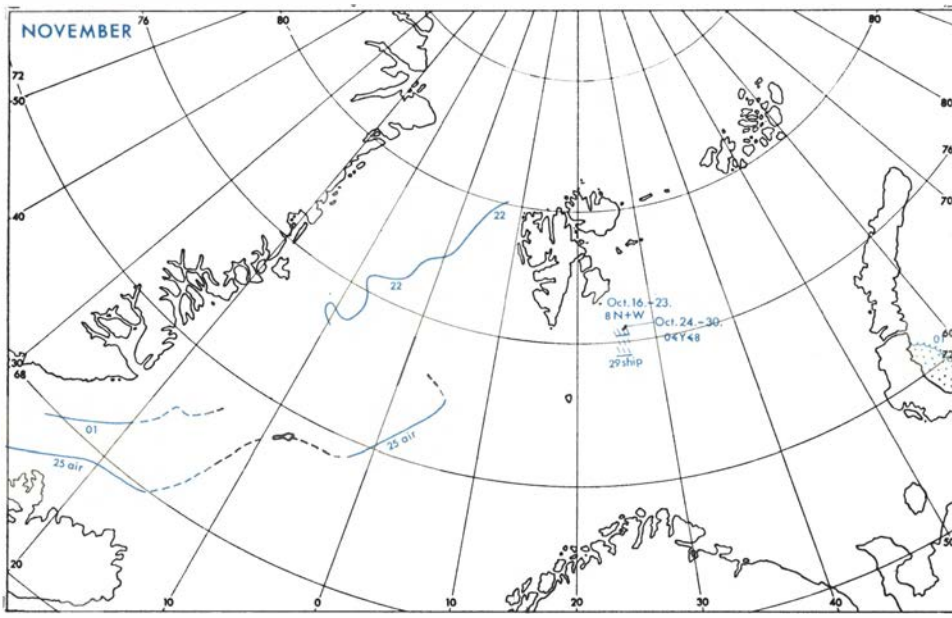
NOVEMBER
Oct. 16.-23.
8N+W
Oct. 24.-30.
29 ship
25 air
01
22

Fig. 11.

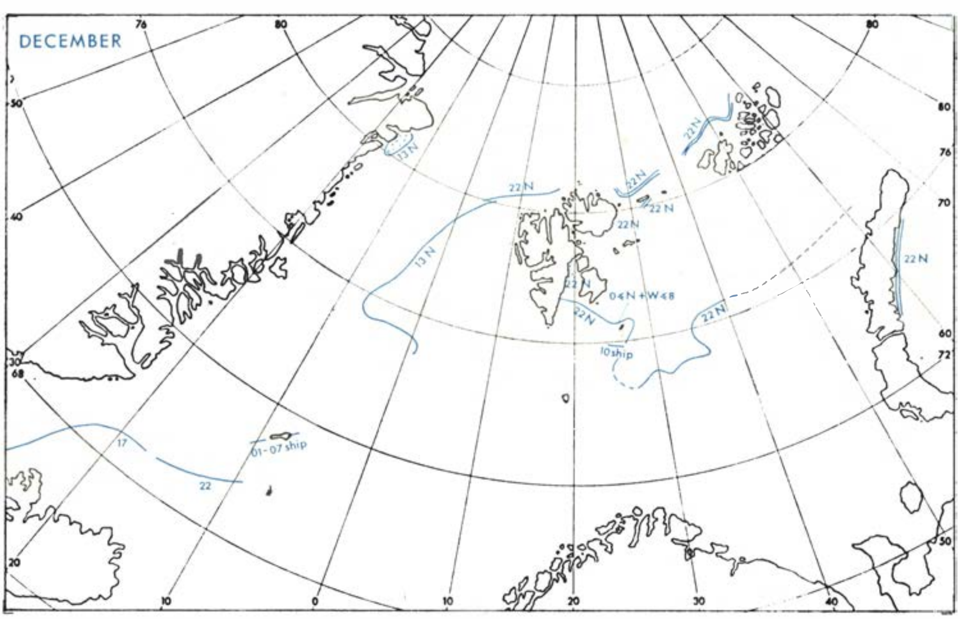
DECEMBER
22N
13N
04N+W<8
10 ship
01-07 ship
17
22

Fig. 12.

Iakttagelser over dyrelivet på Svalbard 1969

(Observations of animal life in Svalbard 1969)

(Наблюдения над фауной Свальбарда в 1969-ом году)

AV

MAGNAR NORDERHAUG

Abstract

The present report on observations of animal life in Svalbard is based on records from members of Norsk Polarinstitutt's expedition 1969 and on information from other field-parties and persons visiting Svalbard in 1969.

Ten observations of walruses (*Odobenus rosmarus*) (two of them from 1968) are mentioned.

Coot (*Fulica atra*) (first record from Svalbard) and Common Gull (*Larus canus*) (first record from Spitsbergen) are mentioned.

Observations of some other, less common birds, are summarized in Table 1. Arrivals of various bird species (1968 and 1969) are found in Table 2.

Аннотация

Настоящий отчет о наблюдениях над свальбардской Фауной основан на материалах летней экспедиции Норвежского Полярного Института (Norsk Polarinstitutt) и информации других полевых партий и отдельных лиц, посетивших Свальбард в 1969 г.

Описаны результаты десяти наблюдений моржей (*Odobenus rosmarus*), два из которых были сделаны в 1968 г.

Упоминаются лысуха (*Fulica atra*), впервые обнаруженная на Свальбарде, и сизая чайка (*Larus canus*), впервые обнаруженная на Шпицбергене.

Материалы наблюдений других, менее обычных на Свальбарде птиц собраны в таблице 1.

Время прилетов различных видов птиц (в 1968 и 1969 гг.) приведено в таблице 2.

Innledning

Observasjonsmaterialet fra 1969 kommer fra en rekke ulike kilder. Bare et mindre antall observasjonsskjemaer ble benyttet, da instituttets egen hovedekspedisjon arbeidet samlet.

Under feltsesongen 1969 ble det mulig å foreta biologisk kartleggingsvirksomhet av en mer omfattende karakter i de østlige deler av Svalbard i sammenheng med instituttets anvendelse av helikoptere og et større ekspedisjonsfartøy. En vesentlig del av årets materiale stammer fra instituttets biologiske undersøkelser (Kapp Linné, Edgeøya, Barentsøya, Kong Karls Land og Tusenøyane). Materiale av særlig verdi er dessuten mottatt fra et fangstparti på Ryke Yseøyane, den biologiske vinterekspedisjon på Edgeøya og fra Ny-Ålesund. Informasjonene fra Ryke Yseøyane stammer fra tidsrommet høsten 1967 til sommeren 1969. Også data fra 1967 og 1968 er inkludert i denne oversikten. Materiale er dessuten mottatt fra flere andre feltgrupper på Svalbard. Av plasshensyn er bare de viktigste informasjoner inkludert i denne oversikten. Det øvrige materiale er kartotekført i Norsk Polarinstitutts arkiv.

For bidragsyterne er følgende initialer brukt:

B. ALMKVIST (BA), J. ANGARD (JA), K. BRATLIEN (KB), T. LARSEN (TL), O. LIED (OL), H. MAJOR (HM), O. NORDHUS (ON), K. TORSVIK (KT), Norsk Polar Navigasjons ekspedisjon ved B. JOHANNESSEN (BJ), E. I. VILLAND (EIV) og Norsk Polarinstitutts biologparti (NPB).

Der årstall ikke er angitt, refereres det til 1969.

Takk

Jeg vil med dette få takke instituttets ekspedisjonsdeltagere og de øvrige personer som har bidradd med observasjoner i 1969. En særlig takk går til K. TORSVIK for verdifulle data fra de isolerte Ryke Yseøyane i 1967–69 og til mine assistenter, N. GULLESTAD og K. HAGELUND for deres innsats under feltarbeidet på Svalbard.

Pattedyr

Moskus (*Ovibos moschatus*). – Ved Adventdalens nordside ble en flokk på ca. 12 individer sett 12/8 (HM).

Rein (*Rangifer tarandus platyrhynchus*). – Bohemanflya og Daudmannsøyra ble undersøkt i mai uten at tegn til rein ble sett (JA). To individer ble sett på Templet (ca. 500 m o.h.) 19/8 og en på Rejmyrefjellet (ca. 600 m o.h.) 21/8 (EIV). Fire individer ble sett i Woodfjorden, 5 km sør for Gråhuken 9/5, og 3 individer i Wijdefjorden, 20 km sør for Gråhuken 10/6 (JA). Rester etter to gamle reinshorn ble funnet på Ryke Yseøyane (KT). På Svenskøyas sørvestre del ble sett tallrike reinspor og ekskrementer, hvorav endel må ha vært avsatt i 1969. Etter sporstørrelsen å dømme dreide det seg om mer enn ett individ. På øyas nordre del såes kun gamle hornrester. Det samme gjaldt Kongsøyas vestre del (NPB).

Polarrev (*Alopex lagopus*). – På Ryke Yseøyane ble revespor sett 17/1 og 27/1, 1968 (KT). Individer og spor ble registrert flere steder på Barentsøya, og spor ble registrert både på Svenskøya og Kongsøya (NPB).

Isbjørn (*Thalarctos maritimus*). – Observasjonene av isbjørn i Kong Karls Land-området 4/8–8/8 skal kort nevnes (NPB): To individer ble sett 9 nautiske mil vest av Svenskøya 4/8, og ett individ ble sett 3 nautiske mil sørvest av Svenskøya 5/8. På Svenskøya og Kongsøya og i farvannet mellom de to øyene såes ingen isbjørner på tross av gunstige is- og observasjonsforhold. På Svenskøya såes restene etter ett, muligens to hi i snøskavler mellom Kyrkja og Langgrundisen.

Hvalross (*Odobenus rosmarus*). – En hvalross ble sett i Van Keulenfjorden 4/8 (BJ). Ved Gråhuken såes på langt hold 10/5 et dyr som muligens var en hvalross (JA). Ved Negerpynten (Edgeøya) såes et individ 15/5 og ved Zieglerøyane et individ medio juli (TL). På samme dag i august (dato ukjent) såes et individ 70 nautiske mil øst av Kapp Heuglin (Edgeøya) og ett 5 nautiske mil nordøst av Barentsøya (ON). Ved Ryke Yseøyane såes et individ 19/2 og ett 24/4 (KT).

Fra 1968 foreligger dessuten to hittil ukjente observasjoner:

En hvalross ble sett ved Andréetangen, Tjuvfjorden, i oktober (TL) og en ved Ryke Yseøyane 7/8 (KT).

Hvithval (*Delphinapterus leucas*). – Ved Kapp Linné såes ca. 50 individer 15/6, og to flokker på ca. 80–100 individer 24/6, samt en flokk (antall ukjent) 16/7. Ved Kapp Løwenigh, Edgeøya, såes 10–20 individer (inklusive unger) 12/8 (NPB).

Fugler

Smålom (*Gavia stellata*). – Hekking ble påvist på Svenskøya, Kongsøya, Ryke Yseøyane, Håøya, Lurøya, Bølscheøya og Edgeøya (Gothavika) (NPB).

Svartand (*Melanitta nigra*). – I ferskvannsdammene sør for Kapp Linné hadde et par tilhold i tiden 4/7–23/7. Hekking fant etter alt å dømme ikke sted (NPB).

Havelle (*Clangula hyemalis*). – På Edgeøya ble hekking påvist ved Gothavika (et ungekull) og ved Bjørnbukta (et reir) (TL/NPB). Ved Kapp Linné ble det funnet 7 reir (NPB).

Kortnebbgås (*Anser fabalis brachyrhynchus*). – En flokk på ca. 25 voksne med 7 unger ble sett på Akseløya (BJ). Ved Kapp Linné såes grupper på 2–18 individer i tidsrommet 13/6–7/7 (NPB).

Ringgås (*Branta bernicla hrota*). – Ved Kapp Linné såes 4 individer 23/6–24/6. Fra Barentsøya foreligger to usikre observasjoner fra øyas østkyst i august. På Årdalstangen, Edgeøya, såes 18 individer 21/8 (NPB). På Halvmåneøya såes et individ 14/6 og 4 par 20/6 (TL). Fra Tusenøyane foreligger følgende observasjoner (NPB): Håøya, 19 ad. med 19 unger 9/8; Lurøya, 20 ad. med 23 unger 9/8; dessuten en flokk (antall ukjent) på øya øst for Lurøya og Langåra samme dag; på Bølscheøya såes totalt 60 ad. med 24 unger, samt en flokk med ukjent antall 12/8. Disse observasjonene underbygger tidligere antagelser om at Tusenøyane er et av Svalbards viktigste hekkeområder for ringgjess.

Hvitkinngås (*Branta leucopsis*). – Ved Kapp Linné såes enkeltindivider 14/6 og 18/6. Ved Solfonnbekken hadde minst 2 par tilhold (NPB). På Ryke Yseøyane såes 3 individer 10/6 og 1 individ 12/6 (KT).

I Andsjøen, Barentsøya, såes 4 par med unger 28/7 (NPB). På Zieglerøyane, Tjuvfjorden, såes 1 individ 3/6, og senere 6 individer (TL).

Rype (*Lagopus mutus hyperboreus*). – På Barentsøya ble fjærrester og ekskrementer sett på den sørøstre del, og på Svenskøya ble ekskrementer sett ved Mohnhøgda (NPB). Fra Edgeøya foreligger en observasjon av et ungekull (11 unger) 13/8 (NPB) og en observasjon av 6 individer, Negerdalen 28/9 (TL).

Sothøne (*Fulica atra*). – Et dødt eksemplar ble funnet i Ny-Ålesund 13/5 (JA). Dette er så vidt vites det første funn av arten på Svalbard.

Sandlo (*Charadrius hiaticula*). – Et individ ble sett i Moskushamna (dato ukjent) (BA). Ved Kapp Linné såes opptil 25 individer i tidsrommet 12/6–31/7. Et reir ble funnet (NPB).

Steinvender (*Arenaria interpres*). – Ved Kapp Linné såes 1–14 individer nesten daglig i tidsrommet 13/6–31/7. Hekking ble ikke påvist. Ved Kyrkja på Svenskøya såes en voksen steinvender med 3 ungfugler 8/8. Gruppen holdt seg i et lite område, og forholdene tydet på at lokaliteten var hekkeområdet (NPB).

Polarsnipe (*Calidris canutus*). – Fra Kapp Linné foreligger 8 observasjoner (1–4 individer) i tidsrommet 15/6–30/7 (NPB). Et individ ble sett på Ryke Yseøyane 4/6 (KT). Observasjonen er så vidt vites den tidligste som er kjent fra Svalbard.

Myrsnipe (*Calidris alpina*). – Ved Kapp Linné ble gjort 15 observasjoner av arten (1–4 individer) i tidsrommet 14/6–22/7 (NPB).

Sandløper (*Crocethia alba*). – Ved Kapp Linné ble gjort 7 observasjoner av arten (1–7 individer) i tidsrommet 13/6–18/7 (NPB).

Polarjo (*Stercorarius pomarinus*). – Arten ble registrert på Svenskøya, Ryke Yseøyane, Håøya, Lurøya og Edgeøya. På Hopen ble minst 150 sett 23/8 (NPB). Observasjonene hadde etter alt å dømme sammenheng med trekkbevegelser i de østlige Svalbardfarvann. Ved Kapp Linné ble gjort 5 observasjoner (1–3 individer) i tidsrommet 7/7–1/8 (NPB).

Svartbak (*Larus marinus*). – Ved Kapp Linné ble et individ skutt våren 1969. På samme sted såes enkeltindivider 20/6, 28/6, og 1/8 (NPB). På Ryke Yseøyane såes et individ 7/2 (KT).

Fiskemåke (*Larus canus*). – Et individ ble hørt av biologassistenten KARL HAGELUND ved Kapp Linné 24/6 i direkte sammenligning med krykkje. Tåke forhindret kikkertobservasjon, men omstendighetene taler for at observasjonen bør aksepteres, da den ble gjort av en erfaren feltornitolog. Dette er i såfall det første sikre funn på Spitsbergen.

Rødnebbterne (*Sterna macrura*). – Hekking ble påvist på Svenskøya, Ryke Yseøyane, Håøya, Lurøya, Kalvøya, og Bølscheøya (NPB). I 1967 såes store flokker med rødnebbterner på sørtrekk forbi Ryke Yseøyane den 10/9 (KT).

Snøugle (*Nyctea scandiaca*). – Et individ ble sett på Ryke Yseøyane 20/4 1968. I juni samme år hadde en snøugle tilhold på disse øyene. Den livnærte seg av rødnebbterner og rugende ærfugl. Et tredje individ ble registrert samme sted 20/3 (1969) (KT). Fra Tjuvfjordområdet foreligger følgende observasjoner (TL): Kvalpynten 7/4, 2 individer, Negerpynten 4/5, 1 individ; samt 2 individer på Halvmåneøya 15/4. Individene ved Kvalpynten og Negerpynten holdt til ved råkkanten. På begge steder er det store fuglefjell.

Table 1 and 2 – see next page

Tabell 1.

Observasjoner i 1969 av noen mindre vanlige arter, ikke omtalt i teksten.
Observations in 1969 of some less common birds, not mentioned in the text.

Art *Species*	Lok./dato *Loc./date*	Anmerkning *Remarks*	Observatør *Observer*
Heilo *(Pluvialis apricaria)*	Kapp Linné, 9/7	Ett eksemplar	NPB
Småspove *(Numenius phaeopus)*	Engelskbukta, 1/6	—»—	JA
Rødstilk *(Tringa totanus)*	Kapp Linné, 14/6	—»—	NPB
Svømmesnipe *(Phalaropus lobatus)*	—»— 16/7	—»—	—»—
Storjo *(Catharacta skua)*	Rudibkt. Hornsund, aug.	—»—	BA
Hettemåke *(Larus ridibundus)*	Ny-Ålesund, 12/5	—»—	JA
—»— —»—	Kapp Linné, 9/7	—»—	NPB
—»— —»—	Andréetangen, Edg., 10/8	—»—	—»—
Steinskvett *(Oenanthe oenanthe)*	Ryke Yseøyane, 6/6–68	—»—	KT
Stær *(Sturnus vulgaris)*	Ny-Ålesund, nov./des.	Flere	JA

Tabell 2.

Ankomstdato for en del fuglearter på Svalbard, 1968–69.
Date of arrival of some bird species in Svalbard, 1968–69.

Art *Species*	Ankomst Ryke Yseøyane *Arrival Ryke Yseøyane*		Ankomst Tjuvfjorden, Edgeøya *Arrival Tjuvfjorden, Edgeøya*	Ankomst Ny-Ålesund *Arrival Ny-Ålesund*	Observatør *Observer*
	1968	1969	1969	1969	
Gavia stellata	4/6	7/6			KT
Fulmarus glacialis	2/3	16/2	9/2	6/2	KT/TL/JA
Somateria mollissima	9/4	9/4	7/4		KT/TL
Anser branchyrhynchus	21/5		22/5	26/5	KT/TL/JA
Branta bernicla	6/6	17/6	14/6		KT/TL
Branta leucopsis		10/6	3/6		KT/TL
Arenaria interpres				5/6	JA
Stercorarius parasiticus	31/5	5/6	9/6	8/6	KT/TL/JA
Pagophila eburnea	24/3	18/3			KT
Larus hyperboreus	29/3	17/3			KT
Rissa tridactyla	20/4	17/4	7/4		KT/TL
Sterna macrura	1/6	6/6	13/6	5/6	KT/TL/JA
Plautus alle	28/3				KT
Uria lomvia	17/3	15/3			KT
Cepphus grylle	18/2	5/2			KT
Plectrophenax nivalis	7/4	20/4			KT

Norsk Polarinstitutts virksomhet i 1969

AV

TORE GJELSVIK

Organisasjon og administrasjon

Personale

Norsk Polarinstitutt hadde i 1969 32 faste stillinger, like mange som foregående år. Alle stillinger var besatt, men karttegner MAGNE GALÅEN hadde permisjon fra 8/1–1/7.

Midlertidig engasjerte:

Fullmektig ELI HOLMSEN
Assistentbibliotekar VIBEKE EEG-HENRIKSEN
Cand. real. HARALD PLEYM
Cand. real. MAGNAR STUBERG
Cand. mag. JOHAN H. RYE
Student KAROL MIŠUTTA
Assistent INGEBJØRG HELLE

Stipend og forskningsbidrag er ytt til:

Cand. mag. SIGMUND MESSEL, stipend til å studere materialbalansen på Omnsbreen nord for Finse.

Stud. mag. art. BENEDICTE INGSTAD SANDBERG, stipend til dekning av utgifter i forbindelse med etnografiske studier i Christianshåb på Grønland.

Jordskjelvstasjonen, Universitetet i Bergen, stipend til studium av seismisitet i Svalbardområdet.

Cand. real. NILS ARE ØRITSLAND, stipend til å bearbeide materiale fra zoofysiologiske studier av isbjørn på Svalbard.

Cand. mag. NILS GULLESTAD, stipend til dekning av utgifter til bearbeidelse av innsamlet materiale om sjørøye på Svalbard.

Oppnevnelser:

Direktør TORE GJELSVIK til medlem av en 3-manns prosjektkomité for NTNFs kontinentalsokkelundersøkelser.

Underdirektør KAARE Z. LUNDQUIST til konsulent for Sjøgrenseutvalget.

TORGNY VINJE til Norsk Polarinstitutts representant i Det offentlige isutvalg. Etter VIDAR HISDAL overtok han vervet som norsk representant i SCAR Working Group on Meteorology.

REGNSKAPET FOR 1969

Kap. 950. Poster:	*Bevilget:*	*Medgått:*
1. Lønninger	kr. 1 527 800	kr. 1 544 000
9. Deltakelse i Antarktisekspedisjon	» 130 000	» 84 300
10. Kjøp av utstyr	» 345 000	» 340 700
15. Vedlikehold	» 36 000	» 35 500
20. Ekspedisjoner til Svalbard og Jan Mayen	» 1 155 000	» 1 212 300
29. Andre driftsutgifter	» 300 000	» 349 500
70. Stipend	» 40 000	» 27 000
	kr. 3 533 800	kr. 3 593 300
Kap. 31. Fyr og radiofyr på Svalbard	kr. 26 000	kr. 8 300
Kap. 340. Forskningsstasjonen på Svalbard:		
9. Driftsutgifter	kr. 241 000	kr. 165 500
30. Innredning og vitenskapelig utstyr	» 183 000	» 125 000
	kr. 424 000	kr. 290 500
Kap. 3950. Inntekter	*Budsjettert*	*Innkommet*
1. Salgsinntekter	kr. 25 000	kr. 65 100
2. Refusjon fra Svalbardbudsjettet	» 300 000	» 300 000
	kr. 325 000	kr. 365 100
Kap. 4908. Tilfeldige inntekter	—	kr. 6 000

Kommentarer til regnskapet:

Kap. 950.

Post 9. Deltakelse i Antarktisekspedisjonen. – I 1968 fikk vi departementets tillatelse til å overskride posten med kr. 30 000 mot tilsvarende innsparing i 1969.

Post. 20. Ekspedisjoner til Svalbard og Jan Mayen. – Ved egen proposisjon var det foreslått tilleggsbevilgning på kr. 300 000 til oljeundersøkelser. Proposisjonen ble trukket tilbake etter at en del forhåndsdisponering til dette ekspedisjonsopplegget var foretatt, og det ble for sent i sesongen til å endre opplegget helt. Ved reduksjon av deltakerantall og på annen måte lyktes det likevel å begrense merforbruket til ca. kr. 57 000.

Post 29. Andre driftsutgifter. – Merforbruket skyldes bl. a. økte utgifter til kopiering av flybilder, som blir kompensert av større salg. Dessuten hadde vi departementets tillatelse til å overskride «Ymse»-posten» med kr. 17 000 for å finansiere et studieopphold for en av våre hydrografer i USA.

Post 70. Stipend. – Her er kr. 12 000 innspart for å medvirke til å finansiere forannevnte studieopphold.

Kap. 31. Fyr og radiofyr.

Besparelsen skyldes vesentlig at det av spesielle grunner ikke ble beregnet fartøyleie dette år. Dessuten ble noe spart ved at en del vedlikeholdsarbeider måtte utsettes.

Kap. 340. Forskningsstasjonen på Svalbard.

Mindreforbruket skyldes at en spesialbygd båt ikke kunne leveres før i slutten av sesongen. Bevilgningen til innredning og vitenskapelig utstyr er overførbar til 1970.

Kap. 3950. Inntekter.

Post 1. Salgsinntekter. – Merinntekten skyldes vesentlig større salg av flybilder enn forutsett.

Feltarbeid

NORGE

Breundersøkelser

På Storbreen og Hardangerjøkulen ble akkumulasjonen målt i begynnelsen av mai. På begge breene var snømengden svært liten. I løpet av sommeren ble ablasjonen målt flere ganger, siste gang i september. Den varme sommeren førte til usedvanlig stor ablasjon, som sammen med den lave akkumulasjonen gav det største underskudd som er registrert siden Norsk Polarinstitutt satte i gang målinger av breer i 1948 (på Hardangerjøkulen –1,90 m).

Hovedfagsstudent SIGMUND MESSEL avsluttet sine undersøkelser av materialbalanse og energiomsetning på Omnsbreen høsten 1969.

Lengdevariasjonen av ni breer i Sør-Norge og av Engabreen (Svartisen) ble målt. Alle viste tilbakegang så nær som Engabreen og Briksdalsbreen.

Den 30/8 luftfotograferte OLAV LIESTØL Hardangerjøkulen og Folgefonni. Den 18. og 19/9 var han på Blåmansisen, hvor han tok fotografier og satte i gang kontinuerlige målinger av en av bretungene.

SVALBARD

(Se Fig. 1, 2 og 3)

Norsk Polarinstitutts sommerekspedisjon til Svalbard ble organisert og ledet av operasjonssjef THOR SIGGERUD, og omfattet 36 personer – 16 av instituttets faste medarbeidere og 20 engasjerte, hvorav 6 fagmedarbeidere, 7 faglige assistenter og 7 vanlige assistenter. De første deltakerne kom til Svalbard 12/6, og de siste forlot landet 11/9. Været i det østlige området var lite gunstig for helikopteroperasjoner; det var stille og mye tåke. Nedover mot Bjørnøya var vindstyrken også liten (ikke over 4 Beaufort), men tåka var ikke til hinder for posisjonsbestemmelser med HI-FIX. På vestkysten var været som normalt temmelig overskyet med noe nedbør. Issituasjonen var vanskelig i operasjonsområdene til ut i august, især i Storfjorden. Rundt Sørkapp og opp til Hornsund skapte isen problemer mer eller mindre hele sommeren, særlig for hydrograferingsarbeidet. Det første feltpartiet ble på turen til Ny-Ålesund sterkt forsinket av vinterisen, som lå til midt i juni. Tross dette ble ekspedisjonen stort sett gjennomført etter planene.

Ekspedisjonsfartøyet M/S «Polarstar» med kaptein KÅRE STOKKEHOLM og 13 manns besetning ble overtatt av ekspedisjonslederen i Ålesund 14/7 og kom tilbake dit 6/9. Det ble hovedsakelig nyttet til base for helikopteroperasjoner, foruten til å frakte utstyr, sette ut og hente inn feltpartier. Fra ekspedisjonsfartøyet ble også sendt værmeldinger, som var nødvendige for å utføre flyfotografering i de østlige deler av Svalbard.

Det var utleid 4 Bell 47 d 1-helikoptre fra A/S Flytransport, med 6 manns besetning. Selskapet klarte ikke å oppfylle kontrakten helt, og en del av tiden stod bare 3 helikoptre til disposisjon. Ifølge en samarbeidsavtale fikk bergmesteren disponere helikoptrene 10 dager i august.

Ekspedisjonens hovedarbeid ble utført av topografer, geologer og biologer i området Storfjorden – Edgeøya – Barentsøya – Kong Karls Land – Hopen. Med så forskjellige fagdisipliner representert i en operasjon ble det et stort arbeid for ekspedisjonslederen å sørge for optimal utnyttelse av fartøy og helikoptre under skiftende vær- og isforhold og samtidig for størst mulig faglig utbytte av ekspedisjonen. Siden «Polarstar» er meget kraftigere enn de fartøyer som tidligere har vært leid, var ekspedisjonen i stand til å trenge lenger inn i isen enn før.

O/S «Andenes» med kaptein JOHAN PEDERSEN som skipssjef og 30 manns besetning var utleid til Norsk Polarinstitutt av Sjøforsvaret for hydrografering. Som toktleder overtok JOHAN H. CHRISTIANSEN fartøyet i Bodø 12/7, og det ble tilbakelevert samme sted 4/9 av underdirektør KAARE Z. LUNDQUIST, som hadde overtatt ledelsen av toktet 9/8.

Til å utføre flyfotografering for Norsk Polarinstitutt var et Cessna-337-fly med to manns besetning leid av Widerøe's Flyveselskap A/S. Det var stasjonert i Ny-Ålesund. Ekspedisjonsfartøyet brakte og hentet fotoutstyret.

Direktør GJELSVIK fulgte i tiden 10–19/8 et tokt med forskningsfartøyet «Vema», tilhørende Lamont Geological Observatory, Columbia University, i sørlige del av Barentshavet og opp til Longyearbyen. Fartøyet var utrustet med hypermoderne gravimetrisk, magnetisk og seismologisk utstyr og apparater til satellittnavigering. På Svalbard hadde direktøren drøftinger med sysselmannen og representanter for Store Norske Spitsbergen Kulkompani A/S og deltok på Statens vegne i utmålsforretning hos bergmesteren 22/8. I tiden 21–28/8 deltok han i Svalbardutvalgets befaringer og konferanser: reise til Ny-Ålesund med inspeksjon av forskningsstasjonen, til Van Keulenfjorden med besøk på den glasiologiske stasjonen og til Sveagruva, der de hadde kontakt med HORNBÆKS hydrografparti. På grunn av forsinket levering av den nye båten til forskningsstasjonen i Ny-Ålesund fikk GJELSVIK ikke anledning til å utføre planlagt geologisk feltarbeid på Svalbard.

Hydrografi

Hydrograf HELGE HORNBÆK med assistentene Svein BENTSRUD, IVAR LUND-MATHIESEN og SIVERT UTHEIM hadde en feltsesong på 80 dager. De reiste tidlig opp for å skifte inn ny og kraftigere motor i hydrograferingsbåten «Svalis», som ble brukt til detaljlodding i Hornsund (i målestokk 1:50 000), da Norsk Polar Navigasjon A/S hadde bedt om det av hensyn til sine forestående oljeundersøkelser, og i Van Mijenfjorden (i målestokk 1:2 000 og 1:50 000). I Hornsund

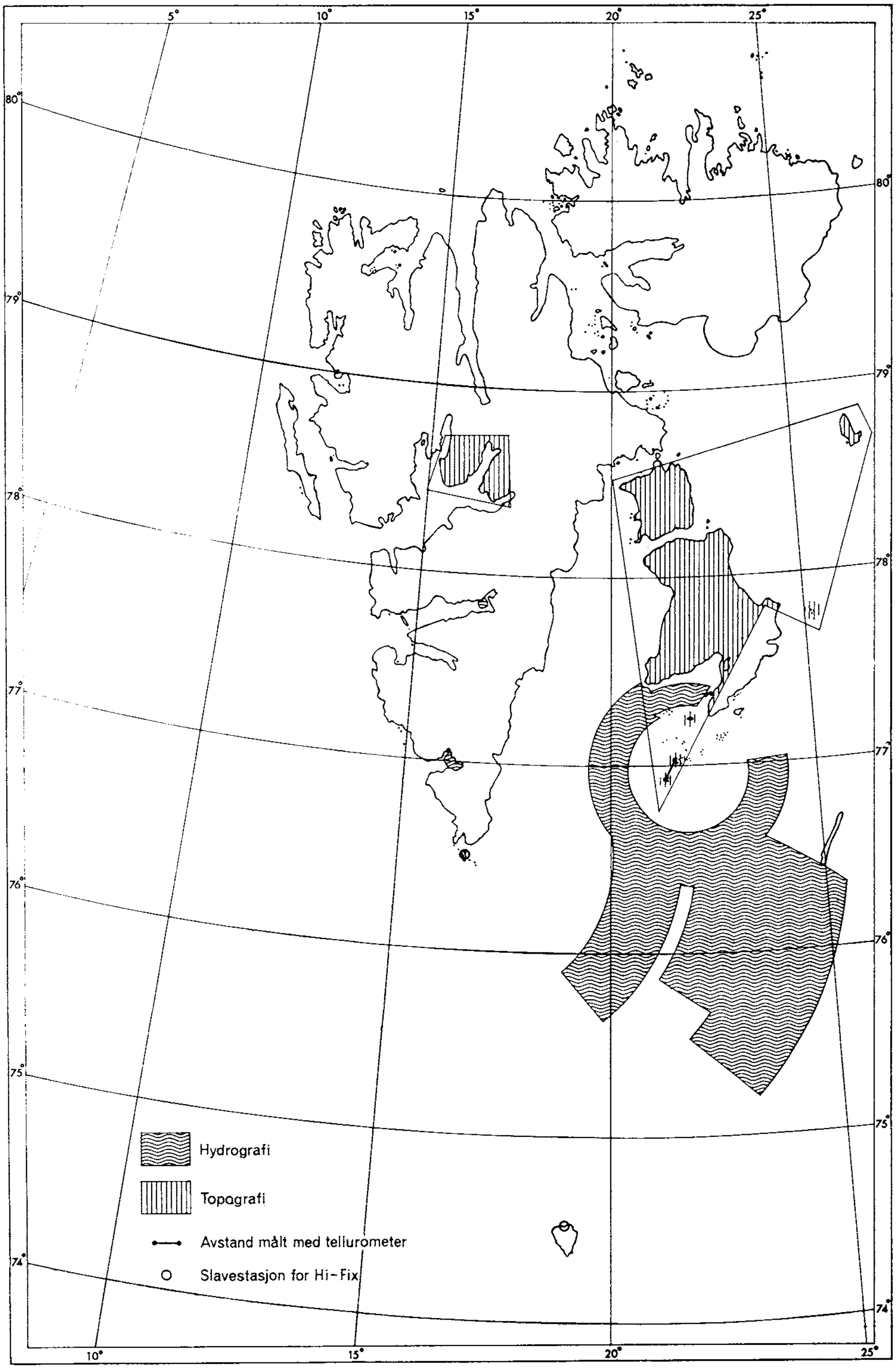

Fig. 1. *Kartet viser hvor Norsk Polarinstitutts hydrografiske og topografiske feltpartier arbeidet sommeren 1969.*

ble arbeidet fortsatt sterkt hemmet av drivis, og istedenfor å hydrografere i et sammenhengende felt måtte arbeidet derfor fordeles på områdene innen- og utenfor Treskelodden og i Burgerbukta. I Van Mijenfjorden ble loddingene for nytt kaianlegg for Store Norske Spitsbergen Kulkompanis Sveafelt ved Kapp Amsterdam fullført som planlagt.

Hydrograferingsarbeidet med «Andenes» ble først ledet av hydrograf JOHAN HENRIK CHRISTIANSEN og siden av underdirektør KAARE Z. LUNDQUIST med ingeniør EINAR NETELAND som teknisk leder under hele toktet. Assistenter på slavestasjonene var JON CHRISTIAN BRINCH, EILIF CARSTENS, OTTAR LIED og JAN WADEBRO. Arbeidet i farvannet Bjørnøya–Hopen–Sørkapp, som ble påbegynt i 1968, ble videreført, idet sektoren mot Hopen og tidligere loddinger rundt Tusenøyane ble utfylt. I alt ca. 6 000 n. mil loddelinjer ble gått. Slavestasjoner for det elektroniske posisjonssystem HI-FIX ble som før opprettet på Bjørnøya (Kapp Posadowsky) og på Sørkappøya, der den for øvrig ble flyttet til varden for det trigonometriske punktet på øya. Begge steder ble det oppsatt gode hytter, siden man trenger stasjonene i flere sesonger ennå.

Topografi – geodesi

Med ekspedisjonsfartøyet «Polarstar» som mobil base og med bruk av helikoptrene til transport i felten arbeidet topograf DAG NORBERG med assisterende engasjerte topografer HALVOR M. PEDERSEN og JON SUNDSBY på Edgeøya, Barentsøya, Tusenøyane, Ryke Yseøyane og Svenskøya (Kong Karls Land) i en måned fra slutten av juli. Nesten hele dette området ble ferdig rekognosert for triangulering og avstandsmålinger, og signaler ble oppsatt i punktene. Siden det var brukbart arbeidsvær bare en sjettepart av tiden, og helikoptrene var i tjeneste for bergmesteren halvparten av de brukbare arbeidsdagene, ble resultatet av innsatsen mindre enn en hadde håpet på.

Engasjert topograf EILIV VILLAND med assistentene HANS PETTER NÆSLUND og OLAV NILSSEN arbeidet i tiden 20/7–28/8 i området Dickson Land og Bünsow Land. Oppdraget, som omfattet passpunktmålinger og identifisering av eldre triangelpunkter på vertikalflybilder, ble nesten fullført. Dermed er feltarbeidet som skal danne grunnlag for konstruksjon av kartblad C8 Billefjorden og C7 Dicksonfjorden så å si avsluttet.

Geodet OLA STEINE arbeidet på Bjørnøya 25–29/6, der han målte inn de nye CONSOL-mastene for Forsvarets fellessamband.

Geologi

HARALD MAJOR, som arbeidet på Svalbard en kortere tid i april og fra 29/7 til 11/9, foretok befaringer og undersøkelser ved Gruve III, V, VI og VII i Adventdalen, og i nærliggende prospekteringsområder øst for Todalen og i Bolterdalen. Han deltok dessuten i opprettelse og avmerking av funnpunkter på mineral- og kullforekomster og representerte Staten ved utmålsforretninger hos bergmesteren.

BOYE FLOOD, JENÖ NAGY og THORE WINSNES med assistentene ULF JØRGEN BORGEN, PER SONGSTAD og JOHN MARTIN ØSTBY arbeidet i tiden 23/7–30/8 i området Edgeøya–Barentsøya med avstikkere til Kong Karls Land og Hopen.

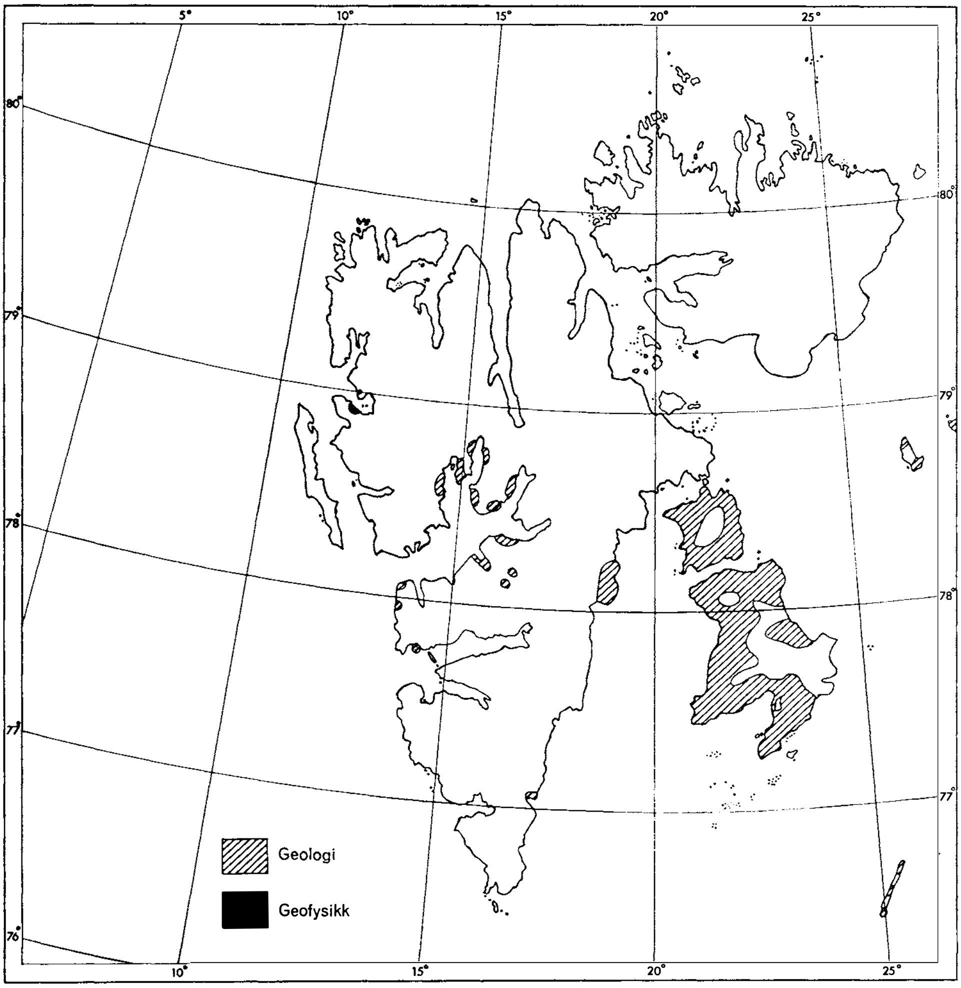

Fig. 2. *Kartet viser hvor Norsk Polarinstitutts geologiske og geofysiske feltpartier arbeidet sommeren 1969.*

Hovedvekten ble lagt på kartlegging og stratigrafisk undersøkelse for utarbeidelse av et geologisk kart i målestokk 1:500 000. Arbeidet foregikk parallelt med topografiske målinger i samme område. THOR SIGGERUD målte samtidig radioaktivitet i bergarter. Partiet hadde ekspedisjonsfartøyet «Polarstar» som base og helikopterstøtte når været ikke tillot topografarbeid.

NAGY representerte dessuten instituttet ved utmålsbefaringer sammen med bergmesteren i tiden 4—11/8.

Geofysikk

De helårlige målingene på austre Brøggerbreen og midre Lovénbreen ble utført av JENS ANGARD ved forskningsstasjonen i Ny-Ålesund. Begge breene viste stort underskudd.

VIDAR HISDAL og TORGNY VINJE oppholdt seg i Ny-Ålesund fra slutten av juni til midten av juli. De ble sterkt forsinket grunnet isvansker og andre uforutsette hindringer. Tiden i Ny-Ålesund kunne imidlertid utnyttes godt takket være gunstig vær. I tillegg til de rutinemessige strålingsmålingene ble det utført en del mer spesielle undersøkelser: kalibrering av det solarimeter som er montert på stedet, måling med monokromater av totalstrålingens spektrale fordeling, parallell registrering av totalstrålingen og strålingen innenfor enkelte smale bølgebånd.

I midten av april deltok VINJE i en isrekognosering med det amerikanske "Birds Eye"-flyet øst for Svalbard.

Et feltparti fra Universitetet i Bergen under ledelse av vitenskapelig assistent ERIK HALVORSEN (Geofysisk institutt) med assistentene cand. mag. OLE THUE (Geologisk institutt) og førstepreparant THORSTEIN STORETVEDT deltok i instituttets ekspedisjon. Partiet samlet i tiden 19/7—1/9 materiale til en paleomagnetisk analyse av devonske sedimenter og mesozoiske diabaser i indre deler av Isfjorden. Det ble utsatt og hentet av ekspedisjonsfartøyet.

Biologi

MAGNAR NORDERHAUG med assistentene NILS GULLESTAD og KARL HAGELUND arbeidet på Svalbard i tiden 12/6—1/9 i to områder: Spitsbergen (Kapp Linné) og de østre Svalbardfarvann (Edgeøya, Barentsøya, Kong Karls Land). På Spitsbergen ble det vesentlig utført ornitologiske undersøkelser, særlig av produksjonen hos ærfugl. På Edgeøya og Barentsøya ble en del reinundersøkelser foretatt, bl. a. bestandstellinger fra helikopter. Arbeidet på Kong Karls Land omfattet faunistiske undersøkelser og innsamling av plantemateriale. I løpet av feltsesongen ble dessuten 1 205 fugler ringmerket, derav 1 018 voksne havhester.

Flyfotografering

Med Wild RC8-kamera ble østlige områder av Svalbard flyfotografert fra ca. 8 000 m høyde i målestokk ca. 1:50 000. Det leide Widerøe-flyet, som opererte fra Ny-Ålesund i tiden 24/7—31/8, ble ført av GØSTA JOHANSON, mens HELGE SKAPPEL navigerte og fotograferte. På grunn av dårlig vær ble resultatet av flygingen mindre enn ventet.

Fyr og radiofyr

Utskifting av gassbeholdere og batterier i fyr og radiofyr fant sted i månedsskiftet august—september. Da ekspedisjonsfartøyet var engasjert i andre oppdrag på østkysten av Svalbard, ble M/S «Nordsyssel» nyttet til transport under fyrettersynet. Arbeidet ble utført av KÅRE BRATLIEN assistert av mannskapet ombord.

Samarbeidende ekspedisjoner

Isbjørn-ekspedisjonen fra Universitetet i Oslo oppholdt seg på Andréetangen på Edgeøya fra august 1968 til august 1969. Foruten lederne cand.real. THOR LARSEN og cand. real. NILS ARE ØRITSLAND deltok assistentene TOR ALF ANDERSEN og KJELL REIDAR HOVELSRUD. Ekspedisjonen drev vesentlig økologiske og zoofysiologiske studier av isbjørn i vinterhalvåret, men utførte dessuten noen reinundersøkelser på Edgeøya. Fire isbjørner ble merket, og dermed er det totale

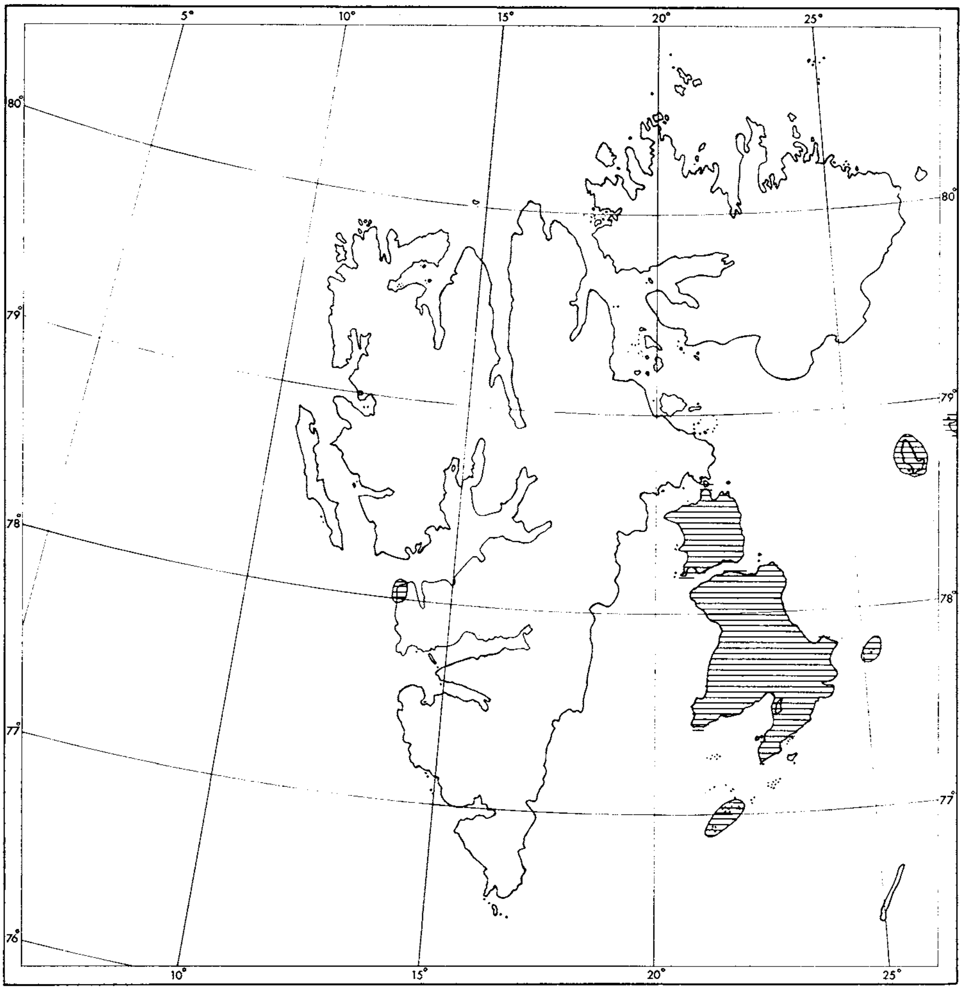

Fig. 3. *Kartet viser hvor Norsk Polarinstitutts biologiske feltparti arbeidet sommeren 1969.*

antall merkede isbjørner på Svalbard oppe i 103. Dessuten ble det utført trekkundersøkelser, lokalisering av hi og innsamling av forskjellige prøver. De zoofysiologiske undersøkelser tok sikte på å klarlegge mekanismen ved isbjørnens termoregulering. Deltakerne returnerte gruppevis fra Edgeøya i juli–september. Utstyret ble hentet og transportert til Norge med Norsk Polarinstitutts ekspedisjonsfartøy.

JAN MAYEN

Topografi – geodesi

OLA STEINE målte inn CONSOL-mastene på Jan Mayen i tiden 10–13/7, men arbeidet ble ikke helt fullført p.g.a. dårlig vær og mangler ved utlånt utstyr.

ANTARKTIS

Etter å ha blitt fløyet fra Oslo, via U.S.A. og New Zealand til den amerikanske McMurdo-basen i Rosshavet, startet Norsk Polarinstitutts ekspedisjon derfra 23/11 1968 for å fly til Vestfjella i Dronning Maud Land. Ekspedisjonen, som ble ledet av THORE WINSNES, bestod av to geologer, en topograf, en geodet, en glasiolog og en radio-operatør og mekaniker. Ekspedisjonsdeltakerne, med 5,5 tonn proviant og utstyr til 75 dagers feltopphold, ble fraktet med et amerikansk fly. Det meste av utstyret var også utlånt fra amerikanske lagre. Etter 8 timer i lufta og mellomlanding på Sydpolen for etterfylling av bensin, ble ekspedisjonen satt ned sør for den sentrale del av Vestfjella, der hovedbasen, Camp Norway I, ble opprettet. Herfra ble området ved hjelp av snøscootere utforsket på sledeturer som strakte seg over ca. 800 km.

Ved siden av de primære oppgaver – topografisk og geologisk kartlegging og glasiologiske undersøkelser – ble det gjort observasjoner og tatt prøver av plante- og dyreliv. Radiokontakt med de nærmeste stasjoner og med Norge ble opprettholdt under hele ekspedisjonen.

Arbeidsforholdene viste seg så gunstige at programmet var gjennomført i god tid før den planlagte avhenting med fly. Avreisen ble derfor fremskyndet en uke – til den 20/1, og ekspedisjonen var hjemme igjen 5/2 1969. (Se også foreløpig rapport i Norsk Polarinstitutt Årbok 1968, s. 55–57.) Ekspedisjonen ble muliggjort ved generøs assistanse av U.S. National Science Foundation.

Topografi – geodesi

Topograf DAG NORBERG og geodet OLA STEINE bestemte et punkt astronomisk, målte to basislinjer med tellurometer (MRA3), triangulerte i 14 stasjoner jevnt fordelt i området og skar fram ca. 50 passpunkter. De la vekt på å knytte de engelske målingene i Heimefrontfjella og Mannefallknausane til det norske nettet. Til alle vinkelmålingene ble det brukt WILD T2 universalteodolitt. Målingene er mer enn tilfredsstillende for et kartverk i målestokk 1:250 000 over Vestfjella.

Geologi

THORE WINSNES og AUDUN HJELLE kartla og undersøkte Vestfjella geologisk. Her ble funnet svakt metamorfe, basiske lavadekker, som heller slakt mot vest. Helt sørvest i fjellrekken ligger et område med ultrabasiske intrusiver. De foreløpige undersøkelsene tyder på at både lavaer og intrusiver er mesozoiske. I østre del av området ble det dessuten funnet karbon-permiske planteførende lag. Både metamorfosegrad og struktur i Vestfjella synes å tyde på sammenheng med den transantarktiske fjellkjedes svakt metamorfe, senpaleozoiske og mesozoiske bergarter.

Geofysikk

TORBJØRN LUNDE stod for de glasiologiske undersøkelser. Hovedarbeidet, som bestod i å bestemme akkumulasjonen, ble gjennomført ved å grave en 10 m dyp sjakt og en boring 8 m videre ned. Spesifikk vekt ble målt for hver 10 cm og snøprøver ble tatt for hver 5 cm for senere bestemmelser av forholdet $0_{16}/0_{18}$. LUNDE dro også ut på isshelfen og tok prøver ned til 12 m dyp.

KÅRE BRATLIEN utførte sammen med LUNDE rutinemessige meteorologiske målinger, og NORBERG og STEINE foretok magnetiske målinger.

Arbeid ved avdelingene

Hydrografi

De nye utgavene av sjøkartene 501 og 503 ble korrekturlest, og det ble gjort forberedende arbeid til trykking av 502 og 507 i nye opplag. Dessuten ble ny utgave av 507 redigert og navnsatt. Etter sommerens målinger ble foreløpige kart over deler av Hornsund og havnekart Kapp Amsterdam utarbeidet. Foregående års konstatering av en differanse på ca. 800 m mellom elektronisk og eldre observert avstand Sørkapp–Bjørnøya ble bekreftet.

Topografi – geodesi

Observasjoner fra Svalbard, fra siste sommer og fra tidligere år, ble beregnet. Blad 2 Edgeøya og blad 4 Nordaustlandet i serien Svalbard 1:500 000 ble fullført og levert til trykking i foreløpige utgaver. Aerotrianguleringer ble utført med Wild A7-autograf med tilleggsutstyr. Beregningene av dette materialet ble gjort på elektronisk datamaskin ved Norges geografiske oppmåling. Av serien Svalbard 1:100 000 ble A4 Vasahalvøya, A5 Magdalenefjorden og A6 Krossfjorden ferdig konstruert, og konstruksjonen av B7 Tre Kroner ble påbegynt. Dessuten var C10 Braganzavågen og C11 Kvalvågen under videre bearbeidelse etter tidligere konstruksjon i målestokk 1:50 000 etter skråfotogrammer. Kartnorm og tekst til sistnevnte serie var også under arbeid. En ny kystlinje innerst i Hornsund ble konstruert. Ajourføring og rettelser på noen kartblad i serien Namnekart Svalbard 1:100 000 ble foretatt, og E8 Barentsjøkulen ble gjennomgått. Et kart over midre Lovénbreen ble konstruert i målestokk 1:20 000 med 10 m ekvidistanse etter flyfoto fra 1969. Det ble konstruert kart over Hellstugubreen i Jotunheimen i målestokk 1:10 000 med 10 m ekvidistanse på grunnlag av flyfoto fra 1968. Observasjonene for bestemmelse av CONSOL-mastene på Bjørnøya og Jan Mayen ble beregnet for Forsvarets fellessamband.

Beregninger av observasjonene fra Den norske Antarktisekspedisjonen 1968–69 til Vestfjella i *Dronning Maud Land* ble påbegynt. Det ble arbeidet med stedsnavn fra forskjellige områder, og L4 og M4 i serien Dronning Maud Land 1:250 000 ble også påbegynt.

Geologi

HARALD MAJOR behandlet spørsmål om statens tidligere utmål som nå er overdratt til A/S Adventdalens Kullfelt, fortsatte de kullpetrografiske studiene av prøver fra Gruve VII og utarbeidet en redegjørelse for Industridepartementet om fortsatte undersøkelser i Gruve III og VII.

THORE WINSNES, JENÖ NAGY og BOYE FLOOD planla om våren de geologiske undersøkelsene ved sommerens ekspedisjon til det østlige Svalbard. Etter tilbakekomsten fra ekspedisjonen bearbeidet de det innsamlede materiale og forberedte utgivelse av et geologisk kart i målestokk 1:500 000 over det sørøstlige Svalbard. Sammenstilling og redigering av materiale til det sørvestre kartblad i samme målestokk, som nå er under trykking, har også krevd mye arbeid av de samme geologene. Til Det IX nordiske geologiske vintermøte i København (Lyngby) utarbeidet de et foredrag: «Stratigrafiske undersøkelser av den triassiske lagrekke på Edgeøya, Barentsøya (og Hopen), Svalbard».

WINSNES bearbeidet sammen med AUDUN HJELLE observasjoner og prøver fra Vestfjella i Antarktis. For Årbok 1968 skrev han artikkelen "The Norwegian Antarctic Expedition 1968–69".

HJELLE klargjorde materiale fra det nordvestlige Svalbard med tanke på publisering. Han besvarte også henvendelser om prospektering på Svalbard.

NAGY omarbeidet og oversatte sin hovedfagsoppgave for publisering i Skrifter og deltok i utarbeidelsen av teksten til geologisk kartblad Adventdalen. I løpet av året var han med på å utarbeide besvarelser på henvendelser om oljeundersøkelser på Svalbard.

FLOOD fortsatte bearbeidelsen av prøver og observasjoner fra 1967 og 1968.

En rammeplan for en stort anlagt undersøkelse av kontinentalsokkelen ved Svalbard og i Barentshavet, utarbeidet av den geologiske avdeling ved NAGY, SIGGERUD og GJELSVIK, ble fremmet for prosjektkomitéen for Norges Teknisk-Naturvitenskapelige Forskningsråds kontinentalsokkelundersøkelser.

Geofysikk

OLAV LIESTØL bearbeidet det glasiologiske feltmateriale fra Svalbard og Norge. For Årbok 1968 skrev han artikkelen «Glasiologiske undersøkelser i 1968».

VIDAR HISDAL fullførte analysen av høydevinden over Maudheim, Dronning Maud Land. Ved hjelp av midler stilt til rådighet av Norsk Hydros Fond ble det innkjøpt kalibreringsutstyr for de instrumenter som anvendes til måling av strålingens spektrale sammensetning. Monteringen av kalibreringsutstyret ble langt på vei fullført, men en del instrumentmakerarbeid gjenstår. HISDAL brukte adskillig tid til redaksjonelt arbeid, spesielt i forbindelse med et nytt nummer av Skrifter. For Årbok 1968 utarbeidet han en oversikt over værforholdene på Svalbard i 1968.

TORGNY VINJE utarbeidet ukentlige havisoversikter, vesentlig på grunnlag av satellittbilder, som kan anvendes fra midten av februar til slutten av oktober. Kopier av oversiktene sendes til norske forbindelser og til tre utenlandske bytteforbindelser. Det har vært økende forespørsel om isforholdene i Arktis fra oljeselskapene. Ellers ble strålingsmålinger fra Ny-Ålesund utregnet. VINJE skrev to artikler for Årbok 1968: "Sea ice observations in 1968" og "Some observations of the ice drift in the East Greenland Current". Videre gjorde han grovutkast til to mindre arbeider: et om strålingsmålinger som han har tatt på Svalbard og i Norge siden 1964, og et annet om turbulens. Som et ledd i rammeplan for kontinentalsokkelundersøkelsen ble skissert planer for observering av isdrift og strøm. Med Meteorologisk Institutt ble innledet drøftelser med sikte på å avlaste Polarinstituttet for ismeldingstjenesten.

Biologi

MAGNAR NORDERHAUG tok seg av henvendelser vedrørende arktisk dyreliv og planlagte biologekspedisjoner til Svalbard. Han samlet inn og bearbeidet biologisk observasjonsmateriale fra feltgrupper på Svalbard, og ferdigbehandlet materiale til det andre av de tre arbeidene om svalbardgjessenes status. Videre bearbeidet han og sammenfattet data om svalbardreinen. Til Årbok 1968 innleverte han tre artikler: "The present status of the Brent goose (*Branta bernicla hrota*) in Svalbard", "The present status of the Barnacle goose (*Branta leucopsis*) in Svalbard" og «Iakttagelser over dyrelivet på Svalbard 1968.»

Arbeidsgruppen for viltstell og naturvern på Svalbard, som NORDERHAUG er formann i, arbeidet videre med planlegging av nasjonalparker og reservater på øygruppen.

Biblioteket

I årets løp ble 200 bøker og særtrykk registrert, hvorav 44 var innkjøpte bøker. Biblioteket fikk ca. 430 tidsskrifter og serier i bytte; det abonneres på 32 publikasjoner. Særtrykksamlingen økte med 120 nummer til 5 420. Tilvekstlister distribueres nå til ca. 50 interesserte.

Arbeidet med registrering av gammel bestand fortsatte: biografiene og noen tidsskrifter ble registrert, mens bl. a. kartsamlingen gjenstår. Det daglige rutinearbeidet ble utført av VIBEKE EEG-HENRIKSEN. Instituttets korrespondanse med bytteforbindelsene ble overført til biblioteket.

Konsulent- og informasjonstjeneste

Administrasjonen og de forskjellige fagavdelinger tok seg av konsulent- og informasjonstjenesten innenfor sine fagområder.

SØREN RICHTER ble konsultert i spørsmål om polaregnenes arkeologi, etnografi, geografi og historie.

ELI HOLMSEN stod for den tekniske bearbeidelsen av publikasjoner til trykking og fungerte som redaksjonssekretær for instituttets Årbok.

PETER HAGEVOLD utarbeidet, sammen med andre av medarbeiderne, instituttets årsrapport, gjennomgikk innkommen faglitteratur på russisk og oversatte en del av denne.

Reiser, møte- og kursvirksomhet

Direktør GJELSVIK deltok 14—16/7 i møte i eksekutivkomitéen for SCAR i Cambridge (England) og besøkte på samme turen British Antarctic Survey's geologiske avdeling i Birmingham. I tiden 6—16/9 deltok han som vitenskapelig rådgiver i et møte som var arrangert av Den internasjonale geologunion (IUGS) og UNESCO for å drøfte utkast til "International Geological Correlation Programme", og som var lagt til Budapest i anledning hundreårsjubileet for den ungarske geologiske undersøkelse.

HELGE HORNBÆK var to ganger i Stavanger (15/1 og 5/11), henholdsvis for vurdering av motortype til «Svalis» og anskaffelse av strømmåler m. m.

JOHAN H. CHRISTIANSEN reiste i august til Washington for å delta i et ettårig kurs i hydrografi og oseanografi ved Education and Training Office, Oceanographic Office.

THOR SIGGERUD deltok i mars i et symposium på Scuola Enrico Mattei i Milano i moderne radiometrisk prospekteringsteknikk.

BOYE FLOOD var med i et symposium i malmleting ved Norges tekniske høgskole i Trondheim 13–14/1.

OLAV LIESTØL og VIDAR HISDAL deltok 9–12/4 i "Tagung der Deutschen Gesellschaft für Polarforschung" i Münster, der LIESTØL holdt foredrag om "Glacier fluctuation in Spitsbergen". HISDAL besøkte deretter Geophysikalisches Observatorium, Kl. Feldberg (Taunus) og Deutscher Wetterdienst, Zentralamt (Offenbach).

OLAV LIESTØL deltok i et symposium i Cambridge 6–13/9 om "Glacier Hydrology".

VIDAR HISDAL og TORGNY VINJE deltok 8–11/12 i et seminar ved Meteorologisk Institutt i Oslo om bruk av satellittbilder, der VINJE holdt et foredrag om bestemmelse av isgrenser.

TORGNY VINJE var i tiden 3–24/3 på studiereise i Sovjetunionen, der han besøkte vitenskapelige institusjoner i Leningrad og Moskva. Han fikk da høve til å avlegge et besøk også på den drivende stasjon "Severnyj poljus-16" i Sentral-Arktis med fly fra Leningrad over Amderma og Tiksi.

MAGNAR NORDERHAUG deltok i oktober i Canada i en konferanse om biologisk produktivitet og naturvern i Arktis. På konferansen holdt han foredrag om "Conservation and wildlife problems in Svalbard".

EINAR NETELAND var i Bergen i juni og fikk instruksjon i bruk av radarmåleenheten DNR-397-112 A for måling av nøyaktige avstander. Fra 15 til 19/11 var han på kurs for laboranter med erfaring i elektronikk og kjemi, arrangert av Norges Teknisk-Naturvitenskapelige Forskningsråd.

Forelesnings- og foredragsvirksomhet

Direktør GJELSVIK holdt forelesninger om arktiske problemer ved Forsvarets høgskole. I et program arrangert av Skolekringkastingen – «I dag møter vi direktøren for Norsk Polarinstitutt» – svarte han på spørsmål om instituttets arbeidsoppgaver. I Militærteknisk studiegruppe, Kjeller, holdt han foredrag om Svalbard og norsk overhøyhet og i Bergens geofysiske forening om norsk forskningsvirksomhet på Svalbard. I Det norske geografiske selskab holdt han en innledningstale om Den norske Antarktisekspedisjon 1968–69. Ved avdukingen av general Nobiles «Italia»-monument i Tromsø hilste han fra norsk polarforskning. Han deltok også i radio- og fjernsynsprogrammer, særlig i forbindelse med Antarktisekspedisjonen.

AUDUN HJELLE holdt 16/10 foredrag med film og lysbilder i «Gæa Norvegica» med tittelen «Fra Den norske Antarktisekspedisjonen 1968–69», med hovedvekt på geologi, og 11/11 i Norges Banks Fotoklubb, med hovedvekt på fotografering og filming i polarstrøk.

OLAV LIESTØL holdt i vårsemesteret en forelesningsrekke i glasiologi ved Universitetet i Oslo, der han fremdeles fungerer som sensor ved hovedfagseksamen i limnologi, fysisk geografi og geofysikk.

DAG NORBERG holdt 18/9 kåseri med lysbilder i Rena Rotaryklubb om «Antarktisekspedisjonen 1968–69» og 2/10 foredrag i Fotogrammetrisk kollokvium i Oslo om «Norsk Polarinstitutt – kartavdelingens mål, midler og resultater».

MAGNAR NORDERHAUG holdt to økologiforelesninger på Zoologisk laboratorium ved Universitetet i Oslo: Gåsepopulasjonene på Svalbard (26/9) og Trekk av Svalbardreinens økologi (14/11). I desember holdt han i Norsk ornitologisk forening i Oslo foredrag om «Pågående ornitologiske undersøkelser i Svalbardområdet».

OLA STEINE holdt 14/3 i Jordskifterlaget ved Norges landbrukshøgskole foredrag med lysbilder om «Landmålerliv i polarstrøk».

THORE WINSNES holdt foredrag om Antarktisekspedisjonen 1968/69 i Det norske geografiske selskab i mars og deltok samme måned i et fjernsynsprogram om Antarktis.

Publikasjoner

Skrifter:

Nr. 78 – ANDERS K. ORVIN: Outline of the geological history of Spitsbergen. (2nd printing.)

Nr. 145 – RODNEY A. GAYER: The geology of the Femmilsjøen region of north-west Ny Friesland, Spitsbergen.

Nr. 146 – B. FLOOD, D. G. GEE, A. HJELLE, T. SIGGERUD, T. S. WINSNES: The geology of Nordaustlandet, northern and central parts. With geological map 1:250 000.

Nr. 148 – TORGNY E. VINJE: The turbulent transfer over an Antarctic ice shelf.

Meddelelser:

Nr. 98 – JEAN-PIERRE PORTMANN: Some superficial deposits within the map sheet Adventdalen, Vestspitsbergen.

Årbok:

Årbok 1967.

Sjøkart:

501 Bjørnøya, 1:40 000 (nytt opplag).

502 Bjørnøyfarvatnet, 1:350 000 (nytt opplag).

503 Fra Bellsund til Forlandsrevet med Isfjorden, 1:200 000 (ny utgave).

507 Nordsvalbard, 1:600 000 (nytt opplag).

Instituttets medarbeidere har utenom instituttets serier publisert:

OLAV LIESTØL: Glacier surges in West Spitsbergen. *Canadian Journ. of Earth Sciences.* **6** (4), 1969.

— skrev bidrag til Glasiologiske undersøkelser i Norge i 1968. *Rapport nr. 5/69, Vassdragsdirektoratet, Hydrologisk avdeling.* Oslo 1969.

MAGNAR NORDERHAUG: Svalbard-reinens utbredelse i 1960-årene. *Fauna,* (2), 1969, s. 132–139. (Årgang 22.)

— Svalbard-reinen i 1960-årene. Beiteareal og bestand, *Fauna,* (4), 1969, s. 253–264. (Årgang 22.)

SØREN RICHTER skrev bidrag til *Norsk biografisk leksikon.*

TORGNY VINJE skrev to artikler i *Aftenposten* om polarisen.

THORE WINSNES: Norwegian Antarctic Expedition, 1968–1969. *Antarctic Journ. of the United States.* **4** (4), 1969.

The activities of Norsk Polarinstitutt in 1969

Extract of the annual report

BY

TORE GJELSVIK

The permanent staff of the institute in 1969 numbered 32 persons, the same as in the previous year. In addition, ten persons worked on short-term contracts.

Field work

NORWAY

Glaciology

Mass balance of Storbreen (Jotunheimen) and Hardangerjøkulen in South-Norway was studied, fluctuations of nine glacier tongues in South-Norway and one in North-Norway were measured. Aerial photographs were taken of the glaciers Hardangerjøkulen and Folgefonni. Investigations of mass balance and energy exchange of Omnsbreen at Finse were concluded in the autumn 1969. See p. 116.

SVALBARD

The summer expedition of Norsk Polarinstitutt, organized and led by T. SIGGERUD, comprised 36 persons exclusive of the crews of the two ships chartered, which numbered 13 and 30 persons respectively. The main expedition was based on M/S «Polarstar» and used four Bell 47 d 1 helicopters for transport of parties in the field. A Cessna-337 aeroplane was contracted from Widerøe's Flyveselskap A/S to carry out aerial photography. Charting off the coast was carried out with O/S «Andenes». The first participants of the expedition arrived in Svalbard on 12 June, while the last to return, left for home on 11 September.

The weather in the eastern region was rather unfavourable for aerial operations, as it was calm and foggy. Conditions in the waters south of Spitsbergen–Edgeøya were satisfactory except for drift ice around Sørkapp. On the west coast the weather was as usual rather cloudy, with some precipitation. In July and part of August the sea ice strongly hampered the operations of the expedition vessel, particularly in Storfjorden. The first field party to Ny-Ålesund was delayed by the winter ice, which remained till the middle of June.

Hydrography

H. HORNBÆK worked with the surveying boat «Svalis» in the inner part of Hornsund, and was here much hindered by sea ice. He also made a harbour survey near Sveagruva, where a new pier is planned.

The hydrographical work with «Andenes» was first carried out by J. H. CHRISTIANSEN and later by K. Z. LUNDQUIST with E. NETELAND as a technical leader. The sounding took place in the waters between Bjørnøya, Hopen, and Sørkapp. HI-FIX was used for positioning, and about 6 000 naut. miles of sounding lines were obtained.

Topography-geodesy

In August, D. NORBERG, H. M. PEDERSEN, and J. SUNDSBY with logistic support provided by the expedition vessel and helicopters made a reconnaissance of the Edgeøya–Barentsøya area and set up cairns for a combined trilateration and triangulation net. Owing to bad weather, only a small part of the planned measurements could be carried out.

During the same period a field party led by E. VILLAND worked in Dickson Land and Bünsow Land, where control points were measured and identified in the vertical photographs.

At the end of June, O. STEINE determined the position of the new CONSOL masts on Bjørnøya in relation to the triangulation net.

Geology

H. MAJOR inspected and examined the Longyear coal mines Nos. III, V, VI, and VII and also carried out work connected with coal claims in Spitsbergen.

B. FLOOD, J. NAGY, and T. WINSNES with logistic support provided by the expedition vessel and helicopters worked in the Edgeøya–Barentsøya area, on Kong Karls Land, and Hopen. The main purpose of their investigations was geological mapping, stratigraphical measurements, and collecting of fossils.

Geophysics

The all-year mass balance measurements were carried out on the glaciers Austre Brøggerbreen and Midre Lovénbreen in Spitsbergen by J. ANGARD at the research station in Ny-Ålesund.

In the middle of April, T. VINJE took part in an aerial reconnaissance of the sea ice east of the Svalbard area at the invitation of US Naval Oceanographic Office («Birds Eye» Project).

V. HISDAL and T. VINJE made radiation measurements in Ny-Ålesund from the end of June to the middle of July. In addition to routine measurements, more special investigations were performed, such as calibration of pyranometers and measurements of the spectral composition of the short-wave radiation.

E. HALVORSEN, Geophysical Institute, University of Bergen, collected rocks for paleomagnetic measurements of Devonian sediments and Mesozoic diabases in Isfjorden.

Biology

M. NORDERHAUG worked for two months in June–August in two regions of Svalbard: Spitsbergen (Kapp Linné) and eastern Svalbard regions (Edgeøya, Barentsøya, Kong Karls Land). In Spitsbergen the work consisted in ornithological investigations, and in particular the study of reproduction in eider ducks. In Edgeøya and Barentsøya the reindeer population was examined and counted from helicopter. In Kong Karls Land faunistic investigations and collection of plant material were carried out. In the course of the field season, 1 205 birds were ringed, of which 1 018 were adult fulmars.

Aerial photography

Parts of eastern Svalbard were photographed from the air with a Wild RC8 camera approximately on the scale of 1:50 000. This work was done by Widerøe's Flyveselskap A/S, using a Cessna-337 aeroplane with operation base in Ny-Ålesund, in the period 24 July–31 August. Owing to cloudy weather the results were not up to expectations.

Associated expeditions

The zoological expedition of the University of Oslo, consisting of four men led by T. LARSEN and N. A. ØRITSLAND, in cooperation with Norsk Polarinstitutt, stayed in Edgeøya from August 1968 till August 1969. The work of the expedition comprised ecological and zoophysiological studies of the polar bear during the winter, but investigations of reindeer in Edgeøya were also carried out. Four bears were marked, which means that the total of marked bears in Svalbard numbers 103. In addition, migration studies, localization of dens, and collection of samples were made. The zoophysiological investigations were intended to throw light upon the thermoregulation of the bear.

JAN MAYEN

Topography-geodesy

From July 10 to 13, O. STEINE made an attempt at determining the position of the new CONSOL masts. The work was not completed owing to defects in the equipment borrowed.

ANTARCTICA

On 23 November 1968, the Norwegian Antarctic Expedition 1968–69 was flown from McMurdo to Vestfjella in Dronning Maud Land. The expedition, led by T. S. WINSNES, consisted of two geologists, one topographer, one geodesist, one glaciologist, and one radio operator and mechanic.

The main base, Camp Norway I, was erected south of the central part of the mountains, and the area was explored by motor toboggans.

Besides the primary programme, topographical and geological mapping and glaciological investigations, observations and sampling of plants and birds were made.

Weather and snow conditions proved so favourable that the programme was completed one week ahead of the schedule, and the expedition was picked up by an aeroplane on 20 January 1969. The expedition was made possible by generous assistance from the U. S. National Science Foundation.

Topography-geodesy

O. STEINE and D. NORBERG measured one astrofix and two base lines with tellurometer, triangulated at 14 stations, and fixed about 50 control points. Efforts were made to connect the English measurements in Heimefrontfjella and Mannefallknausane to the Norwegian triangulation net in Vestfjella.

Geology

T. WINSNES and A. HJELLE made stratigraphical, structural, and petrographical observations. The rocks of Vestfjella may tentatively be correlated with the Mesozoic Beacon rocks of the Transantarctic Mountains.

Geophysics

Glaciological investigations were carried out by T. LUNDE. The main purpose was to measure the accumulation, and samples were taken at short intervals in pits for density and $0_{16}/0_{18}$ measurements. K. BRATLIEN and LUNDE made routine meteorological measurements at the major synoptic hours, and NORBERG and STEINE made magnetic measurements.

Preparation of data

Hydrography

Preliminary charts from parts of Hornsund and a harbour area at Sveagruva were prepared in connection with the processing of sounding data from the expedition. New editions of chart Nos. 501, 503, and 507 were prepared.

Topography-geodesy

Sheet 2 Edgeøya and sheet 4 Nordaustlandet in the series Svalbard 1:500 000 were completed for printing in preliminary editions. Aerotriangulations were carried out on a Wild A7 autograph. In the series Svalbard 1:100 000, construction of 3 sheets was completed. Preparation of C10 Braganzavågen and C11 Kvalvågen continued according to previous construction on the scale of 1:50 000 from oblique photograms. A map of the glacier Midre Lovénbreen was constructed on the scale of 1:20 000 with an equidistance of 10 m, using aerial photographs from 1969. A map of the glacier Hellstugubreen in *Jotunheimen*, on the scale of 1:10 000 with an equidistance of 10 m, was constructed on the basis of aerial photographs from 1968.

Calculations of observation data from the Norwegian Antarctic Expedition 1968–69 to Vestfjella in *Dronning Maud Land* were initiated. Toponymy from various parts of this area was dealt with, and preparatory work on sheets L4 and M4 in the series Dronning Maud Land 1:250 000 was undertaken.

Geology

H. MAJOR prepared reports on the Longyear mines and continued his studies of coal petrology.

T. WINSNES, J. NAGY, and B. FLOOD prepared material from eastern Svalbard for a 1:500 000 geological map. They also compiled and edited data from the southern part of Spitsbergen for another map on the same scale. At the IX Nordic Geological Winter Meeting at Lyngby, Denmark, they presented a paper on the Triassic sequence of eastern Svalbard.

T. WINSNES and A. HJELLE worked on material and observations collected in Dronning Maud Land, Antarctica.

A. HJELLE also prepared material from north-west Spitsbergen.

J. NAGY prepared a paper on the "Ammonite faunas and stratigraphy of Lower Cretaceous (Albian) rocks in southern Spitsbergen" for publication, and also took part in the preparation of the description of the geological map sheet Adventdalen.

B. FLOOD continued his preparation of material collected in 1967 and 1968.

J. NAGY, T. SIGGERUD, and T. GJELSVIK worked out plans for investigations of the continental shelf around Svalbard and in the Barents Sea.

Geophysics

O. LIESTØL prepared glaciological material from Svalbard and Norway. For Årbok 1968 he wrote the article "Glasiologiske undersøkelser i 1968" (Glaciological investigations in 1968).

V. HISDAL completed the analysis of the upper wind data from Maudheim, Antarctica. An account of the weather in Svalbard in 1968 was prepared for Årbok 1968.

T. VINJE made weekly reviews of the distribution of the sea ice in the Atlantic sector of the Polar Ocean, mainly on the basis of satellite photographs. The global radiation registered in Ny-Ålesund was calculated. VINJE wrote two articles for Årbok 1968: "Sea ice observations in 1968" and "Some observations of the ice drift in the east Greenland Current".

In connection with the planned investigations of the continental shelf, projects were outlined for measuring sea currents and ice drift speed in the Svalbard area. He also took part in discussions with representatives of the Norwegian Meteorological Institute on the future organization of ice reporting.

Biology

M. NORDERHAUG collected and prepared biological observations from Svalbard made by various field parties. He prepared a third paper on the status of the Svalbard geese, and collected data on the Svalbard reindeer. He contributed to Årbok 1968 three papers: "The present status of the Brent goose (*Branta bernicla hrota*) in Svalbard", "The present status of the Barnacle goose (*Branta leucopsis*) in Svalbard", and "Iakttagelser over dyrelivet på Svalbard 1968" (Observations of animal life in Svalbard 1968).

The working group for wildlife management and conservation in Svalbard, of which NORDERHAUG is the chairman, continued work on projects for national parks and nature reserves in the archipelago.

Field work of scientific and economic interest carried out by expeditions to Svalbard in 1969

BY

TORE GJELSVIK

Nationality	Institution or company	Number of participants Name of leader(s)	Area of investigation Period	Work
Norwegian	Norsk Polarinstitutt[1]			
—»—	University of Oslo[2]			
—»—	Norsk Polar Navigasjon A/S	c. 15 GUNNAR S. PEDERSEN IVAR YTRELAND	Eastern Svalbard areas, Berzeliusdalen March 4–May 22, June–Aug. 23	Staking out claims and overhauling of drilling equipment
—»—	A/S Berabo	GUNNAR MIKALSEN	Sveagruva, Longyearbyen Aug.	Prospecting for oil
Norwegian-Belgian	Norsk Fina A/S (Oslo), Petrofina (Brussels)	c. 15 N. GOLENKO	Longyearbyen, Hornsund, Edgeøya, Barentsøya, Hopen, Kong Karls Land July 2–Sept. 15	Prospecting for oil, seismical measurements, geology
Belgian-German-Norwegian	Observatoire Royal de Belgique (Brussels), Institut für theoretische Geodäsie (Bonn), Norges geografiske oppmåling (Geographical Survey of Norwya) (Oslo)	7 PAUL MELCHIOR (Belgium)	Longyearbyen, Adventdalen, June 8–July 12	Geodetical work, registration of periodical movements of the Earth's crust, satellite observations, measurements of land rise[3]
British	University of Cambridge, Department of Geology: The Cambridge Spitsbergen Expedition 1969	8 N. T. HORSFIELD	June 27–Aug. 23	Geology

Dutch	State Institute for Nature Conservation Research (Zeist)	4 ERIC FLIPSE	Kapp Lee, Edgeøya Aug. 14, 1968–Sept. 11, 1969	General ecological studies, marking of polar bears. In cooperation with the expedition of the University of Oslo
—»—		3 C. M. LOK	July 10–Aug. 23	Ornithology
Finnish	Botanical Institute, University of Oulu	2 SEPPO EUROLA	Inner parts of Van Mijenfjorden June 12–Aug. 23	Botanical studies
—»—	Zoological Institute, University of Turku: The Finnish Zoological Expedition	3 ERIK S. NYHOLM	Sveagruva Aug. 22, 1968–June 27, 1969	Marking and studies of polar bears, ringing of birds
French	Centre National de la Recherche Scientifique (Paris)	19 J. P. LEHMAN	June 17–Sept. 1	Searching for fossils
German	Geographisches Institut der Universität Würzburg	5 ULRICH GLASER	Kongsfjorden, Krossfjorden, Forlandsundet July 10–Aug. 23	Geobotanical and morphological investigations: studies of strand terraces and stages of glacier retreat
—»—	Frauenklinik am Robert-Koch-Krankenhaus (Hannover)	1 HORST SMOLKA	Longyearbyen, June 12–27	Influence of Arctic climate on women
Soviet	Scientific Research Institute of the Geology of the Arctic (Leningrad)	V. N. SOKOLOV	Inter alia Bjørnøya ?–Sept. 15	Geology
Swedish	Naturgeografiska Institutionen, University of Stockholm	3 PEDER KNAPE	Sørkapp, south-west Spitsbergen July 12–Aug. 23	Quaternary geology

[1] See pp. 145–159 and 161–165.
[2] Se pp. 94–100.
[3] **Part** of the programme "Astro-geoproject Spitsbergen 1968–1970". MANFRED BONATZ (Bonn) remained in Longyearbyen for the winter to continue registration work.

Notiser

Pingos i yttre delen av Adventdalen

Abstract. Three pingos in the outer part of the Adventdalen are investigated from morphogenetic and chronologic points of view. Though effected by floods and thermo-karst processes, the outermost pingo is still in active development (closed system type). The other two pingos are now influenced by alluvial fans but may originally have been of the same type. By means of radiocarbon dating of drift wood the middle pingo is found to be about 2650 years of age.

Inledning. – Såsom förberedelse till fältundersökning av permafrostfenomen på Spitsbergen sommaren 1968 analyserades ett antal flygfotografier, vilka ställts till förfogande av Norsk Polarinstitutt. Utöver en mängd lokaler med iskilspolygoner i olika nivåer och i olika geologisk omgivning upptäcktes också ett flertal pingos (SVENSSON 1969). Av dessa visade sig några tidigare vara kända och kortfattat beskrivna. Detta gällde t. ex. pingon i Eskerdalen samt två pingos vid, resp. 1,5 km ovanför, föreningen av Helvetiadalen och Adventdalen (PIPER and PORRITT 1966). Tre pingos längre ut i Adventdalen, alla på nordsidan av Adventelvas 'braided river-system', finns däremot ej omnämnda (Fig. 1).

Dessa pingos uppvisar 1) en del morfologiska olikheter, 2) befinner sig i något olika utvecklingsstadier och 3) kan ge anledning till vissa kronologiska överväganden, varför det kan vara befogat att taga upp dem till diskussion och hålla deras fortsatta utveckling under observation. I det följande benämnes dessa pingos: Lagunpingon, Longyearpingon och Hyttepingon.

A. Pingon i Moskuslaguna (Lagunpingon). — I den allra yttersta delen av Adventdalen framträder en mjukt välvd, c:a 300 m lång ryggform invid den nordöstra stranden av Moskuslaguna (Fig. 2). Ryggen är ej helt kontinuerlig utan något kuperad och delvis uppdelad i diffusa kullar. Erosions- och degenerationsprocesser i sidorna bidrager till att ge ryggen dess komplexa konturer. Bredden kan genomsnittligt uppskattas till 45 m. På utsidan bär ryggen i sina lägre delar tydliga spår av marin abrasion (Fig. 3). Kringspridda bräder och drivtimmer på och invid ryggen anger också havets inflytande.

Höjden av den praktiskt taget helt vegetationslösa ryggen är maximalt 4 m. Materialet utgöres av finkorniga sediment, närmast av typen fjordsediment, med sommartid en torr och fast överyta, överdragen av saltutfällningar. Smärre hål uppträder i ytan efter instörtningar.

Morfologiskt sett utgör den ej någon typisk pingo, och det är främst degenerationsprocesserna, som fäster uppmärksamheten på ryggen och klassificerar den såsom en frostmarksform av pingotyp. Ett flertal krater- eller nischlika instörtningsformer, innehållande vattengenomdränkt finmaterial, förekommer sålunda och vittnar om de termokarstprocesser (SVENSSON 1970), som är verksamma. Även de ovannämnda, smärre hålen i den torra överytan är att uppfatta såsom resultat av smältning i ryggens inre. Permafrostytan återfanns (2/8 1968) på något varierande djup under ryggens överyta. Minsta djupet var 90 cm, men flerstädes låg den på större djup än 130 cm.

Även utanför den mera sammanhängande ryggformen finns kollapsformer i

Fig. 1. *Flygfotografi (1961) över yttre delen av Adventdalen.*
A – Lagunpingon, B – Longyearpingon, C – Hyttepingon.
Ungef. bildskala 1:45 000.

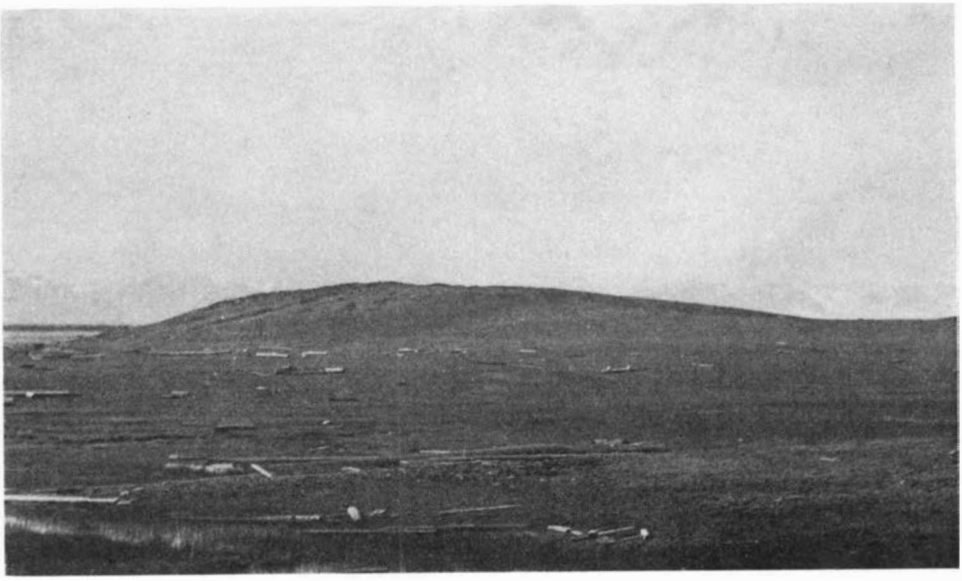

Fig. 2. *Del av Lagunpingon (A i fig. 1).*

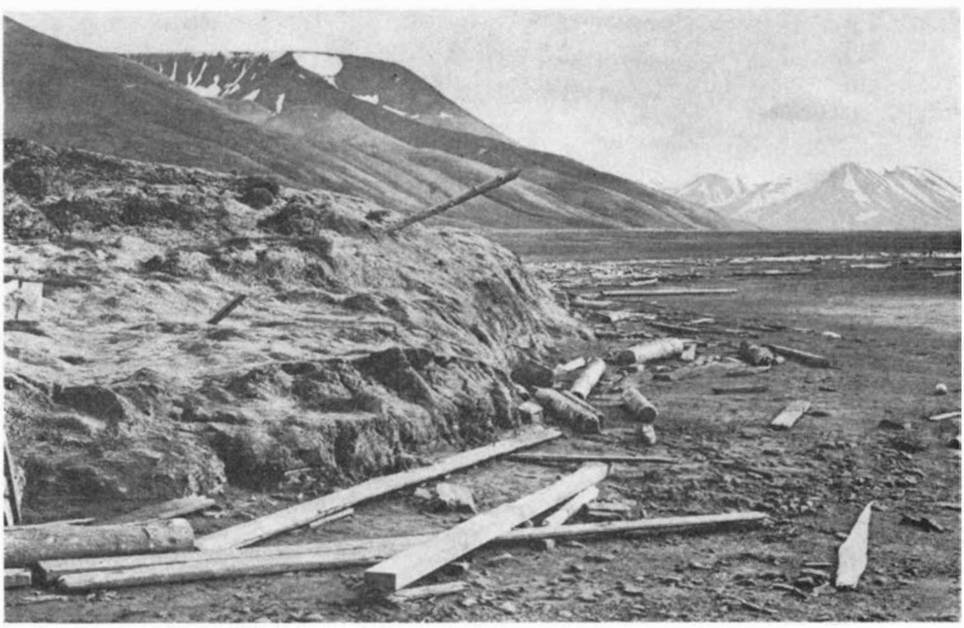

Fig. 3. *Lagunpingon avgränsas från deltaytan av en nertill abraderad sluttning.*

blott obetydliga upphöjningar i lagunens sedimentyta. Överhuvudtaget är termokarstprocesserna i ryggen och dess omgivning snabbt verkande och kraftigt omgestaltande processer.

Anmärkningsvärt är att ryggen med dess ur kornstorlekssynpunkt lättrörliga material ej i någon större utsträckning omformas genom jordflytning. Massrörelser åtföljer den lokala smältningen i termokarstprocessen men präglar i mycket ringa grad pingons sluttningar. Anledningen härtill synes vara, att det finkorniga och i och för sig flytbenägna materialet vid frysningen kommer att innehålla isen såsom segregationsis, vilken uppdelar massan i aggregat med jämna ytor. Vid smältningen bibehålles denna aggregatstruktur, vilken trots den ursprungliga finkornigheten ger jorden en grynig koncistens med en hög inre friktion. Samma förhållanden återfinnes i nordskandinaviska palsar med mineraljordskärna (SVENSSON 1964, ÅHMAN 1967), där en grov aggregatstruktur med stort luftinnehåll sommartid har en isolerande effekt.

I sin fortsatta utveckling kommer Lagunpingon så småningom att påverkas av utsvämningskäglor på samma sätt som Longyearpingon och Hyttepingon nu influeras av dylika. En svämkägla från Hiorthfjellet har redan börjat deformera den närbelägna strandkonturen hos Moskuslaguna (se Fig. 1).

B. Pingon mellan Mälardalens och Ugledalens utlopp i Adventdalen (Longyearpingon). — Av de här behandlade är denna pingo den mest framträdande. Den ligger 3 km in i Adventdalen (Fig. 1) och kan skönjas från Longyearbyen såsom en välvd kulle, en främmande reliefform i den flacka dalbottnen (Fig. 4).

Pingon ligger i en nivå över den recenta Adventelvas 'braided river-system', men den terrasskant, som något längre åt sydost tydligt markeras, är i jämnhöjd med pingon utjämnad. Höjden över den recenta havsytan är vid foten 5–7 m. Mot dalsidan omges pingon av alluvialkoner, som även växer ut att omge pingon i väster och öster (Fig. 1). Pingon har en diameter av 325 m och en största höjd av 27 m.

I västsidans nedre delar är en flack ryggform avskiljd och komplicerar pingons

Fig. 4. *Longyearpingon (B i fig. 1) fotograferad från norr.*

i övrigt relativt regelbundna baskontur. Toppytan innehåller en flack skålform, från vilken en markerad delvis fluvialt omformad ränna leder nerför sluttningen åt sydost. På den motsatta sidan är en nisch under utbildning genom inverkan av termokarstprocesser. Öppna hål i toppytan liksom slutna vattensamlingar på ett par ställen vittnar också om termokarstaktivitet. Av andra erosionsprocesser är särskilt vinderosionen på pingons överyta påtaglig med anrikning av grövre fraktioner i den helt vegetationslösa ytan.

Pingon saknar kraterform, men ovannämnda flacka skålform kan vara ett förstadium till en dylik. De kraftigaste termiska angreppen sker i stället i pingons sidor, i den markerade rännan och framförallt i nischbildningen på västsidan. Flygbilden från 1961 (Fig. 1) visar, att från den tiden en icke oväsentlig breddning och förlängning av nischen ägt rum.

Uppkomsten av den fluvialt gestaltade rännan på ostsidan är något dunkel. Klart är att de vattenmängder, som erfordras för utformningen av en dylik ränna, ej kan ha haft sitt ursprung i snö- eller vattenackumulation inom toppområdet. Sannolikt har rännan såsom förstadium haft en öppen spricka, bildad under tillväxten av pingon (eventuellt också dränerande interpermafrostvatten). Senare har rinnande vatten efter snösmältning och nederbörd bidragit att prägla sprickan.

C. Pingon nedanför Bassenfjellet (Hyttepingon). – Pingon ligger 5,5 km in i Adventdalen och helt nära den norra dalsidan (Fig. 1). Den har en avlång form med längdaxeln i dalriktningen. Längd- resp. tvärmått är c:a 825 och 275 m. Största höjden av pingon är c:a 30 m (på utsidan). I sin långsträckta form samt i läget i förhållande till dalsidan har denna pingo en klar likhet med Lagunpingon.

Närheten till dalsidan medför att pingon starkt influerats av vattenflöden och materialackumulationer från fjällsluttningen. Den är sålunda genombruten av två vattenflöden och pålagras i sin sluttning mot fjällsidan av utsvämmat material. Konturen av pingon är i sin helhet rätt diffus.

Erosionsrännorna avgränsar ett mittparti med komplicerad överyta, påverkad av termokarstprocesser och vinderosion. Ytterpartierna, vilka är mera vegetationsklädda bildar en välvd övergång till omgivningen. I vegetationsytan framträder nät av iskilspolygoner. Med en sond påträffades permafrostytan på 30–50 cm djup i ytterområdena av pingon (2/8 1968).

Överytan innehåller en del grövre material. I de fluviala rännorna, där markblock lateralt avlossnar genom smältning och erosion, blottas höga skärningar i finkornigt, väl stratifierat material med innehåll av mollusker.

Diskussion. – Inledningsvis nämndes tre punkter, kring vilka huvudintresset centrerades för Adventdalens ytterst belägna pingos. Punkt 1 har behandlats i den morfologiska lokalbeskrivningen. I denna har även skillnader i utvecklingsstadium (punkt 2) framkommit. Tilläggas kan emellertid här att Adventdalens yttre pingos kan ha ett vidare intresse än att blott bli registrerade på t. ex. en karta över pingoförekomster. Man kan i Lagunpingon och Longyearpingon se led i en utvecklingslinje, i vilken några av pingoformerna längre in i Adventdalen eventuellt också ingår, så att en hel pingokedja erhålles. Tankegången skall i det följande utredas och närmare granskas.

Adventelvas sedimentlaster i förening med landhöjningen ger nytt land i Adventfjorden. I dessa nya landytor breder permafrosten efterhand ut sig. De vattenhaltiga fjord- och deltasedimenten med den från sidorna invandrande permafrosten utgör en lämplig miljö för isoleringen av en talik, ur vilken en hydrolakolit kan bildas med åtföljande uppvälvning av marken, d.v.s. för uppkomsten av pingos.

Vid utbildningen av en ny pingo i deltaområdet balanserar de rent litologiska och klimatologiska förutsättningarna mot havets termiskt modifierande inflytande.

Initialskedet för en dylik pingo bör därför innebära en existens på gränsen för de morfogenetiska villkoren (jfr. Lagunpingon).

Med bibehållet klimat skall enligt ovan framförda tankegång förutsättningar finnas för en successiv utbildning av nya pingos i laguner eller sjöar allt längre ut i Adventelvas växande fjorddelta. Omvänt bör befintliga pingos eller vissa av dem bilda en serie av allt äldre individer, ju längre in i dalen de är belägna. Utan tillfälle att studera de av PIPER och PORRITT (1966) beskrivna formerna längre in i Adventdalen och dess sidodalar är det ej möjligt att ha någon uppfattning om teorins giltighet för dem. De kan alla, eller några inbördes, vara likåldriga, särskilt gäller det de som ligger nära varandra. Att de tre yttersta, här beskrivna pingoformerna (Lagunpingon, Longyearpingon och Hyttepingon) ur ålders- och utvecklingshänseende kan bilda en sekvens synes emellertid möjligt.

Tolkningen ovan av Lagunpingon såsom en hydrolakolit, instängd av en från sidorna avancerande permafrostyta, är i enlighet med principerna för bildningen av pingos i ett 'closed system' (MÜLLER 1959, MACKAY 1963). Huruvida Longyearpingon och Hyttepingon tillhör samma variant eller är av typen 'open system' är ej utan vidare klart. De av PIPER och PORRITT undersökta pingoformerna längre in i Adventdalen anges tillhöra den senare typen, d.v.s. bildade under inflytande av en hydraulisk gradient med möjlighet för vatten att injiceras i eller under permafrosten och vid frysningen ge upphov till en hydrolakolit.

Även om såväl Longyearpingon som Hyttepingon i nutiden tillhör ytor med hydraulisk gradient, så är detta ett förhållande, som sammanhänger med den för Adventdalen och andra dalgångar på Spitsbergen mycket typiska fluviala tillförseln av material från dalsidor och sidodalar med uppbyggandet av solfjäderformiga, flacka alluvialkoner (jfr. Fig. 1). Man skall ej låta sig påverkas av denna recenta dalside- och dalbottentopografi för att utan vidare bedöma utgångsläget för redan välutvecklade pingos såsom en 'open system' situation.

I Longyearpingon utgöres grundmassan av finkornigt material även om också en del sten ingår. Drivvedsmaterial förekommer i ytan. I en bäckskärning genom Hyttepingon blottas marina mollusker. Ingen av dessa pingos kan sägas bära den mantel av grovt material av det slag, som uppträder i omgivande alluvialkoner och som borde utgjort en signifikant beståndsdel, om dessa pingos varit av 'open system' typ, genererats av en hydraulisk gradient i övergången till dalsidan och primärt höjts ur svämkäglornas material. Tillväxten av Longyearpingon och Hyttepingon har sålunda startat, innan alluvialkonerna fått någon större utbredning. De kan därför ha anlagts såsom 'closed system' pingos, d.v.s. på samma sätt som den nutida Lagunpingon i en strandsjö eller igensedimenterande vattensamling i ett deltaområde.

Inledningens punkt 3, pingoformernas kronologiska ställning, har i det föregående kommit att beröras i och med att en relativ ålder diskuterats från yngre (närmast recent) mot allt äldre inåt dalen. För Longyearpingon finns emellertid en angreppsvinkel, som kan ge vissa synpunkter på en mera absolut eller i varje fall maximal ålder. I den vegetationslösa toppytan påträffades vedfragment, som vid grävning visade sig härstamma från en tämligen välbevarad trädstam, dold av sedimenten (Fig. 5). Stammen bör ha utgjort ett stycke drivved, som – liksom nu är fallet vid Lagunpingon – strandat och inbäddats i fjordsedimenten för att vid pingobildningen höjas upp till sitt nuvarande läge. Longyearpingon är alltså yngre än trädstammen.

Sammanfattning. – Klimatiskt och litologiskt föreligger förutsättningar för uppkomsten av pingos av 'closed system' typen i Adventelvas recenta delta (Lagunpingon). Så länge havets termiska inflytande (t. ex. tidvattnet) är kännbart, motverkas pingotillväxten av kraftiga termokarstprocesser. Till följd av den

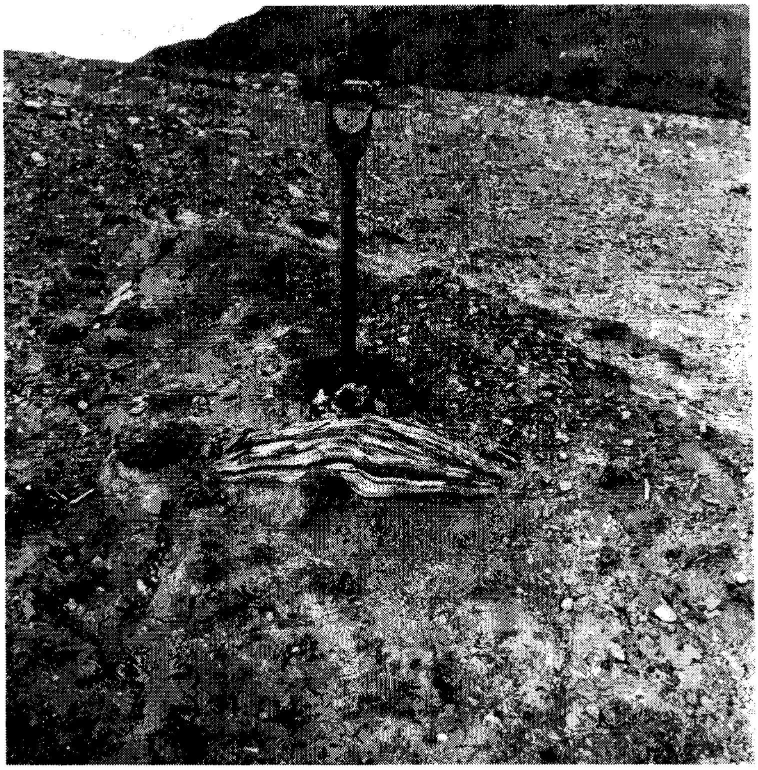

Fig. 5. *Del av trädstam, inbäddad i övre delarna av Longyearpingon.*

fortgående landhöjningen elimineras detta inflytande successivt. En av havet ostörd tillväxt såsom hos Longyearpingon vidtager därefter.

Den yttersta pingon (Lagunpingon) är av 'closed system' typ. Longyearpingon och Hyttepingon har ett nutida läge och en topografisk omgivning, som tyder på en tillhörighet till 'open system' typen. De kan emellertid ursprungligen (detta gäller speciellt Longyearpingon) börjat anläggas på samma sätt som Lagunpingon i den främre delen av Adventelvas fjorddelta, vilket successivt vuxit utåt och givit lämplig mark för nya pingos.

Den yttersta pingon är i recent tillväxt. De två närmaste i raden har börjat växa, innan alluvialt material från dalgångar och sluttningar i större utsträckning börjat täcka deltaytan. Den mellersta pingon (Longyearpingon) är yngre än 2650 år (2650 $\pm$ 55 B.P.) vilket är åldern av drivvedsstocken i toppen av pingon.

Dateringen av drivveden har utförts av laboratoriechef SÖREN HÅKANSSON vid Laboratoriet för C14-datering i Lund. (Provets laboratorienr. Lu-241.)

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Harald Svensson
Naturgeografiska institutionen
Sølvegatan 13
223 62 LUND, Sverige

Forskningsstasjonen på Svalbard

1969 var det første året Forskningsstasjonen på Svalbard var i permanent drift på helårsbasis, selv om stasjonen ennå ikke kan sies å være helt utbygd; særlig er det ønskelig med mer aktivitet i den biologiske sektor.

Forskningsstasjonen disponerer nå to hus som leies av Kings Bay Kull Comp. A/S: hovedhuset i bebyggelsen i den gamle gruvebyen og et hus ved fjellfoten ca. 2 km sør for bebyggelsen.

Stasjonshuset i byen er innredet til kontorer, laboratorier, fotorom, mørkerom, etc. i 2 (3) etasjer; i alt er det ca. 180 m² gulvflate. For å få en større observasjonsplatform på taket er dette hevet på en del av husets langside, noe som gir en 3. etasje. Det er også luker opp til observasjonsplatformen, slik at målinger kan foretas innenfra, f. eks. ved nordlysundersøkelser.

Huset ved Zeppelinfjellet er en ca. 200 m² stor uisolert betongbygning på ett gulv. Elektrisk strøm er lagt opp, men ikke vann og sentralvarme. En del av huset er innredet for den seismiske stasjonen med kontrollrom, seismometerrom og recorderrom. I dette huset er det gode utvidelsesmuligheter for virksomhet som kan utføres her og som ikke vil forstyrre de seismiske registreringer.

Ved stasjonen disponeres også en del mindre hytter for f. eks. magnetisk stasjon o. l.

Innkvartering og bespisning av det faste personell og gjestende forskere skjer i messen til Kongsfjord Telemetristasjon som drives av Norges Teknisk-Naturvitenskapelige Forskningsråd. Stasjonen er tilknyttet telemetristasjonens varme- og sanitæranlegg og får også elektrisitet derfra.

En rekke norske forskningsinstitusjoner og forskere har benyttet seg av de muligheter stasjonen byr for innsamling av data, spesielt ved oppstilling av registrerende instrumenter.

Følgende prosjekter har vært i gang i 1969:

1. Bredbånds solintensitetsmålinger i det tidsrommet solen er oppe, dvs. fra mars til oktober.
2. Spektrale intensitetsmålinger av sol- og himmelstråling, juni–juli.
3. Massebalansemålinger av breer, dvs. den årlige nedbør og avsmeltning.
4. Tidevannsregistreringer gjennom hele året.
5. Ozonmålinger fra april til september.
6. Ionosfæremålinger foregikk hele året.
7. Målinger ved kontinuerlig mottaking av VLF-signaler hele året.
8. HF absorbsjonsmålinger ved riometre hele året.
9. Fotometrering av pulserende nordlys fra oktober til mars.
10. Fotometrering av 2 spektrallinjer i zenit fra november til mars.
11. Elektrontetthetsmålinger er foretatt periodevis.
12. Natthimmelfotografering med "all-sky"-kamera fra oktober til mars.
13. Registrering av jordmagnetismen er foretatt hele året.
14. Seismiske registreringer av 6 komponenter er foretatt hele året.
15. Elektrontetthetsmålinger av F-lag er foretatt fra november til mars.
16. Biologiske observasjoner er foretatt hele året, men særlig i april/mai.

Ved stasjonen har det vært tilsatt en tekniker, konstruktør JENS ANGARD. I sommertiden og mens han var under opplæring for justering av utstyret var det to forskjellige vikarer.

Det ble dessuten gjort avtaler med forskjellige personer, bl. a. med bestyreren av telegrafstasjonen, om hjelp til rutinearbeid. Dette har vært meget fordelaktig, da det ikke var nok arbeid for to mann ved stasjonen.

Båten, som var en betingelse for de oseanografiske og marinbiologiske undersøkelsene, ble dessverre så forsinket at disse undersøkelsene ikke kom i gang i 1969. Båten, som er døpt «Aurora», kom imidlertid frem like før isen la seg. Det er en spesielt forsterket sjark på 25 fot, bygget av glassfiberplast og med ishud i rustfritt stål. Båten er utstyrt med en 20 hk SABB dieselmotor. Den har en etter båtstørrelsen meget rommelig kabin og et åpent dekk akterut. Båten kan kjøres både fra dekk og kabin. Av utstyr kan nevnes radiotelefon, et godt ekkolodd, vinsj med davit og wire for prøvetaking i sjøen. «Aurora» er også utstyrt med radar for å kunne navigere og ikke minst gå til bestemte posisjoner uavhengig av sikten.

Forskningsstasjonen på Svalbard drives av Norsk Polarinstitutt med en bevilgning på Kap. 340 under budsjettet til Kirke- og undervisningsdepartementet. Til stasjonen var bevilget kr. 371 000 og det medgikk kr. 290 467. En del regninger kom p.g.a. vanskeligheter med postgangen så sent inn at de må føres på 1970-regnskapet, men innsparingen skyldes hovedsakelig at driften ved stasjonen har vært innskrenket og at dette resulterte i at bare en mann var fast ansatt. Ca. kr. 58 000, bevilget til utbygging av stasjonen og anskaffelse av vitenskapelig utstyr, er overført til 1970, da det bl. a. vil bli anskaffet en del alminnelig feltutstyr for utlån når Forskningsstasjonen benyttes som base for arbeid i Kongsfjordområdet.

Thor Siggerud

A.W. BRØGGERS BOKTRYKKERI A/S - OSLO