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Fra traversen gjennom Dronning Maud Land i den antarktiske sommeren 1965–66. Et sledetog gjøres klart for å trekkes over en sprekk. Foto: OLAV ORHEIM.

Innholdsfortegnelse

The composition of some granitic rocks from Svalbard

By
Audun Hjelle

Abstract

Modal analyses and approximate chemical compositions of the main types of granitic rocks in Svalbard are presented. Petrographically the rocks range from acid granites to quartz diorites. A tentative division, according to petrography, chemistry and texture is: I) Medium grained grey granite to quartz diorite in NW Vestspitsbergen, often occurring as dyke rocks in migmatite. II) Coarse, often porphyritic rocks of mainly quartz monzonite composition, in NW Vestspitsbergen, central NE Vestspitsbergen and the Nordkapp area of NW Nordaustlandet. These intrusions are often batholithic in appearance. III) Medium grained leucocratic granites in the Brennevinsfjorden and Rijpfjorden areas of Nordaustlandet.

О составе некоторых гранитиых пород со Свалбарда

Резюме.

Вместе с обзором ранее произведенных исследованнй, приводятся результаты новых минералогических подсчетов (модальный анализ) и приблезительных химических анализов. Минералогический подсчет основывается на подсчете точек в шлифах и пластинах горных пород. А приблизительные химичиские анализы — на обработке вычислительными машинами результатов минералогическаго подсчета. Таблицы 1—3 и фигуры 1—4 показывают часть результатов.

Географически и петрографически можно выделить несколько основних типов гранитних пород на Свалбарде:

1. Серые, среднезернистые, содержащии биотит, дайковые породы, известны с СЗ Шпицбергена, с составем вариирощем от гранита до кварцдиорита.

2. Красноватые, крупно-и среднезернистые биотитовокварцевые монцониты, известны с СЗ Шпицбергена.

3. Розовые, розовато — серые и серые крупнозернистые, порфировидные, содержащии биотит и амфибол, кварцевые монцониты-граносиенты, известны из Ню-Фрисланда.

4. Крупнозернистые, отчасти порфировидные, биотитово-кварцевые-монцониты, известны из окрестностей Нордкапа, Северовосточная Земля.

5. Розовато-серые, среднезернистые, содержащии биотит К-граниты. Известны из окрестностей Бренневинсфиорда и Сабинабухты, Северовосточная Земля.

6. Светлосерые, содержащии мусовит, нормальные граниты. Найдены в окресностях Рийпфиорда и Валленбергфиорда, Северовосточная Земля.

Петрографически, химически и структурно все эти породы можно разделить на три главные группы:

I. Среднезернистые дайковые породы с изменчивым составом — от гранитов до кварцевых диоритов (№ 1 выше).

II. Крупнозернистые, частично порфировидные кварцевые монцониты (№ 2, 3 и 4 выше).

III. Главным образом среднезернистые граниты (№ 5 и 6 выше).

Облости восточнее Дювефиорда, Северовосточная Земля, пока еще не достаточно изучены, но исследовании проведенные Норск Поларинститут в 1965 году (Б. Флоод и Д. Г. Гее) указывают на сходство их с СЗ Шпицбергеном и с северной частью области кварцевых монцонитов около Нордкапа. В этой облости найдены и магматические гнейсы, и метоосадки, и грубые серые гранитные породы, которые похожи на породы окружения Нордкапа, и среднезернистые, серые породы, очень похожие на породы СЗ Шпицбергена.

Introduction

A number of descriptions of granitic rocks from Vestspitsbergen and Nordaustlandet have been published, but few complete modal and chemical analyses of these rocks are available, and no comparative study of the various types has so far been attempted. The present paper summarizes the results of previous investigations, gives a brief account of the author's own observations concerning the field relations of each of these masses and gives the results of modal analyses of a number of selected specimens together with their approximate chemical composition as calculated from the mode. The material for analyses was selected from the collections of A. Hoel's expedition of 1923 and the Norsk Polarinstitutt's expeditions 1957-65. (see lower part of table 2). The specimens were carefully chosen: 1) To obtain megascopically typical rocks. 2) To avoid marginal zones with xenoliths and random anomalies. 3) To cover the respective areas geographically.

Methods

Modal analyses. Point counting of thin sections and rock slabs was used to obtain modal analyses. For each analysis one or two thin sections were counted on a grid which gave about 1000 counts within the 6 cm^2 of an average thin section. In the case of coarse grained or coarse to medium grained rocks, counts were also made on one or more rock slabs using about 5 counts/cm^2, the average area counted being 100–500 cm^2. Both thin sections and slabs were etched with concentrated HF and stained with a saturated solution of $Na_3[Co(NO_2)_6]$ to facilitate rapid iden-

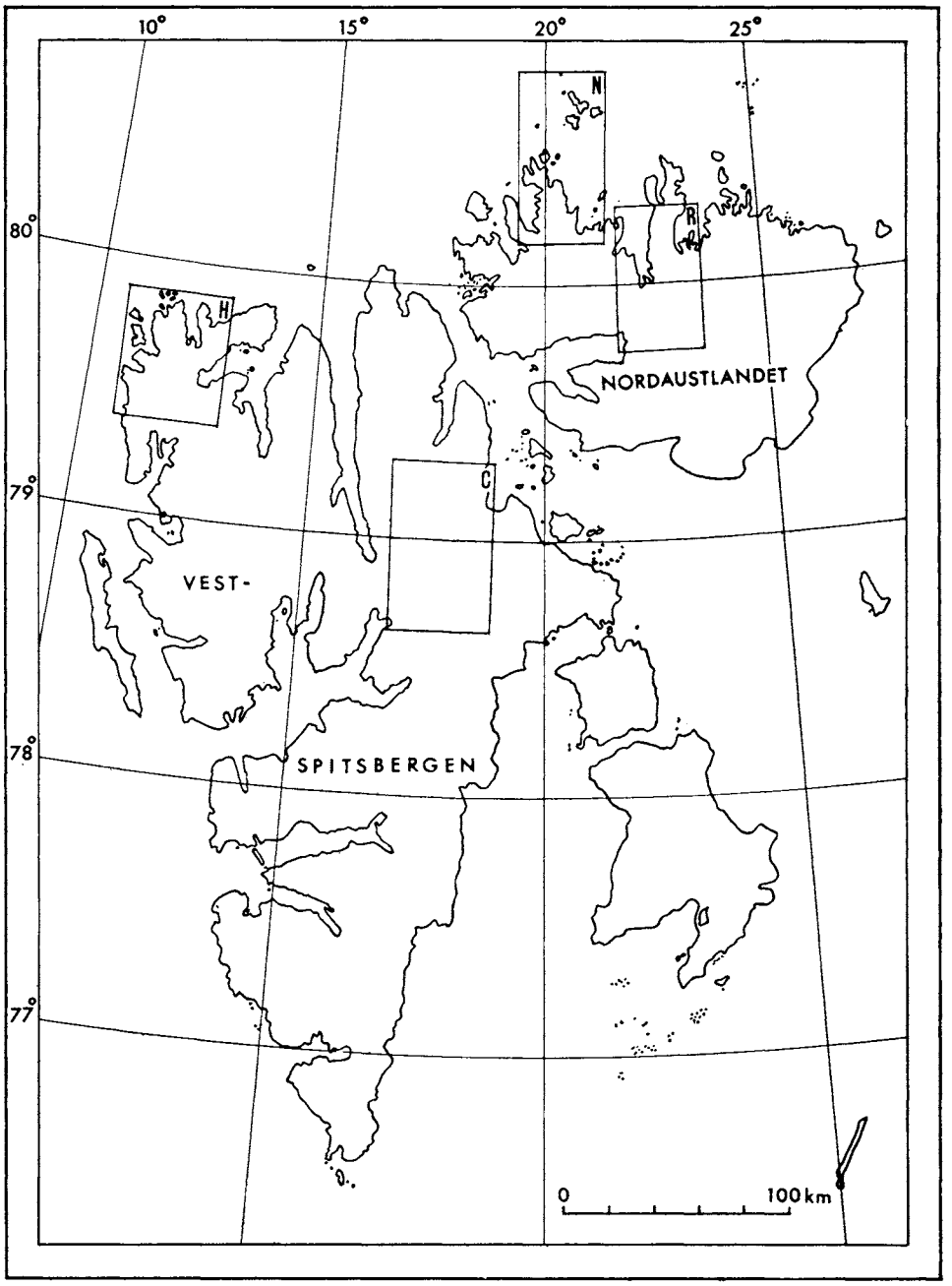

Fig. 1. *Key map showing the locations of the investigated areas.*

tification of the K-feldspar. The An content of the plagioclases was obtained by measuring the maximum extinction angle in sections ⊥ 010. When measuring zoned plagioclases an universal stage was used.

Computer calculations. A computer programme prepared by DIETRICH and

SHEENAN (1964) was used (with minor modifications) as a basis for the calculations. The computer used was an IBM 1620 II housed at the Mathematics Institute of Oslo University. The programme (Fortran II type) accepts as input data, the modal percentage of each mineral in a rock and produces an approximate chemical analysis of the rock in terms of oxide percentages and cation percentages plus total associated oxygen equivalents. In addition, the weight percentages of the minerals and the specific gravity of the rock are also printed on the output sheet.

Rutile, zircon, orthite and leucoxene, wich are all minor constituents of the examined rocks (<1%), are not listed in the programme. Rutile and leucoxene have been added to ilmenite, zircon to biotite, and orthite to epidote. In addition to the ideal types of pyroxene, amphibole and biotite, the programme also contains "average" augite, hornblende and biotite from igneous rocks. These "average minerals" were used in the present calculations. The use of different average values will clearly alter the output figures. Thus for example, in a rock containing 5 vol.% biotite with 10–30% FeO and 5–15% MgO, a variation of the FeO/MgO ratio from 1 to 5 will cause a variation of approx. 0.6 in the weight % figures of FeO and MgO in the total rock. In a rock containing 8 vol.% hornblende a variation of 1 weight% in one of the hornblende components (i.e. FeO) will cause a variation of approx. 0.1 weight% of the corresponding oxide in the total rock analysis. For a rock containing 30 vol.% K-feldspar and 30 vol.% plagioclase, a combined variation of 10 in the Ab% of the K-feldspar and 4 in the An% of the plagioclase will cause a variation of approx. 0.5 in each alkalic oxide weight% and approx. 0.25 in the CaO weight%.

For the present study the Na_2O and K_2O percentages of the K-feldspars were determined by means of a flame photometer in one or more specimens from each of the main petrographic types. Regarding the K-feldspars as pure Or-Ab-feldspars, the Ab percentages were calculated (table 3) and the average Ab percentage of each type assigned to all other K-feldspars in rocks of the same petrographic type.

Definitions

The igneous rock terms used in the present investigations are defined in Fig. 3. The term migmatite is used for megascopically composite rocks which consist of igneous or igneous-appearing and/or metamorphic materials (SØRENSEN 1961). In textural descriptions, fine, medium and coarse grained, indicate grain sizes of respectively less than 1 mm, 1 to 10 mm and more than 10 mm.

"Grey granites" in NW Vestspitsbergen

Previous investigations. DUROCHER (GAIMARD 1855) mentioned two types of granite from NW Vestspitsbergen, without giving their further location, a grey medium grained, somewhat foliated type with transitions into gneiss, and a younger, coarse greyish white to light red granite which intruded the first type as dykes.

From what he called "the great northwest granite region" (N and NE of Magdalenefjorden) BLOMSTRAND (1864) gave examples showing plutonic grey granite

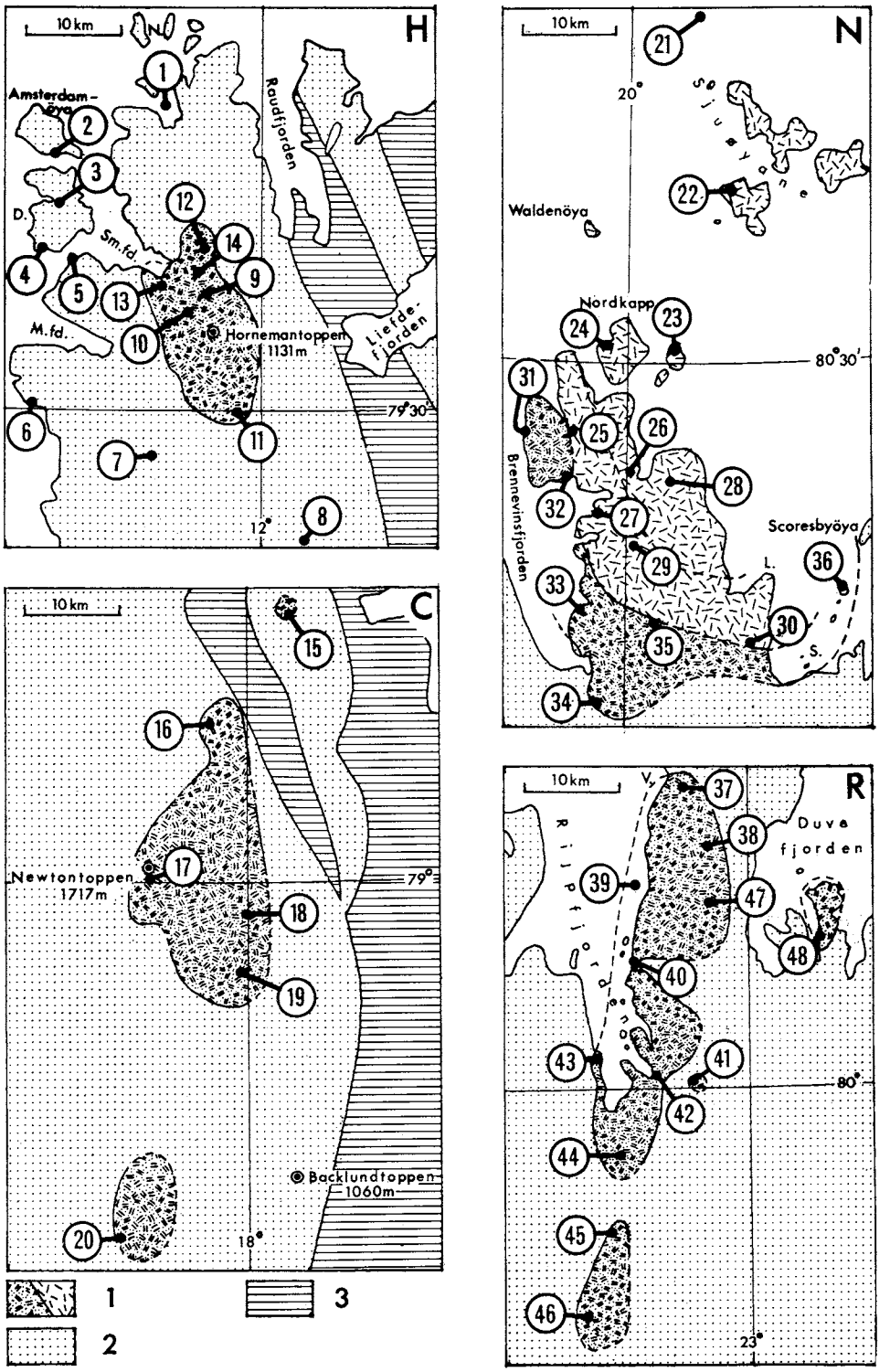

Fig. 2. *Maps showing the geological setting and sample locations of the examined granitic rocks. 1: Granitic rocks. 2: Hecla Hoek rocks, mainly supracrustals and migmatites. 3: Downtonian and younger rocks. Abbrevations: D = Danskøya, Sm.fd. = Smeerenburgfjorden, M.fd. = Magdalenefjorden, L. = Kapp Lindhagen, S. = Sabinebukta. V = Vindbukta.*

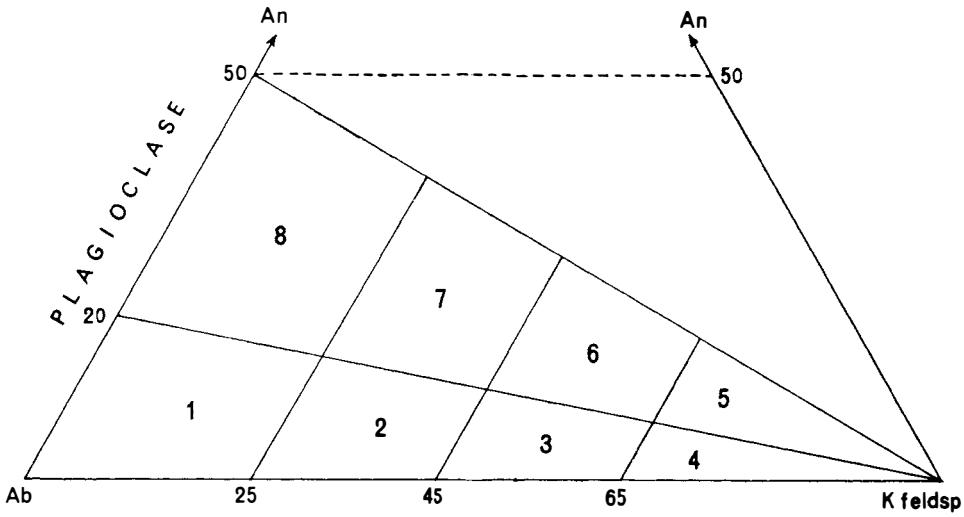

Fig. 3. *The quantitative petrographical classification of granitic rocks used in this paper. Quartz > 10 vol%, Feldspars > 30 vol%.*
1: Trondhjemite. 2: Na-granite. 3: Normal granite. 4: K-granite. 5: Granosyenite. 6: Quartz monzonite. 7: Granodiorite. 8: Quartz diorite.

intruding both sedimentary rocks and granitic gneiss and often causing contact metamorphism. He recorded the following contact minerals: idocrase, wollastonite, garnet, scapolite and augite.

v. DRASCHE (1874) described a hornblende-quartz syenite in gneisses (Magdalenefjorden). He mentioned the possibility that this rock might have been of metamorphic rather than igneous origin. The other rocks in his descriptions were erratics and are mostly of little value.

BRYANT (1905) examined rocks collected by the physician Dr. SEITZ, most of them being probably erratics. This was exclusively a thin section description, and did not deal with the general geology of the area. Among the rocks described should be mentioned:1) grey, rather fine grained granite of Magdalenefjorden with homogeneous K-feldspar, zoned plagioclase, quartz showing strain extinction, reddish brown biotite and some light red garnet. 2) Amphibole granite from Smeerenburg, Amsterdamøya, with equal amounts of K-feldspar and zoned labradorite, reddish brown biotite and green hornblende.

SCHETELIG (1912) based his work mainly on notes and collections from J. HORNEMAN (ISACHSEN expedition 1906). He described rocks from what was called the Archaean complex of northwest Spitsbergen (gneisses and granitic rocks). The fact, already mentioned by BLOMSTRAND, that grey granitic rocks intrude older gneisses and mica schists, was confirmed and a number of sub-types of the grey granite were identified. According to SCHETELIG the main type was of light grey colour, homogeneous fine to medium grained with nearly unaltered K-feldspar and plagioclase (composition approx. An 30, zoned), strained quartz and reddish brown biotite. Subordinate minerals were muscovite, chlorite and epidote. Myrmekitic intergrowths between the two feldspars were common.

HOLTEDAHL (1914, 1926) was the first who pointed out the absence of the Archaean in NW Vestspitsbergen. Observations during a sledge crossing from Krossfjorden to Raudfjorden by himself and HOEL 1909, showed "that there existed no simple boundary between the large area of granites and gneisses in the northwest and the Heclahook phyllites, mica schists and quartzites farther south". Both unaltered and partly compressed granites were seen as intrusive bodies in the metamorphosed sediments, the latter often showing transition into gneiss. The higher grade of metamorphism towards the north was thought to indicate greater upheaval and denudation in this area, which has exposed the zone of intrusions.

SCHENK (1937) worked for a short time on the mainland E of Amsterdamøya, and from his observations along a 8 km profile, he states that the grey granite of N Spitsbergen is a paragranite developed as a result of anatexis of Hecla Hoek rocks. The intrusion took place under static conditions after the Caledonian orogenesis. From older scattered observations of grey granite in NW Vestspitsbergen, SCHENK suggested an envelope of grey granite mantling the red granite centered on Hornemantoppen (W of Liefdefjorden).

During reconnaissance work in the Danskøya–Raudfjorden area, GJELSVIK (1963, not publ.) recorded intensely folded migmatite with rotated heterogenous and stretched relics. Here too he found granitic rocks of migmatitic origin which showed signs of emplacement by liquid intrusion and were seen to transgress a marble band.

Present investigations. General. The existence of various types of grey granitic rocks in NW Vestspitsbergen, more or less foliated and more or less migmatized, was confirmed by GEE and HJELLE (1965) and by later investigations of the present author.

The general impression after some work with these rocks is that there must be two main periods of intrusion, one earlier, relatively deep seated, which gave rise to extensive migmatization and clearly occurred before the end of the main orogeny (since some of the migmatites have subsequently been folded) and one post orogenic. The first intrusion caused development of feldspathized metasediments in the southern part of the area, schlierengneiss further N and migmatites in N and NE. The granitic material which occurs in these rocks is more or less foliated and concordant with the older Hecla Hoek sediments. It is considered to be part of the gneisses and migmatites and will not be described here. The second, younger generation of intrusions are unfolded granitic rocks cutting the migmatite gneisses and metasediments.

These grey medium grained unfoliated rocks, generally occur as dykes with trends mainly approximating to NW–SE and with varying dips. The width of the dykes varies but of the 114 dykes measured on Danskøya, about 60% had a width less than 1 m, although both in the northern and in the southern parts of the area, dyke-like intrusions of considerably greater width occur (up to nearly 2 km, E of Krossfjorden (GEE and HJELLE)). Pegmatitic dykes which in size and orientation are very similar to the granitic dykes, often accompany the latter.

The veins and dykes of "coarse greyish white to light red granite" recorded by DUROCHER, were most probably pegmatites.

Composition. The grey granitic rocks show a wide range of composition. This variation is in some cases easily recognized as being a result of assimilation. The degree of assimilation of surrounding rocks varies according to their composition and also according to the size of the intrusion.

A hypidiomorph equigranular texture is the most common, and the main constituents are quartz, plagioclase and K-feldspar with about 30 vol.% of each. Table 1 shows the mean composition of a number of specimens (GEE and HJELLE), and the classification scheme in Fig. 3 shows that quartz monzonite, granodiorite and quartz diorite are all represented.

The quartz commonly shows undulating extinction, in some cases the undulation is strong, with transition to cataclastic textures. In K-feldspar polysynthetic microcline twinning is rare, the commonest seems to be orthoclase microperthite. Only slight decomposition to sericite is seen. Analysis of Na_2O and K_2O are listed in Table 3, nos. 1 to 6. In plagioclase an An content of 20 to 35 percent predominates, zoned crystals are not rare, the composition of these may vary from approx. An 15 in the outer part to approx. An 45 in the core, a common variation is from An 20 to 40. Sericitisation is common, especially in the central parts of crystals, zoisite is also seen, but in lesser quantities. Myrmekitic intergrowths are seldom lacking. In the biotite X = pale yellow, Y = Z = reddish brown. $n\gamma \sim 1.660$, $n\gamma \div n\alpha \sim 0.060$. Chlorite after biotite is a common, but not abundant alteration product. Muscovite may also accompany, but always in subordinate quantities. Common accessories are zircon, garnet, orthite and magnetite.

SCHETELIG described cordierite and hypersthene facies of grey granitic rocks, it is, however, uncertain whether these belong to discordant intruded rocks or to granitic migmatite metatect. According to preliminary investigations, cordierite is not uncommon in the migmatite gneisses, while in younger granitic dyke rocks it occurs only rarely.

In Table 2, the grey granitic rocks of NW Vestspitsbergen are listed in nos. 1 to 8. The chemical analyses correspond closely to the "plutonic granite" of DALY (1933). Using the magma classification of NIGGLI (BURRI and NIGGLI 1945) the rocks may be described as acid, salic, alkalirich to intermediate alkalic, c-poor, the magmas being of leucogranitic and trondhjemitic types.

The Horneman quartz monzonite in NW Vestspitsbergen

Previous investigations. v. DRASCHE recorded rounded erratics of red granitic rocks from the area around Smeerenburgfjorden and other localities and suggested they might have been transported from a granite outcrop in the interior, which at that time had not been explored. These Smeerenburgfjorden erratics most probably belong to the quartz monzonite intrusion further described below.

In 1906 HORNEMAN (ISACHSEN expedition) mapped an area of red granitic rocks

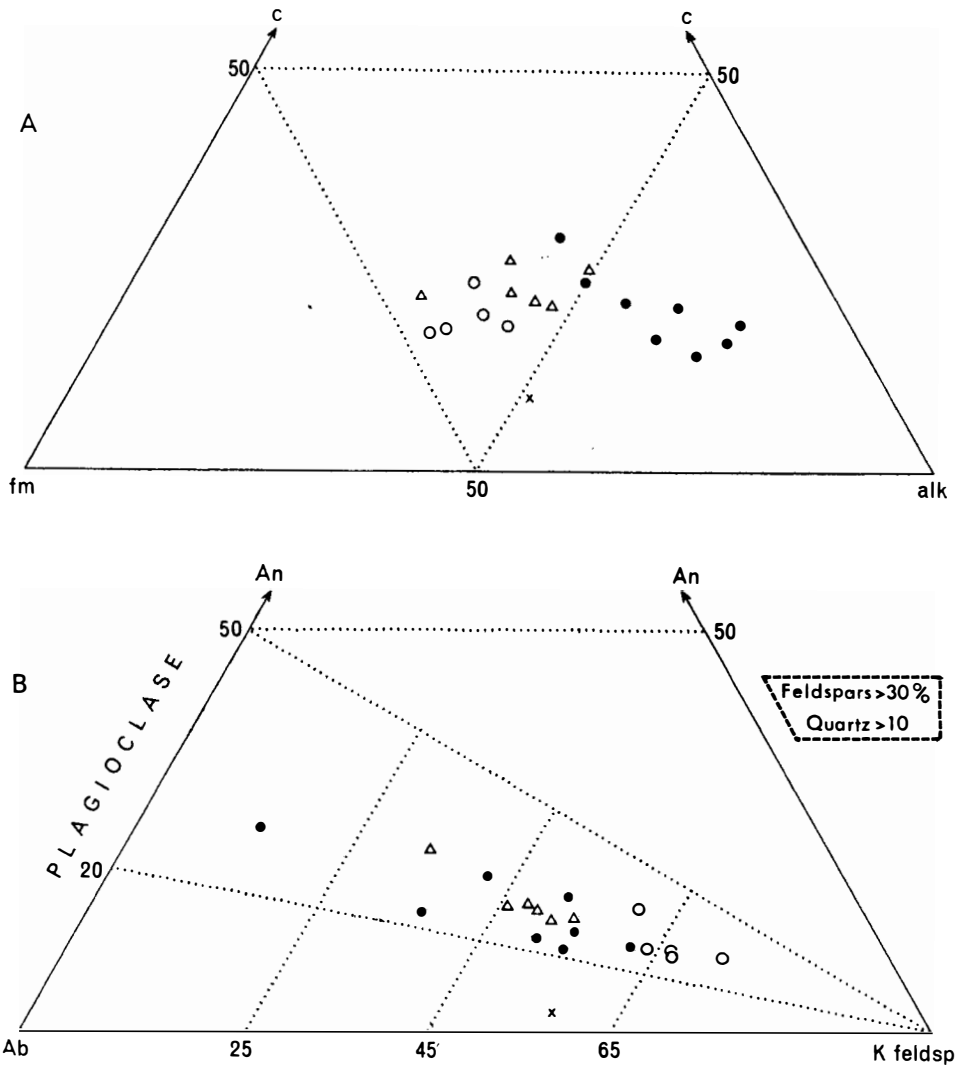

Fig. 4. *Composition diagrams. A:* NIGGLI *values, B: Feldspar proportions.*
Dots: Grey granitic rocks, NW Spitsbergen (Nos. 1–8).
Triangles: Horneman quartz monzonites (nos. 9–14).
Circles: Chydenius quartz monzonite-granosyenites (nos. 15–19).
Cross: Nordenskiöldbreen granite (no. 20).

centered on Hornemantoppen (Plate XXII, HOEL 1914). Samples from his collection were later described in detail by SCHETELIG who stated that this intrusion was undoubtly younger than the grey granitic rocks in the same region, and differed from them in its reddish colur and relatively coarse texture. The common type carried about equal amounts of K-feldspar and plagioclase, a relatively large amount of quartz and some biotite. In addition, the following accessory minerals were recorded: sphene, pyrite, magnetite, zircon, apatite, diopside and orthite. Some chlorite and epidote were also seen as alteration products of biotite. The

reddish colour of the rock was caused by the K-feldspar which contained iron oxides. The plagioclase often showed compositional zoning from approx. An 20 in the outer parts to approx. An 30 in the core. In the marginal parts of this great granite intrusion, rosy granitic dykes were seen to intrude the surrounding gneisses and meta-sediments.

HARLAND (1961) made a reconnaissance visit to NW Vestspitsbergen in 1959, and in general the observations made by earlier geologists were confirmed. A preliminary comparison with the coarse granitic rocks of Ny Friesland indicated that the intrusion carried fewer xenoliths, and had a smaller proportion of accessory minerals such as sphene, zircon, apatite and iron oxide.

Present investigations. General. During the helicopter surveying carried out by Norsk Polarinstitutt in NW Spitsbergen in 1964, GEE and HJELLE mapped the Horneman intrusion in further detail, and representative collections were taken for modal and chemical analyses.

This is clearly a batholithic type of intrusion, and in the northern part, where the roof zone is well exposed, horizontally foliated migmatite gneiss is seen partly assimilated near the contact. Except for the marginal zones, the rock is unfoliated and coarse to medium grained.

Composition. The dominating minerals are quartz (approx. 30 vol. %) and K-feldspar and plagioclase (each about 25 %). The light red K-feldspar gives the rock a reddish colour differing markedly from other rocks in NW Spitsbergen. The biotite content and the content of secondary minerals such as sericite, chlorite and epidote are higher than in the grey granitic rocks described above. Fig. 4 shows the positions in the modal classification scheme of the 6 specimens examined. Most of them are situated in the quartz monzonite field, only the most calcic and mafic (no. 9) falls in the granodiorite field. A hypidiomorph equigranular texture prevails, however transitions into more porphyritic varieties are also seen.

Both the strained quartz and the microperthitic K-feldspar are late crystallized minerals. The K-feldspars normally fill the interstices between other minerals (mainly plagioclase) and also carry inclusions of these minerals. The Na_2O and K_2O content of two K-feldspars are shown in Table 3 nos. 11 and 14. The plagioclase in part has a more marked compositional zoning than in the grey granitic rocks, and the composition may vary from approx. An 15 at the margins to An 50 in the cores. An average composition of An 25 to 35 is common. The crystals are often strongly decomposed to sericite and zoisite, calcite may also occur but is less common. Myrmekitic intergrowths are only occasionally found.

In biotite X = yellow, Y = Z = dark brown or rarely reddish brown. $n\gamma \sim 1.665$ and $n\gamma - n\alpha \sim 0.065$.

Common accessory minerals are sphene, apatite, pyrite, ilmenite, magnetite and zircon.

In Table 2, the rocks of the Horneman quartz monzonite are listed in nos. 9 to 14. The average of the approximate chemical analyses occupies an intermediate

position between DALY's "plutonic granite" and "plutonic granodiorite". In NIGGLI's magma classification the rocks may be described as acid, salic, intermediate alkalic and c-poor, representing granodioritic and trondhjemitic magmas.

The Chydenius quartz monzonite-granosyenite

Previous investigations. In the Billefjorden area v. DRASCHE collected granite erratics which had probably been transported southwestwards from the large igneous complex in Olav V Land and Ny Friesland. This complex was later visited by BACKLUND (1908) during the Swedish-Russian arc of meridan expedition 1900. In general BACKLUND described the rocks as porphyritic granites carrying relatively large amounts of coarse K-feldspar crystals in a more fine grained groundmass essentially composed of quartz and plagioclase. Among the dark minerals biotite prevailed, green amphibole occurring in lesser amounts.

The rocks were divided in two groups according to petrographical and textural differences. In the southeastern area, S and E of Tsjernysjovfjellet (Tsj. = No. 18, map C, Fig. 2) large K-feldspar phenocrysts and dark minerals were present in abundance, the latter often developed as dark aggregates. In the central area, around Newtontoppen and in N Tsjernysjovfjellet the rocks were reported to have a relatively fine grained texture, K-feldspar megacrysts playing a less dominant role. Dark minerals were less abundant than in the southeastern type, and aplite and pegmatite veins were common.

NORDENSKIÖLD (1875), GARWOOD (1899) and NATHORST (1910) also remarked on the common occurrence of granite erratics, often of porphyritic type in the Billefjorden area.

TYRELL (1922) summarized earlier information about pre-Devonian igneous rocks in the Billefjorden–Nordenskiöldbreen area, however, he did not mention BACKLUND's investigations. TYRELL's descriptions of intrusive rocks were based mainly on morainic material and the rocks were divided into two types: 1) leucocratic to melanocratic granites and syenites collected on the moraines of Nordenskiöldbreen and on the shores of Billefjorden, which were of pink or red colour, rich in microcline perthite and with varying amounts of quartz. The melanocratic types carried green augite and/or hornblende. When present, the plagioclase was of oligoclase composition. 2) A large boulder of porphyritic adamellite-granite was reported from Mohnbukta (E coast of Vestspitsbergen), however, the possibility of this having been transported from Nordaustlandet rather than from Ny Friesland was not precluded. Oligoclase and microcline perthite were present in approximately equal amounts, the latter mainly as red megacrysts embedded in a matrix of quartz, microcline, oligoclase, biotite and chlorite.

In 1921 and 1923 ODELL (1927) visited parts of the inland area of Olav V Land and Ny Friesland. His investigation did not confirm BACKLUND's suggestion of an interior and exterior type of granite in "the Chydenius massif", the difference in appearance seemed to be caused more by varying degree of weathering than by difference in composition. In Raudberget (No. 15, map C, Fig. 2) Carboniferous beds were seen resting on red porphyritic granite, while further south the

same granite intruded Hecla Hoek beds. ODELL regarded the intruding granitic rocks to be of Caledonian age.

HARLAND (1959) suggested that the intrusions were a series of batholiths, probably related at depth, and he gave a preliminary average composition of the main coarse rock of the socalled Chydenius granite, based on point counts: quartz 17%, K-feldspar (often microcline perthite) 39%, oligoclase 25%, biotite (+ sec. chlorite) 11%, hornblende (+ occasional augite and sec. chlorite) 7%, sphene 0.6%, apatite 0.2%. Intrusive contacts with variable and often very wide zones of xenolithic and hornfelsed rocks were recorded.

Present investigations. General. In 1961 T. GJELSVIK paid a short visit to Newtontoppen, and in 1963 the present author had the opportunity to visit granitic outcrops in the area from Nordenskiöldbreen to Raudbergbreen. In both cases large specimens were collected, especially of the coarse rocks, to provide material for modal analyses. Except for the marginal zones and for specimens taken near to xenoliths, the rocks from the main outcrops, in the Chydenius massif and from the exposures near Raudbergbreen, are of relatively homogeneous composition, showing slight textural and mineralogical variations.

In general the Nordenskiöldbreen outcrops give the impression of being a batholith roof area, with its intruded Hecla Hoek beds and granitic rocks of xenolithic and migmatitic types alternating with aplitic and pegmatitic dyke intrusions. Occasionally small irregular bodies of basic rocks occur, some of them having a spherulitic texture.

Composition. The main granitic rocks in the Chydenius massif and at the isolated locality at Raudbergbreen are coarse grained and porphyritic, containing approx. 35 vol.% K-feldspar of light red colour. Quartz and plagioclase constitute each about 20% and biotite and amphibole each about 5–10% of the rock. Chlorite, epidote and occasionally augite occur in small amounts, and sphene and magnetite form almost constant accessories (Table 2, nos. 15 to 19). The classification scheme given in Fig. 3 shows that these rocks are mineralogically of quartz monzonitic to granosyenitic composition.

K-feldspar occurs mainly as megacrysts of microperthitic orthoclase, some crystals showing transitions to microcline. Inclusions of sodic plagioclase are common. In Table 3 nos. 15 to 17 the Ab content of some of the K-feldspars are listed.

The medium grained matrix is composed mainly of quartz and plagioclase, the latter averaging An 30 in composition. Most crystals are partly clouded by sericite, some are also vaguely zoned. Myrmekitic embayments in the K-feldspar are common. Usually quartz shows moderate undulatory extinction, however, cataclastic varieties also occur, with partly recrystallized quartz penetrating the feldspars.

In the biotite X = light yellow, Y = Z = blackish brown. $n\gamma \sim 1.650$ and $n\gamma \div n\alpha \sim 0.055$. The amphibole is a common hornblende, X = pale yellow, Y = olive green and Z = bluish green. $n\gamma \sim 1.675$, $n\gamma \div n\alpha \sim 0.02$. Z Λ c on

(010) $\sim 17°$ and 2V $\sim 80°$. As an alteration product, chlorite with dark ultra blue interference colours often accompanies both biotite and hornblende. Muscovite occurs almost entirely as sericite in the plagioclase.

The granitic rocks of the Nordenskiöldbreen area are normally equigranular, medium grained, with some transition to more porphyritic types. An average modal analysis obtained from point counts on 5 specimens gives microcline 37.1 %, quartz 20.2 %, plagioclase 26.4 % (approx. An 10) biotite 7.4 %, chlorite 3.2 %, and amphibole 0.5 %. In addition calcite, sphene, apatite and zircon are present in accessory amounts. Thus the modal analysis given in Table 2 no. 20 is fairly typical.

With regard to chemical composition, the main coarse rock may well be compared to DALY's "plutonic granodiorite", while the granitic rocks of Nordenskiöldbreen correspond well to the "plutonic granite". Using NIGGLI's magma classification, the main coarse rock is acid, salic to isofal, alkalirich, c-poor, representing a granitic to syeno-granitic magma. The examined Nordenskiöldbreen rocks are acid, salic, alkalirich, c-poor and represent a granitic magma.

The Nordkapp quartz monzonite and the Brennevinsfjorden granite

Previous investigations. In 1827 PARRY (1828) collected scattered rock specimens from this area and these were briefly described by R. JAMESON in the same paper. They were all classified as "primitive rocks". A coarse grey to red granite associated with garnetiferous mica schist was reported from Beverlysundet, just SW of Nordkapp, and grey and reddish granite and granite gneiss, occasionally containing garnet, from Waldenøya and the N Sjuøyane region.

NORDENSKIÖLD (1863) suggested that the gneissic and granitic rocks in the peninsula E and NE of Brennevinsfjorden and the adjacent islands, including Sjuøyane, were a part of "the old granite-gneiss formation". Equigranular granites were described from the E entrance of Brennevinsfjorden and from Kapp Lindhagen, further N the rocks were reported to be gneiss and granite, more or less foliated, often intruded by aplite and turmaliniferous pegmatite dykes.

SANDFORD (1926) reported pink granite, muscovite pegmatite and gneiss from the Nordkapp region and owing to the general absence of gneissic structures, he suggested that the granitic rocks were considerably younger than the gneiss-granite complex, and that the intrusion had taken place after the main Caledonian folding. Later (1950) he reaffirmed his view and stated that he considered the grey granite-mica-schist to be part of a gneissic core, older than the Hecla Hoek sediments, possibly Archaean. These views were mainly based on air photo interpretations from the inner part of Sabinebukta, where Hecla Hoek sediments seemed to rest unconformably on granite gneiss, and on observations of differences in structure and grade of metamorphism in the same rocks elsewhere in Nordaustlandet. Without giving locations, the grey granite was briefly described as containing dominant quartz and orthoclase in about equal proportions, some microcline and plagioclase subsidiary to orthoclase, and either muscovite or bio-

tite. On the basis of further air photo interpretation of the structures, SANDFORD (1956) suggested a general southerly dip in the suggested old metamorphic complex ("The regional dip is clearly southerly, and no more than a few degrees.", p. 357) and also stated that this dip seem to be unrelated to that of the Hecla Hoek sediments "resting with essential unconformity upon the denuded surface of the complex".

In 1931 KULLING (1934) visited the eastern shores of Brennevinsfjorden, where an intrusive contact between older Hecla Hoek beds and a fine to medium grained granite was observed at Kontaktberget, near the head of the fjord. As the older beds were only slightly affected by the intruded rocks, which were seen to be perfectly massive, KULLING suggested the granite to be slightly younger than the Caledonian folding, and to be intruded under fairly quiet conditions.

KRASIL'ŠČIKOV (1965) reported coarse grained biotite granite of rapakivi type and a fine to medium grained biotite granite from the peninsula E of Brennevinsfjorden, the latter probably forming an exterior zone of a large granite area. Both types gave isotopic ages of about 400 m. y. Thus the granitic rocks in the Brennevinsfjorden–Sjuøyane region were considered to be of Caledonian age, although KRASIL'ŠČIKOV did not wholly preclude Caledonian recrystallisation of older rocks. From the Nordkapp–Sjuøyane submeridional "Caledonian directions" of structural trends were reported.

Present investigations. General. Work done by HJELLE and WINSNES 1957, GJELSVIK 1962 and HJELLE 1965 shows that there exist two main types of granitic rocks in the Brennevinsfjorden–Sabinebukta–Sjuøyane region. Along the E side of Brennevinsfjorden and near Sabinebukta a medium grained, acid, alkalic type prevails, while a coarse grained, in part gneissic, less acid and more calcic type extends towards the northeast. In 1965 some observations in this north-eastern area seemed to indicate a more migmatitic composition towards Sjuøyane, with increasing amounts of gneissic and metasedimentary inclusions and also a higher degree of assimilation and recrystallisation. In some metasediments, K-feldspar porphyroblastesis has transformed these to para-augengneisses. The increase in size of the porphyroblasts towards the granite contact suggests that the granitic rocks are the principal source of K.

When exposed, the contact between the two main types of granitic rocks often seems to be transitional, at least considering the texture. According to GJELSVIK (personal communication) a transition zone of a few tens of metres is observed at several places along the eastern shore of Brennevinsfjorden. Evidence of a marked difference in age has not yet been found, and this seems to agree well with the consistent isotopic ages obtained by KRASIL'ŠČIKOV (1965) both on "coarse grained biotite rapakivi granite" and "medium grained biotite granite", even though exact locations for these rocks were not given.

KULLING's record of a perfectly massive granite on the E side of Brennevinsfjorden is not wholly confirmed. A slight foliation with fairly constant strike NE–SW to NNE–SSE is observed in both types of granitic rocks, from Brennevinsfjorden to Sjuøyane. The dips are also fairly constant, 30–80° towards ESE–

SE, with some more variation in the N part. Thus these observations confirm and extend the "Caledonian directions" observed by KRASIL'ŠČIKOV in the Nordkapp–Sjuøyane area, but differ considerably from the S to SW dips suggested by SANDFORD (1956)

Where the contact between the Brennevinsfjorden granite and Hecla Hoek rocks is exposed, as in Kontaktberget (KULLING 1934) and Sabinebukta, clearly intrusive relations are seen, with a fine grained border facies of granite and veins of aplite and quartz. Near Sabinebukta partly assimilated host rocks were seen in the granite near the contact (SIGGERUD, personal communication). The interpretations of air photographs from this last area (SANDFORD 1950) must thus be revised. The Hecla Hoek rocks here do not rest upon an old complex, but are intruded by younger granitic rocks.

Composition of the Nordkapp quartz monzonite. This rock is mainly greyish, coarse grained equigranular to porphyritic, with K-feldspar megacrysts up to about 6 cm long. The average composition is approx. 30 vol.% each of quartz and K-feldspar, 25% plagioclase, 10% biotite and about 5% muscovite. Chlorite, apatite, magnetite, epidote and tourmaline are almost constant minor constituents. Fig. 5 shows the position of the 10 examined specimens in the modal classification scheme, nearly all fall in the quartz monzonite field.

The idiomorphic to hypidiomorphic K-feldspar megacrysts, which in general are microperthitic, often show microcline twinning and occasionally the plagioclase rims typical of rapakivi granite are present. Inclusions of altered plagioclase are common, the largest of these having the same composition as the plagioclase in the groundmass. Composition of some K-feldspars are given in Table 3 nos. 23 to 28.

The quartz often has strained appearance, with rather intense undulatory extinction, especially in larger grains. Veins of fine grained quartz often transgress plagioclase, K-feldspar and also the larger quartz grains, thus indicating two generations of quartz.

The plagioclase ranges in composition from approx. An 20 to 40, with An 30 as an average. No systematic variations in the plagioclase from different parts of the quartz monzonite have been found. The inner parts of the plagioclase grains are often clouded by sericite and occasionally zoisite, while myrmekitic intergrowths are common in the margins near the K-feldspar.

Biotite mostly occurs associated with muscovite, sphene, apatite, zircon and ores. It normally has pleochroism X = pale yellow, Y = Z = reddish brown to dark brown. $n\gamma \sim 1.665$, $n\gamma - n\alpha \sim 0.06$. The biotite is often altered to chlorite along its cleavages and margins and may also contain grains of epidote.

More than 2/3 of the muscovite occurs as sericite in plagioclase and the remainder is commonly associated with biotite.

The approximate chemical analysis correspond to the "plutonic granite" and "granodiorite" of DALY. Using NIGGLI's classification the quartz monzonites are acid, salic, c-poor and the rocks mainly represent magmas with approximately Na-rapakivitic and normal rapakivitic composition.

Composition of the Brennevinsfjorden granite. This light grey to red rock is normally medium grained, in part porphyritic and with a somewhat cataclastic texture. It often bears the imprint of shearing visible to the naked eye. The average modal analysis shows quartz and K-feldspar as the main constituents, each about 35 vol.%, and plagioclase about 15%. Muscovite exceeds biotite, and tourmaline and apatite form almost constant accessories. According to its content of quartz and feldspar, the rock is classified as granite (Fig. 3).

In the area near E Sabinebukta, the granites differ somewhat from the average composition. A relatively high epidote content and low content of K-feldspar suggests an exchange of Ca and K between the granite and the adjacent quartz porphyry and calcic shale. Migmatitic transition zones are observed in S Scoresbyøya.

K-feldspar occurs most commonly as part of the medium grained groundmass, however, large phenocrysts up to about 3 cm long may also occur. The feldspar is often pronouncedly perthitic and may also carry larger inclusions of albite. The crystals in part show microcline twinning and sporadically a slight sericitization. Analyses of Na_2O and K_2O in two of the K-feldspars are listed in Table 3 nos. 32 and 34.

The quartz usually shows intense banded undulatory extinction, and brittle deformation of the grains is common. In hand specimen the colour is bluish.

Plagioclase occurs in the groundmass and is often heavily sericitised, the An content varying between 5 and 15%. Some grains have bent twin lamellae. Zoisite occurs sporadically.

Biotite shows pleochroism X = yellow, Y = Z = dark brown. $n\gamma \sim 1.66$. $n\gamma \div n\alpha \sim 0.050$.

Chlorite occurs as rims on biotite and as separate aggregates.

About half the amount of muscovite occurs as sericite in plagioclase, the remainder mostly in association with biotite and partly interfingering with it.

The Brennevinsfjorden granite is pronouncedly acid and corresponds chemically to DALY's "plutonic granite", whereas the granite in NIGGLI's terms is acid, salic, c-poor, representing aplite granitic and Na-granite aplitic magmas.

The Rijpfjorden granite

Previous investigations. During his sledge journey of 1873 NORDENSKIÖLD (1875) recorded small granite outcrops near the head of Wahlenbergfjorden, without giving a further description of the rock.

Based on morainic material SANDFORD (1926) suggested the rock observed by NORDENSKIÖLD to be a pink granite, in part with fragments of pink augengneiss. From this and other observations elsewhere in Nordaustlandet it was suggested that intrusion of considerable masses of pink granite had taken place in the central and S parts of N Nordaustlandet, these being younger than the grey granites and gneisses of the N coast.

Observations from GLEN's expedition 1934–1935 were summarised by SANDFORD (1950) and a further extension of the outcrops of the pink granite along the

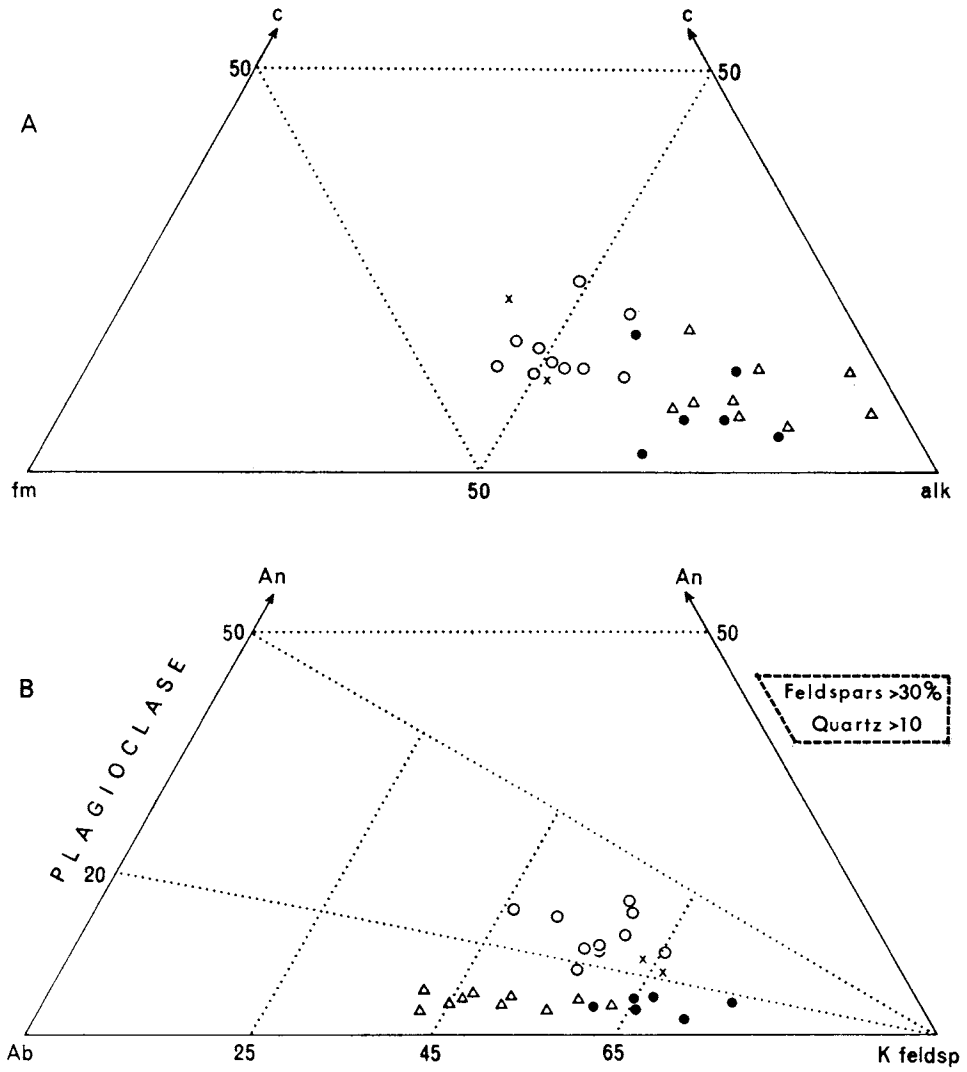

Fig. 5. *Composition diagrams. A:* Niggli *values, B: Feldspar proportions.*
Circles: Nordkapp quartz monzonites (nos. 21–30).
Dots: Brennevinsfjorden granites (nos. 31–36).
Triangles: Rijpfjorden granites (nos. 37–46).
Crosses: Granitic rocks near Duvefjorden (nos. 47 and 48).

head and E side of Rijpfjorden, and between Rijpfjorden and Wahlenbergfjorden was suggested. The granitic rocks were described as felsic granodiorites with quartz, orthoclase and plagioclase as main constituents, the plagioclase ranging from An 6 to An 12. Some of the rocks examined contained microcline, muscovite was usually prominent and biotite subordinate.

Mainly on the basis of air photograph interpretations, Sandford (1956) revised his earlier view of the extension of the pink granodiorite, restricting this to a small area W of the head of Rijpfjorden (observed by Glen), some small islands

near the E side of Rijpfjorden and the previously known outcrops E of the head of Wahlenbergfjorden.

KRASIL'ŠČIKOV (1965) stated that two-mica granites and granodiorites, often with cataclastic structures constituted the greater part of the peninsula E of Rijpfjorden, from Vindbukta to the head of Rijpfjorden and probably extends further towards the central parts of Nordaustlandet. Near Vindbukta the contact was clearly intrusive, further S xenolithic facies of the granite were recorded, indicating migmatitisation of the Hecla Hoek sediments.

Present investigations. General. During Norsk Polarinstitutts' work in 1957 and 1965 intrusive contacts against Hecla Hoek sediments and gneissic rocks were observed near the head of Wahlenbergfjorden, in Rijpdalen and in the Rijpfjorden district. About 5 km E of the innermost branch of Rijpfjorden, and also further NNE, the pink granite intrudes homogeneous grey augengneiss of approximately quartz diorite composition, whereas in upper Rijpdalen, near the water shed, the intruded rocks are mainly shales and quartzites. W of Ahlmannfonna (E and SE of no. 40, map R in Fig. 2) transitions from medium grained grey homogeneous gneiss to red granite is common. This granite often contains xenoliths of grey homogeneous gneiss, which frequently contain in their centre lenticular remnants of dark metasediments. In the whole granite area, from the exposures E of Wahlenbergfjorden to Vindbukta, scattered occurrences of large blocks (>50 m across) of country rocks occur, often as "caps" in the upper parts of hills, giving the general impression of a roof zone. Within the granite there are numerous irregular veins and bodies of quartz and pegmatite, the latter approaching the granite in composition and appearance.

Composition. The texture is hypidiomorphic medium grained and often shows signs of post-magmatic movements. The colour is normally distinct pink or red. The most abundant minerals are quartz with an average of 30–35 vol. % and K-feldspar and plagioclase each about 25 %. With an average of about 10 %, muscovite exceeds biotite in all examined specimens. Almost constant accessories are iron hydroxides and fluorite, the latter also occasionally occurs as a coating on fissures. In the classification scheme the 10 analyses of Rijpfjord granite mainly occupy the normal granite field. The quartz shows imprints of strain, with a relatively strong patchy undulatory extinction. Some feldspar margins are embayed and replaced by quartz, which also fills fissures in broken grains, especially of plagioclase.

K-feldspar most often occurs as microcline microperthite with inclusions of plagioclase, occasionally also with rounded grains of quartz. In some grains the microcline twinning is only feebly developed. Table 3 nos. 37 to 46 gives examples of the K-feldspar composition.

The composition of the plagioclase varies between An 5 and 10, the most calcic seems to occur in granite rich in xenoliths, such granites may also contain some biotite, and myrmekitic intergrowths in plagioclase are common. The plagioclase grains often show bent and broken twin lamellae.

Muscovite occurs mainly as unorientated somewhat bent flakes, sericite in plagioclase playing a subordinate role.

Biotite is only sparsely present, the commonest type has pleochroism X = pure yellow, Y = Z = reddish brown. $n\gamma \sim 1.670$, $n\gamma \div n\alpha \sim 0.055$.

Small amounts of olive coloured chlorite occur in most of the specimens, the interference colour being pale greyish blue. $n\gamma \div n\alpha \sim 0.007$.

The average chemical analysis of the Rijpfjorden granite corresponds rather well to DALY's "plutonic granite", in NIGGLI's terms the rocks are acid, pronouncedly salic, c-poor and representing aplite granitic and Na-granite aplitic magmas.

It should be mentioned that rocks similar to the Rijpfjorden granite have also been reported from outside the Rijpfjorden–Wahlenbergfjorden region. SANDFORD (1950, 1954) described pink granite from S of Kapp Leigh Smith (extreme E of Nordaustlandet) and FLOOD (personal communication) reports a dyke-like intrusion of a two-mica granite with prominent muscovite, very similar to the main Rijpfjorden granite, from S Repsøya, by the E entrance to Duvefjorden.

In addition to the 10 specimens of the Rijpfjorden granite, 2 specimens of a possibly genetically related rock in an adjacent area have been examined. This rock occurs between Rijpfjorden and Duvefjorden (Fig. 2, map R, no. 47) where it forms a small, vaguely defined outcrop within the main granite with apparently gradual transition between the two. At the locality near the inner branches of Duvefjorden (no. 48), the rock penetrates migmatitic gneisses, although here also the contact is not clearly defined (FLOOD, personal communication). Both specimens have a medium to coarse grained, somewhat porphyritic texture, with megacrysts of K-feldspars in a medium grained matrix of K-feldspar, plagioclase, quartz and biotite. K-feldspar constitutes about 35 vol. % of the rock, quartz about 25%, and plagioclase about 20%. Both strongly undulating and homogenous late recrystallised quartz occurs, the latter often in embayments within plagioclase and biotite. The K-feldspar is commonly of microcline microperthitic type, in part having the imprints of brittle deformation. One Na_2O–K_2O analysis of K-feldspar is given in Table 3 no. 48. The plagioclases of the two specimens contain respectively 22% and 25% An, and are in part sericitized. Myrmekitic rims in contact with K-feldspar are common. The biotite having pleochroism X = yellow, Y = Z = dark brown, $n\gamma \sim 1.650$, $n\gamma \div n\alpha \sim 0.055$. More than 3/4 of the muscovite is present as sericite in plagioclase.

These rocks may possibly be regarded as hybrid, being a result of extensive assimilation of older rocks by the main Rijpfjord granite magma.

Somewhat gneissic rocks of apparently similar composition occur in Snauvola (E of no. 47, near Duvefjorden).

Concluding remarks

The facts available from previous and present investigations make it clear that in Svalbard several petrographically distinct types of granitic rocks occur, of which the most abundant types are: G) grey medium grained biotite quartz monzonite to biotite quartz diorite in NW Vestspitsbergen, occuring mainly as

dyke intrusions. H) Reddish coarse to medium grained, in part porphyritic, biotite quartz monzonite in NW Vestspitsbergen. C) Light red to grey coarse porphyritic biotite and hornblende bearing quartz monzonite-granosyenite in Olav V Land and Ny Friesland, central NE Vestspitsbergen. (The intrusion in H and C are apparently batholithic). N) Coarse, in part porphyritic biotite quartz monzonite in the Nordkapp area of Nordaustlandet. B) Pink to grey, medium grained, in part porphyritic biotite K-granite in the Brennevinsfjorden–Sabinebukta area of Nordaustlandet. R) Mainly pink medium grained muscovite normal-granite with its main extension in the Rijpfjorden–Rijpdalen–Wahlenbergfjorden area of Nordaustlandet.

Chemically the Horneman quartz monzonite (H), the Chydenius quartz monzonite-granosyenite (C) and the Nordkapp quartz monzonite (N) have many similarities. Similarly the Rijpfjorden and Brennevinsfjorden granites (R and B) resemble each other in many respects.

The petrography and chemical composition and the texture of the granitic rocks of Svalbard suggest a tentative division into three main groups: I) Grey medium grained rocks, ranging petrographically from quartz monzonite to quartz diorite (G above). II) Coarse often porphyritic rocks of mainly quartz monzonite composition (H, C and N above). III) Medium grained leucocratic muscovite granites (B and R above). The rocks in group I show some chemical resemblance to the granites in group III, but petrographically they often differ considerably.

The area E of Duvefjorden, Nordaustlandet, is relatively little known, however preliminary results from Norsk Polarinstitutt's investigations 1965 (by B. FLOOD and D. G. GEE) show that the rocks here include migmatitic gneisses, metasediments and coarse and medium grained granitic rocks, the latter often occurring as dyke intrusions. Thus resemblances both to NW Spitsbergen and to the N part of the coarse Nordkapp quartz monzonite are obvious.

Average compositions of the main types of the examined rocks, according to the petrographical and geographical divisions, are shown in Table 4, the letters G, H, C, N, B and R correspond to the divisions above.

Diagrams showing the variations of alk, fm and c, respectively modal An, Ab and K-feldspar are shown in Figs. 4 and 5.

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Table 1.
Mineral composition of grey granitic rocks in NW Spitsbergen (GEE and HJELLE, 1965).

Quartz	32
K-feldspar	25
Plagioclase	31
Muscovite	3
Biotite	6
Chlorite	x
Epid. cl. zoisite	x
% An in plagioclase	27

Table 3.
Composition of K-feldspars. Specimen numbers refer to the maps in Fig. 2.

	G				H		C			
	1	2	5	6	11	14	15	16	17	20
wt % Na_2O	2.23	2.13	1.88	2.72	2.92	2.44	2.33	3.21	2.68	1.88
wt % K_2O	12.97	13.15	13.33	13.07	13.09	13.28	13.33	12.83	13.14	13.02
Mol.% Ab	19.7	18.8	16.8	22.9	24.2	20.8	20.0	26.3	22.6	18.1
Mol.% Ab aver.	19.6				22.5		23.0			

	N				B		R			
	23	25	27	28	32	34	37	45	46	48
wt % Na_2O	2.23	2.79	2.03	1.91	3.22	3.87	1.51	1.02	1.68	1.78
wt % K_2O	12.98	13.29	13.70	13.33	12.02	10.70	14.05	15.19	14.25	12.27
Mol.% Ab	19.7	23.1	17.5	17.0	27.8	33.9	13.3	8.8	14.4	17.1
Mol.% Ab aver.	19.3				30.8		12.2			

Table 2.

Composition of granitic rocks. Specimen numbers refer to the maps in Fig. 2. Oxide and kation percentages, NIGGLI values and specific gravity are calculated from the mode.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39*	40	41	42	43*	44	45	46	47	48
Modal analyses (vol. %)	Quartz	26.7	32.4	33.2	34.0	28.0	32.3	29.7	31.8	25.9	29.7	32.0	32.8	34.7	29.6	18.6	25.5	17.9	25.4	27.3	21.3	29.5	30.1	31.9	30.6	34.7	24.6	26.9	28.1	27.5	32.1	31.8	36.8	35.6	38.4	30.1	34.0	30.4	30.7	32.1	30.4	31.7	32.0	34.2	37.3	35.2	35.2	26.8	24.8
	K-feldspar	33.8	38.5	22.1	22.1	34.9	32.3	7.7	32.3	15.0	26.3	25.2	25.5	25.0	24.6	37.2	33.0	43.0	37.9	35.5	34.4	26.3	32.0	29.5	28.0	27.5	38.7	30.5	32.3	32.9	27.4	37.4	33.6	38.8	32.4	38.2	25.9	30.2	34.1	25.1	26.1	32.1	28.7	24.4	23.1	23.7	21.7	37.7	34.7
	Plagioclase	31.3	23.9	38.9	31.2	28.9	27.3	49.3	31.7	29.6	27.2	21.7	27.9	23.7	30.0	24.7	18.7	16.5	19.3	17.7	25.8	31.4	23.8	23.1	27.0	20.2	20.7	21.2	23.4	22.1	21.1	18.6	18.2	12.6	13.2	20.0	16.7	23.9	20.4	36.2	25.3	23.0	28.3	28.3	27.6	30.0	30.5	19.3	20.3
	Muscovite	1.6	1.8	1.0	4.1	2.0	3.3	4.3	1.2	7.5	3.7	7.5	2.5	5.4	5.4	1.7	2.0	1.5	3.0	1.5	4.3	2.9	3.1	4.2	7.4	8.0	2.4	6.1	2.5	4.0	10.7	6.6	5.6	8.4	9.5	8.7	13.5	9.5	9.8	5.2	12.4	8.0	9.8	10.1	11.3	8.9	10.5	4.4	4.4
	Biotite	5.4	2.9	4.8	7.4	5.5	4.7	6.0	3.0	16.3	6.1	4.1	8.1	7.3	6.2	8.0	11.1	8.0	7.0	9.1	6.7	7.1	8.5	10.4	6.2	8.0	12.2	13.8	12.9	11.4	7.4	3.7	5.5	3.7	5.0	2.7	5.1	4.3	4.3	0.7	1.7	3.7	0.4	1.2	0.2	0.1	1.1	10.0	9.8
	Chlorite	0.6	x	x	0.4	0.7	0.1	2.2	x	2.0	2.6	1.3	1.2	1.1	0.7	0.1	0.3	1.5	0.5	x	4.9	0.5	1.5	0.3	0.3	1.1	0.2	0.2	0.2	0.7	0.2	0.1	–	x	–	x	0.7	0.4	–	–	2.0	0.2	0.1	1.1	0.2	0.6	0.4	0.1	2.1
	Amphibole	–	–	–	–	–	–	–	–	x	0.1	–	–	–	–	7.4	8.2	9.4	5.5	7.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Epid. zois.	x	–	x	0.8	x	–	0.2	x	2.6	2.3	6.0	1.2	2.3	2.9	0.1	0.3	0.3	x	x	0.2	0.1	x	x	x	0.1	0.3	0.2	–	–	0.3	1.4	–	–	x	–	–	3.0	–	–	0.4	–	–	–	–	–	–	x	–	0.6	–
	Apatite	–	–	x	x	x	–	x	–	0.2	0.2	0.1	0.3	x	x	0.2	0.1	0.1	0.2	0.5	0.1	0.1	0.2	0.2	0.3	x	0.2	x	x	0.5	0.1	x	0.1	0.1	x	x	0.1	0.3	0.5	0.2	0.4	0.2	0.1	0.1	x	0.1	0.1	0.2	0.4
	Sphene	–	–	–	–	x	–	0.2	–	0.5	0.6	0.1	x	x	0.2	0.7	0.7	0.5	0.5	0.7	0.1	0.1	–	–	–	0.2	–	–	–	x	0.3	0.3	–	–	–	–	0.7	0.2	–	–	–	–	–	–	x	x	0.1	x	–	0.2
	Magnetite	–	x	–	x	x	–	–	x	0.4	–	0.6	0.3	0.2	–	0.3	–	0.7	0.1	x	–	0.1	–	x	0.1	–	0.4	0.1	0.1	x	–	–	0.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.7	x
	Zircon	x	x	x	x	x	x	–	x	–	x	0.1	x	x	x	x	0.1	x	x	x	0.1	x	0.1	x	0.1	–	0.2	0.2	x	–	x	x	0.1	–	–	–	–	x	x	–	–	–	–	–	–	–	–	–	0.1	–
	Other minerals		0.5[1] x[2]	x[3]	x[10]	x[3] x[10]		x[4] 0.4[5] x[8] x[10]	x[6] x[7]	x[5] x[8]	x[3] x[7] 1.2[8] x[9]	0.1[3] x[5] 1.2[8]	0.1[5] 0.1[9]	0.2[5] 0.1[8] x[10]	x[4] 0.4[9]	0.5[5] 0.3[6] 0.2[9] x[11]		x[3] 0.2[5] 0.3[6] 0.1[9]	0.2[5] 0.3[6] 0.1[11]	x[7] 0.2[11]	0.1[3] 0.1[5] 1.2[8] 0.2[9] 0.1[9]	0.6[4] 0.1[5] 0.1[9] 0.1[12]	0.1[3] 0.1[5] x[10]	0.4[4] 1.1[5] 0.1[9] x[7] x[8]	x[5]	0.1[3] 0.1[5]	x[4] x[8] 0.1[4]	0.6[4] 0.2[6] x[10]	x[4]	0.1[3] x[7] x[8] 0.2[9]	0.1[4] 0.2[7]	0.1[3] x[9]		0.6[4] x[4]	0.6[4] 0.9[6]	0.2[7] x[4]	0.1[3] 0.1[5] 0.1[9]	x[7] 0.1[9] 0.2[10]		0.1[4]	0.8[5] 0.5[10]	0.4[2] 0.4[6] 0.1[7] 0.1[10] x[12]	0.1[5] 0.5[6]	0.4[5] 0.1[10]	0.2[4] x[7] 0.1[9] x[10]	x[3] 1.3[8]	0.5[6] x[10]	x[7] 0.1[10]	1.1[5] x[7] 0.1[8] 0.2[9] 1.0[10]
		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.6	100.0	99.5	100.0	100.0	100.0	100.0	100.0	99.5	99.4	99.9	100.0	100.0	99.8	100.0	99.9	100.0	99.5	99.8	100.0	99.6	99.9	100.0	99.9	100.0	100.0	100.0	100.0	99.1
	% An in plagiocl.	34	27	23	33	27	22	29	23	34	29	30	30	28	28	38	28	33	30	28	5	28	26	24	30	24	28	36	39	30	18	13	12	15	6	8	8	6	9	9	9	10	7	9	8	7	5	22	25
Weight %	SiO_2	70.3	74.2	74.1	71.8	71.5	73.7	69.3	74.4	63.4	68.0	67.6	70.6	71.2	69.4	63.9	67.1	63.4	68.1	68.4	66.2	69.7	70.0	71.1	70.6	71.8	67.7	67.1	68.4	68.3	70.8	73.3	75.1	74.4	74.3	73.1	70.9	71.5	72.1	75.2	70.3	72.2	73.9	73.9	75.8	74.4	74.8	68.6	65.0
	Al_2O_3	15.9	14.2	14.4	15.1	15.2	14.4	16.7	14.4	17.0	15.1	15.8	14.5	14.7	16.0	15.7	13.9	14.8	14.5	13.4	15.2	15.1	14.4	14.3	15.8	14.5	15.2	15.9	15.3	15.2	15.4	14.7	13.2	14.1	13.5	15.1	15.5	14.9	15.1	14.6	15.6	14.5	15.1	14.8	14.6	14.2	14.6	14.9	14.7
	Fe_2O_3	0.2	0.1	0.2	0.3	0.2	0.2	0.3	0.1	1.2	0.3	1.1	0.8	0.6	0.4	1.4	0.8	2.1	1.1	0.7	0.5	0.4	0.4	0.4	0.4	0.4	1.1	0.7	0.7	0.5	0.3	0.2	0.4	0.2	1.4	0.5	0.5	0.2	0.2	–	0.1	1.5	0.9	–	–	1.7	0.7	1.4	0.4
	FeO	1.8	1.0	1.0	1.7	1.4	1.1	2.0	0.7	4.3	2.1	1.7	2.4	2.1	1.9	3.2	3.7	4.1	2.6	3.1	3.6	2.3	2.8	2.5	1.5	2.1	3.0	3.6	3.0	2.9	1.8	0.9	1.3	1.2	1.2	0.7	1.4	1.6	1.0	0.2	1.3	0.9	0.2	0.7	0.2	0.2	0.4	2.6	3.7
	MgO	0.7	0.3	0.5	0.8	0.7	0.5	1.0	0.3	2.0	1.0	0.6	1.0	0.9	0.7	1.9	2.3	2.3	1.6	2.0	1.4	0.8	1.1	1.1	0.7	1.0	1.3	1.5	1.4	1.3	0.8	0.4	0.6	0.4	0.5	0.3	0.6	0.5	0.5	0.1	0.5	0.4	–	0.3	0.1	0.1	0.2	1.1	1.3
	CaO	2.3	1.4	1.9	2.5	1.7	1.3	3.4	1.6	3.3	2.7	3.2	2.4	2.2	2.7	3.7	2.7	2.9	2.4	2.7	1.2	2.6	1.5	1.4	1.9	1.3	1.5	1.7	2.0	1.8	1.1	1.1	0.6	0.5	0.2	0.4	1.6	0.6	0.7	0.9	1.2	0.6	0.5	0.8	0.5	0.5	0.4	1.3	2.1
	Na_2O	3.2	2.9	4.0	3.0	3.2	3.4	4.2	3.6	2.7	2.9	2.4	3.0	2.7	3.1	2.7	2.7	2.5	2.7	2.5	3.7	3.2	2.8	2.8	2.9	2.6	2.7	2.3	2.4	2.5	2.7	3.2	3.0	2.7	2.8	3.5	2.7	3.1	2.7	4.2	3.0	2.9	3.5	3.4	3.3	3.6	3.6	2.5	2.5
	K_2O	5.1	5.6	3.5	4.1	5.5	4.9	2.1	4.7	4.2	4.3	4.3	4.3	4.5	4.4	5.8	5.2	6.3	5.8	5.5	5.6	4.5	5.4	5.3	5.2	5.2	6.5	6.1	5.8	5.9	5.6	5.4	5.2	5.8	5.1	5.7	5.0	5.8	6.5	4.3	5.4	5.9	5.4	4.9	4.8	4.4	4.7	6.5	6.1
	H_2O	0.3	0.2	0.2	0.4	0.3	0.3	0.6	0.1	1.0	0.7	0.7	0.5	0.6	0.6	0.5	0.6	0.7	0.5	0.4	1.0	0.4	0.5	0.5	0.5	0.7	0.4	0.7	0.5	0.6	0.7	0.5	0.4	0.5	0.7	0.5	0.9	0.6	0.6	0.3	0.9	0.6	0.6	0.7	0.6	0.7	0.7	0.5	0.7
	P_2O_5	–	–	–	–	–	–	–	–	0.1	0.1	–	0.1	–	–	0.1	–	–	0.1	0.2	–	–	0.1	0.1	0.1	–	0.1	–	–	0.2	–	–	0.1	–	–	–	–	0.1	0.3	0.1	0.2	0.1	0.1	–	–	–	0.1	0.1	0.2
	TiO_2	0.2	0.1	0.2	0.3	0.2	0.2	0.3	0.1	0.9	0.5	0.2	0.4	0.3	0.7	1.0	0.9	0.8	0.6	0.8	1.0	0.4	0.8	0.4	0.2	0.4	0.5	0.5	0.6	0.6	0.6	0.3	0.2	0.1	0.2	0.2	0.7	0.8	0.3	–	0.4	0.2	–	0.1	0.1	0.1	–	0.4	1.5
	CaF_2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.3	–	–	0.6	0.1	–	0.1	–	–	–	0.1	1.2
	CO_2	–	–	–	–	–	–	0.2	–	–	–	–	–	0.1	–	0.2	–	0.1	–	–	–	0.5	0.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.4	–	–	0.2	–	–	–	–	0.5
	FeS_2	–	–	–	–	–	–	–	–	–	2.2	2.2	–	0.2	–	–	–	–	–	–	–	–	0.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.2
		100.0	100.0	100.0	100.0	99.9	100.0	100.1	100.0	100.1	99.9	99.8	100.0	100.1	99.9	100.1	99.9	100.0	100.0	99.7	99.9	99.9	100.0	99.9	99.8	100.0	100.0	100 1	100.1	99.8	99.8	100.0	100.1	99.9	99.9	100.0	99.8	100.0	100.0	99.9	99.9	99.9	100.2	99.9	100.0	99.9	100.2	100.0	100.1
Kation %	Si	65.6	69.6	69.1	67.5	66.8	69.0	64.8	69.4	60.0	64.8	64.8	66.6	67.4	65.3	60.1	63.1	59.8	64.1	64.5	62.4	65.7	66.1	66.9	66.4	68.0	63.6	63.3	64.5	64.4	66.8	68.7	70.7	70.1	70.5	68.4	67.2	67.3	67.8	69.9	66.5	68.1	69.3	69.5	71.2	70.1	70.2	64.7	62.1
	Al	17.5	15.7	15.8	16.8	16.7	15.9	18.3	15.8	19.0	17.0	17.9	16.1	16.4	17.8	17.4	15.5	16.5	16.1	14.9	16.9	16.7	16.0	15.9	17.5	16.2	16.8	17.7	17.0	16.9	17.1	16.2	14.7	15.7	15.0	16.7	17.3	16.5	16.8	16.0	17.4	16.1	16.6	16.4	16.2	15.7	16.1	16.5	16.5
	Fe^{+++}	0.2	0.1	0.1	0.2	0.2	0.1	0.2	0.1	0.9	0.2	0.8	0.6	0.4	0.3	1.0	0.6	1.5	0.8	0.5	0.4	0.3	0.3	0.3	0.3	0.3	0.8	0.5	0.5	0.4	0.2	0.1	0.3	0.1	1.0	0.4	0.3	0.1	0.1	–	–	1.0	0.6	–	–	1.2	0.5	1.0	0.3
	Fe^{++}	1.4	0.8	0.8	1.3	1.1	0.8	1.5	0.5	3.4	2.7	2.4	1.9	1.7	1.5	2.5	2.9	3.2	2.0	2.4	2.9	1.8	2.3	1.9	1.2	1.7	2.3	2.8	2.3	2.3	1.5	0.7	1.0	1.0	1.0	0.5	1.1	1.2	0.8	0.1	1.1	0.7	0.1	0.6	0.2	0.2	0.3	2.1	3.0
	Mg	0.9	0.4	0.7	1.2	0.9	0.7	1.3	0.4	2.8	1.5	0.9	1.4	1.3	1.0	2.6	3.3	3.3	2.2	2.9	2.0	1.1	1.6	1.6	1.0	1.4	1.9	2.1	1.9	1.8	1.1	0.6	0.8	0.6	0.7	0.4	0.9	0.7	0.6	0.1	0.7	0.6	0.1	0.4	0.1	0.1	0.2	1.5	1.9
	Ca	2.3	1.4	1.9	2.5	1.7	1.3	3.4	1.6	3.3	2.8	3.3	2.5	2.3	2.8	3.7	2.7	2.9	2.4	2.8	1.2	2.7	1.5	1.4	2.0	1.3	1.6	1.7	2.0	1.9	1.1	1.1	0.6	0.5	0.2	0.4	1.6	0.8	0.8	1.0	1.7	0.7	0.5	0.9	0.5	0.5	0.4	1.4	3.0
	Na	5.8	5.3	7.3	5.4	5.8	6.1	7.7	6.5	4.9	5.4	4.5	5.4	4.9	5.7	5.0	4.9	4.6	4.9	4.7	6.8	5.9	5.1	5.1	5.2	4.7	4.9	4.2	4.3	4.6	4.9	5.9	5.5	4.9	5.1	6.4	5.0	5.7	4.9	7.6	5.6	5.3	6.3	6.1	6.0	6.7	6.6	4.6	4.6
	K	6.1	6.7	4.1	4.9	6.6	5.9	2.5	5.6	5.1	5.2	5.3	5.1	5.4	5.3	6.9	6.3	7.5	6.9	6.6	6.7	5.4	6.5	6.4	6.2	6.2	7.8	7.3	7.0	7.1	6.7	6.5	6.2	7.0	6.2	6.8	6.1	7.0	7.8	5.1	6.6	7.1	6.5	5.9	5.7	5.3	5.6	7.9	7.4
	P	–	–	–	–	–	–	–	–	0.1	0.1	–	0.1	–	–	0.1	–	–	0.1	0.2	–	–	0.1	0.1	0.1	–	0.1	–	–	0.2	–	–	–	–	–	–	–	–	0.1	0.2	0.1	0.2	0.1	–	–	–	0.1	0.2
	Ti	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.6	0.4	0.2	0.3	0.2	0.5	0.7	0.6	0.6	0.4	0.6	0.7	0.3	0.6	0.3	0.2	0.3	0.3	0.4	0.4	0.4	0.4	0.2	0.2	0.1	0.1	0.1	0.5	0.6	0.2	–	0.3	0.2	–	0.1	0.1	–	–	0.3	1.1
		99.9	100.1	99.9	100.0	99.9	99.9	99.9	100.0	100.1	100.1	100.1	100.0	100.0	100.2	100.0	99.9	99.9	99.9	100.1	100.0	99.9	100.1	99.9	100.1	100.1	100.1	100.0	99.9	100.0	99.8	100.0	100.0	100.0	99.8	100.1	100.0	100.0	100.0	99.9	100.1	99.9	100.0	99.9	100.0	99.8	99.9	100.1	100.1
Niggli values	al	45.1	47.4	45.9	44.7	45.3	46.8	44.3	47.6	38.2	40.5	42.2	40.9	43.0	44.7	35.5	33.8	32.7	37.6	34.4	39.0	42.0	41.2	42.0	46.3	44.6	39.5	40.7	40.4	41.0	46.7	48.4	46.2	49.3	46.8	50.3	47.7	47.3	49.1	51.3	47.8	46.4	52.0	52.2	55.1	49.4	51.8	40.4	36.7
	fm	12.7	7.8	9.7	14.6	12.1	10.0	14.8	6.3	28.2	21.0	19.2	19.7	18.1	14.0	25.1	29.7	31.5	23.5	26.8	24.2	16.2	21.1	20.2	13.1	18.2	23.3	24.9	22.7	21.4	15.4	8.3	13.2	10.4	16.7	7.7	12.8	11.9	9.2	1.7	9.8	13.6	4.9	6.4	1.8	9.4	6.6	22.2	23.2
	c	11.7	8.4	11.1	13.2	9.2	7.8	16.4	9.5	13.4	13.3	15.5	12.5	11.9	13.8	15.2	11.9	11.6	11.4	12.9	5.7	13.5	7.9	7.4	10.4	7.1	7.4	7.8	9.7	9.0	6.2	6.4	3.7	3.2	1.4	2.2	9.1	4.5	4.4	6.1	9.1	4.3	3.1	5.9	3.2	3.5	2.5	6.9	13.4
	alk	30.6	36.4	33.3	27.5	33.4	35.5	24.6	36.6	20.2	25.2	23.1	26.8	27.0	27.4	24.2	24.5	24.1	27.5	25.9	31.1	28.3	29.8	30.4	30.2	30.1	29.8	26.7	27.1	28.5	31.6	36.9	36.8	37.1	35.1	39.8	30.4	36.3	37.2	40.9	33.3	35.7	40.0	35.6	39.9	37.7	39.1	30.5	26.7
	si	337	421	402	360	362	407	313	418	242	309	306	339	354	328	245	276	237	299	298	288	330	340	353	351	374	299	291	307	312	364	409	445	440	439	413	370	385	397	448	365	392	433	442	484	441	451	316	276
	k	0.51	0.56	0.36	0.48	0.53	0.49	0.25	0.46	0.51	0.49	0.54	0.49	0.53	0.48	0.58	0.56	0.62	0.59	0.59	0.50	0.47	0.56	0.56	0.54	0.57	0.62	0.63	0.62	0.61	0.58	0.52	0.53	0.59	0.55	0.51	0.55	0.55	0.62	0.40	0.54	0.58	0.51	0.49	0.49	0.45	0.46	0.63	0.62
	mg	0.37	0.33	0.43	0.43	0.42	0.41	0.44	0.43	0.40	0.33	0.22	0.37	0.37	0.37	0.43	0.48	0.41	0.44	0.49	0.39	0.35	0.38	0.41	0.39	0.42	0.38	0.39	0.41	0.41	0.40	0.40	0.40	0.34	0.28	0.31	0.38	0.35	0.41	0.39	0.38	0.25	0.08	0.39	0.27	0.10	0.24	0.33	0.36
	D_t g/cm³	2.66	2.64	2.65	2.68	2.65	2.65	2.69	2.64	2.75	2.72	2.75	2.69	2.69	2.70	2.72	2.72	2.73	2.70	2.71	2.68	2.68	2.68	2.68	2.67	2.68	2.68	2.71	2.69	2.68	2.69	2.66	2.66	2.66	2.67	2.65	2.70	2.67	2.66	2.64	2.67	2.67	2.65	2.65	2.65	2.66	2.66	2.69	2.71
	Coll.	V	V	VIII	VIII	V	VIII	VII	IX	VII	VII	VIII	VII	VII	VII	VI	VI	VI	VI	VI	VI	I	XI	XI	II	II	IV	III	XI	XI	XII	IV	IV	XI	XI	XI	XI	XI	XI	XI	XI	II	XI	XI	II	II	XI	X

[1] Garnet [2] Hematite [3] Orthite [4] Tourmaline [5] Calcite [6] Goethite [7] Rutile
[8] Pyrite [9] Ilmenite [10] Fluorite [11] Pyroxene [12] Sillimanite

* Foliated
x = < 0.1 %

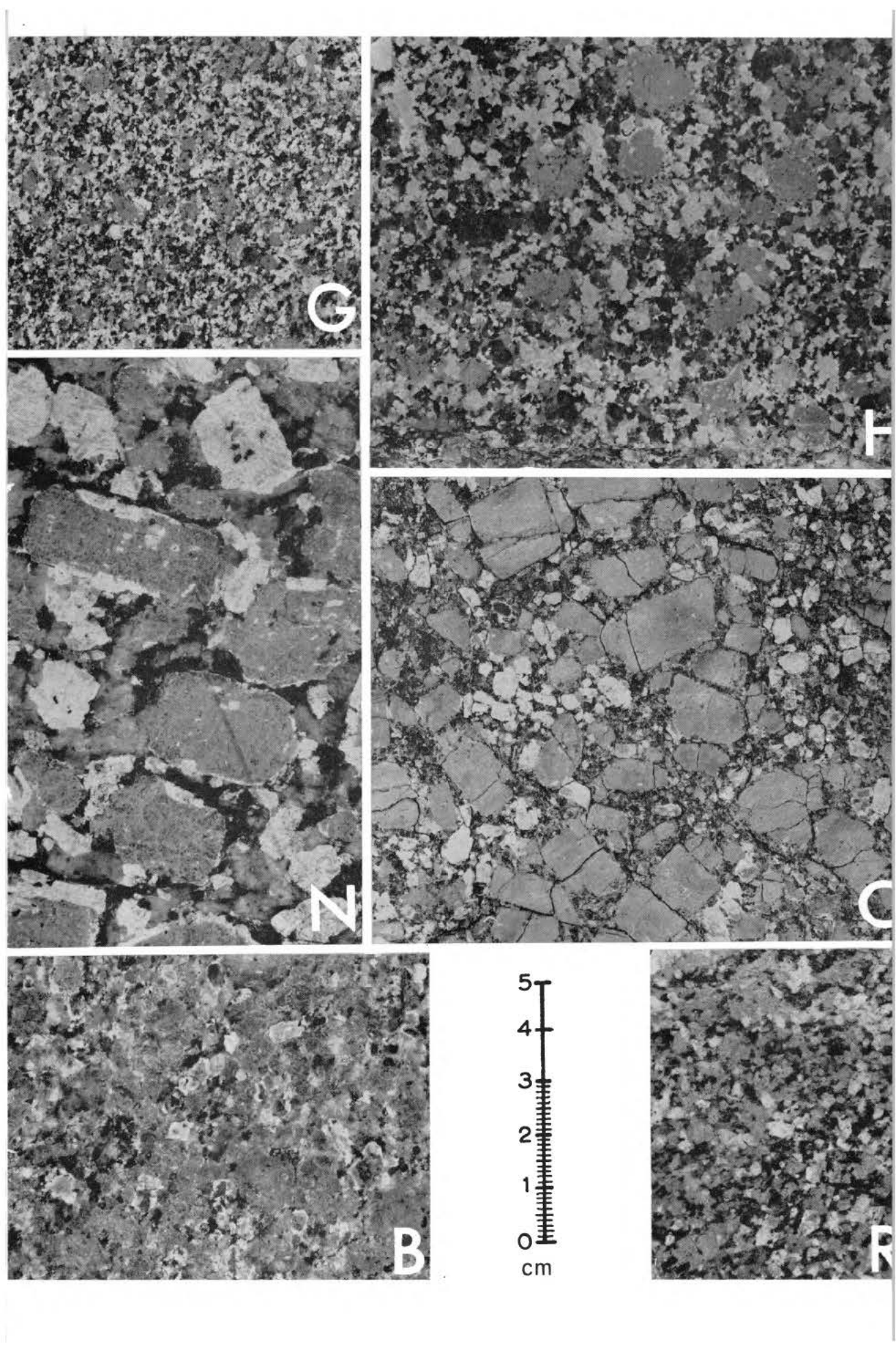
I: A. HOEL exped. 1923 — II: T. S. WENNEVIS, NP 1957 — III: A. HJELLE, NP 1957
IV: T. GJELSVIK, NP 1962 — V: T. GJELSVIK, NP 1963 — VI: A. HJELLE, NP 1963
VII: D. G. GEE, NP 1964 — VIII: A. HJELLE, NP 1964 — IX: T. VAN AUTENBOER, NP 1964
X: B. FLOOD, NP 1965 — XI: A. HJELLE, NP 1965 — XII: T. SIGGERUD, NP 1965
(NP = Norsk Polarinstitutt expedition)

Table 4.

Average compositions of the main types of granitic rocks in Svalbard. G: nos. 1–8. H: nos. 9–14. C: nos. 15–19. N: nos. 21–30. B: nos. 31–36. R: nos. 37–46. For locations see Fig. 2 and also the text to Pl. I.

		G	H	C	N	B	R
Modal analyses (vol.%)	Quartz	31.1	30.9	23.0	29.6	34.5	32.9
	K-feldspar	28.0	23.6	37.4	30.5	34.4	26.9
	Plagioclase	32.8	26.7	19.4	23.4	16.6	27.4
	Muscovite	2.4	5.3	1.9	5.1	8.7	9.6
	Biotite	5.0	8.0	8.6	9.8	4.3	1.8
	Chlorite	0.5	1.5	0.5	0.5	0.1	0.5
	Amphibole	0	x	7.6	0	0	0
	Epid. zois.	0.1	2.8	0.1	0.1	0.7	0
	Apatite	x	0.1	0.2	0.2	0.1	0.2
	Sphene	x	0.2	0.6	0.1	0.2	x
	Ore mins.	x	0.8	0.6	0.2	0.2	0.4
	Garnet	0.1	0	0	0.1	0.1	x
		100.0	99.9	99.9	99.6	99.9	99.7
	% An in plagiocl.	27	30	31	28	10	8
Weight %	SiO_2	72.4	68.4	66.2	69.6	73.5	73.4
	Al_2O_3	15.0	15.5	14.5	15.1	14.4	14.8
	Fe_2O_3	0.2	0.7	1.2	0.5	0.5	0.5
	FeO	1.3	2.4	3.3	2.5	1.1	0.7
	MgO	0.6	1.0	2.0	1.1	0.5	0.3
	CaO	2.0	2.8	2.9	1.7	0.7	0.7
	Na_2O	3.4	2.8	2.6	2.7	3.0	3.3
	K_2O	4.4	4.3	5.7	5.5	5.4	5.2
	H_2O	0.3	0.7	0.5	0.6	0.6	0.6
	P_2O_5	x	0.1	0.1	0.1	x	0.1
	TiO_2	0.2	0.5	0.8	0.5	0.3	0.2
	CaF_2	x	x	x	x	x	0.1
	FeS_2	0	0.8	x	0	0	0
		99.8	100.0	99.8	99.9	100.0	99.9
Niggli values	al	45.9	41.6	34.8	42.4	48.1	50.2
	fm	11.0	20.0	27.3	19.7	11.5	7.5
	c	10.9	13.4	12.6	8.6	4.3	4.7
	alk	32.2	25.0	25.2	29.3	36.0	37.6
	si	378	313	271	332	419	424
	k	0.46	0.51	0.59	0.58	0.54	0.51
	mg	0.41	0.34	0.45	0.39	0.35	0.29
	D. g/cm³	2.66	2.72	2.71	2.68	2.67	2.66

Pl. 1. *Photographs showing examples of the main types of granitic rocks in Svalbard. (Polished rock slabs, etched with HF and stained with sodium cobaltinitrite solution). K-feldspar and quartz appear grey, plagioclase white.*
G: Grey granitic rocks, NW Vestspitsbergen. H: Horneman quartz monzonite, NW Vestspitsbergen. C: Chydenius quartz monzonite-granosyenite, NE Vestspitsbergen. N: Nordkapp quartz monzonite, NW Nordaustlandet. B: Brennevinsfjorden granites, NW Nordaustlandet, R: Rijpfjorden granites, N Nordaustlandet.


G
H
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Some new Permian gastropods from Spitsbergen and Alaska[1]

BY

ELLIS L. YOCHELSON[2]

Abstract

A specifically indeterminate *Omphalotrochus* from southern Spitsbergen is the northernmost record of this widely ranging genus. The new genus *Nordospira* is proposed for other Spitsbergen specimens, with *N. henningsmoenae* new species, as type. The new specific name *N. vostokovae* is applied to previously described but unnamed specimens from northern Alaska.

Introduction

During 1962, field parties of Norsk Polarinstitutt working in southern Spitsbergen collected two lots of fossils containing Permian gastropods. Mr. THORE S. WINSNES of Norsk Polarinstitutt kindly permitted me to examine these specimens at Paleontologisk Museum, Oslo, and later lent them for further study in Washington. My trip to Oslo was made possible by the National Science Foundation grant 17911 to the Smithsonian Institution.

Systematic Paleontology

Superfamily Euomphalacea KONINCK

Family Omphalotrochidae KNIGHT

Genus *Omphalotrochus* MEEK, 1864

Omphalotrochus species

Plate 1, figures 7, 8.

Discussion: The occurrence of *Omphalotrochus* on Spitsbergen is based on one incomplete specimen. The shell apparently lay base downward after death and was then overgrown by a syringoporoid coral. The basal part of the shell and the steinkern were later eroded. The coral is silicified, though it cannot be determined whether

[1] Publication authorized by the Director, U. S. Geological Survey.

[2] U. S. Geological Survey, Washington, D. C., U.S.A.

silicification preceded or followed loss of the gastropod base. Most of the shell has been retained, but it can only be viewed from its inner surface. The shell is also silicified and cannot be removed from the coral by acid or mechanical preparation. Thus, the resulting mold is of the interior of the shell, except for a few patches where the shell is broken away and reveals part of the profile of external whorl surface against the coral.

The specimen is relatively highspired, has only a slightly increasing apical angle with increasing growth, and so far as one can see has a steeply inclined outer whorl face at maturity. Though no growth lines can be observed, the shape of the specimen leaves no doubt as to its generic placement.

Details of the whorl profile and apical angle are similar to those of the larger of two specimens described as *Omphalotrochus whytnei* [sic] *rossica* LICHAREV from the White River region of northern Timan, U.S.S.R., (LICHAREV, 1939, pl. 31, fig. 9) though the Spitsbergen specimen is too incomplete for close comparison.

The principal interest in this specimen lies in that it confirms the occurrence of Sakmarian age rocks on Spitsbergen by yet another group of fossils. This is also the northernmost known occurrence of the genus. *Omphalotrochus* is now known to range from the Lake Titicaca region of Peru south of Lat. 15° S, to Spitsbergen north of Lat. 75° N.

Occurrence: Permian, Spiriferkalk at Tempelfjorden.

Figured specimen: Paleontologisk Museum, Oslo, Nr. A-29779.

Superfamily Pleurotomariacea SWAINSON

Family Eotomariidae WENZ

Subfamily Eotomariinae WENZ

Nordospira, new genus

Type species: Nordospira henningsmoenae new species.

Description: Pleurotomariaceans with a narrow concave selenizone on a flangelike expansion near midwhorl; shell moderately highspired; whorl surface little arched above selenizone, well inflated to globose below; anomphalous; selenizone at periphery above midwhorl and located on narrow, distinct flange; ornament limited to fine growth lines.

Discussion: Since publication of the most recent classification of Paleozoic gastropods (KNIGHT, BATTEN, and YOCHELSON, 1960), several new genera of pleurotomariaceans have been described. *Nordospira* is distinct from these as well as from those described prior to 1960. The combination of flangelike selenizone, anomphalous base, and lack of prominent ornament appears to be unique.

Classification below the subfamily level has not been employed for *Nordospira;* the genus does not fit well into either tribe in being both anomphalous and moderately highspired. It seems likely that when a few more new genera are defined, the arrangement of tribes and subfamilies now in use for Paleozoic pleurotomaria-

ceans will have to be revised. Future classifications should allow more significance to be placed on the characters of the base and on the slit depth.

The range of *Nordospira* within the Permian of Spitsbergen is not firmly fixed, as the precise correlation of much of the postfusulinid-bearing Permian strata of the Arctic is still a matter of conjecture. One brachiopod in the type lot was identified by Dr. G. ARTHUR COOPER, U. S. National Museum, as *"Productus" arcticus* WHITFIELD. COOPER suggests (oral communication) that this is a senior subjective synonym of the taxon identified by HARKER and THORSTEINSSON (1960) from the Canadian Arctic as *Dictyoclostus* cf. *D. neoninflatus* LICHAREV. Their species occurs in the Assistance Formation which they place in the Svalbardian Stage (HARKER and THORSTEINSSON, 1960, p. 14).

A second species of *Nordospira* from Alaska occurs with brachiopods that J. THOMAS DUTRO, JR., U. S. Geological Survey, suggests (oral communication) are of Word age. In terms of the American stratigraphic section, therefore, *Nordospira* occurs in beds dated as from late Leonard to Word age.

So far as it is known, no other described species of Permian pleurotomariaceans can be referred to this genus.

Nordospira henningsmoenae, new species

Plate 1, figures 1–3.

Description: Shell moderately highspired, with prominent flangelike selenizone, and almost all of lower half of penultimate whorl covered by body whorl; nucleus and early growth stages unknown; sutures distinct, not impressed; outer whorl face vertical for about one-sixth of its total length, bending steeply downward for about half its length and then sweeping outward to form the upper, outer edge of a selenizone; whorl profile below selenizone trending sharply inward at first with same curvature as area above selenizone, then curving smoothly downward and slightly more strongly inward to anomphalous basal surface; selenizone narrow, slightly concave between bordering lirae, upper lira projecting only slightly, if at all, over lower; growth lines simple, not lamellose or raised, on upper surface trending downward at an angle approximately thirty degrees from vertical and with comparatively little curvature to near flangelike selenizone, their course unknown on upper surface of flange, but below flange curving strongly opisthocline for about the width of the flange, their course unknown then for a short distance, but on remainder of whorl proceeding distinctly prosocline with virtually no curvature; lunulae well curved, not prominent; slit depth and nature of inner lip unknown; ornament consisting only of closely spaced growth lines; shell thick, especially in area of selenizone, composed of at least two layers.

Discussion: This description is based on twenty specimens; several occur on a few slabs. Only two of the specimens are fairly well preserved. All specimens are in chert or cherty shale and many have been flattened by compression. A few have a thin outer skin of silicified shell material, but most of the thickness of the shell is calcite. Attempts to free specimens from the matrix with hydrochloric acid

resulted only in damage to the specimens. Attempts to remove the dense matrix by mechanical means were equally unsuccessful as the shells exfoliated.

Some of the crushed specimens superfically resemble the Permian genus *Babylonites* which has a prominent carina near the periphery; however, *Babylonites* does not possess a true selenizone such as found in *Nordospira*. Steinkerns of *Nordospira henningsmoenae* are strikingly different from the true exterior shape, as they possess a fairly large umbilicus and give no indication of the flange.

The specific name is given in recognition of the work of Mrs. KARI EGEDE HENNINGSMOEN of Oslo on the Quaternary stratigraphy and palynology of Norway.

Occurrence: Near fossil horizon 13 in Festningen profile, south Isfjorden Spitsbergen. Paleontologisk Museum, Oslo, Nrs. A-29776–29778; Edfjellet, Dalslandryggen, North Isfjorden, Spitsbergen, A-29765–29775.

Figured specimen: Paleontologisk Museum, Oslo, Nr. A-29778 (holotype). All the remaining unfigured specimens are designated paratypes.

Nordospira vostokovae, new species

Plate 1, figures 4–6.

New genus? B, YOCHELSON and DUTRO, 1960, p. 139–140, pl. 14, figs. 26, 27.

Discussion: In their work on late Paleozoic gastropods of northern Alaska, YOCHELSON and DUTRO (1960, p. 139) informally described from Permian strata two specimens of an unnamed species which they designated as "New genus? B." This species is here placed in the genus *Nordospira* and is named *Nordospira vostokovae*. The specimen first illustrated by YOCHELSON and DUTRO and reillustrated here as plate 1, figures 4 and 5, is designated holotype; the second specimen is the only known paratype.

Comparison with *N. henningsmoenae* indicates that whereas *N. vostokovae* may have an exceedingly shallow depression in the umbilical area, it does not posses an umbilicus, a morphologic detail in question at the time of the original description. The base of the paratype was prepared from the resistant dense matrix, and it is undoubtedly anomphalous. The possibility of an umbilical depression seems slight but cannot be ruled out, as the specimen was partially exfoliated during preparation.

Even though the two species have the basic characteristic of a flangelike selenizone, there are several differences between them. In *N. henningsmoenae* the upper and lower edges of the concave-faced flange lie essentially in the same vertical plane, but in this species the upper edge forms the periphery of the whorl and clearly overhangs the lower edge. Not only is this species lowerspired than *N. henningsmoenae,* but the upper whorl surface has a lower inclination and is slightly arched rather than flattened. The most prominent difference is in the postion of the body whorl. In *N. henningsmoenae,* the body whorl embraces the penultimate whorl just below the flange, but in *N. vostokovae* a significant portion of the outer whorl face of the penultimate whorl is not covered. Collectively these differences

may be enough to form the basis for yet another unit of generic rank, but until more species are known and the ranges better defined, I prefer to consider these two forms as congeneric.

The specific name is given in recognition of the work of Mrs. V. A. VOSTOKOVA of Leningrad in describing Paleozoic gastroposd from U.S.S.R., and particularly from the northern regions of that country.

Occurrence: U. S. Geological Survey locality 13215-PC, Kilingwa River valley, lat. 68°35′N., long. 158°20′W., Howard Pass quadrangle, Alaska. The unnamed Permian formation of DUTRO and YOCHELSON is now designated the Nuka Formation (TAILLEUR and SABLE, 1963.)

Figured specimens: Holotype, U. S. National Museum No. 136551, Paratype, U.S.N.M. No. 145012.

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Explanation of Plate

1–3. *Nordospira henningsmoenae* YOCHELSON, *new genus, new species. Oblique side view, side view, and oblique basal view of holotype. From South Isfjorden, Spitsbergen; Permian from horizon* 13 *of "Festning profile". Note the flangelike selenizone, best preserved in the penultimate whorl. One and one-half times natural size. Paleontologisk Museum, Oslo, No. A–*29778.

4–6. *Nordospira vostokovae* YOCHELSON, *new species.* 4, 5. *Top view and side view of holotype.* 6. *Basal view of paratype. The patch of shell has been partially excavated, but it is still evident that no umbilicus existed. From Kilingwa River valley, Alaska, Permian, Nuka Formation. Natural size, United States National Museum Nos.,* 136551, 145012.

7, 8. *Omphalotrochus species. View of internal mold and oblique top view of artificial steinkern. From Tempelfjorden, Spitsbergen; Permian, Spiriferkalk. Natural size. Paleontologisk Museum, Oslo, No. A-*29779.


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A reinvestigation of the Middle Devonian gastropods *Arctomphalus* and *Omphalocirrus*[1]

BY

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Abstract

Arctomphalus, from the Eifelian strata of Ellesmere Land, is distinguished from the Givetian genus *Omphalocirrus,* which occurs in the Rhine Valley. Specimens of both genera are large, and ornamented by spines on a circumbilical ridge, but differ in whorl profile and ornament pattern. The two genera are transferred from the Macluritidae to the Euomphalidae.

Introduction

Among the numerous fossils collected by the second "Fram" expedition (1898–1902) to Ellesmere Land and adjacent Islands was one gastropod species for which the generic name *Arctomphalus* was proposed (TOLMACHOFF, 1926, p. 48). The type and only known species of this genus, *A. grandis*, was redescribed by KNIGHT (1941, p. 45). KNIGHT, BATTEN and YOCHELSON (1960, p. 1–189) placed *Arctomphalus* in the synonymy of *Omphalocirrus* RYCKHOLT. These three works are apparently the only references to the genus in primary paleontologic literature.

The original description, while quite complete, did not emphasize one of the more unusual features of the type species, the presence of abundant septa. The second description was based only on the lectotype, as the original work did not indicate clearly that more than one specimen was available, and the lectotype does not show obvious septa.

This study indicates that although *Arctomphalus* and *Omphalocirrus* have some features in common, they should be considered distinct taxa.

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for further study. Professor Dr. ULRICH JUX, Geologisches Institut der Universität Köln, loaned two additional examples. Both gentlemen also supplied information on the geologic occurrence of the species.

Dr. DIGBY J. MCLAREN, Geological Survey of Canada, permitted the study of some of ELKANAH BILLINGS' and J. F. WHITEAVES' types in Ottawa, Canada, and arranged for the loan of others.

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Systematic Paleontology

Class GASTROPODA CUVIER, 1797

Subclass PROSOBRANCHIA MILNE-EDWARDS, 1848

ORDER ARCHAEOGASTROPODA THIELE, 1925

SUBORDER MACLURITINA COX AND KNIGHT, 1860

Superfamily Euomphalacea DE KONINCK, 1881

Family Euomphalidae DE KONINCK, 1881

Genus *Arctomphalus* TOLMACHOFF, 1926

Type species: A. grandis TOLMACHOFF, 1926

Description. Large, exceedingly low-spired gastropods multiseptate at maturity; upper whorl surface flattened, body whorl embracing penultimate whorl at periphery, located high on outer whorl face; widely phaneromphalous; ornamented by coarse growth lines and circumbilical serrations developing into spines; numerous, closely spaced septa developed in earlier whorls.

Remarks. The most distinctive feature of this genus appears to be the unusual whorl profile, in that an exceedingly low but distinct "stair-step" profile is developed apparently without the presence of an upper angulation, and that the periphery is high on the whorl, causing the outer whorl face to slope inward. There is little question that this genus fits readily within the family Euomphalidae.

Only the type species was ever assigned to *Arctomphalus*. No other described species or undescribed material known to me can be referred to the genus.

Arctomphalus grandis TOLMACHOFF, 1926

Plate I, figs. 1, 6; plate II, figs. 1, 2

Arctomphalus grandis TOLMACHOFF, 1926, p. 49, pl. 4, figs. 1–2, pl. 5, fig. 1; KNIGHT, 1941, p. 45, pl. 68, figs. 2a–b.

Description. Exceedingly large, extremely low-spired gastropods ornamented by serrations on the basal angulation. Nucleus unknown. Early juvenile whorls orthostrophic and slightly depressed below more mature whorls; basal sutures distinct, probably slightly depressed, upper sutures and most of shell features of upper surface unknown; upper whorl surface nearly horizontal, only slightly arched from suture to near outer edge, definitely without an angulation in the

early growth stages and probably without one at maturity, near outer edge abruptly curving steeply downward and outward to the periphery which is located about one-fourth of the distance between the upper and basal surfaces, and then proceeding gradually inward and strongly downward, with essentially little curvature, to the basal angulation. Basal angulation sharp in earliest stages, less abrupt and marked by a line of elongate serrations at increasing maturity, its precise condition and ornament at full maturity unknown; in early growth stages, whorl profile curves gradually upward after crossing the basal angulation and then sharply into the widely phaneromphalous umbilicus, but umbilical walls become more inflated with increasing maturity, the umbilical angle near 130 degrees in early growth stages; growth lines slightly opisthocline on upper surface at juvenile stage, unknown at other growth stages; orthocline on lower part of outer whorl face at intermediate stage, unknown at other growth stages; on basal whorl surface at early growth stages crossing basal angulation and bending slightly prosocline to near the edge of stronger curve of this surface into umbilicus, when they then return to orthocline and proceed into umbilicus, at slightly more mature stage either being interrupted by serrations at basal angulation or between serrations, proceeding orthocline from outer whorl face to umbilical area, and at a still slightly more mature stage bending gently prosocline on base; growth lines unknown at full maturity. Ornament of coarse but closely spaced growth lines, the intervening areas being about as wide as the lines, and a cord on the basal angulation in the early growth stages which gives rise to low, elongate, narrow serrations, the area between each serration being slightly shorter than intervening areas, these serrations becoming slightly less pointed and slightly longer with increasing maturity, but their probable presence in the mature shell cannot be confirmed. Shell thin and of two layers; intermediate, and possible early, growth stages partitioned off by numerous concave septa exceedingly thin and non-uniformly curved, thereby allowing their inner and outer edges to intersect the wall of the whorl at the same relative point, the spacing and number of septa unknown except that in part of the area of their occurrence they are only about 2.5 mm apart.

Remarks. TOLMACHOFF (1926, p. 49) gave no indication of the number of specimens available except to indicate that the species occurred in one locality and "probably" in a second; he figured one specimen. KNIGHT (1941, p. 45) assumed that the figured specimen was the holotype and only known representative. The originally figured specimen, Paleontologisk Museum of Oslo, A-19229 is here designated lectotype; in addition to the part which has been figured previously, a scrap of the upper surface of this specimen is also available and is illustrated herein. A second specimen, A-29790, is here designated paralectotype and illustrated for the first time. Specimen A-29789, collected in the same area, has a similar form but is badly worn and is generically indeterminate.

Both specimens figured here are in a dense, black limestone. The lectotype (pl. I, fig. 1; pl. II) is primarily a steinkern except that the basal surface of the early and intermediate whorls has been preserved. It has a width of more than

180 mm. Even though this specimen has been figured twice, it is reillustrated here to bring out details of the whorl profile.

The paralectotype (pl. I, fig. 6) is a steinkern having a maximum width of about 130 mm; the basal surface is mainly concealed by matrix. Part of the upper surface has been ground away, presumably by TOLMACHOFF, to reveal the numerous septa, and the description of septa is taken entirely from this specimen. While there is a similarity in size and general shape between the two specimens, admittedly they are difficult to compare. Fortunately, the scrap of the upper surface of the lectotype shows that it too has at least one similar septum. Therefore, I feel justified in considering the two forms conspecific.

Arctomphalus grandis was collected in Goose Fjord, Ellesmere Land, an area where the *"Fram"* spent two years. The lectotype was obtained from the west side of the fjord and the paralectotype, probably from the east side, as indicated by TOLMACHOFF; the uncertainty about the second occurrence is in the original label. The specimens are from SCHEI's series Db. According to Dr. DIGBY J. MCLAREN, Geological Survey of Canada, Db falls within the Blue Fjord Formation of Eifelian age (1963, p. 324–328). MCLAREN spent five days in the Goose Fjord area collecting fossils and examining the geologic section but did not obtain any specimens of the genus (written communication, 1963). Although inquiries have been made to other sources, no additional specimens are known to have been collected. One can only conclude that this is an exceedingly rare species.

Genus *Omphalocirrus* RYCKHOLT, 1860

Type species: Euomphalus goldfussi ARCHIAC and VERNEUIL, 1842.

Description. Large, septate, planorbiform gastropods with a spinose circumbilical angulation; upper whorl surface flattened, except that earlier whorls are distinctly depressed; outer whorl face well rounded with periphery at mid-whorl; widely phaneromphalous; ornamented by distinct growth lines and elongate circumbilical nodes developing into spines; septa developed in at least the early whorls.

Discussion. This genus is closely allied to *Arctomphalus* and there is some logic in the previously proposed synonymization of that generic name. *Omphalocirrus* differs in the profile of the upper surface and of the upper and outer whorl surfaces. This genus is without a spire and the outer whorl face is more well rounded than in *Arctomphalus*. I propose to treat these as two distinct genera in order to call attention to these differences.

There are at least two other spinose euomphalids in the Middle Devonian of North America which are distinctive on the generic level. Although it might be appropriate to consider *Arctomphalus* and these two undescribed genera as subgenera under *Omphalocirrus*, I do not judge this to be the appropriate zoological action at this time. In our current interpretations of euomphalid morphology, the differences in the profile outweigh the similarities. Further, there are differ-

ences in ornament between these two genera and the two undescribed genera not formally discussed here.

Two junior objective generic synonyms, *Coelocentrus* ZITTEL, 1882, and *Polyenaulus* ETHERIDGE, JR., 1917, have been proposed for *Omphalocirrus*. Their nomenclatural history is noted by KNIGHT (1941, p. 212) in connection with his study of the type species.

Three species were listed when the genus was originally diagnosed (RYCKHOLT, 1860, p. 187). The first, *Euomphalus goldfussi* ARCHIAC and VERNEUIL is now the type species. The second, *E. spinosus* GOLDFUSS (1844, p. 85, pl. CXL, figs. 3a–b), I consider to be a junior subjective synonym of the type species. The third, *E. cristatus* PHILLIPS (1836, p. 225), is now the type species of *Phanerotinus* SOWERBY.

COSSMANN (1915, p. 214) assigned three additional species to the genus at the time he designated *Euomphalus goldfussi* as type. The first of these, *Pleurotomaria elora* BILLINGS, is from the Silurian Guelph Formation of Ontario, Canada. The original illustration and description was of internal molds (steinkerns) (BILLINGS, 1862, p. 154, fig. 135), (holotype, Geological Survey of Canada, No. 2901). WHITEAVES (1895, p. 74, pl. 11, figs. 5 and 6) subsequently referred two spinose specimens to this species (G.S.C. No. 2982); this second description was the basis of COSSMANN's reference of the species to *Omphalocirrus*. I have examined both primary types and hypotypes. They have a conical shape and long tube-like spines, among other features; WHITEAVES' specimens are representative of *Hystricoceras* JAHN. Since the specimens of WHITEAVES' are virtually topotypes of *P. elora* and since he showed no hesitancy in identifying them with BILLINGS' form, it is logical to transfer *P. elora* to *Hystricoceras* even though comparison of well preserved specimens to steinkerns is necessarily a highly subjective matter. So far as I know, this is the first recognition of *Hystricoceras* in North America.

The second species assigned by COSSMANN, *Euomphalus venustus* (MÜNSTER), is a small euomphaliform gastropod relatively rare in the Triassic St. Cassian beds of Austria. The species shows a nodose periphery and nodose upper and lower angulations; BROILI, 1907, pl. 7, fig. 7 was cited by COSSMANN, but earlier illustrations of the species are similar. These several rows of nodes and their distribution are quite unlike those of *Omphalocirrus* and the species is rejected from the genus. Proper placement of this form is not apparent; for the time being it can be questionably transferred back to *Straparollus* (*Euomphalus*).

The third species listed by COSSMANN is *Omphalocirrus manitobensis* (WHITEAVES, 1890, p. 100, pl. 6, figs. 2a–2b) from the early Middle Devonian of Lake Winnepegosis, Manitoba, Canada. WHITEAVES originally described this species as *Euomphalus* (Cotypes, Geological Survey of Canada nos. 4173, 4173a); his primary types are generically indeterminate. Subsequently on the basis of additional material, WHITEAVES (1892, p. 327, pl. 93, figs. 5–77) transferred the species to *Omphalocirrus* (hypotypes G.S.C. nos. 4176, 4177). Additional hypotypes (MCCAMMON, 1960, p. 70; G.S.C. no. 14894) are indeterminate. WHITEAVES' hypotypes are distinct from *Omphalocirrus* and represent a new genus, as they have a prominent upper angulation and a whorl profile much like that of

Euomphalus, in addition to ornament somewhat different from that of *O. goldfussi*.

Reports of the presence of *Omphalocirrus manitobensis* (WHITEAVES) in the Rogers City Limestone of Michigan (EHLERS and RADABAUGH, 1938) are based on yet another distinct, undescribed genus which differs from *Omphalocirrus* and from *"O." manitobensis* in having a more triangular cross-section. It is beyond the scope of this paper to formally describe and discuss these two new genera.

Since the primary types of *"O." manitobensis* are indeterminate and the hypotypes clearly do not belong to this genus, I consider *Omphalocirrus* to be monotypic.

Omphalocirrus goldfussi (ARCHIAC and VERNEUIL)

Plate I, fig. 2; plate II, figs. 2–5

Euomphalus Goldfussi ARCHIAC and VERNEUIL, 1842, p. 362, pl. 34, figs. 1–1a, 2–2a; HOLZAPFEL, 1895, p. 353; KIRCHNER, 1915, p. 223.

Euomphalus Goldfussii GOLDFUSS, 1844, p. 84, pl. CXC, fig. 2a–d; QUENSTEDT, 1884, p. 396, pl. 300, fig. 83.

Euomphalus (Coelocentrus) goldfussi, PAECKELMANN, 1922, p. 36–37.

Omphalocirrus goldfussi, KNIGHT, 1941, p. 212–213, pl. 68, figs. 4a–b; pl. 69, figs. 2a–c.

Euomphalus spinosus GOLDFUSS, 1844, p. 85, pl. CXC, fig. 3a–b; SANDBERGER, 1854, p. 208, pl. 25, fig. 1; QUENSTEDT, 1882, p. 396, pl. 200, fig. 85; KIRCHNER, 1915, p. 220.

Cirrus spinosus ORBIGNY, 1847, *fide* ORBIGNY, 1850, p. 68.

Omphalocirrus spinosus KOKEN, 1896, p. 511.

Description. Large, planorbiform gastropods ornamented by elongate nodes, serrations and, at maturity, spines on the basal angulation; nucleus unknown, earliest known growth stages orthostrophic; early whorls slightly depressed, most of upper surface flattened and nearly horizontal; sutures distinct, slightly impressed. Upper whorl surface slightly inflated in early growth stages, nearly horizontal at maturity; outer edge of upper whorl surface curving smoothly downward without an angulation; outer whorl face moderately well rounded with periphery at mid-whorl, the curve approximating the arc of a circle: juncture of outer and basal whorl surfaces marked by a slight angulation in early growth stages, moderately well rounded and inconspicuous at most later stages, the smooth curve of whorl continuing upward inside umbilicus so that upper slope of umbilical walls is nearly vertical. Umbilical sutures distinct and impressed; umbilical angulation near ninety degrees; growth lines straight in early growth stages, slightly opisthocline to orthocline from suture on upper whorl surface, unknown on upper part of outer whorl face but presumably orthocline or prosocline, at mid-whorl swinging to slightly prosocline and proceeding with essentially no curvature to just above the basal angulation, there becoming orthocline; growth lines at more mature stages, unknown on the upper whorl surface and upper half of the outer whorl face, on lower part of face proceeding downward, and prosocline at a low angle, to just above angulation there bending to orthocline, immediately upon entering umbilicus bending to prosocline and only gradually arching to orthocline; at most mature stage, same general pattern occurring, but interrupted by formation of large basal spines. Ornamented by closely spaced sub-lamellose growth

lines prominent on the upper surface only in early growth stages and on the lower part of the outer whorl face and the umbilical area at early and slightly older growth stages, but diminishing in strength with increasing age; growth lines on the outer whorl face crossed by lines of ornament, opisthocline at a low angle, thus forming quincuncial arrangement of small, elongate papillae; basal part of earliest whorls ornamented only by growth lines, then developing a sharp basal angulation ornamented by small, closely spaced nodes, interspaces little wider than nodes, angulation continuing fairly sharp at later growth stages and nodes developing into elongate serrations separated by only insignificant interspaces; finally at maturity, basal angulation becoming rounded, interspaces increasing in width and basal part of surmounted serrations opening and projecting outward, nearly vertical to whorl, thereby forming scoop-like spines. Early whorls, at least, partitioned off by septa.

Discussion. In the original description the trivial name was rendered *Goldfussii* in the text and *Goldfussi* on the plate. Many subsequent authors rendered the name with *ii*. I have followed the currently recommended usage of a single *i*.

The ornament of this peculiar species is most elaborate. The quincuncial development on the lower part of the whorl face is so confusing that it is difficult to determine the course of the growth lines. The upper half of their course remains unknown; I presume that this part is essentially orthocline so that the upper part of the aperture in effect projected forward comparable to the "prong" in *Centrifugus* BRONN and other euomphalids.

The final development of the ornament into scoop-like spines on the basal angulation is unusual, though many of the euomphalid gastropods develop nodes. The length of the spines at maturity is unknown. According to Professor ULRICH JUX (written communication, 1963) the illustrations by ARCHIAC and VERNEUIL and by GOLDFUSS showing remarkably long spines do not exaggerate this feature. It is an open question as to whether these spines were functional. KNIGHT interpreted them as growing along the upper angulation and serving as an exhalant channel for deoxygenated water moving from the mantle cavity. The orientation used by him is not followed here (p. 45) and his interpretation must necessarily be discarded. The fact that the spines develop gradually from nodes would seem to imply that they served no vital function.

A detailed comparison of *O. goldfussi* and *A. grandis* shows that at least in the early growth stages the umbilical suture is at the circumbilical angulation in *O. goldfussi*, but on the outer side of it in *A. grandis*. There is also an indication that at the immature stage, the nodes of *A. grandis* are smaller than those of *O. goldfussi*. The quincuncial ornament on the outer whorl face of *O. goldfussi* is distinctive.

The type specimens of ●. *goldfussi* in the École national supérieure des Mines are silicified and presumably were derived from a limestone at Paffrath, Germany. Each of the eight additional specimens available to me retains patches of limestone matrix. Two collected from the Paffrath beds (Lower Plattenkalk, uppermost part near the "Hornstein Partie") from Flora near Bergisch Gladbach, nine miles east

of Cologne, Germany, are in light brown, exceedingly fine-grained limestone, containing numerous microfossils and fragments of larger fossils. Three others from the *Stringocephalus* beds at Sotenich, Eifel, Germany, are in a medium dark-gray limestone which is fairly fine-grained and which contains some microfossils. One specimen from *Stringocephalus* beds at the Muhlenberg quarry near Gerolstein, Eifel, Germany, is in a light-gray fine-grained limestone. Finally, two specimens from upper *Stringocephalus* limestone at Villmar, Germany, are in a coarsely crystalline white limestone; the friable nature of the specimens suggests that they have undergone slight metamorphism or weathering.

In all these localities, the species occurs in rocks dated as Givetian. Professor ULRICH JUX (written communication, 1963) notes that the specimens from Flora occur in the uppermost Givetian. Dr. HERMANN JAEGER (written communication, 1963) notes that the fossils from the last three occurrences are from rocks of Givetian age. Neither knows of any occurrences of the species in older beds. PAECKELMANN (1922, p. 91) reported the species from the Massenkalk of Paffrath and Schwelmeskalk of Schwelmes, both names for limestone of latest Givetian age.

KNIGHT (1941, p. 213) suspected the presence of septa in this species. In order to compare this feature with the septation observed in *Arctomphalus grandis*, two of the most suitable specimens were sectioned. The first, from Sotenich, yielded no evidence of septation. The second, from Bergisch Gladbach (Flora), showed two prominent septa. The internal filling of most of this shell is recrystallized calcite. Within this calcite, there is a suggestion of numerous septa as closely spaced as in *Arctomphalus grandis*, though at an earlier growth stage than those preserved in the paralectotype. The material is too poorly preserved to show a convincing photograph of these septa. These specimens are quite instructive in demonstrating how septation can be lost through recrystallization or completely removed from shells which are well preserved externally.

All descriptions of the species which I have encountered have been included in the synonymy, though I cannot be sure that some references in the German literature have not been overlooked. References to the species name in textbooks and paleontological compilations have not been included.

I have not examined the original specimen(s) of *Euomphalus spinosus* GOLDFUSS, but the illustrations strongly suggest that GOLDFUSS applied ARCHIAC and VERNEUIL's name to a steinkern at the same time that he described a well preserved *E. goldfussi* specimen as a new species. KIRCHNER (1915, p. 223) who had a first-hand knowledge of the Middle Devonian fauna, suggested that *E. spinosus* might be referred to *Porcellia*, though the occurrence of spines on the basal angulation of the species makes this a most unlikely generic assignment.

General considerations

The reinvestigation has shown that *Arctomphalus* is not a subjective synonym of *Omphalocirrus*. The type species of each genus is distinctive, and only the type species is correctly assigned to each of these taxa; the descriptions of type species

given here amplify those presented by KNIGHT (1941). These monotypic genera are both geographically restricted and each seems to be confined to a single stage of the Middle Devonian. All specimens of *Arctomphalus* and *Omphalocirrus* studied occur in generally similar limestones, and it is possible that these two spinose genera are characteristic of a particular environment.

Nodose euomphalids are known from all systems of the upper Paleozoic. The occurrence of numerous large steinkerns in the Lower Devonian, which are commonly referred to *Pleuronotus* in the American literature, and their similarity to the Middle Devonian steinkerns identified as *Omphalocirrus* would seem to imply that there might well be large, nodose to spinose euomphalaceans below the Eifelian. This possibility need not interfere with the stratigraphic utility of *Omphalocirrus* and *Arctomphalus*, but it is apparent that identification of these two genera requires well preserved material.

The familial placement of these two taxa is a point of more general interest. KNIGHT (1941, p. 212), in redescribing the type of *Omphalocirrus*, expressed reservation about its orientation by stating that "this species is arbitrarily regarded as dextral". Later (KNIGHT, 1952, p. 37) he placed this genus within the Macluritacea, a group of gastropods considered to be hyperstrophically coiled, that is, with the spire depressed into a pseudoumbilicus. *Omphalocirrus* was considered to be a sinistrally coiled member of this group (KNIGHT, BATTEN, and YOCHELSON, 1960, p. 189).

I cannot now agree that the shell should be oriented so that the nodes or spines on the angulation are on the upper surface of the shell, using the term "upper surface" as it is employed by most malacologists. The shape of the aperture is not like that of *Maclurites* or its close allies, as the height of the whorl is not significantly larger than the width. Even more important, the whorl profile of these genera lack the "notch keel" or sharp angulation around the umbilicus which in *Maclurites* is considered to have acted as an excurrent water channel (KNIGHT, 1952, p. 36). On the other hand, all features of *Omphalocirrus* and *Arctomphalus* which was considered to be a synonym, are characteristic of the Euomphalidae within the Euomphalacea, and the two taxa are transferred accordingly. This action has the coordinate effect of restricting the Macluritidae to rocks of Ordovician age.

Perhaps the only feature of these Devonian species which is suggestive of the Macluritidae is their large size. In width, though not in height of whorls, *Arctomphalus* approaches the largest of the Macluritidae; it is possible that this may have been a feature which subjectively influenced the morphologic interpretation of this genus as a sinistral hyperstrophic form related to *Maclurites*. Although the specimens of *Arctomphalus* are large, they are not unique in this feature. The species described by KONINCK as *Straparollus grandis* (KONINCK, 1881, p. 126, pl. 16, fig. 1) from the Viséan of Belgium has a width of about 130 mm. Undescribed euomphalids as large as this have been collected from the Mississippian Keokuk Limestone near Burlington, Iowa, in North America. The largest euomphalid that I have seen is from Carboniferous limestone and is presently in the British Geological Survey and Museum; it has a width of more than 210 mm.

If any conclusion can be drawn from the occurrence of these large euomphalids,

it is that the largest specimens are not necessarily the youngest representatives of this group. This observation, coupled with a similar observation on the Bellerophontacea (YOCHELSON, 1960, p. 219–223) would tend to confirm that the concept of phyletic size increase cannot be proven within the Paleozoic gastropods and may be incorrect.

Part of the confusion between *Arctomphalus* and *Omphalocirrus* stems from their both being large, spinose, and from Middle Devonian strata. Though the differences in whorl profile between them are clear, they are similar enough to be easily confused. Their former association with Ordovician *Maclurites*, because of large size at maturity, is an example of heterochronous homoeomorphy (GEORGE, 1962).

It should be reemphasized that far too little is known of the occurrence and distribution of septa in Paleozoic gastropods. Septa are by no means confined to the Euomphalacea. LINDSTRØM (1884, p. 136), for example, placed *Loxonema* in the same family with *Eomphalus,* in the strict sense, because each had apical whorls filled with a secondary deposit. This, of course, is an extreme example of high taxonomic value being placed on the occurrence of septa. Unpublished investigations that I have made of Swedish Ordovician gastropods suggest that septation is far more common than has been noted in the literature. Until detailed investigations are made of suites of septate specimens preserving the septa, little taxonomic and zoologic importance should be attached to this feature.

It is still premature to propose any revision of the Euomphalidae. I suggest that a reclassification of the family may have the shape of the aperture, and especially the outer whorl face, as a first criterion and the height of the coil as a second criterion. The importance of septa remains an enigma. Ornament is probably not an important criterion for suprageneric classification, though elaborate ornament such as is shown in these genera will undoubtedly be given prominence.

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Explanation of Plate I

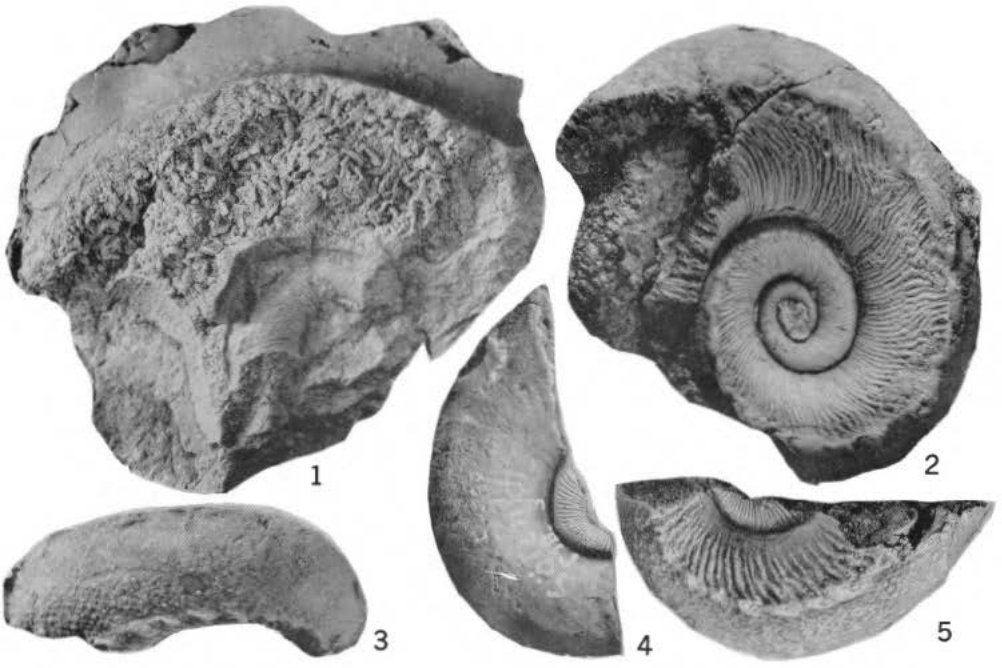
1. *Plaster cast made from fragment of upper surface of Arctomphalus grandis* TOLMACHOFF, *lectotype; from Goose Fiord, Ellesmere Land, probably from the Eifelian age Blue Fiord Formation. Natural size. Note curved wall of septum in lower left and ornament on basal surface of juvenile whorls. Paleontologisk Museum, Oslo, No. A*-19229.
2. *Basal view of Omphalocirrus goldfussi* (ARCHIAC and VERNEUIL); *from Vilmar, Germany, of Givetian age from upper Stringocephalus Limestone. Natural size. Humboldt-Universität, Berlin, Germany.*

3–5. *Slightly oblique side view, top view, and basal view of Omphalocirrus goldfussi* (ARCHIAC and VERNEUIL); *from Sotenich, Germany, Givetian age from Stringocephalus Limestone. One and one-half times natural size. Humboldt-Universität, Berlin, Germany.*

6. *Paralectotype of Arctomphalus grandis* TOLMACHOFF; *from Goose Fiord, Ellesmere Land, probably from the Eifelian age Blue Fiord Formation. One and one half times natural size, but portions of the outer whorl have been trimmed to fit the plate. Note the closely spaced septa shown in ground portion of shell near the center. Paleontologisk Museum, Oslo,* No. A-29790.

Explanation of Plate II

1, 2. *Oblique side view and basal view of latex replica made from main part of Arctomphalus grandis* TOLMACHOFF, *lectotype; from Goose Fiord, Ellesmere Land, probably from the Eifelian age Blue Fiord Formation. Natural size. Note that figure* 1 *has been turned to better show the whorl profile of the steinkern, and the exceedingly low spire as indicated by the difference in level between the inner whorls and the outer whorl reflected on the inner surface of the shell. Note that figure* 2 *clearly shows that the outer angulation on the inner whorls is not at the umbilical wall. Paleontologisk Museum, Oslo.* No. A-19229.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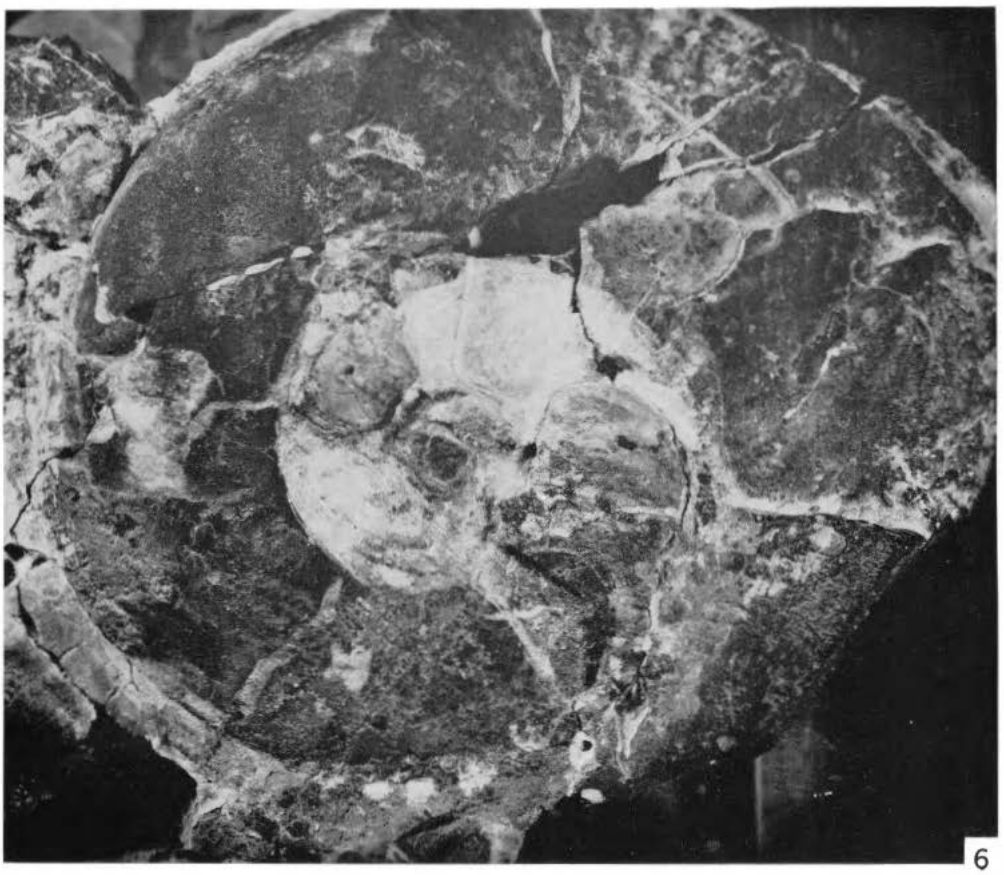
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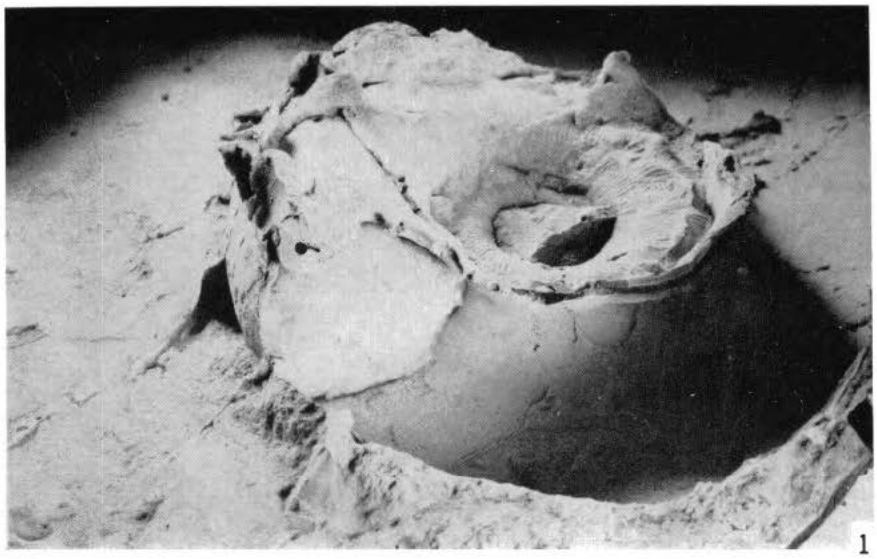
Pl. II



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Ginkgo spitsbergensis n. sp.

from the Paleocene of Spitsbergen and a discussion of certain Tertiary species of *Ginkgo* from Europe and North America

BY

SVEIN MANUM[1]

Abstract

Ginkgo spitsbergensis n.sp. is described on new material from the Paleocene of Spitsbergen, with particular regard to its epidermal characters. Probably all the older finds of *Ginkgo* in the Spitsbergen Tertiary should be referred to the new species. The epidermal characters of *G. wyomingensis* n. sp. from the Paleocene of North America are also described. The two new species are compared in detail with the previously best known Tertiary species, *G. adiantoides* (UNG.) HEER emend. FLORIN and *G. gardneri* FLORIN.

Introduction

Ginkgo leaves were discovered in a new locality in the Tertiary of Spitsbergen in 1962, which brings the total number of localities containing *Ginkgo* to four. The specimens from previous localities are impressions, whereas those from the new find have their cuticles preserved. A comparison with other species whose epidermal characters are known has led to the conclusion that the new specimens represent a distinct species, *Ginkgo spitsbergensis* n. sp., which is described in this paper.

The Tertiary sediments in Spitsbergen, all dated to the Paleocene-Eocene, include some coal seams and rich plant beds, from which large collections have been made on numerous expeditions over more than a century. A great deal is now known about the composition of the flora through studies of leaves and other megafossils by various authors (i. a. HEER 1868, 1870, 1876, NATHORST 1910, 1919, SCHLOEMER-JÄGER 1958), supplemented by evidence from palynological investigations (MANUM 1962, which also includes a catalogue of the entire flora). There is certainly still more to be done, particularly in the way of more reliable determinations of many megafossils. However, the megafossil material is hardly inspiring for someone who seeks more than gross-morphological characters to base his

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identifications upon, for apart from petrified stems the preservation has previously permitted a study of microscopic structures in only two cases, as far as I am aware.

The specimens described here as *Ginkgo spitsbergensis* were collected on expeditions in 1962 and 1964. The leaves are abundant in a thin bed exposed at the foot of the mountain Basilika on Van Keulenfjorden. The bed belongs to the very lowermost part of the Tertiary sequence in Spitsbergen and is considered to be of Paleocene age. Details about the locality have already been published by MANUM (1963).

Ginkgo in the Spitsbergen Tertiary

From the work that has been done so far it appears that *Ginkgo* occurs rather sporadically in the Tertiary flora of Spitsbergen. HEER, who studied extensive collections from many localities for his "Flora fossilis arctica", did not have a single specimen of *Ginkgo*. NATHORST had seen perhaps equally large collections when he published the first finds of the genus (1919). They were a few leaf impressions which he referred to *G. adiantoides* (UNG.) HEER, from near Sveagruva on Braganzavågen, and some poorly preserved impressions recognizeable as belonging to the genus, from Grønfjorden. Finally, SCLOEMER-JÄGER (1958) reported two leaf fragments, described as *Ginkgo* sp., in a collection from the coal-fields in Brøggerhalvøya.

All the finds up to this time have been made in the plant-bearing formation forming the lowermost part of the Tertiary sequence. There is no record of *Ginkgo* from the even richer plant-bearing formation with a very similar flora, which forms the uppermost part of the sequence in Spitsbergen and is separated from the lowermost formation by roughly one thousand metres of sediments.

The specimens described in this paper as *Ginkgo spitsbergensis* n. sp. have gross-morphological characters very similar to *G. adiantoides*, and on such characters they cannot be distinguished from NATHORST's specimens from Sveagruva which he referred to that species. It cannot be established beyond doubt that NATHORST's specimens also belong to the new species since they have no cuticles, but I think it most likely that they do so. The fragments described by SCHLOEMER-JÄGER show insufficient characters for specific determination, but they could well belong to the same species too. One of her specimens appears to have been a leaf rather more deeply lobed than the others seen from Spitsbergen, but since this character is highly variable in *Ginkgo,* hardly any significance can be attached to it. Thus, from the material brought to light so far, there is no evidence of more than one species of *Ginkgo* in the Spitsbergen Tertiary.

In this connection *Torellia rigida* HEER (1870) from the lowermost part of the Tertiary at Grønfjorden deserves mentioning because of its suggested ginkgoalean relationship. It is interesting also because the specimens have yielded cuticles, described by FLORIN (1936a p. 140). (Only one more record of cuticular structures in a plant from the Spitsbergen Tertiary is known to me, namely

Taiwania schaeferi SCHLOEMER-JÄGER 1958.) *Torellia bifida* HEER (1870), from the same locality, is a species of highly questionable value, based on a single specimen.

I have bulk macerated material from the Basilika locality but found no other cuticles than those of *G. spitsbergensis*. Pollen was sought for, particularly in hope of finding grains referable to *Ginkgo* since they have not as yet been recovered from the Spitsbergen Tertiary. However, only a few indeterminable exines were seen. This is in keeping with previous observations that macerations of Spitsbergen Tertiary sediments other than coals rarely yield determinable exines (cp. MANUM 1962 pp. 9–11).

Associated with *Ginkgo* in the Basilika locality are the most common plants in the Spitsbergen Tertiary. They are frequent branchlets of *Metasequoia occidentalis* (NEWB.) CHANEY and leaf fragments of *Cercidiphyllum* cf. *arcticum* (HEER) BROWN, the latter also reported by NATHORST (1919) to be associated with *Ginkgo* at the Sveagruva locality. Furthermore, a few specimens of *Nordenskiöldia borealis* HEER were observed at Basilika together with indeterminable fragments of other angiosperms.

Comparison with Tertiary Ginkgo from some other localities

As stated already, the *Ginkgo* in the Spitsbergen Tertiary is held to belong to a distinct species on its epidermal characters as shown in the cuticle. I have compared it with *G. adiantoides* (UNG.) HEER emend. FLORIN (1936b) and *G. gardneri* FLORIN (l.c.), the previously best known Tertiary species of *Ginkgo*. I have examined the type slides for both species, and for *G. gardneri* I have also studied additional preparations made from the type material for the present study. Furthermore, preparations of a previously undescribed *Ginkgo* from the Paleocene of Wyoming, U.S.A. have been at my disposal. Rather large portions of both cuticles are represented. I consider the epidermal characters of this *Ginkgo* distinct from those of the species named above, and therefore I describe it in the present paper as *Ginkgo wyomingensis* n. sp. Like *G. spitsbergensis* it has gross-morphological characters very similar to *G. adiantoides*.

In the table p. 52 I have included the characters which may be used to distinguish *Ginkgo adiantoides, G. gardneri, G. spitsbergensis,* and *G. wyomingensis* from one another. It will be seen that *G. gardneri* occupies a position somewhat removed from the others, essentially because of the papillosity and the pattern of the cell walls in the upper epidermis, and the very pronounced convexity of the cell surfaces in the lower epidermis. The three remaining species are less different from one another. *G. adiantoides* and *G. wyomingensis* are similar in the sinuosity of the cell walls in the upper epidermis, but they are easily distinguished on their lower epidermis, which is conspicuously papillose in *G. wyomingensis* but lacks papillae in *G. adiantoides*. *G. spitsbergensis,* on the other hand, differing from the two in the much less pronounced sinuosity of the walls in the upper epidermis, comes close to *G. wyomingensis* in its papillosity of the lower epidermis, and particularly that of the subsidiary cells.

Comparison of certain characters in four Tertiary species of *Ginkgo*

	Ginkgo gardneri FLORIN Material: Eocene, Isle of Mull; British Museum (Nat. Hist.)	*Ginkgo adiantoides* (UNG.) HEER emend. FLORIN Material: Pliocene, Frankfurter Klärbecken; Riksmuseet, Stockholm	*Ginkgo spitsbergensis* n. sp. Material: Paleocene, Spitsbergen; Paleontologisk Museum, Oslo	*Gingko wyomingensis* n. sp. Material: Paleocene, Wyoming; Princeton University, Princeton N.J.
Veins in lamina	Approx. 13 per cm	(Approx. 20 per cm, one leaf)	Approx. 20 per cm	Approx. 20 per cm
Resin bodies between the veins	Very frequent	Moderately frequent	Rather scattered	(Moderately frequent)
Upper cuticle:				
Anticlinal walls	Straight	Markedly sinuous, amplitudes usually about 4μ, sometimes up to 6μ	Straight to slightly sinuous, amplitudes rarely over 3μ	Markedly sinuous, amplitudes usually between 3μ and 6μ
	Thickening broad, indistinctly delineated	Thickening narrow, well defined	Thickening narrow, moderately clear	Thickening well marked, with jagged lateral extensions
Periclinal walls	Flat, usually one (occas. 2-3) prominent papillae on almost every cell	Flat, no papillae	Flat, no papillae	Flat to slightly convex, slightly thickened towards centre
	Phase contrast: Finely pitted, 2–3μ across pits	Phase contrast: no distinct pattern	Phase contrast: coarsely pitted to irregularly reticulate, 2–15μ across "meshes"	Phase contrast: coarsely pitted or irregularly reticulate, 2–15μ across "meshes"
Cell shape and arrangement	Between veins almost rectangular, length–width ratio usually less than 2, arrangement more or less clearly longitudinal	Between veins greatly varying, irregularly polygonal, randomly orientated	Between veins irregularly polygonal, randomly orientated	Between veins irregularly polygonal, randomly orientated
	Along veins markedly elongate	Along veins tendency towards rectangular shape and longitudinal arrangement	Along veins a few rows of rectangular, somewhat elongate cells	Along veins slightly elongate, longitudinally arranged
Lower cuticle: Periclinal walls of ordinary epidermal cells	Prominently convex so as to form a rounded papilla occupying the greater part of the cell surface	Very slightly convex, no papillae	Usually convex and a varying number of the cells with a more or less prominent, hollow, median papilla; non-papillose cells not thickened towards wall centre	Many cells almost flat, others with a prominently projecting, hollow, median papilla; cuticle thickening towards wall centre
Papillosity of subsidiary cells	Prominent papillae, completely covering the stomatal pit	Slight bulges towards the stomatal pit, usually leaving most of the guard-cells visible	Prominent papillae, usually covering the stomatal pit completely	Prominent papillae, projecting towards the stomatal pit and to varying degrees covering it.

In the following key the most conspicuous differences are employed for the separation of the four species:

1 { Anticlinal walls upper epidermis straight 2
  { Anticlinal walls upper epidermis sinuous 3

2 { Upper epidermis papillose ..... *G. gardneri*
  { Upper epidermis not papillose ..... *G. spitsbergensis*

3 { Lower epidermis papillose 4
  { Lower epidermis with no prominent papillae ..... *G. adiantoides*

4 { Sinus amplitudes of anticlinal walls upper epidermis $< 3\mu$ *G. spitsbergensis*
  { Sinus amplitudes of anticlinal walls upper epidermis
  { mostly $> 3\mu$ ..... *G. wyomingensis*

In connection with this comparison I would like to draw attention to three more references to Tertiary *Ginkgo* where the cuticle is known to a limited extent. LAMOTTE (1936 p. 107) reported *G. adiantoides* (UNG.) HEER from the Miocene of northwestern Nevada and adjacent parts of California (Upper Cedarville Formation). He examined the epidermis and concluded that the stomatal structures were not essentially different from those of *G. biloba*. LAMOTTE offered no description, but his drawings of stomata show that they resemble those of *G. adiantoides* as emended by FLORIN (1936b) in lacking prominent papillae on the subsidiary cells. The other reference, by SZAFER (1961 p. 13), is also to *G. adiantoides* (UNG.) HEER. The specimens came from the Miocene of Stare Gliwice in Upper Silesia. Epidermal characters are not described, but two figures of the lower cuticle (l.c. pl. 3 figs. 5 and 6) show non-papillose cells with very slightly sinuous walls, and subsidiary cells which bulge slightly into the stomatal pit. The available evidence suggests that the Silesian specimens are close to *G. adiantoides* emend. FLORIN. The third reference is by JORDANOV & KITANOV (1963 p. 27) who reported "*Ginkgo biloba* L. *fossils*" from the Pliocene near Gotse Delchev in southwestern Bulgaria. This is again a fossil clearly resembling *G. adiantoides* emend. FLORIN in its epidermal characters but the available information is not sufficient for a more detailed discussion in its relationship.

All four species dealt with in this paper are very similar in gross morphology to the Recent *Ginkgo biloba*. Specific distinction between them would hardly be practicable without using epidermal characters, and the fossils would be included in *G. adiantoides* in the old sense of that species as has been the practice in the past. In epidermal characters *G. adiantoides* emend. FLORIN comes quite close to the Recent species (cp. FLORIN 1936b p. 30), and the specimens reported by LAMOTTE and SZAFER also seem to come close to it, whereas *G. gardneri*, *G. spitsbergensis*, and *G. wyomingensis* have less in common with *G. biloba*.

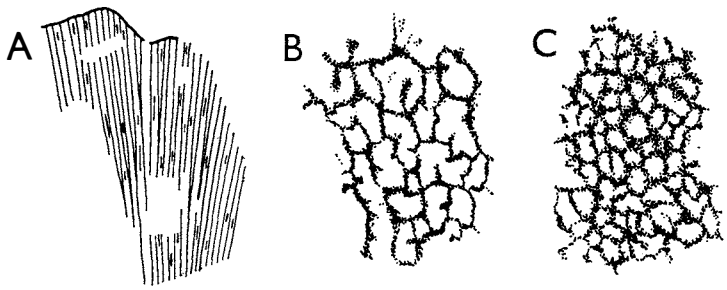

Fig. 1. A, Ginkgo spitsbergensis *n. sp., part of naturally macerated leaf showing resin bodies between veins, ×1.5, PA 2988; B, micro-pattern of the internal side of the upper cuticle as seen under phase contrast illumination, ×1000, PA 2994;* C, Ginkgo gardneri FLORIN, *as in B, Brit. Mus. V. 25 001 a.*

Descriptions

Ginkgo spitsbergensis n. sp.

Pl. I figs. 1–5, 7, 8, pl. II figs. 1, 2, 4–6, text-figs. 1 A, B, 2 A.

"*Ginkgo adiantoides* (UNG.) HEER", NATHORST 1919 p. 235.
"*Ginkgo* cf. *adiantoides* (UNG.) HEER", MANUM 1963 p. 151.

Diagnosis. Leaf fan-shaped, lamina about 5 cm long and 8 cm broad, petiole approx. 1.5 mm thick; distal margin usually with shallow notches and gentle undulations, median notch more prominent but rarely very deep. Lamina traversed by regularly dichotomising veins at a concentration of about 20 per cm. Resin bodies rather few, fusiform and about 0.5–1.0 mm by 0.1 mm.

Lamina hypostomatic. Upper epidermis with slightly elongated cells along veins, more or less polygonal and irregularly arranged cells between veins. Anticlinal walls straight to finely sinuous, fairly clearly marked by narrow thickenings in the cuticle. Periclinal walls with no noticeable convexity nor papillae. Lower epidermis with numerous stomata between veins, none along the veins. Epidermal cells along the veins much elongate, between the veins irregular and much as in the upper epidermis. Anticlinal walls faintly marked, straight to slightly sinuous. Periclinal walls convex and frequently with a median papilla in the form of a rounded bulge with somewhat thickened cuticle. Stomata randomly arranged and orientated, very rarely so close as to share subsidiary cells. Subsidiary cells each with a prominent papilla usually covering the stomatal pit completely.

Type specimen: Pl. 1 figs. 1, 7, and 8. PA 2983 (cuticle prep. PA 2989) in Paleontologisk Museum, Oslo; Paleocene, foot of mountain Basilika, Vestspitsbergen.

Description. No complete leaf has been obtained from the type locality, because the rock easily breaks up into small pieces. One of the specimens recorded by NATHORST (1919) from Sveagruva and here held to belong to the same species is nearly complete, but the preservation is not such as to yield epidermal characters. It appears that the leaves were rather small; extremes estimated are 57 mm long

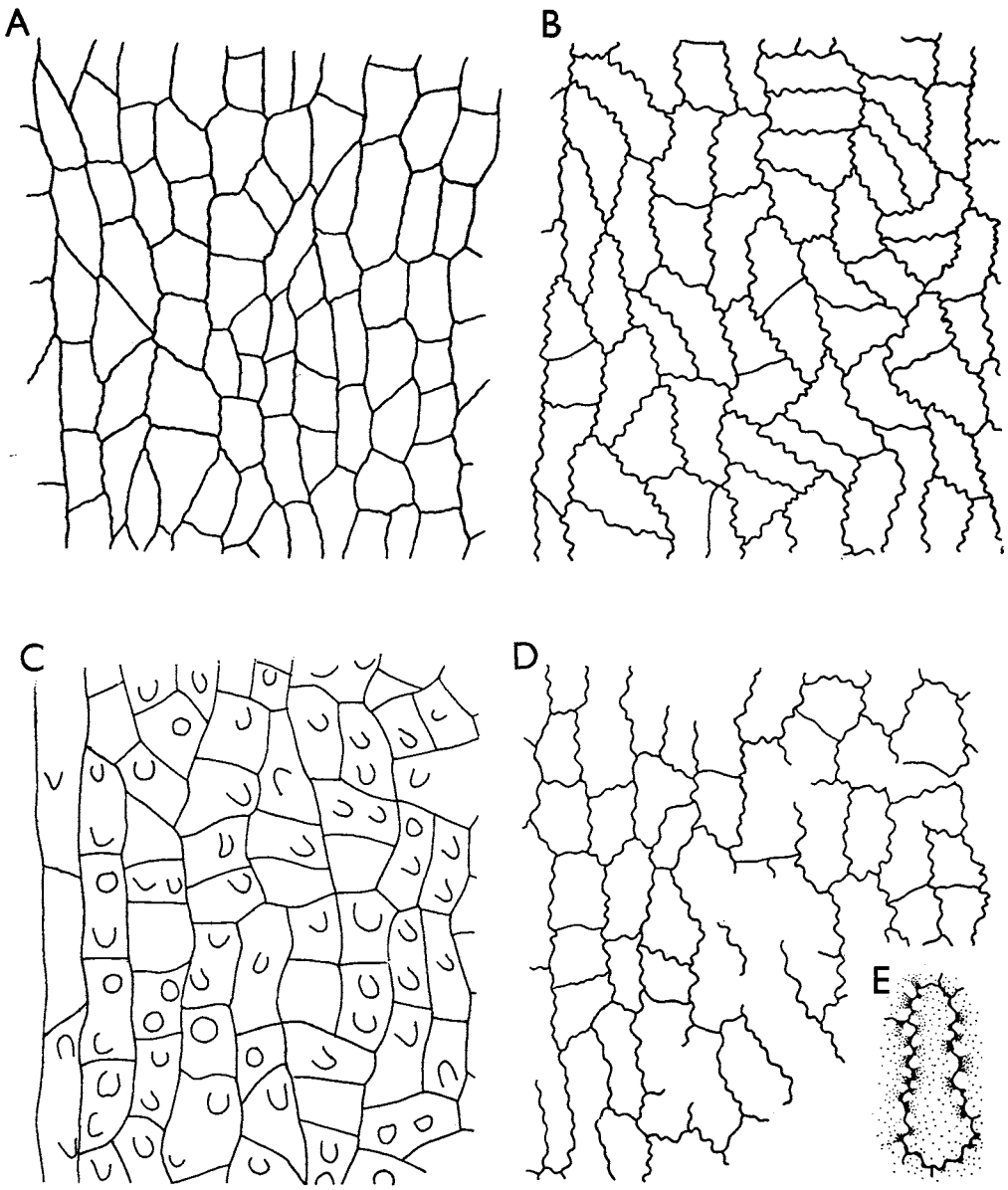

Fig. 2. *Upper cuticles of: A*, Ginkgo spitsbergensis *n. sp., PA 2996; B*, G. adiantoides (UNG.) HEER *emend.* FLORIN, *Riksmus. Stockh. coll.; C*, G. gardnerli FLORIN, *Brit. Mus. V. 14 849 d; D, E*, G. wyomingensis *n. sp., Princeton Univ. Col.; A–D* ×*200, E* ×*400.*
In A–D a vein is just to the left in each figure.

and 94 mm wide, 25 mm long and 48 mm wide. Resin bodies seen in naturally macerated specimens are rather scattered.

The preservation of the cuticle varies considerably. The anticlinal walls are not always clear in the upper cuticle, and rarely so in the lower, but usually the essential characters can be distinguished. The thickness is moderate, the upper being slightly thicker than the lower.

Three of the characters shown in the cuticles are somewhat variable:

1. The sinuosity of the anticlinal walls of the upper epidermis; it may be slight but distinct in most walls in some specimens, other specimens have straight as well as more or less clearly sinuous walls, whereas in some the walls are basically straight, although inconspicuously sinuous in a few places.
2. The papillosity of the cells in the lower epidermis; the most heavily papillose specimens show one papilla (occasionally two or three) on nearly every cell, many specimens are less papillose, and some have only scattered papillae.
3. The convexity of the periclinal walls of the lower epidermis, being from very slightly to prominently dome-shaped, as indicated by the extent to which folds occur along the cell margins.

The papillosity of the subsidiary cells is rather constant; the cuticle is thickened in the papillae.

When examined under phase contrast illumination, the inner surface of the cuticle shows a pattern of minute pits separated by irregular ridges. Sometimes, in good specimens, this pattern is seen as a clear reticulation with narrow ridges and very irregularly shaped meshes measuring 2–15μ across. The pattern is occasionally visible also under ordinary illumination. It is essentially similar in both cuticles, but shows up clearer in the upper.

Ginkgo wyomingensis n. sp.

Pl. II figs. 3, 7, text-figs. 2 D, E, 3.

Diagnosis. Leaf fan-shaped, traversed by regularly dichotomising veins at a concentration of about 20 per cm. Fusiform resin bodies 0.2 to nearly 2 mm long, moderately frequent.

Lamina hypostomatic. Upper epidermis with more or less polygonal and irregularly arranged cells between veins, slightly elongate and longitudinally arranged along veins. Anticlinal walls sinuous, marked by rather narrow and distinct thickenings in the cuticle. Periclinal walls with somewhat thickened cuticle towards the centre, which may also be very slightly convex, but neither thickening nor convexity prominent. Lower epidermis with numerous stomata between veins, none along veins. Ordinary epidermal cells of much the same shape and arrangement as in the upper epidermis. Anticlinal walls finely sinuous, not so clearly marked as in the upper cuticle. Periclinal walls usually markedly thickened towards the centre, which may or may not be raised into a prominently projecting, hollow papilla. Stomata randomly arranged and orientated, very rarely so close as to share subsidiary cells. Subsidiary cells each with a prominent papilla, usually more thickly cutinized than those of ordinary epidermal cells, and projecting towards the stomatal pit and most often covering it.

Type specimen: All figures. Slide in collections of Princeton University, New Jersey; Lower Paleocene, Wyoming.

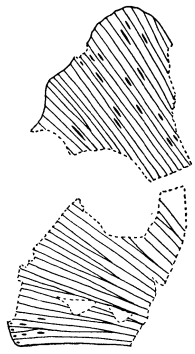

Fig. 3. Ginkgo wyomingensis *n. sp. Type specimen, veins and resin bodies as shown in the cuticle.* ×*1.5.*

Description. The description is based on the study of rather large pieces of cuticle of a single leaf, which is well preserved. The thickness of the upper cuticle is *c.* 3.5 μ, of the lower *c.* 2.5 μ. The somewhat thickened central part of the periclinal walls is more strongly developed in the lower than in the upper cuticle. In the upper cuticle more or less prominent jagged thickenings occur along the anticlinal walls, sometimes clearly extending on to the surface wall (text-fig. 2 E). Similar thickenings occur also in the lower cuticle, but there they are much less noticeable. The inner surface of the cuticle has a reticulate micropattern very similar to that observed in *G. spitsbergensis,* sometimes clearly visible under ordinary illumination.

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Explanation of plates

Specimens and preparations with PA numbers are kept in Universitetets Paleontologiske Museum, Oslo.

PLATE I

Figs. 1–5, 7, 8. *Ginkgo spitsbergensis n. sp., Paleocene, foot of mountain Basilika, Vestspitsbergen.*

Fig. 1. *Type specimen,* × 1, *PA* 2983.

Fig. 2. *PA* 2986, × 1.

Fig. 3. *PA* 2985, × 1.

Fig. 4. *Upper cuticle, showing "reticulate" pattern of internal surface,* × 300, *PA* 2994.

Fig. 5. *Upper cuticle in phase contrast illumination,* × 300, *PA* 2995.

Fig. 7. *Upper cuticle prepared from type specimen,* × 150, *PA* 2989.

Fig. 8. *Lower cuticle prepared from type specimen,* × 150, *PA* 2989.

Fig. 6. *Ginkgo gardneri* Florin, *Eocene, Isle of Mull. Upper cuticle in phase contrast illumination,* × 300, *British Museum V. 14 849 c.*

PLATE II

Figs. 1, 2, 4–6. *Ginkgo spitsbergensis n. sp.*

Fig. 1. *Upper cuticle with distinctly sinuous anticlinal walls,* × 150, *PA* 2993.

Fig. 2. *Lower cuticle, five stomata,* × 400, *PA* 2991.

Fig. 4. *Lower cuticle, heavily papillose specimen,* × 150, *PA* 2991.

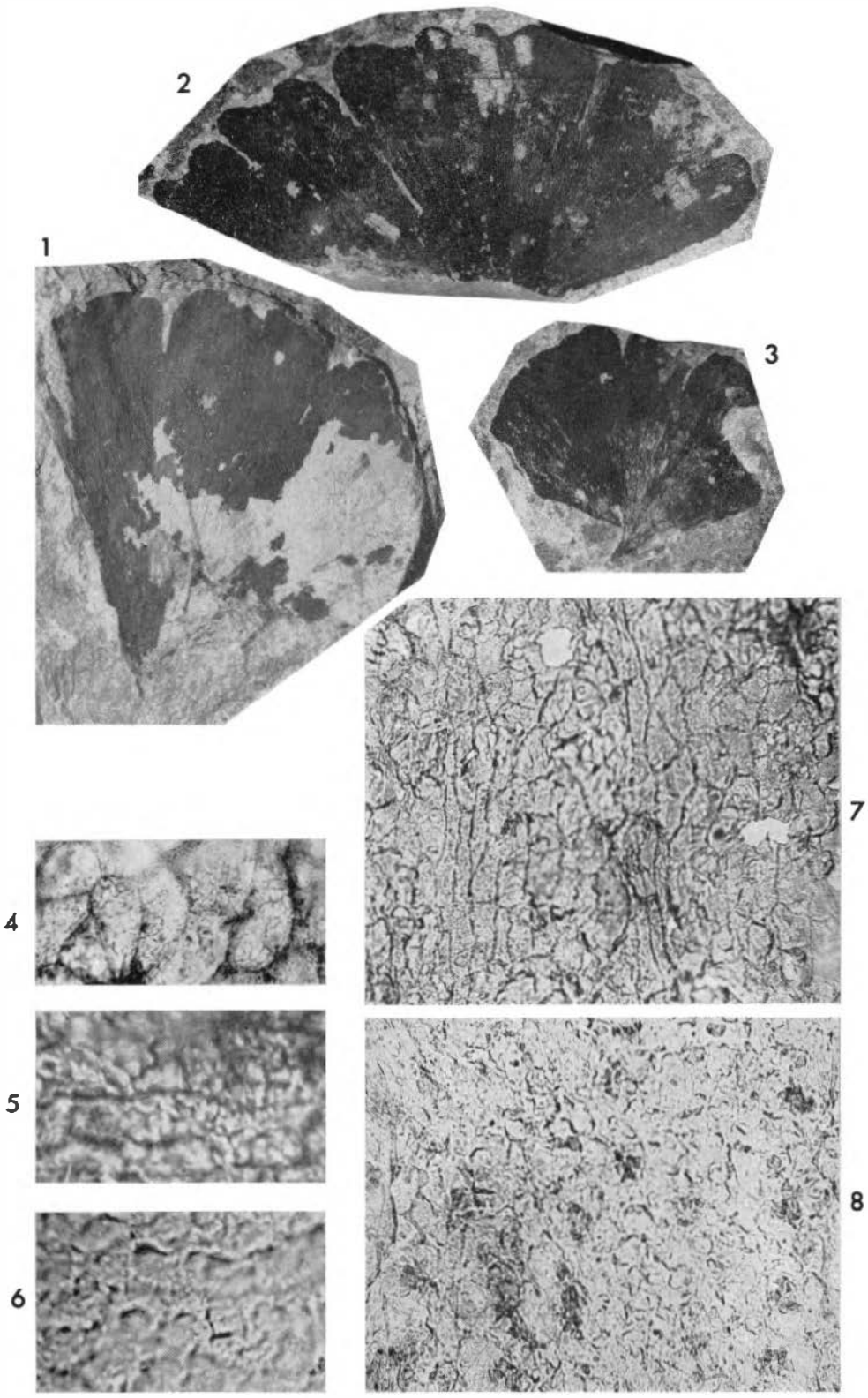
Fig. 5. *Lower cuticle,* × 150, *PA* 2996.

Fig. 6. *Lower cuticle in phase contrast illumination,* × 150, *PA* 2992.

Figs. 3 and 7. *Ginkgo wyomingensis n. sp., Lower Paleocene, Wyoming, U.S.A., Princeton University collection.*

Fig. 3. *Lower cuticle, three stomata,* × 400.

Fig. 7. *Lower cuticle,* × 150.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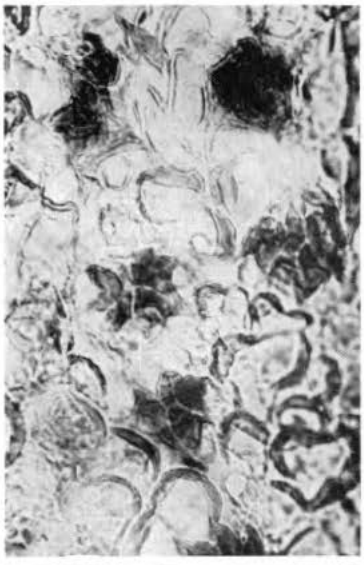

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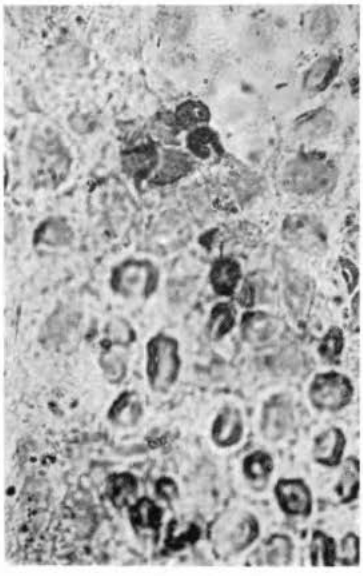

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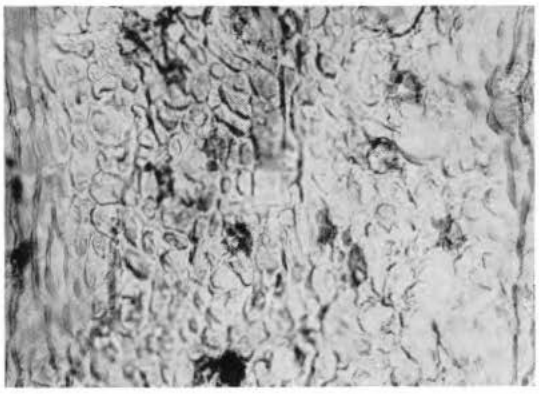

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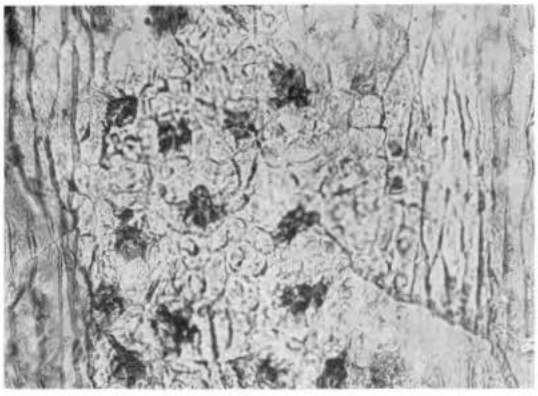

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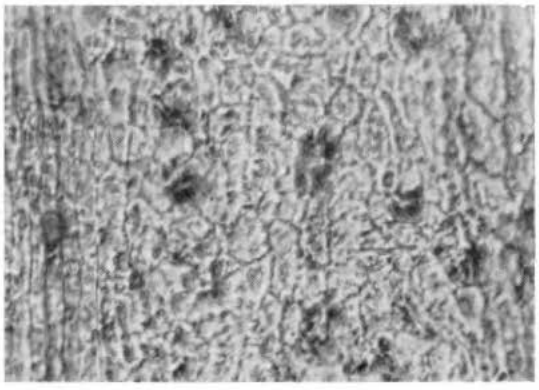

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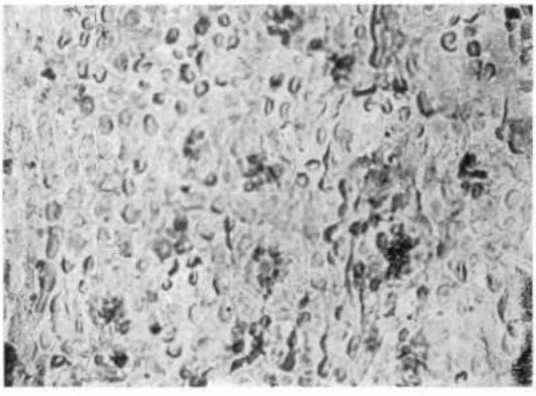

7

New unit terms for the Devonian of Spitsbergen and a new stratigraphical scheme for the Wood Bay Formation

BY

PETER F. FRIEND[1], NATASCHA HEINTZ[2] and MARK MOODY-STUART[3]

Abstract

The stratigraphical unit term "Series" is replaced by Formation or Group throughout the Devonian of Spitsbergen, to comply with international usage. A revised and simplified lithostratigraphical scheme is proposed for the Wood Bay Formation of north and central Vestspitsbergen. This is related to an amplification of the existing biostratigraphical scheme.

Change of stratigraphical unit terms

The original division of the Devonian of Spitsbergen into "Series" (HOLTEDAHL, 1914) has been continued in all recent publications (e. g. WINSNES, HEINTZ and HEINTZ, 1960; FRIEND, 1961). However, the use of this term for lithostratigraphical units is contrary to the "Statement of principles of stratigraphic classification and terminology" published by the International Geological Congress at its Norden meeting (HEDBERG, 1961). In order to avoid misunderstanding we propose therefore to replace the unit terms so that their lithostratigraphic meaning will be immediately clear. Similar changes to conform with international usage have recently been carried out in a number of other parts of the Spitsbergen succession (Permian to Tertiary, Norsk Polarinstitutt, Map C 9 G, 1964; Carboniferous and Permian, CUTBILL and CHALLINOR, 1965).

We propose to replace the name Wood Bay Series by Wood Bay Formation. The unit term Formation is preferred to Group, in spite of the great thickness of the unit, because as the following discussion shows, it cannot be completely divided on lithological grounds. Similarly we propose that Grey Hoek, Wijde Bay, Mimer Valley and Marietoppen (Hornsund) Series become Formations. However, we propose that the Red Bay Series become a Group, because it includes four mapable units which are given formation rank, the Red Bay Conglomerate, Andréebreen Sandstone, Fraenkelryggen and Ben Nevis Formations. We agree

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with FØYN and HEINTZ (1943) that the geographical terms should be retained in their original whether English or Norwegian.

Flexibility in the rank of unit terms (Groups, Formations, Members and Beds) is accepted internationally, so that we may expect some promotion or demotion as knowledge grows.

Sub-division of the Wood Bay Formation

The main object of this paper is to report some new observations on the fossils and sediments of the Wood Bay Formation, and use these as a basis for a new and simplified system of lithological sub-division. One of us (N. H.) has studied the anatomy and occurrence of certain pteraspid vertebrates; the others (P.F.F. and M.M.-S.) have investigated variations in lithology and distribution of the commonest fossils over the greater part of the outcrop area.

The Wood Bay Formation is estimated to have an aggregate maximum thickness of about 2,900 m and it outcrops in an area of north and central Vestspitsbergen of about 60 km by 150 km. Its sub-division is made difficult by a number of features typical of thick non-marine successions. Fossils occur only very sporadically, and the groups represented (vertebrates, plants, plant spores, ostracods) are a relatively specialist study, and in the case of the plants and the vertebrates, always more or less fragmentary. The exposures consist of monotonous successions almost entirely of clastic rocks of limited lithological range.

Palaeontological sub-division

FØYN and HEINTZ (1943) first divided the Wood Bay Formation. Their three "Divisions" were defined partly on palaeontological grounds, each being characterized by certain "guide" fossils:

1) Kapp Kjeldsen Division; *Gigantaspis* sp., *Arctaspis*
2) Lykta Division; *Doryaspis,* including *D. nathorsti*, *Arctolepis*
3) Stjørdalen Division; Monaspids

We shall demonstrate in the next section the unsatisfactory nature of the "Divisions" of FØYN and HEINTZ (1943) for widespread *lithological* sub-division. We propose therefore that they be used purely for purpose of palaeontological subdivision. To make this clear we give them the unit term "faunal Division".

Recent work on some of the pteraspids from the Wood Bay Formation has confirmed the existence of a *Gigantaspis* fauna, including at least two species, *G. isachseni* and *G. bocki* (N. HEINTZ, 1962). It has also shown that a small form of *Doryaspis* with shield shapes and sculpture different from *D. nathorsti* occurs with this *Gigantaspis* fauna.

Field work shows that there is a narrow zone of intermingling of this *Gigantaspis* fauna with specimens also of *D. nathorsti.* In Woodfjorden this zone, containing *Gigantaspis, D. nathorsti* and possibly also the small *Doryaspis*-form, is 50 m thick.

We may therefore summarize present knowledge of the faunal sub-division of the lower part of the Formation:

1) Kapp Kjeldsen faunal Division; species of *Gigantaspis,* the small species of *Doryaspis,* and near the top, *D. nathorsti.*

2) Lykta faunal Division; *D. nathorsti,* with absence of both *Gigantaspis* and the small *Doryaspis.*

The upper part of the Wood Bay Formation, viz. Stjørdalen faunal Division is not discussed in this connection, as neither the *Gigantaspis*-forms nor the *Doryaspis*-forms are found in this faunal Division.

Lithological sub-division

FØYN and HEINTZ' (1943) three "Divisions" were defined partly on lithological grounds in the mountains round southern Woodfjorden. FRIEND (1961) found that the lithological criteria could not be applied in Dickson Land, and proposed modifications to the scheme and some new units for Dickson Land. Further knowledge of the lithologies both of Dickson Land and of Woodfjorden now makes it advisable and possible to replace this cumbersome scheme with a simpler and more flexible one.

The conclusion which underlies the new scheme is that the Wood Bay Formation is characterized by one dominant lithofacies. The most abundant lithology is red siltstone and this usually occurs as a constituent of the clastic fining-upwards cyclothems which are so common a feature of the Formation (FRIEND, 1965). We propose therefore to regard red clastic and generally cyclothemic outcrops as typical of the Wood Bay Formation, and only to name units *within* the Formation where the lithology differs markedly from this. Distinctive geographical and lithological terms will be given to these units which will be designated as Members within the Formation. This is illustrated in Fig. 1, and described in the paragraphs below.

The top of the Kapp Kjeldsen Division was placed by FØYN and HEINTZ (1943) at the top of a pale (non-red) zone which occurs in the mountains of south-east Woodfjorden. Recent observations show that this is of limited lateral extent and therefore of no value as a Formation-wide stratigraphical marker. We now know that non-red cyclothemic parts of the Wood Bay Formation outcrop in a number of areas. They occur at different horizons relative to the palaeontological sub-divisions, and are usually restricted individually to a small part of the outcrop area of the Formation. They are interpreted as areas in which iron in the sediment has been reduced by a temporary relatively high level of the water-table, probably associated with lacustrine or swampy conditions. We shall call the pale zone of FØYN and HEINTZ (1943) the "Vaktaren Green Member". Its top coincides with the top of the Kapp Kjeldsen faunal Division, and it dies out southwards within 15 km of its first appearance above sea level. The "Orsabreen Green Member," about 50 km to the south is at least 600 m below the top of the Kapp Kjeldsen

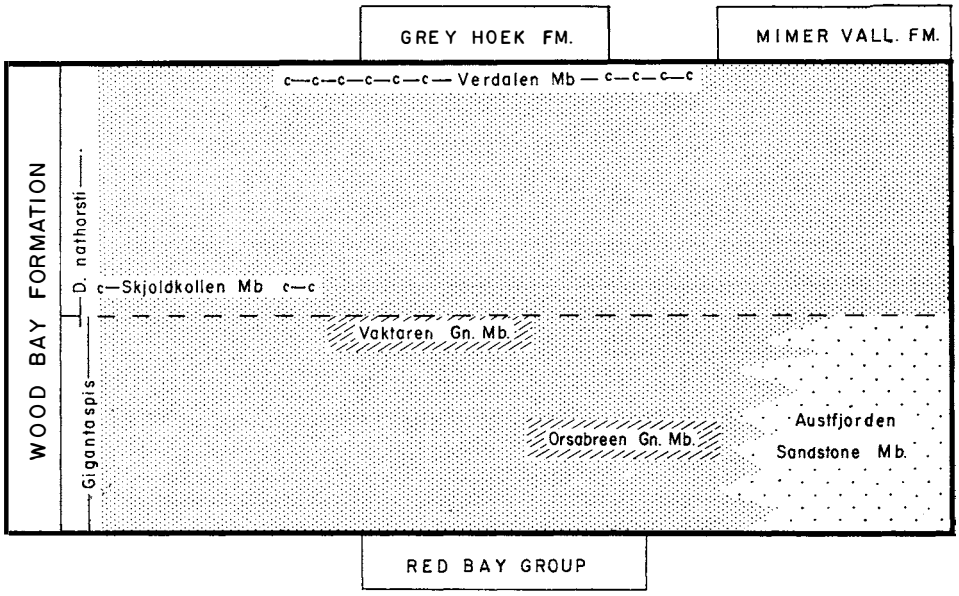

Fig. 1. *Diagram (not to scale) showing relationships of lithostratigraphic units within the Wood Bay Formation, and in contact with it.*

faunal Division, and passes northwards into red-beds. Most of the non-red outcrops occuring in Dickson Land belong to the "Austfjorden Sandstone Member". This unit was described by FRIEND (1961) and given Formation rank. Although its exposures in east Dickson Land differ markedly from the normal Wood Bay red beds in being dominantly sandstone and non-cyclic, there is a continuous passage westwards into cyclothemic red-beds. It belongs entirely to the Kapp Kjeldsen faunal Division.

FØYN and HEINTZ (1943) defined their Lykta Division lithologically on the coarser general grain-size and the "rougher" appearance of its hillsides east of Woodfjorden relative to the overlying Division. This effect does not appear to form a practical basis for Formation-wide sub-division. A careful study of grain-size has been made in the field using sets of specimens of standard grain-size. As well as establishing the cyclothemic nature of most of the successions (FRIEND, 1965), which is responsible for the roughness of the hillsides, this has also shown how complex and diachronous the variation in the nature of the cyclothems is. It is extremely difficult to measure this variation without detailed bed-by-bed records and a uniform degree of good exposure. Statistical treatment of sampling of these cyclothem variations will be presented in a later paper but it is sufficient here to report that they do not form a practical basis for sub-division.

Other variations, however, which can be usefully distinguished within the Wood Bay Formation, are the carbonate-rich zones. These are usually less red than the surrounding strata, consisting of a number of cyclothems which include a carbonate-rich bed. These occur at various levels relative to the faunal Divisions and are of restricted lateral extent. They are interpreted as the result of periods of

intermittent lacustrine deposition. The "Verdalen Carbonate Member" forms the highest part of the Formation in Andrée Land and north Dickson Land. The "Skjoldkollen Carbonate Member" is a 40 m thick unit in Reinsdyrflya in which there are several 5 m thick green marlstones. Its base is about 100 m above the top of the Kapp Kjeldsen faunal Division, and it can be traced laterally south-westwards for 8 km before it passes into normal red beds.

The Dicksonfjorden Sandstone (FRIEND, 1961) can now be incorporated in the undivided Wood Bay Formation, and the name is no longer necessary. Further field work in Dickson Land also makes it possible to abolish two of FRIEND's other units. The Mimerbukta Sandstone can now be regarded as the highly deformed eastern parts of both the Wood Bay and Mimer Valley Formations. The Reuter-skiöldfjellet Sandstone is best regarded as part of the Austfjorden Sandstone Member, except for the Red Member which is assigned to the undivided Wood Bay Formation.

Present knowledge of the interrelations of the palaeontological and lithological sub-divisions is outlined in Fig. 1.

Other outcrop areas

Since FRIEND's (1961) review of outcrops of the Wood Bay Formation outside its main area, new information has been published on all of them. CUTBILL and CHALLINOR (1965) have shown that the red-beds of "Brøggerhalvøya, once regarded as probably Devonian in age, are Carboniferous" (their Brøggertinden Formation). The area mapped as " ?Devonian" rocks north-east of the head of St. Jonsfjorden has been shown to be Triassic (HEINTZ and SIGGERUD, 1965).

BIRKENMAJER (1964) described outcrops in the northern part of the outcrops centred on Hornsund. He used the term "Marietoppen Series" (our Formation) for the Devonian of this area and suggested the correlation of the Lower and Middle sub-divisions of this with the Wood Bay Formation. There seems to be every advantage in using this separate name for the Hornsund Devonian outcrops, in view of the rather different lithology of this quite distinct area.

Acknowledgements

P.F.F. and M.M.–S. would like to thank Professor O.M.B. BULMAN and his staff of the Department of Geology, University of Cambridge, and in particular Mr. W.B. HARLAND, who has initiated and directed all Cambridge geological work in Svalbard over the last 17 years. M.M.–S. acknowledges receipt of a Shell studentship.

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Nodular gypsum and anhydrite rocks in the Billefjorden region, Spitsbergen

BY

DOUGLAS W. HOLLIDAY[1]

Abstract

Extensive gypsum and anhydrite rocks were formed in Central Vestspitsbergen during Middle Carboniferous and again in Lower Permian times. These sulphate rocks, which occur at the centres of sedimentary basins, are dominantly made up of nodules. The nodules are described and compared with Recent evaporite sediments, and it is concluded that the Spitsbergen sulphates formed during early diagenesis in intertidal and supratidal flats in an arid region. This conclusion is supported by the associated red beds (alluvial fan and playa deposits) and limestones (shallow, hypersaline lagoonal deposits). These results support SHEARMAN's (1965) suggestion that even thick extensive evaporites can be diagenetic in origin, and are not necessarily precipitates from deep saline water.

Introduction

Gypsum and anhydrite rocks occur at a number of horizons in the Carboniferous and Permian sequence of the Billefjorden region. The lowest stratigraphical horizon at which they have been found is in Ebbadalen at the top of the Billefjorden Group, where rare pink gypsum nodules occur. The first major development of sulphate rocks is in the Middle Carboniferous i.e. the Lower Gypsiferous Series of GEE, HARLAND & MCWHAE (1953) or Ebbadalen Formation and (in part) Minkinfjellet Member of CUTBILL and CHALLINOR (1965). Here in a cyclic sequence, gypsum-anhydrite rocks, alternating with carbonates and shales, are found in a sedimentary basin, at the centre of which are c. 800 m of evaporite bearing strata (GEE *et al.* 1953, CUTBILL and CHALLINOR 1965). The thickness of the individual evaporite beds ranges from a few centimetres to 50 m. Gypsum-anhydrite rocks probably make up about two-thirds of the whole sequence. A few minor bands of sulphate rock occur in the overlying carbonates, but the next major development is in the Lower Permian Upper Gypsiferous Series (GEE *et al.* 1953) renamed the Gipshuken Formation by CUTBILL and CHALLINOR (1965). Unlike the Middle Carboniferous evaporites this higher development is not restricted to the Billefjorden region, but occurs extensively throughout much of

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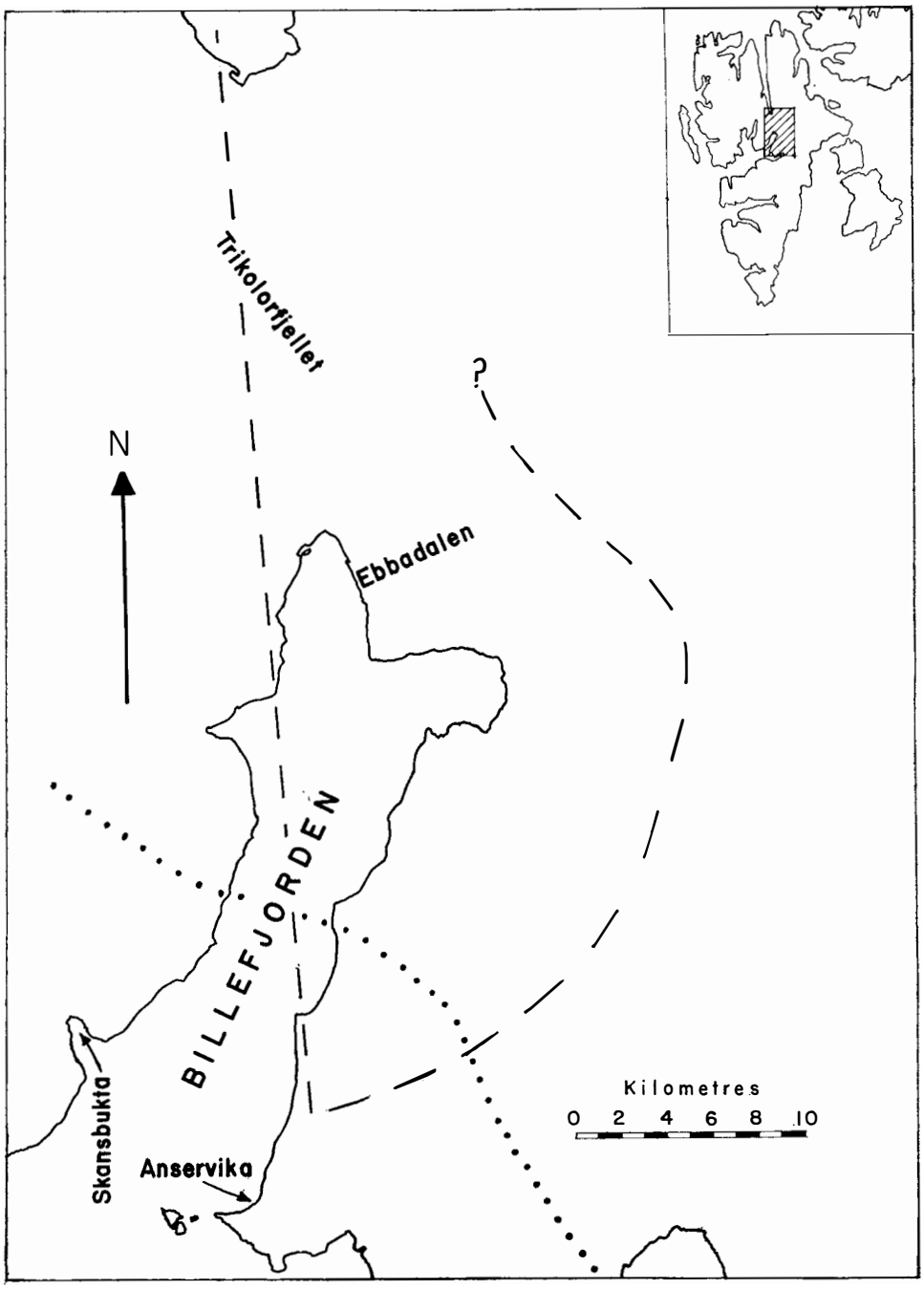

Fig. 1. *Map showing location of place-names mentioned in the text and the approximate extent of the two main gypsum and anhydrite developments in the Billefjorden region. The broken line indicates the limits of the Middle Carboniferous evaporites. The dotted line indicates the northerly limit of the Lower Permian evaporites. For the extent of these latter rocks throughout Central Vestspitsbergen as a whole see Fig. 5 of* CUTBILL *and* CHALLINOR (*1965*).

Central Vestspitsbergen in a basin centred on Isfjorden (CUTBILL and CHALLINOR 1965).

The following account is largely based on the gypsum-anhydrite rocks of Middle Carboniferous age. The sulphate rocks of the Gipshuken Formation have been briefly examined at Skansbukta and Anservika, and a short description of these rocks is included. The author visited the Billefjorden region in 1963, 1964, and 1965 while engaged on a study of Middle Carboniferous stratigraphy and sedimentation of that area (HARLAND 1964, 1965, HARLAND and WALLIS 1966). During this time the author was receiving a Department of Scientific and Industrial Research Studentship. The work has been supervised by Dr. W. W. BLACK, and Mr. W. B. HARLAND, the Director of the Cambridge Spitsbergen Expeditions, enabled me to visit Spitsbergen and readily gave access to material collected by previous expeditions.

Nodular sulphate rocks of the Middle Carboniferous

In the Middle Carboniferous of Central Vestspitsbergen gypsum and anhydrite may be found as authigenic replacements in carbonate rocks, as cement in sandstones, or even as detrital fragments (HUTCHINS 1962), but the dominant mode of occurrence of these minerals is as nodules. These may occur singly or in groups producing lenses and more commonly beds (Fig. 2). All gradations exist, from solitary and isolated nodules to rocks almost entirely composed of nodules in which the "skin" of sediment between the nodules is reduced to a minimum.

Fig. 2. *Ovate anhydrite nodules in a dolomite matrix. Minkinfjellet Member, sea-cliffs south of Ebbadalen.*

Fig. 3. *Anhydrite nodules and enterolithic veins, Minkinfjellet Member, sea-cliffs south of Ebbadalen. At A monoclinic anhydrite nodules pseudomorph gypsum. At B enterolithic veins cut across undisturbed laminations in the host rock. At C veins 'fold back' on themselves to form nodules.*

This latter case, elsewhere, has often been referred to as chicken-wire structure. Sometimes the chicken-wire structure is only preserved by lines of dark gypsum or anhydrite, rather than the usual carbonate or shale matrix. Examination of such rocks in thin section suggests that the dark sulphate is a replacement of the carbonate skin. Within the nodules the sulphate is usually white or grey, though anhydrite often has a bluish cast. However when associated with red shales the nodules take on a pink colour.

The size of the nodules ranges from 1 mm to 1 m in diameter. In some localities the nodules are fairly uniform in size, but in others the variation may be quite extreme. The shape is also highly variable and, although a rounded ovate shape is probably the commonest (Fig. 2), elongated and angular shapes do occur, and at one or two localities monoclinic anhydrite nodules are pseudomorphs after

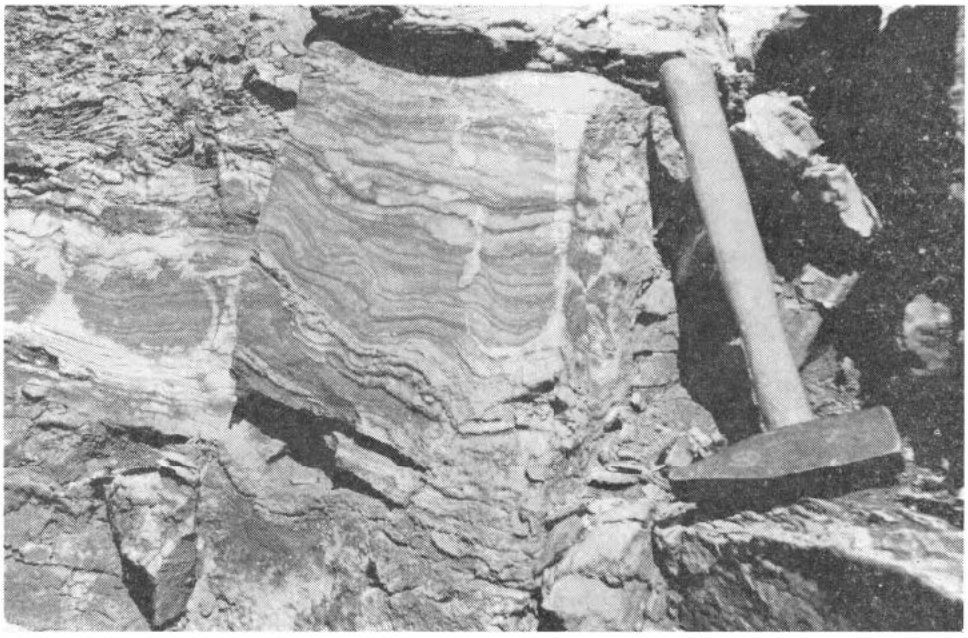

Fig. 4. *Banded anhydrite, partially hydrated to gypsum, composed of contorted flat elongated nodules. Ebbadalen Formation, north side of Ebbadalen.*

gypsum (Fig. 3). At one of these localities irregular contorted veins of anhydrite (enterolithic veins) are also to be seen, transgressive to the stratification (Fig. 3). These veins appear to be closely related to the nodules, and locally seem to grade into them. Some nodules are formed by the veins "folding back" on themselves (Fig. 3).

Some of the massive sulphate beds are banded, consisting of alternating layers of white and dark gypsum and anhydrite (Fig. 4). The layers may be contorted and the darker bands often contain small nodules of the white variety. This layering, though clearly sub-parallel to the bedding, does not seem to represent original sedimentary stratification. The dark layers do not persist laterally, fading out into the white sulphate. In many cases the dark bands can be seen to join and to bifurcate, and the banded appearance is often clearly a two dimensional expression of a rock made up of flattened and very elongated lenses and nodules. Locally this variety may be at least five or six metres thick. At many localities it can be seen to grade both upwards and downwards into the more normal nodular rocks. This change must also take place laterally though it has not yet been directly observed, due to the difficulties of following beds along their outcrop.

Lower Permian nodular sulphate rocks

The Upper Gypsiferous Series was examined at Skansbukta, in order to compare it with the Middle Carboniferous evaporites. The whole of the exposed sequence is composed of partially gypsified nodular anhydrite. In general the

nodules in this formation closely resemble those in the older evaporites, and even the banded variety is to be seen. Examination of fallen blocks on the shore at Anservika suggest that a similar situation exists there.

A minor post-consolidation disturbance has occurred in the nodular sulphates at Skansbukta. A thin carbonate band (ca. 1 m thick) is folded into a series of open anticlines and synclines, showing at the same time signs of boudinage. Between the boudins there are small diapirs of coarse anhydrite a few centimetres high. Near this folded bed the nodules in the anhydrite have a "streaked out" appearance, except in the crests of the folds where the normal ovate shape is preserved. These features suggest localised post-consolidation flowage in the anhydrite.

Origin of the nodular sulphate rocks

The occurrence of nodular forms of calcium sulphate rocks is now known to be common in many parts of the world. The origin of this structure has recently been discussed by WITHINGTON (1961), KERR and THOMSON (1963), MURRAY (1964), and WEST (1965). Although there is not complete agreement, the common view of these authors is that the sulphate grew in situ after the host sediment was deposited but before it consolidated. That is to say, the structure is truly nodular and not produced by flowage (RILEY and BYRNE 1961) or by slumping (RAYMOND 1962).

Abundant evidence for a similar origin for the Spitsbergen Middle Carboniferous evaporites has been found. The following points seem especially significant: –

1. The nodular structure occurs repeatedly throughout several hundreds of metres of strata which extend for hundreds of square kilometres.
2. The stratification of adjacent rocks is comparatively undisturbed.
3. All gradations exist from single isolated nodules to the chicken wire structure.
4. Occasional patches of undisturbed stratified carbonate occur within the nodular beds.
5. The larger nodules are clearly formed by the coalescence of several smaller nodules.
6. Nodules of anhydrite pseudomorphing single crystals of gypsum are sometimes found.
7. The rarely occurring enterolithic veins cut across undisturbed stratification in the host rocks.

It is thought that a similar origin can also be ascribed to the banded type. As previously described these rocks show close affinities to the common nodular type and seem to be one of its variants. The similarities to such banded rocks as occur in the Castile Formation of Texas and New Mexico are superficial, and there is no approach to the regular and laterally persistent close interbanding of sulphate and carbonate as occurs in that formation. Compare, for example, Fig. 4 of this paper with Fig. 3 of MURRAY (1964, p. 516).

Evaporite sediments of this general type are forming at the present day at many scattered localities in hot arid regions (MASSON 1955, KERR and THOMSON 1963, MURRAY 1964, HOLSER 1966, ILLING and WELLS 1964, BUTLER, KENDALL, KINSMAN, SHEARMAN, and SKIPWITH 1965). In these areas gypsum, sometimes with halite, grows within the pre-existing sediment, both carbonate and non-carbonate, in intertidal and supratidal flats. Precipitation occurs either from highly evaporated ground waters in the capillary zone, or by evaporation of periodic marine incursions. One of the most significant of these areas is just inland of the Trucial Coast in the Persian Gulf. Here, extending over approximately 1000 square miles, wide flat areas, known as sabkhas, lie only very slightly above the high water mark, and are composed of dominantly aragonitic sediment within which gypsum and anhydrite nodules and lenses are growing (BUTLER *et al.* 1965). In these sabkhas, not only do the evaporites form from the evaporation of ground waters in the capillary zone, but the saline ground waters also react with the host sediments to produce dolomite and either gypsum or anhydrite. Contorted beds or lenses and enterolithic veins of anhydrite also occur in the Trucial coast sabkhas.

In view of the close similarities shown by the nodular sulphate rocks of the Middle Carboniferous of Central Vestspitsbergen and the modern evaporites of the Trucial Coast and elsewhere, together with the evidence for growth of these Spitsbergen sulphate rocks within pre-existing sediment, it is suggested that the nodular sulphates formed in intertidal and supratidal flats in an arid climate. The presence of pseudomorphous nodules after gypsum indicates that some, at least, of the sulphate was primarily gypsum.

Sediments associated with the Middle Carboniferous sulphate rocks

CUTBILL and CHALLINOR (1965) have recently described, in general terms, the facies distribution in the Middle Carboniferous of the Billefjorden region (see for example their Fig. 7a, p. 430). As they point out, the evaporite rocks occur in the centre of a basin, passing westwards into red clastic sediments. This facies change is magnificently exposed on the north-east face of Trikolorfjellet. The eastward passage of evaporites into carbonates, on the other hand, is well known from the earlier work of GEE *et al.* (1953).

Many of the limestones interbedded with the nodular sulphate rocks contain abundant sessile foraminifera indicating shallow water deposition. The occurrence of ooliths, calcite mudstones, faecal pellet rocks, and composite aggregates of many types including bahamites (BEALES 1958), provides further evidence in favour of shallow water deposition of these rocks, possibly in hypersaline lagoons only a few fathoms deep. Comparison might be made, for example, with the Recent sediments occurring beneath the shallow hypersaline waters of the Bahama Bank (PURDY, 1963).

The coarse red beds are highly variable, often poorly sorted and lack fine material. The depositing currents appear to have been initially powerful, reworking

previous sediments, but soon decreasing in velocity with the result that only the finer grades were carried away. Streams seem to have been numerous and to have had only small channels, frequently changing course and channelling previous sediments. Sheetfloods may also have occurred. These features are indicative of deposition on alluvial fans in arid or semi-arid regions with low seasonal rainfall (ALLEN, 1965). The red shales, which separate the coarse clastics from the evaporites, would therefore be playa deposits formed from the finer grades of sediment washed out from the fans.

Thus the sediment types associated with the Middle Carboniferous sulphates are in accord with the postulated origin of these evaporites in intertidal and supratidal flats.

Discussion

Until recently thought on the origin of evaporites has been dominated by the concept of the "barred basin" (SLOSS 1953, STEWART 1963). Such evaporites as the Middle Carboniferous and Lower Permian sulphates of Central Vestspitsbergen, which occur in thick sedimentary basins, were thought to be precipitated from standing bodies of deep marine waters (e. g. SLOSS 1953, Fig. 6). The fact that many modern evaporite deposits are not of this type, but rather form during early diagenesis in environments similar to the Trucial Coast sabkhas described above, has thrown doubt on this hypothesis. SHEARMAN (1965, p. 76) has recently written – "One is tempted to enquire whether, if it had not been for the firmly held conviction that the evaporites had originated by the evaporation of standing bodies of sea water, it would not have been equally valid on the basis of the petrographic evidence to conclude that these evaporite piles were wholly diagenetic. There is good evidence for believing that some of the ancient marginal and back-reef evaporites were essentially of sabkha type; but can the concept also be extended to the so-called "basin evaporites"? Because an evaporite sequence now forms a basin-like deposit several thousands of feet in thickness, it does not necessarily follow that the sediments were deposited in a sea of that depth."

The occurrence of early diagenetic polyhalite with halite in tidal-flat sediments of the Laguna Ojo de Liebre, Baja California (HOLSER 1966), illustrates that extensive potash deposits can form in a sabkha-like environment. The nodular gypsum and anhydrite rocks in the Middle Carboniferous and Lower Permian sedimentary basins of Central Vestspitsbergen show that diagenetically formed evaporites can form thick extensive sequences. Thus there would seem to be good reason to believe that other thick sequences of evaporites, even with halite and potash salts, could form by diagenetic processes.

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Pingos in northwest Spitsbergen

BY

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Abstract

The occurence of pingos, which were observed by field parties of the 1962 and 1964 Norsk Polarinstitutt expeditions, is described. The pingos (conical-shaped and ice-cored, intrapermafrost mounds) were observed near Supanbreen (northwest Spitsbergen) in latitude 79°N. The pingos belong to the open type and the upheavel affects metamorphosed rocks of the Hekla Hoek formation.

Description

The pingos near Supanbreen were observed by one of the authors (T. VAN AUTENBOER) during the geological reconnaissance work of the 1962 Norsk Polarinstitutt expedition. The pingos were revisited by both authors during a similar survey in the summer of 1964.

The two pingos occur to the west of Kronprins Olavs Fjell, close to the southern, ice-cored, lateral moraine of Supanbreen and approximately at level with the present glacier snout (Fig. 1). The latter glacier, as the other glaciers in the area, shows evidence for a former period of greater activity. It is now completely enclosed within its morainic deposits. In summer, small streams drain the meltwater towards Möllerfjorden. Two of these temporary meltwater streamlets flow past the pingos.

The region forms a rather uniform and flat plain slowly rising towards Kronprins Olavs Fjell. Raised beaches can be seen along the coast. Vegetation (lichens and mosses) is sparse. Polygonal soils are well marked. The origin of the abundant glacial or fluvioglacial boulders (granite or migmatite) covering this plain, can be traced back to the crystalline massifs situated to the north.

The pingos occur within the metamorphic complex of the Hekla Hoek formation. In the Möllerfjorden area, this formation consists of a metasedimentary phyllitic and quartsophyllitic formation, locally containing marble beds. To the north and to the east of Möllerfjorden, this series is strongly migmatised, locally resulting in the formation of anatexitic granitic masses and Ca-silicate bearing

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marble lenses. The southern and western limit of the migmatites is formed by a thin sheet of a younger, intrusive granite.

The pingos seem to be situated in a generally north–south orientated, quartzophyllitic series. The sample of the rock of the pingo is a grey, blue, brecciated, small folded, foliated, mica quartzite interwoven with quartz veins. Locally the rock shows sulphide crystals, which accounts for the rusty colour of the outcrops. In thin section the rock is composed of quartz (79%), orthoclase (10%), plagioclase (albite-oligoclase, 4%) muscovite (4%), biotite (2%) and traces of apatite, zircon and ilmenite, partly transformed into leucoxene.

The pingos appear as two individual, partly eroded, dome shaped structures, rising 10 to 12 meters above the reliefless plain. The contrast between the rust colour of the quartzites and the grey granite of the moraine cover, accentuates the topographic accident. The alingement of the pingos is N. 45°E. The lower parts of the conical structures grade into each other (Fig. 3).

The southernmost and biggest pingo shows a perfect circular section. The stone polygons, developed all around the pingos, grade into stone stripes on their lower slopes. Higher up, the slope steepens and the country rock pierces the overlying moraine cover. The summits of the domes are occupied by a roughly circular depression. This depression shows a rather flat bottom formed by angular, non sorted quartzite blocks. This flat central part is bordered on its periphery by a shallow trench. During the 1962 visit this trench was partly filled with water. No lichens were observed on the lower part of the central depression while these are abundant elsewhere. No morainic material was observed within the craterlike depressions.

Rough measurements were made of the larger pingo which shows the best circular structure (August 1964) (Fig. 2 and 4). The estimated circumference at the foot of the rise is 300 meter, while at the top it is 65 meter. The depth of the central depression varies from 1.5 m on its southern, to 4 m on its northern side. The slope of the inner wall of the depression varies between 22° and 37°, while the outer one varies between 37° and 15°, respectively for its higher and lower part. The orientation and dip of the layering of the larger blocks forming the upper part of the pingo have been taken (Fig. 2).

The northern pingo is slightly smaller than the southern one. Its top part shows a typical horseshoe section opening towards the north-west.

Discussion

Pingos are stable, intrapermafrost features characterised as ice-cored, conical hills. The pressure, resulting in the upheaval of the pingos, is caused either by the degradation (East Greenland or open type) or aggradation (Mackenzie Delta or closed type) of permafrost. They seem mostly related to a belt of specific climatic and permafrost conditions existing in latitudes 65–75°N., where the permafrost is still continuous but thinning out (MÜLLER, 1959).

This distinguishes pingos from the mounds originating entirely within the active zone of permafrost such as icing mounds, frost mounds, etc. (LEWIS, 1962).

MÜLLER (1959) gives a very extensive bibliography. Amongst later publications we mention MÜLLER (1962) and ROSS–MACKAY (1962).

On Spitsbergen, entirely situated within the region of continuous permafrost, pingos seem to be rare. Apart from a photograph of a pingo in Eskerdalen (FITZPATRICK, 1960), the authors have found no references as to their occurrence on these islands.

The description shows that the Supanbreen pingos belong to the open type or East Greenland type, where the presence and freezing of a body of sub- or intrapermafrost water produces the required forces causing the upheavel. In our case, the possibility of the movement of this water, along a minor fracture or joint, perpendicular to the general orientation of the geological formation, seems possible. As for the origin of the water no further indications are available. Drilling and subsequent O^{18}/O^{16} isotopic analysis of the ice could furnish indications as to the juvenile or meteoric (glacial ?) origin of the hydrolaccolith. The horseshoe section of the northern pingo indicates rupturing and overflow of the water.

It should be stressed here that the upheaval of the Supanbreen pingos affects the bedrock composed of a hard mica quartzite, although in general loose material is considered to be most favourable for pingo development. As for the age of their formation, the absence of morainic material within their craterlike depression, as well as their perfectly conserved features, indicate that they were formed after the last glacial coverage. The presence of lichens, on most of the surface rocks, indicate furthermore that considerable time has elapsed since their formation.

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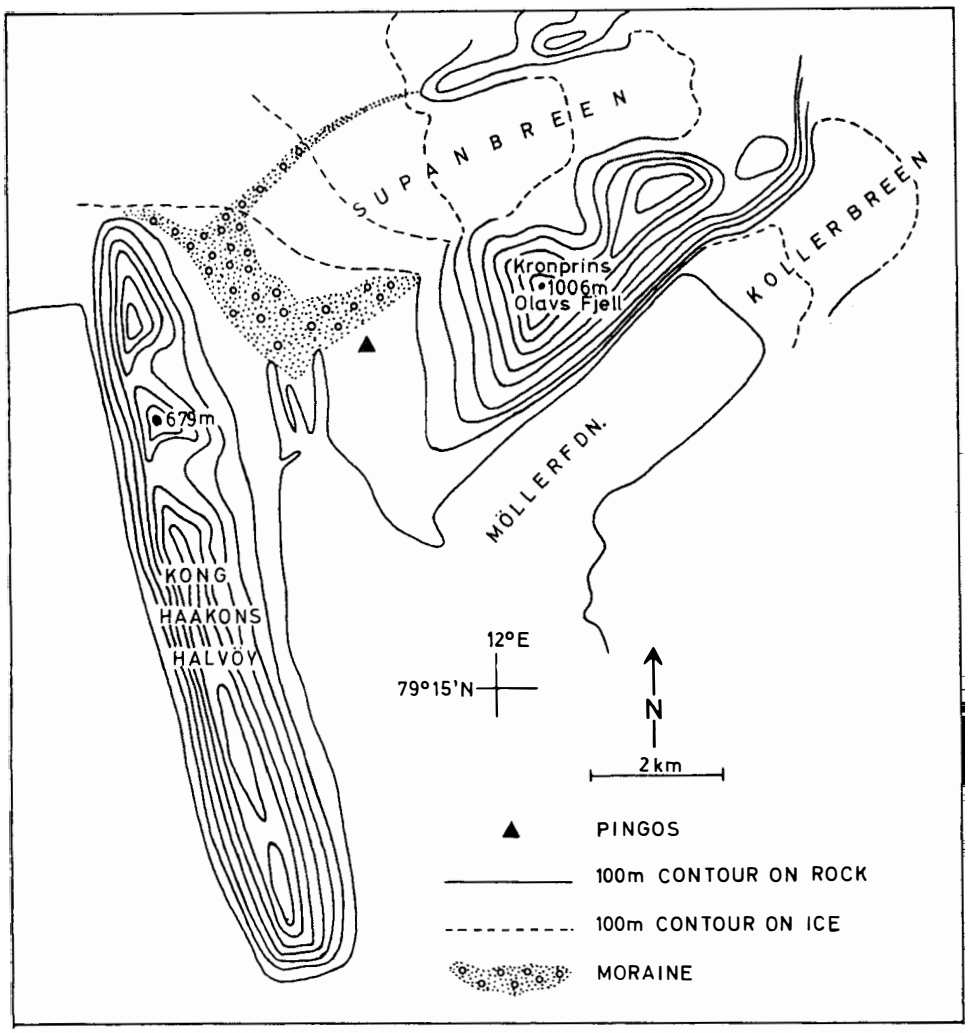

Fig. 1. *Geographic setting.*

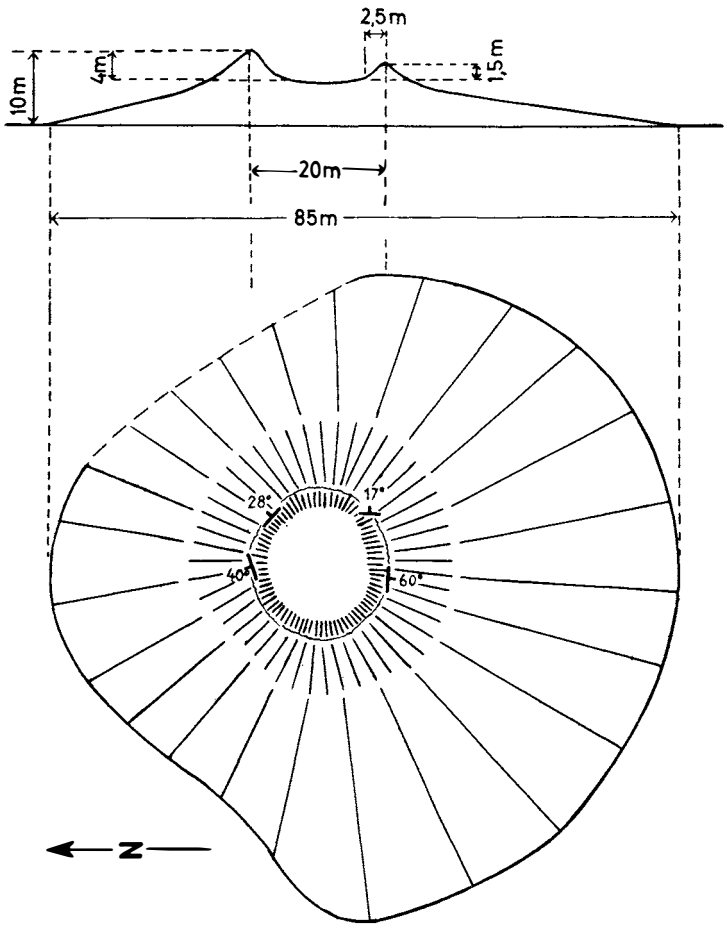

Fig. 2. *Cross section and plan of southern pingo.*

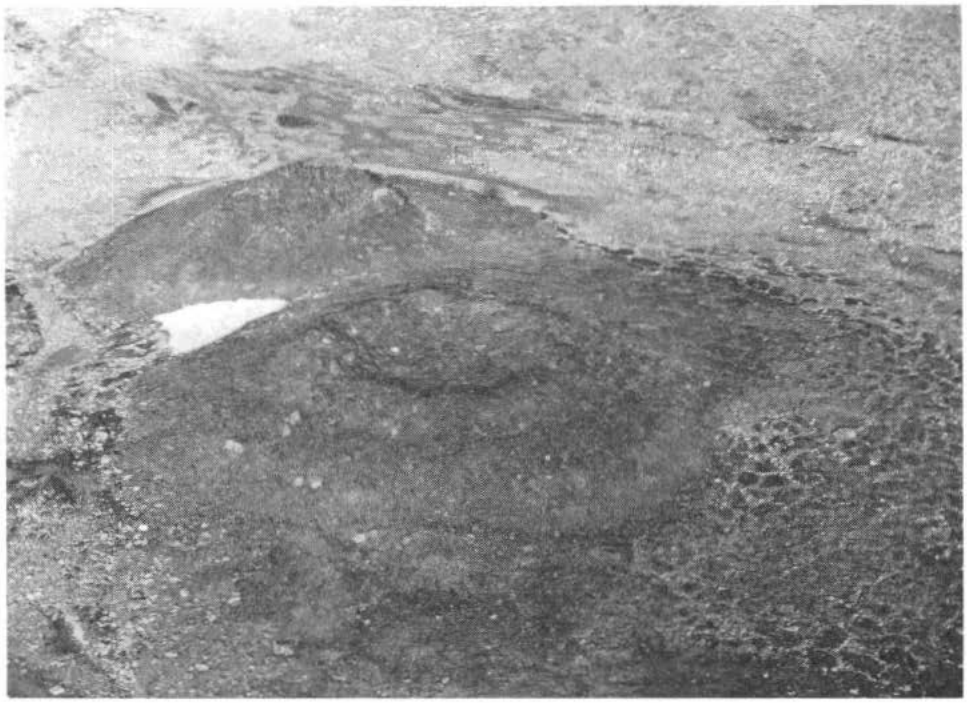

Fig. 3. *Hand held airphotograph of Supanbreen pingos. View towards the south-east.*

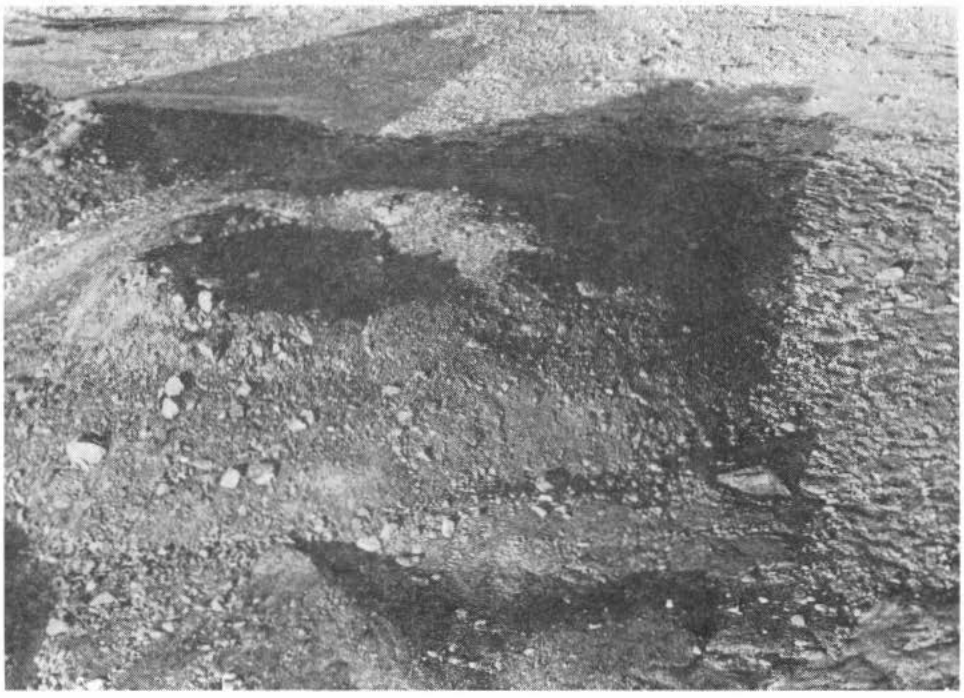

Fig. 4. *Hand held airphotograph of southern pingo. View towards the south-east.*

Some Pingos in Spitsbergen

BY

D. J. W. PIPER[1] and C. J. PORRITT[2]

During the 1964 Cambridge Spitsbergen Expedition (HARLAND 1965), three pingos were investigated in the Upper Adventdalen region. These were (1) in Eskerdalen, about 1 km east of Passhytta; (2) at the junction of Adventdalen and Helvetiadalen (Helvetiahytta is built on this pingo); and (3) in Adventdalen, 1.5 km above the junction with Helvetiadalen (Fig. 1). These observations were made by a member of party F, with the encouragement of the leader J. R. PARKER.

Pingos in this region were noted by JEREMY SMITH (1956) and an entry by him in the Passhytta book stimulated this present work. SMITH investigated the pingo in Eskerdalen and recorded the presence of an ice core.

The Eskerdalen pingo is situated on the valley floor, on Triassic shales, and is composed mainly of comminuted shale with some sandstone pebbles. There is a central mound rising about 25 m above the stream level, with a broad longitudinal hollow at the crest, this probably corresponding to the crestal fissures and craters described in pingos in the Mackenzie Delta, Arctic Canada and in East Greenland (MÜLLER 1959). Upstream is a similar mound, some 15 m high and continuous with the main mound; downstream there is another small mound, about 10 m high, separated from the main pingo by the stream (Fig. 1d). Thus the pingo has an overall elliptical outline, about 400 m long and 200 m wide. The stream is eroding the sides of the pingo. In the lateral mounds, crestal hollows are not developed and there is considerable vegetation cover. The central mound is almost devoid of vegetation and shows evidence of recent ice activity. An exposure of horizontally bedded sandstone pebbles and gravel overlying shale was noted about 20 m above the present stream level; this may represent part of the former stream bed.

The pingo at Helvetiahytta (Fig. 1 locality 2 and Fig. 2) is situated at the south west end of the flat outwash fan of Helvetiadalen. Adventelva flows round the south side of the pingo, causing considerable erosion and very steep slopes down to the river. The steepening at the base of the north side of the pingo suggests that erosion also occurs here when Helvetiaelva is in flood. The pingo is elliptical in plan, measuring 410 m from east to west and 200 m from north to south. The crest of the pingo is asymmetrical, being in the south east immediately above Adventelva. The highest point is 28 m above river level. The crestal region has a complex

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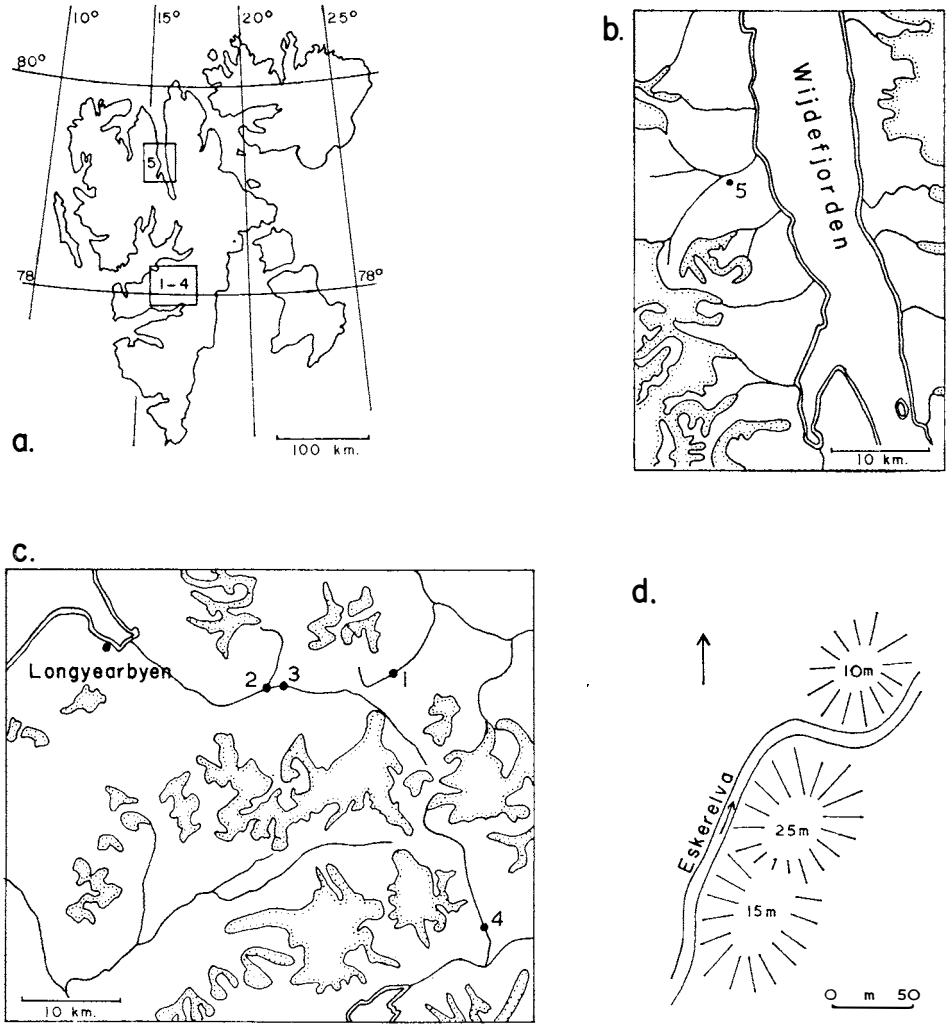

Fig. 1

a. *Map of Spitsbergen to show areas enlarged in figure* 1*b and* 1*c.*

b. *Map to show position of Pingo Locality No.* 5 *in Purpurdalen, Andrée Land.*

c. *Map to show position of Pingo Localities No.* 1–4 (1 *in Eskerdalen,* 2 *and* 3 *in Adventdalen,* 4 *in Lundströmdalen) in Nordenskiöld and Sabine Lands.*

Figures 1*b and* 1*c show coastline, rivers and ice margins and are based on parts of the North and South Sheets respectively of the Norsk Polarinstitutt* 1 : 500 000 *topographical map of Vestspitsbergen,* 1964.

d. *Detail of locality* 1.

Fig. 2

a. *Location map with Pingo Locality No.* 2 *marked by black shape; contour intervals in metres; based on Norwegian surveys.*

b. *Detail of Pingo locality No.* 2.

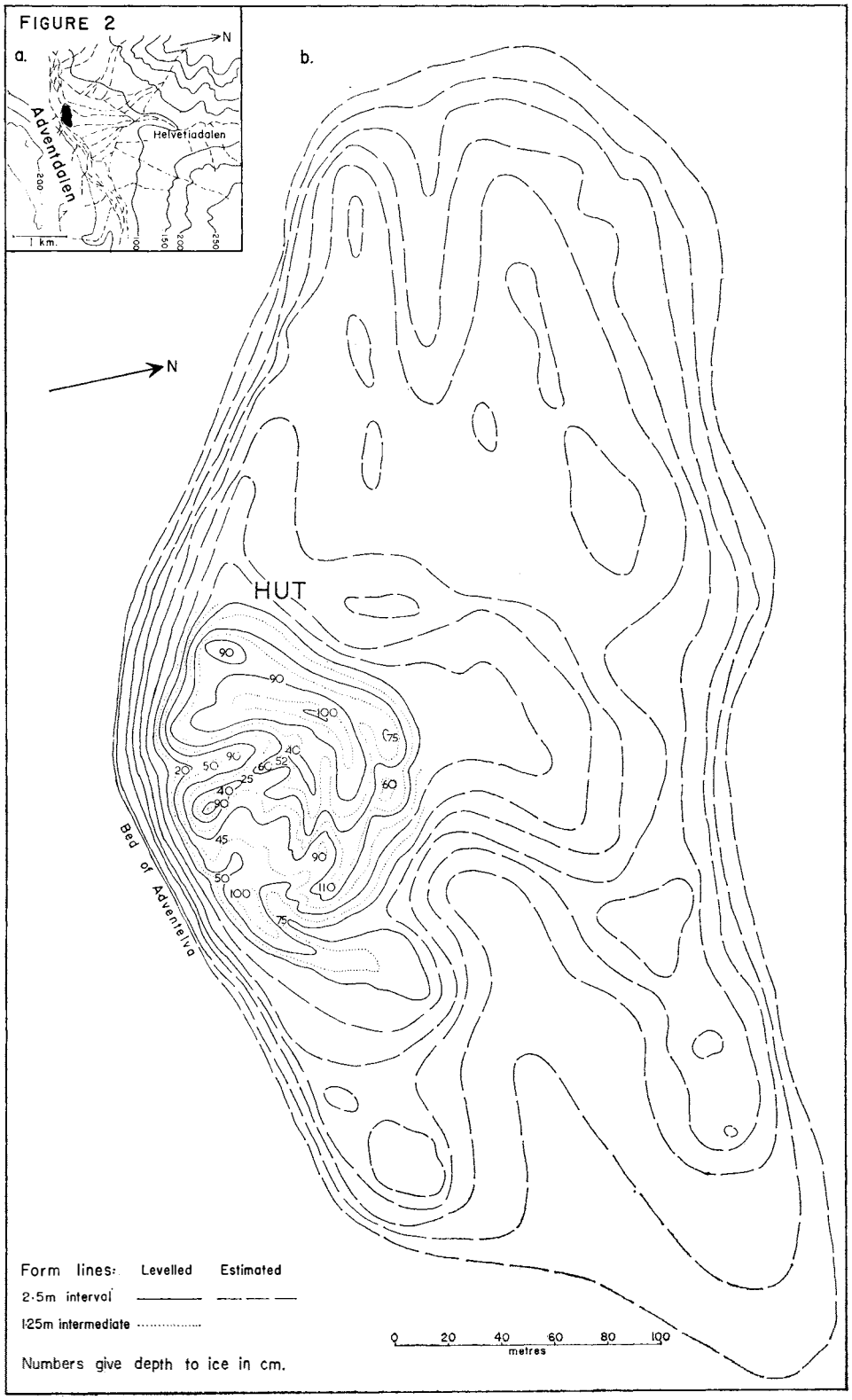
FIGURE 2
a.
N
Adventdalen
Helvetiadalen
200
1 km.
100
150
200
250
b.
N
HUT
90
90
100
75
40
20
50
90
60
52
25
60
40
90
45
90
50
100
110
75
Bed of Adventelva
Form lines: Levelled Estimated
2·5m interval
1·25m intermediate
Numbers give depth to ice in cm.
0 20 40 60 80 100
metres

topography of steep sided (up to 40°) ridges, domes and hollows (Fig. 2b). Much of the shale of which the pingo is formed appears to be freshly exposed in this crestal region. Narrow fissures (up to 10 cm across) are often found along the crests of the ridges; such fissures must be of very recent formation since the soft shale is very easily eroded. In places shale appears to have been erupted under hydrostatic pressure building up beneath a surface layer of ice in the autumn. The ice core of this part of the pingo is generally less than a metre below the surface and follows the surface topography. The topmost ice contains air bubbles but is free from rock debris. The rest of the pingo is only about 10 m high and has low angle slopes with some vegetation cover and little evidence for ice action. Ice was not found by digging to 1.2 m, but it probably exists at depth since the topography of low ridges and hollows suggests that this part of the pingo is not derived by erosion from the higher part.

Pingo 3, 1.5 km upstream from Helvetiahytta, is a single dome 90 m north to south and 50 m east to west, with a maximum height of 7.8 m. It is situated in the river bed and is being eroded at the margins. It is also composed mainly of shale and is devoid of vegetation. The surface is irregular with several small domes and hollows. The ice core was found to be at less than 1 m depth over much of the pingo including the edges.

A pingo, with a small lake in the summit crater was seen by PARKER in 1964 at the south end of Lundströmdalen (Fig. 1c, locality 4). Another pingo, about 30 m high developed in raised-beach sediments with a well-formed central crater, was noted by FRIEND in 1958 (1959) on the south side of Purpurdalen, Andrée Land, about 4 km inland (Fig. 1b).

These Spitsbergen pingos resemble those described by MÜLLER (1959) from East Greenland as "open system type" pingos. Like those in East Greenland they occur on valley floors, either singly or in clusters. The Helvetiahytta pingo (2) shows reactivation in part of an otherwise inactive pingo, as found in some East Greenland examples. However, the springs and lakes at the crests of many of the pingos described by MÜLLER are far less common in Spitsbergen.

AILSA B. REYNOLDS drew the figures and W. B. HARLAND prepared this paper for publication.

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Peter I Island

BY

G. LEONARD JOHNSON[1]

Introduction

Peter I Island was discovered January 22, 1821 by Captain VON BELLINGSHAUSEN in command of the Imperial Russian corvettes "Vostok" and "Mirni" who approached within 15 miles of the island (DEBENHAM 1945). January 17, 1927 the Norwegian whale catcher "Odd I" circumnavigated the island and took a few shallow soundings and 5 dredge samples (RABOT 1927). The second "Norvegia" expedition reached Peter I Island on February 1 1929. The expedition landed and claimed the island for Norway (HOLTEDAHL 1929, GJELSVIK 1963). The island was next visited February 10 1948 by the "Brategg" expedition (MOSBY 1956). The Russian icebreaker "Ob" investigated Peter I Island during cruise 4, however the sounding data are not available at this time. The USS "Burton Island" during the period February 28 to March 1 1960 conducted a reconnaissance survey on the insular shelf and slope of Peter I Island. A nonprecision UQN echo sounder was emplyed to obtain over 540 kilometers of soundings. Combining these data with "Brategg", "Norvegia", "Eltanin" (Cruise 11) and "Atka" soundings a new bathymetric chart has been prepared.

The echo distances have been converted to corrected meters in accordance with MATTHEWS (1939) for area 27. No slope corrections have been made. Soundings were read at every peak, trough, or change in slope. The "Burton Island" survey positions were determined by radar fixes in the island at 10 minute intervals. The radar pictures taken by the "Burton Island" resulted in the construction of a new and more accurate chart of Peter I Island (H. O.chart 6713). The main differences with earlier charts was to lessen the areal extent of the island and give a more accurate altitude to Lars Christensen Peak (1752 meters).

Peter I Island is a heavily glaciated extinct volcanic pile. The island is almost entirely capped by ice with rock outcrops being generally restricted to cliff areas. Peter I Island is about 20.4 kilometers long in a north-south direction and approximately 10.2 kilometers in width. In profile the island is unsymmetrical with the east side dominated by Lars Christensen Peak, while toward the west the island is fairly low and level. The northern and southern extremities of the island are also low lying and are covered with tabular ice flows. CRADDOCK *et al.* (1961)

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reported the exposed rocks at Norvegia Bay were "gray to dusky red, dense to vesicular basalt flows and bedded tuffs which are cross-cut by basic dikes and an hypa-abyssal plug." Dredge samples from the "Odd I" cruise were examined by BROCH (1927). Broch described the majority of samples as an olivine-basalt porphyry. He also reported an andesite and trachy-andesite. CRADDOCK *et al.* (1963) collected samples at Norvegia Bay in 1960 which were olivine-basalt porphyries. CRADDOCK *et al.* (1963) on the basis of chemical and petrographic analyses state that the basalts are similar to the Jones Mountains Tertiary basalts found on the Eights Coast of the Bellingshausen Sea.

Raised beaches are present on the island, however; from the evidence of the embayed coastline it would appear that overall subsidence has been dominent. HOLTEDAHL (1929) attributes the steep eastern side of the island to greater wave erosion on that coast caused by the prevailing strong easterly winds.

Submarine geology

Peter I Island is the subaerial peak of a large seamount. The extension of this seamount is not perfectly known but it probably extends about 15 kilometers in all directions. A restricted archipelagic apron indicative of ponded sediments occurs at the base of the slope at approximately the 4000 meter isobath.

The insular shelf of Peter I Island is almost circular and represents the bevelled portion of the original volcanic pile (Fig. 1). The width of the shelf varies from 1.9 kilometers on the southwestern portion to 5.6 kilometers due east of Tofte Glacier. The insular shelf on the west and east of the island averages close to 5 kilometers. The shelf break was observed by the "Burton Island" to be 180 meters on the northern portion of the island, 130 meters to the east and 180 meters to the west. The shelf break was not traversed to the south of Peter I Island; however, spot soundings hint that it may be somewhat shoaler (110 meters). Where crossed by the "Burton Island" the insular shelf was smooth; however, the presence of glacial activity on the island makes it highly unlikely that the insular shelf is smooth in its entirety.

The insular slope is precipitous. The north, south and west sides of the insular slope average 1 : 3 in gradient to the 2000 meter isobath (Fig. 2), thence lessening to 1 : 5 to the base of the insular slope. The slope on the northeast is extremely steep to the 1000 meter isobath. East of the island two submarine spurs are present. The broadly indented lobate nature of the island is suggestive of underwater volcanic activity. Submarine canyons or channels probably exist in the inter-lobal valleys and would be revealed by use of a precision echo sounder.

The archipelagic apron smooths what is otherwise a rather irregular continental rise (Fig. 2 profile 1). The apron is rather poorly developed ranging in width from 20–60 kilometers (Fig. 2). This is most likely a reflection of the rather limited source area for the sedimentary detritus. Greatest development of the archipelagic apron is found to the west and the least to the south. This is expected as the northward flowing Antarctic bottom water would tend to be an erosional rather than

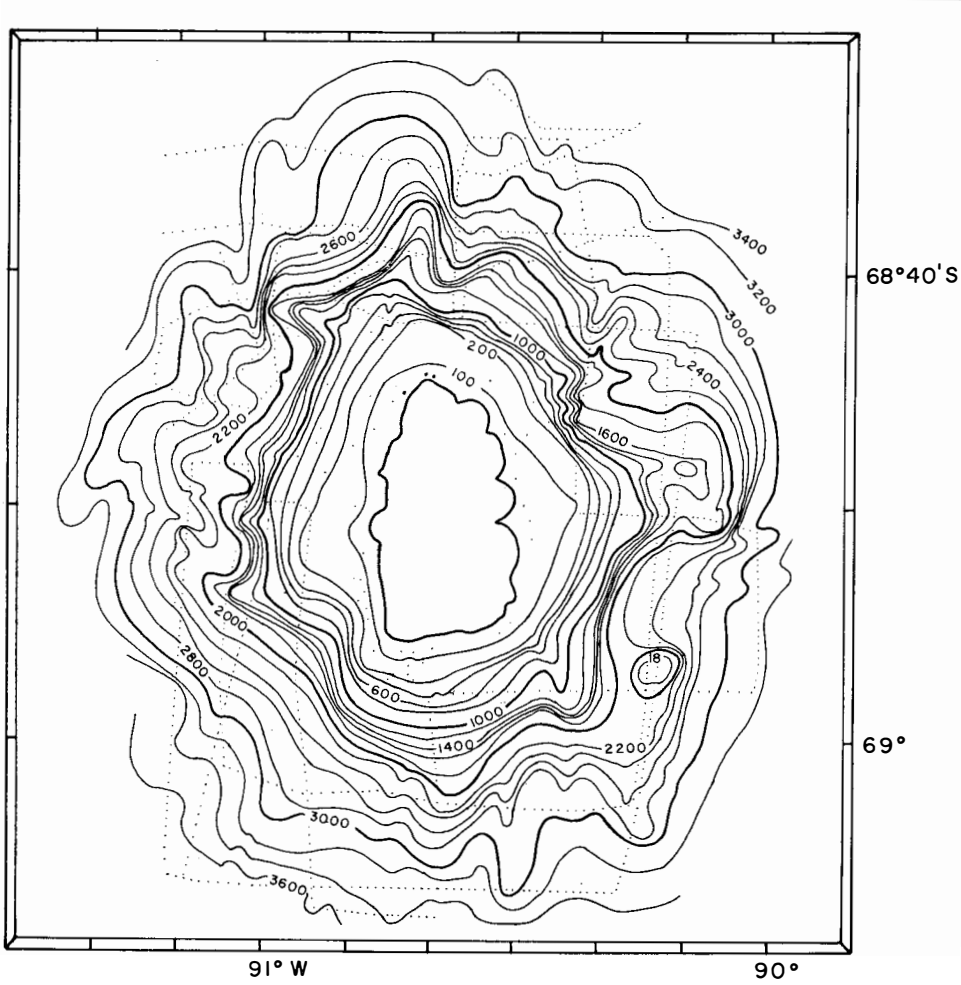


Fig. 1. *Bathymetric sketch map of Peter I Island. Contour interval is 200 meters. Dotted lines indicate control.*

depositional influence on bottom sediments. The dominantly westward winds in the vicinity of Peter I Island with the resultant heavy surf on the east side of the island will tend to sweep the sedimentary detritus toward the west. In the southern oceans the surface currents tend to flow to the east; however, a local gyre appears to be present in the neighborhood of Peter I Island.

Peter I Island as with most islands (MENARD 1964) appears to be surrounded by a moat or depression of the sea floor (Fig. 2). The moat is deepest to the west of the island and of about an equal depth of 4150 meters to the north and south. It is shoalest to the east. The moat is probably caused by general subsidence of the volcanic pile. The existence of scour as inferred from the coarse bottom sediments raises the possibility that erosion or nondeposition by bottom currents may be a factor in the causing or maintaining of the moats.

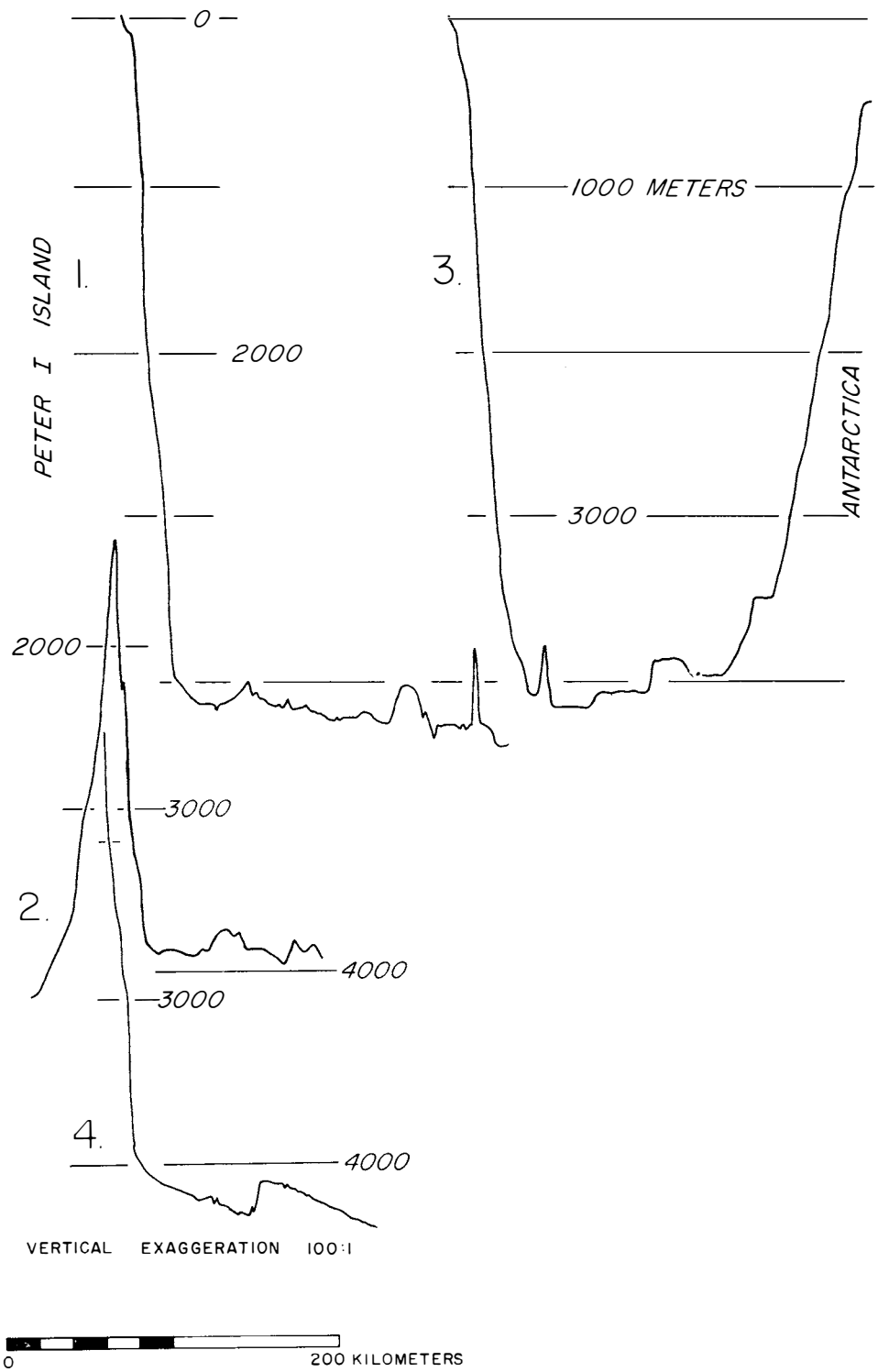


Fig. 2. *Four profiles of the insular margin of Peter I Island. Profiles are indexed in figure 3.*

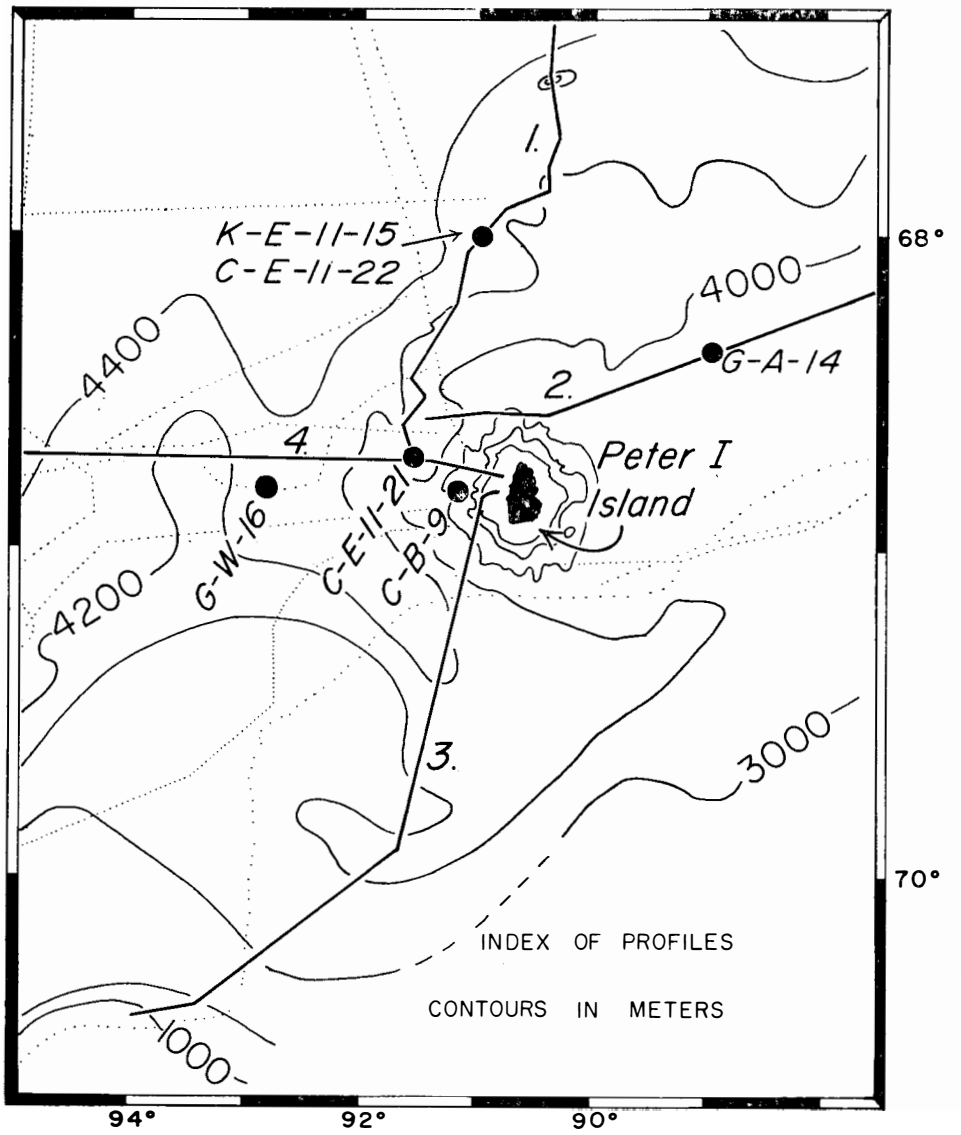


Fig. 3. *Index of profiles, bottom samples and camera station. K= camera station, C= core ("Eltanin" were piston cores and the "Burton Island" a gravity core) G= grab sample. Dotted lines are control for the generalized isobaths.*

Sediments

In the area of Fig. 3 HOLLISTER and HEEZEN (1966) on the basis of underwater photographs, generalize the sea floor as being basically mud with a scattering of glacial erratics of all sizes and shapes. One bottom sample (B-9) was taken on the insular slope and the other four are located on the archipelagic apron of Peter I Island. Table 1 is a list of the bottom samples and the analyses of each which are available at the present time. The two piston cores E-11–21 and E-11–22 were taken by "Eltanin" in January 1964. These cores were opened and analysed

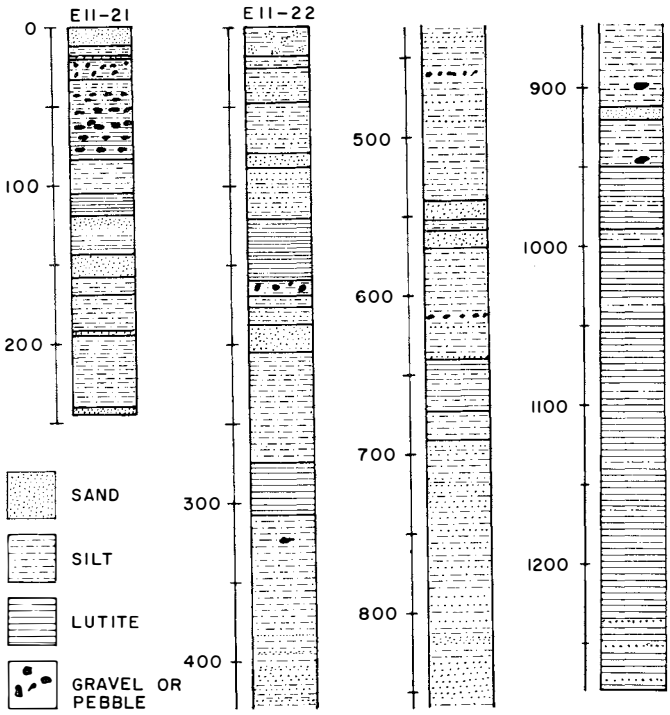


Fig. 4. *Graphic description of "Eltanin" cores E–11–21 and E–11–22. Depth scale is in centimeters.*

by Florida State University (GOODELL 1965). Figure 4 is a pictorial representation of their description.

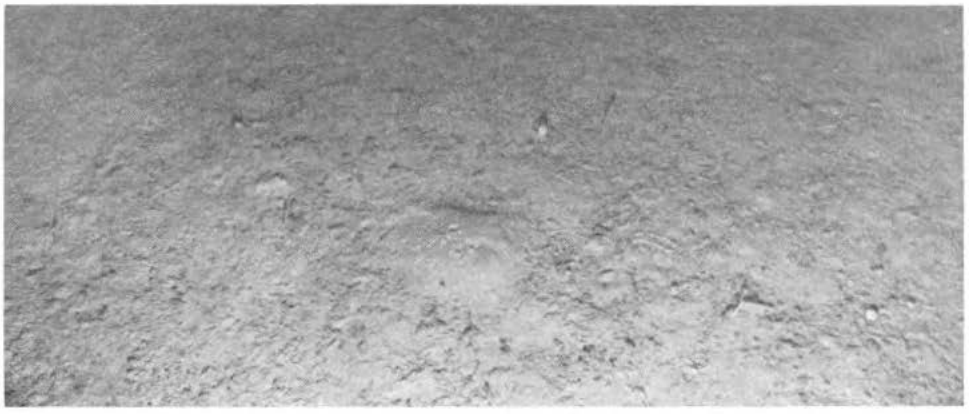
All five bottom samples consist primarily of material of the sand or silt size. In core B-9 taken on the insular slope Peter I Island the analysis revealed sediment ranging from poorly to very poorly sorted (Table 1). This core consists primarily of silts with a few glacial pebbles. Silts are common on continental slopes. The sorting index and sediment type are probably a reflection of both glacial activity and gravity flows.

The four samples from the archipelagic apron are also poorly sorted sands and silts (Table 1). These sediments probably are the coarser residue of the normal terrigenous sediment generated by Peter I Island and the neighboring coast of Antarctica. The fines are presumably carried north toward the Bellingshausen Abyssal Plain. Glacial erratics are common (Fig. 4 E-11–22 at 320 cm, and Fig. 5). The predominance of sands and silts necessarily causes a low organic carbon percentage, and also influences the carbon/nitrogen ratio. Chlorite predominates over illite two to one and in core E-11–22 the calcium carbonate percentage is 5.42 (GOODELL 1965).

Bottom photographs

"Eltanin" camera station 15 (Figs. 3 and 5) was taken in conjunction with "Eltanin" core E-11–22. The surface as revealed by coring is a silt. In Fig. 5

Fig. 5. "*Eltanin*" *camera station* 15: *69°00.5′S., 91°00′W., 4223* meters.
a. Tranquil bottom. Benthic life present includes brittle stars, worm tubes, and coiled invertebrate feces.



b. Tranquil bottom. Benthic life present includes brittle stars, worm tubes and stalked benthic life. The mound with a hole in the center is of probable organic origin.

c. Tranquil bottom. Benthic life present includes a holothurian and brittle stars. Note sediment starting to accumulate on the surface of glacial erratics.
Photographs include an area of approximately 1 × 2.5 metres.

Table 1. *Analyses of bottom samples*

Bottom Sample	Position N. & W.	Depth (cm)	Pebbles	Sand	Silt	Clay	Mean	Standard Dev.[1]	% Carbon	% Nitrogen
B–9	68–47, 91–11	0–7.5	2.525	10.606	71.381	15.488	5.520	2.486	0.173	0.077
		7.5–15	0.202	4.848	77.778	17.172	5.980	1.852	0.393	0.264
		15–25	0.202	5.859	77.778	16.162	5.914	1.823		
		25–27.5	0.202	4.849	78.115	16.835	5.955	1.847		
A–14	68–22, 88–57	0	8.594	76.229	12.400	2.776	2.628	2.811		
W–16	68–49, 92–50	0	0.625	1.942	54.694	42.739	7.534	2.160		

[1] Standard deviation = size sorting; 1.00 to 2.00 = poorly sorted, 2.00 to 4.00 = very poorly sorted.

the bottom is seen as being quiet with no evidence of bottom currents. The sea floor is littered with rocks of all sizes and shapes which have been rafted away from the land masses by glacial action. There is no evidence of scour by bottom currents in this locale. Sediment is seen accumulating on the surface of some of the fresh glacial erratics (Fig. 5 photo c). Benthic life is present although not abundant. Tracks, trails and feces are the exception rather than the rule. A high rate of sedimentation is indicated by dating of the radiolaria contained in the deepest layer penetrated by core E-11–21 (J. HAYS personal communication). This sand layer is no older than 400,000 years and is probably considerably younger.

Discussion

Peter I Island appears to be an isolated volcanic pile. There is no obvious topographic connection to a seamount chain or underwater ridge. The island has suffered considerable erosion and is now smaller in extent than in the past. Peter I Island, as with most islands, has an insular moat. The archipelagic apron is restricted in development. The sediment distribution for the region is dominated by sands and silts reflecting both bottom currents and glacial activity.

Acknowledgements

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The hood and its extrusible balloon in the hooded seal - *Cystophora cristata* ERXL

BY

BJØRN BERLAND[1]

Abstract

The structure and morphology of the hood, which is the greatly enlarged skin of the snout, of the male hooded seal, *Cystophora cristata* ERXL. are described; some of the literature is reviewed. This hood, which is absent in females and immature males, appear as fleshy "Roman" noses in young mature bulls, becoming progressively larger with increasing body size and age. Bulls larger than about 220 cm and older than about 13 years always have large hoods.

In addition to the hood proper, the bull is known to occasionally blow out curious balloons through his nose. Theoretical considerations led the author to believe that the highly elastic mucous nasal septum could be extruded through either nostril by internal air pressure and by keeping the other nostril closed. Experimental inflation of hood and balloon, carried out on cut-off heads, is described; the balloon became extruded as expected. The possible function of hood and balloon is discussed.

In the adult male hooded seal the skin of the snout is greatly enlarged to form an inflatible hood. When uninflated this hangs down in front of the snout proper as a kind of "proboscis". This proboscis has given the species its name in most languages, as well as in Latin; thus it is called *hooded seal, crested seal* and *bladder-nose* in English, *Klappmütze* in German, and in Norwegian *klappmyss*, while the Norwegian terms *hettekall* and *hettegubbe* are restricted to the males only.

The presence of a proboscis is shared with the southern and northern elephant seals (*Mirounga leonina* (LIN., 1758) and *M. angustirostris* (GILL, 1866)), together with which the genus *Cystophora* NILSS., 1820, constitute the subfamily *Cystophorinae* GILL, 1866 within the family *Phocidae* BROOKES, 1828. However, the "proboscis" of the hooded seal differs from that of the elephant seals by being inflated by air, while in the southern elephant seal (*M. leonina*) at least, it is erected by muscular action and vascular pressure, though it may be supplemented by forcible expiration of air (LAWS, 1953; p. 14). This is clearly seen on close-up photographs of elephant seals; in the erected proboscis, the nostrils are wide open. At very close quarters I have on several occasions observed wounded hooded seals close the nostrils before the hood was inflated.

The immature hooded seals of both sexes and the adult female are without a hood. However, their noses are rather fleshy and in front of the eyes there is a

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sulcus or groove across the nose (Pl. 1, fig. 1). The inflated hood of the male may be divided by an indentation above and in front of the eyes, but it can also be inflated to such an extent that all traces of this constriction disappear.

The head and face of both adult male and female hooded seals are always dark. This also applies to the hood which is covered with short, rather stiff black hairs. COLLETT (1912) wrongly says that the male hood is brownish red, which, it may be argued, is the colour an old faded museum specimen may attain.

The hood, being such a prominent feature of the male, has naturally attracted some attention in the past, but the descriptions and illustrations of this are not always satisfactory. The male and its hood was mentioned and depicted by EGEDE (1741). Later, FABRICIUS (1780) correctly described the hood as an inflatable crested skin fold covering the forehead. MERRIAM (1884), having seen the species in the wild, also correctly described the hood as an inflatable proboscis protruding considerably beyond the mouth, which it overhangs. This rectified the previous belief that the hood was a "bunch" on top of the head. WOLLEBÆK (1907) presented a drawing of a male hooded seal, where the hood started at the back of the head and gradually increased in height forward. This drawing was obviously made from a mounted museum specimen.

It is not intended here to give a full list of the pertinent literature on the hood, but a few points of interest may be made. BRØNSTED (1931), describing the anatomy of the male and female head, mentions the snout cartilage (*septum cartilagineum*) with its two triangular flaps (*processi lateralis dorsi*) hinged to the former and being turned out laterally when the hood is inflated. These flaps were also mentioned by OLDS (1950), but he believed them to function as a shutter of the nasal passage between the nares and the naso-pharynx. Some experimental work on live animals will obviously be needed to elucidate their function.

It shall here be mentioned that POPOV (1961) recently described and presented drawings of the male head and hood, and MOHR (1963) presented numerous illustrations of captive male hooded seals.

As said above, the hood is absent in immature males. NANSEN (1924, p. 160) wrote that the adult colouration is possibly complete at four years of age; the hood is then fully developed. According to my experience, the dark patches characteristic of the adult colouration may begin to appear at the second moult, that is at an age of a little more than two years, but more often they make their appearance at the third moult. The hood is definitely not fully formed at such an early age, as suggested by NANSEN. A slight swelling of the nose may be perceptible in males as young as three years, but at the age of four the hood may generally be said to be very weakly developed. The hood is small between four and about eight years. Such young bulls with slightly developed hoods have distinctly "Roman noses" (Pl. 1, fig. 3).

Between the ages of about eight and thirteen years the hood is normally of medium size, while large or very large hoods are normally present in males above this age. On the other hand, there appears to be considerable individual variation in hood size. The size of the hood is, however, not only dependent upon the age of the bull, but also on his body size. In specimens whose body length (nose-tail)

is less than about 185 cm, the hood is inconspicuous. A small hood is present in those about 190–200 cm long, while a medium-sized hood is present in those about 200–220 cm. Above this body length the hood is always large. It is therefore apparent that the hood gradually becomes larger with increasing age and body size.

It was said above that the uninflated hood hangs limply down in front of the mouth. This is quite conspicuous when the resting bull raises his head at intervals from the ice. When undisturbed the hood may be inflated; this I have often observed through binoculars. Particularly during the whelping and mating season, when threatened by an approaching vessel or men, the hood is inflated several times in succession. The beast may play with the hood, shifting air between the anterior and posterior parts of it, so that they are inflated alternately, or he may inflate it so that the transverse indentation clearly marks it off into two parts (Pl. 1, fig. 4). The hood may, however, be inflated to such an extent that this constriction becomes obliterated. The inflated hood is somewhat compressed from side to side.

In addition to the mere inflating of the hood proper, the male is able to extrude through his nostrils a red balloon or bladder. This has long been known to the sealers, but apparently the first reference to this remarkable feat was made by OLDS (1950) as follows: "The sealers will tell you that if you get him mad enough he will blow gert bladders out of his nose. This is so. The redundant mucous membrane is extruded as fiery red paired "bladders" six to seven inches long and five to six inches in diameter". To these curious bladders even FABRICIUS (1780) may have referred by writing "praeter nares veras mares etiam habent spurias in tuberculo, iam 1, iam 2, pro aetate".

MOHR (1952) presented a photo taken in the field of a live male actually extruding these "balloons", but it is not immediately apparent from the photo that there is a pair of them. From the study of a museum specimen she claimed to have found a pair of evertible caeca, which would appear to be turned inside out much in the same manner as glovefingers, in its nose. In a later publication (in EHLERS *et al.*, 1958), she corrected this by explaining that the mucous membranes of the nose had been carefully skinned together with the hood, thus giving the appearance of two evertible caeca.

Between 1956 and 1960 I spent a number of seasons on board commercial sealing vessels in East Greenland waters. Being a little puzzled by these paired balloons mentioned by OLDS and MOHR, and the explanation given for their extrusion, I made enquiries about them among the sealers. It became apparent that they really do exist. However, examining many hooded seals I was unable to find the slightest trace of any additional evertible sacs in their noses. Talking to the sealers, it became clear in March 1958 that there were not a pair of bladders, but only a single one being extruded at a time. I have later seen many males blow up both hood and balloon, the latter unfortunately never at close quarters, but it is certain that only one balloon is extruded. On several occasions I had the opportunity to examine males, within minutes after they were shot, which were known to have extruded this red balloon immediately before the shot struck. No plau-

sible explanation for this balloon was arrived at until at the end of March 1958 I examined a male which had extruded it minutes earlier. When feeling inside his nose, I more or less by chance (and a little exasperation) pulled with my fingers at the membraneous nasal septum. This appeared very elastic and was easily pulled out through one of the nostrils (Pl. 1, fig. 5).

Based on this observation later repeated in other males, the following explanation, which appeared as a short note (BERLAND, 1958), was arrived at. The posterior cartilaginous nasal septum (*septum cartilagineum*) remains short. As the nasal cavity of the hood is divided into equal lateral halves, the anterior membraneous nasal septum, extending from between the nares to the cartilaginous septum, becomes considerably developed as the hood increases in size with age. In well developed hoods, this membraneous elastic septum is very large and thick. By closing one nostril only, and by blowing air into the hood, only the closed half of it will commence to inflate. If, however, at the same time the hood is kept low by muscular action, then the pressure in the closed half will force the elastic septum to bulge into the opposite open half. By sufficiently high internal pressure, the anterior membraneous nasal septum is extruded through the opposite open nare as a balloon (Fig. 1).

This was a theoretical explanation only, which had to be verified experimentally. During the summers of 1958 and 1959 I on several occasions selected heads of large bulls to inflate their hoods artificially.

By suturing one nostril and closing the posterior corresponding choana, the nasal cavity of one side thus closed, this was inflated by the use of a hypodermic needle, rubber tube, bicycle valve and pump. When now by hand exerting some pressure on the inflated hood, thus forcing it down against the skull, the *anterior membraneous nasal septum was made to bulge and to be extruded through the opposite*

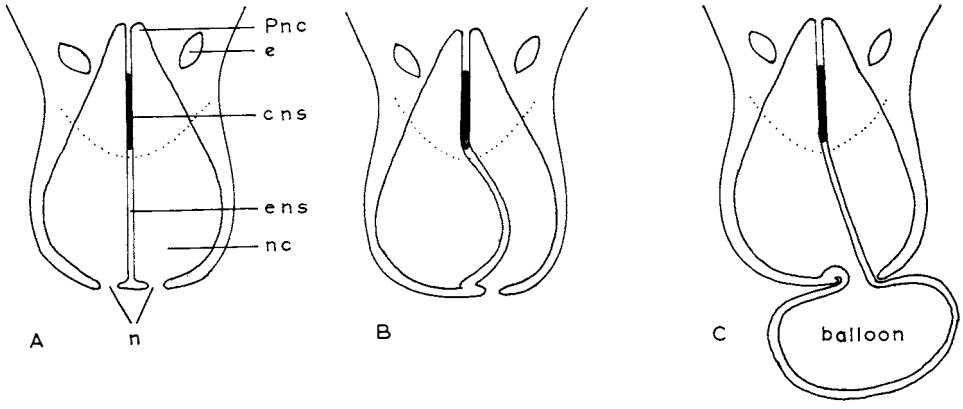

Fig. 1

Schematic drawing of the extrusion of the balloon.

A. Both nostrils are open, nasal cavities normal.

B. *One nostril closed, internal air pressure forces anterior elastic nasal septum to bulge.*

C. By sufficient internal air pressure the anterior elastic nasal septum becomes extruded through the open nostril as a balloon.

e – eye, n – nostril, ens – elastic nasal septum, cns – cartilaginous nasal septum, nc – anterior nasal cavity, pnc – posterior nasal caeca.

and open nostril – as predicted. This experiment was repeated with many heads, and the amount of air pumped into each varied. When only slightly inflated, and by some gentle manipulation, the little balloon appeared bilobed (Pl. 1, fig. 6) but this observation needs confirmation on live animals. When much air was pumped into the hood, it rose upwards to nearly incredible size, but no balloon appeared. However, when forcing the hood proper down against the skull, the balloon became extruded through the open nostril (Pl. 1, fig. 7). The size of the hood and balloon is really startling in these experiments; the experimentally inflated hood and balloon shown in Pl. 1, fig. 6, are undoubtedly more inflated than it would be in the live animal. In Pl. 1, fig. 6 both hood and balloon are inflated at the same time, but we shall not forget that *in life the hood is small when the balloon is fully blown up*. These experiments have previously been briefly referred to in a short note (BERLAND, 1959).

I should like to mention that I a few times have seen males shot dead with the balloon extruded (Pl. 1, fig. 8). This fact appears to support my theoretical explanation and experimental results.

In life, the size of the hood proper and the balloon alternate – when the hood becomes reduced in sice, the balloon makes its appearance. Contraction of the muscles in the wall of the inflated hood is probably responsible for this reduction. In the experiments the choanas were closed artificially, but the mechanism of extrusion of the balloon in the live animals may only be guessed at. Either the pressure in the lungs must be greater than that in the inflated and contracting hood, or the naso-pharynx must somehow be closed to prevent air from being forced back into the lungs. It is not easy to see how the posterior choanas can be constricted, as the soft palate is rather short, if then the cartilages of the larynx should not somehow block the passage, but this possibility does not seem very likely. Anteriorly, the triangular flaps, *processi lateralis dorsi*, may be thought to play a role in closing naso-pharynx, but as the mass of muscles is placed lateral and dorso-lateral to them, this may not be feasible either. If then any closure of the naso-pharynx is not likely to occur in the live animal, it is somehow necessary for the membraneous nasal septum to quickly cover the opened nostril before too much air is lost through it. Further research only may give a satisfactory explanation to these aspects of the mode of extrusion of the balloon.

According to the sealers (BERLAND, 1958) it seems as if two balloons are present. The fully inflated balloon was assumed to be divided into two lobes, the whole structure appearing heart-shaped when viewed from above. The last is certainly not correct, as the fully blown-up balloon is evenly curved. Since my note appeared, I have met more sealers, who having seen the entire extrusion, claim that in the beginning, it appears as if two lobes are present. One in particular, who had observed the process repeatedly at very close quarters, claimed that when the balloon is quite small, it is two-lobed, much as if a string had been held vertically in front of it. My experiments may indicate that the balloon is lobed when it is still small, but I am unfortunately not in a position to give personal observations on live animals on this particular point, as I never had the luck to be that close to a male blowing up the balloon.

In the field the balloon is extruded several times in quick succession, the head often being shaken up and down when the balloon is out. Several sealers claim that the bull may blow the balloon out through either nostril, and that he even may evert it alternately through the left and right ones. From an anatomical point of view it seems possible for him to do so.

As mentioned above it appears that the balloon is not extruded at the same time as the hood proper is inflated. On the other hand, I have often seen the hood being blown up first, and as this was decreasing in size, the balloon would appear. It thus seems that the hood and balloon are inflated alternately, which the experimental results also seem to indicate. The hood is blown up with both nostrils closed, if one is opened the balloon will appear as the hood shrinks. However, the inflating of the hood proper is of very common occurrence, while the extrusion of the balloon is much more rarely observed.

The extruded balloon is normally bright red in live animals, this is probably caused by the blood present in the vascularized mucous membrane of the anterior elastic nasal septum. However, I have also observed it to be rather dark. The membranous nasal septum is normally of light colour, but I have sometimes found it somewhat darkly pigmented.

After my note of 1958 appeared, EHLERS *et al.* (1958) presented photos of the captive male "Hansi" with the balloon extruded. The balloon appeared to be of the same shape as in my experimental cases, although it is smaller.

MOHR (1952), in trying to find the anatomical base for the balloon, referred to BRØNSTED (1931) who mentioned the presence of posteriorly directed nasal caeca. What BRØNSTED explained, and this is easily observed by examining any male hood, is that the anterior part of each nasal cavity, that is of the hood proper, extends dorsally and posteriorly *above* the nasalia ("tectum nasi") *below* the skin of the snout. These caeca reach posteriorly to a level between the orbits (Fig. 1). The posterior ends of the nasal caeca accordingly mark the posterior border of the inflated hood. The hood will thus posteriorly rise from the head somewhat behind the eyes (Pl. I, fig. 4), and not from the neck region, as earlier illustrations tend to indicate.

When a sealing vessel approaches a "family" of hooded seals in the whelping season, or when men stalk it on the ice, it is not uncommon to observe the male inflate the hood and extrude the red balloon several times in quick succession, while shaking his head up and down. This, together with OLD's statement that he blows "gert bladders" if he gets mad enough, led me to believe that the extrusion of the balloon was confined to the mating and whelping season in spring (BERLAND, 1958), when the male is rather exitable and bad-tempered.

Later, however, I have several times during the whelping season through binoculars seen single males resting calmly on the edge of the ice floes, as is often their habit, leisurely blowing up alternately hood and balloon. During the moulting season in June and July in the Denmark Strait I have sometimes seen males also blow up the balloon, not only the hood. In particular I remember one day in the beginning of July 1959. Through binoculars, the animals far ahead of the vessel were seen to rest calmly on the ice. Now and then they lifted their heads leisurely,

and some males would inflate their hoods. At least one of them also blew out the balloon several times, moving his head up and down while doing so. EHLERS *et al.* (1958) stated that the captive "Hansi" was seen to extrude the balloon through his nose when completely undisturbed. It thus seems that the balloon is not only blown out during the whelping and mating seasons or when the animals are alarmed, but also during the summer and when they are at complete rest on the ice.

The hood is obviously used to impress and frighten competitive males and intruders, as seen when a vessel or men approach. However, when men get too near him he does not always inflate the hood, at least I have seen men fighting a most lively male with wooden poles without the hood being inflated, but the loose "proboscis" was of course swinging violently with the movements of the head.

I have many times seen males in the water audibly expire before submerging, so the hood is definitely not used as an air-reservoir during diving. It thus remains that the hood must be a secondary sexual character, which may be of some use during fighting in lessening the impact of blows on the forehead. But what is the function of the balloon? According to LAWS (personal communication) a balloon is not observed in the elephant seals, and its presence in the hooded seal is therefore unique within the mammals. It is simply also an additional secondary sexual character, being an extension, so to speak, of the hood proper? Is it, perhaps augmented by its red colour, used to impress, scare or frighten even more so than the hood proper? This may be the case. But, it may also be possible that the balloon, presenting a large, warm and moist extruded mucous membrane, plays a role in the heat regulation of the male? It may be argued that in that case a balloon would be an advantage also to the females and immature specimens. But, on the other hand, the bulk of the bulls is much larger in relation to body surface than in the females and juveniles.

EHLERS *et al.* (1958), dissecting the captive "Hansi" upon his death, experimentally inflated the hood by forcing air into the trachea. They then found the ventricle to be filled with air, for which reason they believe the stomach to serve as a wind-bag as well, and the air to be shifted back and forth between stomach and hood. I do not regard this explanation as being very likely as much air certainly would impair the digestion. Further, if their assumption was correct, the stomach of shot large males ought (at least sometimes) to be distended with air. This has however never been observed.

Acknowledgement

I am very grateful to prof. A. BRINKMANN jr., Bergen, and my former colleague, cand. real. T. ØRITSLAND, Fiskeridirektoratets Havforskningsinstitutt, Bergen, for their valuable criticism, help and advise during the preparation of this paper. Mr. D. H. BARRY, B. Sc., a former colleague at Kwame Nkrumah University, Kumasi, Ghana, kindly checked the English.

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Pl. I

1. *Hooded seal pup (blueback). Nose is rather fleshy with transverse sulcus in front of eyes. Jan Mayen area 1959.*
2. *Head of dead bull. Partly inflated hood overhangs mouth. Note posterior extension of hood and position of nares. Denmark Strait 1960.*
3. *Young bull with small hood – Roman nose. Denmark Strait* 1957.
4. *Wounded bull inflating hood. Note transverse constriction of hood and its backward extension. Jan Mayen area 1960.*
5. *Cut-off bull's head suspended by elastic mucous nasal septum which has been pulled out through left nostril. The elasticity of the nasal septum is clearly shown. This bull was 220 cm long, age 13 years. Denmark Strait 1959.*
6. *Cut-off bull's head, hood artificially inflated. Hood slightly inflated. By gently manipulating hood as shown, the nasal septum was extruded as a small balloon appearing bilobed. Denmark Strait 1959.*
7. *Cut-off bull's head, hood artificially inflated. Strongly inflated. By forcing hood down the nasal septum came out through the open nostril, forming the large balloon as shown. Denmark Strait 1958.*
8. *Bull shot dead with balloon extruded and photographed a few minutes later. Note moderate size of hood proper and the even curvature of the balloon. Jan Mayen area 1960.*

Photo: B. BERLAND

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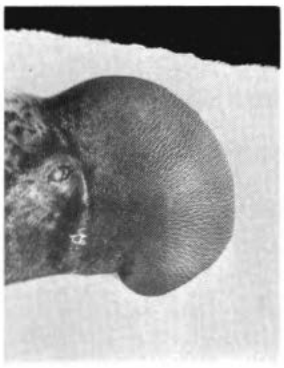

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FRA SVALBARDS DYREVERDEN 11

(On the Svalbard fauna 11)

Iakttagelser over dyrelivet på Svalbard

(Observations of the animal life in Svalbard)

Av
NATASCHA HEINTZ og MAGNAR NORDERHAUG

Abstract

The present observations of animal life in Svalbard mainly covers the year 1965 and is based on records received from Norsk Polarinstitutt's fieldparties, the staff on the radio-stations at Bjørnøya, Hopen and Isfjord Radio, and people wintering in Longyearbyen, Ny-Ålesund, Hornsund and Tjuvfjorden. Some records on bird life from the period 1958–1964 at Bjørnøya and Hopen are also included.

Table 1 gives a review of reindeers (*Rangifer t. spitsbergensis*) observed. Of particular interest are the observations from Nordaustlandet, showing that it is a fairly large population on this island. Table 2 shows the amount of polar bears (*Thalarctos maritimus*) seen. In spite of rather severe ice-conditions around Nordaustlandet – which normally would cause the polar bears to move westwards, very few bears were seen during the summer 1965. During the winter 1964 and summer 1965 altogether eight walruses (*Odobaenus rosmarius*) were observed, partly on the west coast of Vestspitsbergen and partly in Tjuvfjorden. A leg of a hare (*Lepus* sp.) was found at the coast of Lady Franklinfjorden, Nordaustlandet, showing that hares still live on this island, though obviously in very restricted numbers.

The amount of eiders (*Somateria mollissima*) seen is given in Table 3, and Table 4 gives the figures for the pink-footed geese (*Anser f. brachyrhynchus*) and Table 5 for the pale-breasted brent geese (*Branta bernicla*), while barnacle geese (*Branta leucopsis*) mainly were observed at Bjørnøya and in the Hornsund area. Of more rare birds registrated in the Svalbard area during 1965, can i.a. following be mentioned: teal (*Anas crecca*), common scoter (*Melanitta nigra*), whooper swan (*Cygnus cygnus*), lapwing (*Vanellus vanellus*), golden plover (*Pluvialis apricaria*), redshank (*Tringa totanus*), knot (*Calidris canutus*), dunlin (*Calidris alpina*), red-necked phalarope (*Phalaropus lobatus*), great skua (*Catharacta skua*), snowy owl (*Nyctea scandiaca*), and starling (*Sturnus vulgaris*).

Innledning

Når vi her legger fram data vedrørende observasjoner over pattedyr og fugl fra Svalbard vesentlig fra 1965, er vi glad for at disse observasjonene er mer omfattende enn tidligere. Foruten fra Norsk Polarinstitutts egne medarbeidere, har vi også fått en rekke opplysninger fra personalet på de meteorologiske stasjonene på Hopen, Bjørnøya og Isfjord Radio, samt fra folk som har overvintret i Ny-Ålesund, Longyarbyen, Hornsund og Tjuvfjorden. En del data fra utenlandske ekspedisjoner er også kommet inn. Det mest interessante er utvilsomt de mange observasjoner av fugler som hittil er lite kjent fra Svalbardområdet. Disse observasjonene

bekrefter det inntrykk vi allerede har hatt tidligere, nemlig at en rekke mer sydlige arter sporadisk opptrer på Svalbard.

For alle som har arbeidet med Svalbards pattedyr- og fuglefauna, er spørsmålet om bedre beskyttelse av meget stor viktighet. Det er derfor gledelig at det nå er nedsatt to utvalg, hvorav det ene skal se nærmere på spørsmålet om utvidet fredning av Svalbards dyre- og planteverden, og det andre skal fremkomme med forslag til opprettelse av nasjonalparker og reservater på Svalbard.

For å forenkle fremstillingen har vi for Polarinstituttets medarbeidere og assistenter bare tatt med deres initialer. Det gjelder følgende (initialene er angitt i parentes): B. FLOOD (BF), Ø. FÆSTØ (ØF), D. G. GEE (DGG), N. GULLESTAD (NG), H. HORNBÆK (HH), A. HJELLE (AH), T. HARSTAD (TH), K. Z. LUNDQUIST (KZL), J. NAGY (JN), A. H. NEILSON (AHN), S. SIEDLECKI (SS), T. SIGGERUD (TS) og T. S. WINSNES (TSW). Observasjoner foretatt av Polarinstituttets ornitologparti, som sommeren 1965 besto av M. NORDERHAUG (leder) og L. LJØTERUD og E. WRÅNES (assistenter) er angitt med PO.

Takk

Vi vil gjerne få takke alle som har bidratt med observasjoner og opplysninger. Spesielt skylder vi stor takk til O. MUNKEBY og K. TORSVIK som har stilt sine observasjoner fra henholdsvis Bjørnøya og Hopen gjennom flere år til vår rådighet. Til medarbeiderne på radiostasjonene på Bjørnøya, Hopen og Isfjord Radio og A. BRYN i Ny-Ålesund, T. VEGGE i Longyearbyen, E. SLETBAKK som overvintret i Hornsund og O. LØNØ som overvintret i Tjuvfjorden vil vi også gjerne få rette en hjertelig takk. De har alle bidratt med en rekke interessante data vedrørende trekkfuglenes ankomsttider til Svalbardområdet.

Pattedyr

Svalbardrein (*Rangifer tarandus spitsbergensis*). De fleste av Polarinstituttets feltpartier arbeidet sommeren 1965 i områder hvor det finnes rein. Observasjonene er gitt i tabell 1. Av særlig interesse er de mange observasjonene fra Nordaustlandet, hvor det tydligvis fins en forholdsvis spredt, men god bestand. I flere tilfelle ble det imidlertid sett svært magre simler (ØF). Ellers er det typisk at det bare ble påtruffet småflokker. Den største flokken (22 ad. og 5 juv.) ble sett på Roosneset. Jevnt over synes kalveproduksjonen å ha vært ganske god i 1965.

Moskusdyr (*Ovibos m. moschatus*). Fra sommeren 1965 har vi bare to observasjoner av moskusdyr. Dette har sikkert sin årsak i at det arbeidet få partier i de områdene hvor moskusdyrene holder til. 8/8 ble 1 ad. og 2 juv. sett i Foxdalen (PO). I Hiorthamn, Adventfjorden, hadde 10 ad. og 2 kalver tilhold før 7/7 (B. NORDNES personlig meddelelse til NG).

Isbjørn (*Thalarctos maritimus*). Nordaustlandet har vanligvis vært regnet for et av de områder på Svalbard hvor det også om sommeren finnes en ganske god bestand av isbjørn. Som det vil fremgå av tabell 2 var antallet isbjørn sett i løpet av sommeren 1965 på Nordaustlandet forholdsvis beskjedent. Bare i to tilfelle ble det

sett binner med unger, henholdsvis med en og to unger. Dette er påfallende lite når man tar i betraktning at seks partier arbeidet på Nordaustlandet i juli og august. De hadde dessuten to helikoptere til disposisjon og dekket i løpet av denne tiden stadig det vesentligste av den nord- og nordvestlige halvdelen av Nordaustlandet. Det må tilføyes at sommeren 1965 var det usedvanlig vanskelige isforhold i disse farvannene og havisen lå landfast langs det meste av nord- og østkysten av øya. Dette burde ha bevirket at isbjørnen trakk vestover mot åpnere farvann. Disse sommerobservasjonene er mindre positive og kan tyde på at isbjørnforekomstene i Nordaustland-området er overvurdert.

Polarrev (*Alopex lagopus*). Spredte individer ble registrert på Vestspitsbergen og Nordaustlandet. Et hi ble funnet på Tvihyrningen, og videre to hi på Nordaustlandet (S. Pentavika og Innvika).

Storkobbe (*Erignatus barbatus*). Spredte individer ble sett i juli/august i Hornsund- og Bellsundområdet. På Nordaustlandet ble noen individer sett i Lady Franklinfjorden i slutten av juli, og i Duvefjorden og Carolusbukta i august.

Fjordsel (*Phoca hispida*). I Hornsund og Bellsund var det i første halvdel av juli, før fjordisen gikk opp, mye snadd å se. I Burgerbukta (Hornsund) talte PO 6/7 686 individer. I Bellsund ble antallet oppgitt til 1–200 (SS). I Wijdefjorden ble 17/7 sett ca. 50 og 18/7 i Sorgfjorden mer enn 200 individer (ØF). På Nordaustlandet ble det registrert flokker på opptil 15–20 individer i Lady Franklinfjorden og Duvefjorden.

Fig. 1. *En ung hvalross* (Odobaenus rosmarius) *ligger og soler seg på isen i Krossfjorden.*

A young walrus lying on the ice in Krossfjorden.
Photo: G. LORENZ, Deutsche Spitsbergen-Expedition 1964/65.

Hvalross (*Odobaenus rosmarius*). Ved Ebeltoftlagunen, Kapp Mitra, ble det fra «H. U. Sverdrup» 22/8 sett en hvalross som lå på et isflak. Den jumpet i sjøen da fartøyet var omtrent 80 m fra den. Sannsynligvis var det et ungdyr, da støttennene ennå var ganske små. En øst-tysk ekspedisjon (leder U. VOIGT) så 3/6 i Krossfjorden en hvalross (Fig. 1). På østsiden av Rijpfjorden ble det 16/8 på et isflak ca. 200 m fra land sett et ca. 4 m langt, meget tykt, mørkt dyr, som antagelig må ha vært en hvalross (ØF). Ved Sjuøyane så man 12/8 fra «Havella» 1 individ (NG). O. LØNØ så i Tjuvfjorden 16/8 64 en hvalross og 18/10 64 så han i samme område 1 hann og 1 hunn. Ved Halvmåneøya ble det våren 1965 observert 1 individ.

Hare (*Lepus* sp.). I uren under et fuglefjell på sydsiden av Bygebukta ved Lady Franklinfjorden ble 24/7 funnet en bakfot av en hare (ØF). Foten var dekket av hvit hårkledning og kjøtt og sener virket ganske friske, slik at dyret må ha krepert forholdsvis nylig.

Fugl

Norsk Polarinstitutt sendte vinteren 1965 ut et skjema til personalet på de meteorologiske stasjonene, foruten til kontaktfolk i Ny-Ålesund, Longyearbyen og et fangstparti i Hornsund. Det ble bedt om å avmerke ankomstdatoen (sett første gang) for en del angitte fuglearter. Foruten disse data fikk vi sammen med skjemaene tilbake en del observasjoner som K. TORSVIK (KT) hadde gjort på Hopen, O. MUNKEBYE (OM) på Bjørnøya og O. LØNØ (OL) i Tjuvfjordområdet.

Observasjonene er omtalt regionalt sørfra og nordover. De forskjellige artene er nevnt i rekkefølge etter den systematiske oppstillingen som er brukt av LØVENSKIOLD (1964) i hans arbeid om Svalbards fugler.

Storlom (*Gavia arctica*). 6/8 1962 Sassendalen 3 ad. – B. BRÅTEN; 1961-63 Hopen 1 ad. – KT.

Islom (*Gavia immer*). 2/6 65 Bjørnøya 1 ad. – OM.

Smålom (*Gavia stellata*). 28/5 65 Bjørnøya (sett første gang) – OM; 1961–63 Hopen sett flere ganger – KT; sommeren 65 på Dunøyane minst 2 par, Nordre Isøya minst 2 par og Elveflya 1 par – PO; 3/9 65 Kaldneset 1 par med 2 unger – KZL; sommeren 65 området Dirksodden–Mosselbukta 5 par – NG; 22/7 65 vestre Toddyviken, Lady Franklinfjorden 2 ad. – BF; 24/7 65 Russøya 1 ad., 28/7 Snaddvika 4 ad., 21/8 Reinsdyrvidda, Oscar II Land 4 ad. – TSW; juli 65 søre Russøya ad., august Bodleybukta 2 ad., 1 juv. AHN; 22/7 65 Botniahalvøya på innsjø 2,5 km fra Bygebukta 2 ad. – AH.

Havhest (*Fulmarus glacialis*). Våren 65 Bjørnøya sett sålenge det er bart vann eller råker, overvintrer antagelig her – OM; 9/2 64 Hopen – KT; våren 64 Hornsund sett fra det ble så lyst at fugl kunne observeres – E. SLETBAKK; slutten av

januar 65 Isfjord Radio tallrike individer – I. KRISTOFFERSEN; 29/3 65 Negerpynten 2 ad. – OL; 7/3 65 Ny-Ålesund (sett første gang) – A. BRYN; 11/3 65 Longyearbyen ca. 30 ad. (sett første gang) – T. VEGGE; juli 65 Depotodden, Brennevinsfjorden arten funnet hekkende i fjellet – AHN.

Stokkand (*Anas plathyrhynchus*). 23/4 65 Bjørnøya 1 ♂, 5/5 2 ♂♂ – OM.

Krikkand (*Anas crecca*). 1962 Hopen – KT; 31/5 63 Bjørnøya 6 stk. – OM; 10–11/7 65 Nordre Dunøya 1 ♂ – PO.

Brunnakke (*Anas penelope*). 22/4 65 Bjørnøya 1 ♂, 1 ♀, 3/5 1 ♀, 31/5 1 ♂ – OM.

Toppand (*Aythya fuligula*). Mai 1965 Bjørnøya «ganske mange individer» – OM.

Bergand (*Aythya marila*). 13/7 65 Longyearbyen 3 ad. – T. VEGGE.

Kvinand (islandsand) (*Bucephala sp.*) 25/7 65 Nordre Dunøya 1 ♀ – PO.

Havelle (*Clangula hyemalis*). Ved Bjørnøya sett så lenge råker fantes, overvintrer antagelig her – OM; 1961–63 Hopen sett gjentatte ganger – KT; 8/6 65 Tjuvfjorden 1 ad. – OL.

Svartand (*Melanitta nigra*). 11/6 65 Bjørnøya 11 ad. og et reir med 4 egg, eggene var røvet neste dag – OM.

Ærfugl (*Somateria mollissima*). Vinteren 1964–65 angis at ærfugl overvintrer i Hornsund – E. SLETBAKK og ved Kapp Linné – I. KRISTOFFERSEN. En bestandstelling 5–6/8 i området Kapp Linné–Kapp Martin ga en bestand på ca. 5000 individer, derav 416 juv. – PO; august 1965 ble i området Dirkslaguna–Musselbukta den samlete bestand anslått til ca. 250 ♂♂, 180–200 ♀♀; på Bangenhukholmene fantes 157 reir, hvorav 153 var røvet (antagelig av mennesker), 9/8 ble i dette området sett første kull med ærfuglunger – NG.

Praktærfugl (*Somateria spectabilis*). Juli 65 Dunøyområdet 1–4 ♂♂, mellom Kapp Bjørset og Kapp Martin ca. 40 ♀♀ og 35 ♂♂, antagelig også noen ungekull av denne arten – PO.

Grågås (*Anser anser*). 8/4 1959 Bjørnøya skutt 1 ad. – OM.

Kortnebbgås (*Anser fabalis brachyrhynchus*). Se tabell 4. Videre ble registrert 6–7/8 i området omkring Marvågen, Nordenskiöldkysten, en ansamling på mellom 200 og 300 individer, sannsynligvis i forbindelse med det forestående høsttrekket – PO.

Ringgås (*Branta bernicla hrota*). Se tabell 5.

Hvitkinngås (*Branta leucopsis*). 20/5 65 Bjørnøya 3 stk. (sett første gang), 22/5 3+16 stk., 31/5 2 stk., på høsttrekk oppgis arten å være den vanligste gåsearten som gjester Bjørnøya – OM; 24/5 65 Hopen 1 ad. funnet med ring merket British Museum – KT; 17/5 65 Hornsund (sett første gang) – E. SLETBAKK. I juli/august fortsatte i dette området undersøkelser av artens biologi som ble påbegynt i 1962, 6–7/8 langs Nordenskiöldkysten mellom 10–20 ungekull, minst 250 ad. – PO; 20/8 65 Fuglehuken ca. 10 ad. – KZL.

Sangsvane (*Cygnus cygnus*). 24/4 65 Bjørnøya 2 stk. – OM; 1958 Hopen 1 ad. skutt – KT; 22/9 64 Hyttevika, Hornsund, hadde 1 ad. tilhold – E. SLETBAKK; det var antagelig samme individ som tidligere samme sommer ble sett i Hornsundområdet (HEINTZ & NORDERHAUG 1966).

Grønlandsfalk (*Falco rusticolus*). August 1965 Blomstrandhalvøya en usikker observasjon av en falk i stor høyde – S. KAULBERG.

Spitsbergenrype (*Lagopus mutus*). 20/8 65 Sveagruva et kull på 4 juv. – JN; 15/8 65 Brentskaret et kull på 8 juv., 16/8 Adventdalen et kull på 8 juv. – PO; 25/8 65 et kull på 8 juv. – KZL; 17/7 65 Siktefjell 3 ad., forekom ellers spredt i området – TH. Okt. 64 Tjuvfjorden 1 ad. skutt, vinteren 64/65 sett i alt 3 ad. – OL; 30/7 65 Lady Franklinfjorden 1 ad. – AHN og 2 ♂♂ – ØF; 19/8 65 Bengtsenbukta et kull på 8 juv. (så vidt flyvedyktige) – TSW. Den siste observasjonen har spesiell interesse da man tidligere (LØVENSKIOLD 1964) bare kjente til at rypene hekket ved Bodleybukta, som ligger vesentlig lengere syd på Nordaustlandet.

Kjell (*Haematopus ostralegus*). I 1959 1 individ sett på Bjørnøya – OM; 9/7 65 Kvartsittpynten, Hornsund 1 ad. – PO.

Vipe (*Vanellus vanellus*). Våren 1959 2 individer sett på Bjørnøya. 17/4 65 1 ad. samme sted – OM; i årene 1961–63 gjentatte ganger sett på Hopen – KT, hvorfra den tidligere ikke er registrert; 4/8 65 Stabbane, Nordenskiöldkysten 1 ad. – PO.

Sandlo (*Charadrius hiaticula*). 11/6 65 Bjørnøya 2 stk. – OM; 20/5 63 Hopen 1 stk., 4/6 65 1 stk. – KT; 12/6 65 Longyearbyen 2 stk. (sett første gang) – T. VEGGE; 25/7 65 hørt på Dunøyane, 16/7 Hyttevika 1 stk., i området Kapp Bjørset, Nordenskiöldkysten hekket antagelig 2 par, 6/8 ble 2 juv. funnet lenger sør, 1 par hekket og 4 ikke hekkende ad., 1 par ved Stabbane – PO.

Tundralo (*Squatarola squatarola*). 1 individ anføres observert i 1963 på Hopen – KT.

Heilo (*Pluvialis apricaria*). 13/6 65 Bjørnøya 1 stk. – OM; sommeren 1965 ca. 4 km øst for Hiorthamnhytta, Adventdalen, 1 stk. – PO.

Steinvender (*Arenaria interpres*). 1/6 65 Bjørnøya 2 individer – OM, mens LØVENSKIOLD (1964) angir at tidligste dato for observasjon fra Bjørnøya er 22/6. 1965 Store Dunøya 2 individer sett i en flokk med fjæreplytt, 4/8 Kapp Linné minst 5 ad. og et par hekket i en ternekoloni syd for Isfjord Radio – PO.

Storspove (*Numenius arquata*). 26/4 65 Bjørnøya 1 stk. – OM.

Småspove (*Numenius phaeopus*). Våren 1963 Bjørnøya et streif-individ sett rundt husene – OM; juli 65 1 individ sett utenfor Bellsund og det landet på M/S «Ingerseks» – T. VEGGE.

Rødstilk (*Tringa totanus*). 7/6 65 Bjørnøya 1 stk. – OM; 7/8 65 Kapp Martin, Bellsund, 1 dødt individ, antagelig omkommet på vårtrekk – PO.

Polarsnipe (*Calidris canutus*). 26/7 65 Fjørholmen, Dunøyane, 1 individ i sommerdrakt – PO.

Fjæreplytt (*Calidris maritima*). Sett første gang våren 65: 30/4 Bjørnøya 2 stk. – OM; 4/6 Hopen noen stk. – KT; 4/6 Tjuvfjorden 1 stk. – OL; 4/6 Isfjord Radio 4–5 stk. I. KRISTOFFERSEN; 27/5 Longyearbyen – T. VEGGE.

28/7 65 Sandvika, Nordaustlandet, et reir med 4 egg, 9/8 Murchisonfjorden 1 par med 3 juv. – TSW; ellers en del spredte observasjoner fra Floraberget, Bygebukta, Brennevinsfjorden og Rijpfjorden. 23/7 Bygebukta en flokk på ca. 20 stk., den største flokken sett på Nordaustlandet i 1965 – ØF.

Myrsnipe (*Calidris alpina*). Anføres observert i 1964 på Hopen – KT; 8/8 65 Stabbane, Nordenskiöldbreen, 1 individ – PO.

Sandløper (*Crocethia alba*). 7/6 65 Bjørnøya 1 stk. (sett første gang), 11/6 mange individer samme sted – OM; observasjonene er interessante fordi LØVENSKIOLD (1964) anfører at arten tidligere ikke har vært iakttatt på Bjørnøya. 14/7 65 Pyttholmen, Elveflya 1 individ – PO.

Polarsvømmesnipe (*Phalaropus fulicarius*). 28/5 65 Bjørnøya 2 stk. – OM; i juli 65 i Hornsund spredte flokker og enkelte individer, 11/7 Nordre Dunøya 3 flokker tilsammen 36 individer (18 ♂♂ og 18 ♀♀), Isbjørnhamna 1 reir, ved Isfjord Radio 5+1 individ, tydelig på trekk, i ternekolonien der hadde ett, muligens to par tilhold, og 2 små unger ble funnet, 6/8 mellom Isfjorden og Bellsund sett 2+2+1 individ, derav antagelig minst 1 par – PO.

Svømmesnipe (*Phalaropus lobatus*). 29/5 65 Bjørnøya angis observert 2 individer – OM, etter LØVENSKIOLD (1964) skulle dette være første gang arten er iakttatt på Bjørnøya.

Tyvjo (*Stercorarius parasiticus*). Sett første gang i 1965: 2/6 Bjørnøya 2 stk. –

OM; 30/5 Hopen – KT; 27/4 Kvalrosspynthavna, Edgeøya, 6 stk. – P. JOHNSON. Den siste observasjonen er den hittil tidligste kjente dato for vårtrekk for denne arten på Svalbard (ref. LØVENSKIOLD, 1964). Arten ble funnet hekkende i Hornsund, Reinsdyrflya, Fuglehuken, Mosselhalvøya (Mosselbukta–Dirksodden 7 par – NG), Russøya, West Ahlmannisen, Rijpfjorden, Murchisonfjorden, Bygebukta og Lady Franklinfjorden. På Russøya, Murchisonfjorden fant klekkingen i et reir med 2 egg sted 27/7 – ØF. Fra Nordaustlandet ble registrert 5 eksemplarer av den mørke fasen og i området Mosselbukta–Dirksodden var det 1 mørkt individ av totalt 14 stk. – NG.

Storjo (*Catharcta skua*). 25/7 65 Dunøyane 1 stk., 8/8 Kapp Bjørset, Nordenskiöldkysten 1 stk. – PO.

Polarmåke (*Larus hyperboreus*). 5–6/6 65 Hopen reir med nylagte egg – KT; i Hornsund hadde arten sin mest vellykkete ungeproduksjon i perioden 1962–65 – PO. Arten ble sett ofte både langs nord- og nordvestkysten av Nordaustlandet, på tross av vanskelige isforhold (BF, AHN, ØF).

Svartbak (*Larus marinus*). 3/6 65 Hornsund – E. SLETBAK; 9–10/7 65 Store Dunøya 1 individ, dessuten hekket sannsynligvis 1 par der, 10/7 Fjørholmen 1 par og samme dag på Nordre Dunøy 1 individ, 18/7 Nordre Isøy 2 stk. – PO; i juli 65 på Eskjæret i Kongsfjorden sett 1 individ – S. KAULBERG.

Gråmåke (*Larus argentatus*). 22/4 65 Bjørnøya 2 stk. – OM; i juli 65 på Store Dunøy hadde 1–2 individer tilhold – muligens 1 par med territorium – PO.

Fiskemåke (*Larus canus*). 18/4 65 Bjørnøya 1 individ anført observert – OM.

Sabinemåke (*Xema sabini*). I juli 65 Blomstrandhalvøya 1 individ anført observert – S. KAULBERG.

Ismåke (*Pagophila eburnea*). Våren 1965 ble arten sett på Hopen – KT; fra Nordaustlandet foreligger det en rekke spredte observasjoner fra nord- og nordvestkysten. I Thank God Bay, Rijpfjorden, 14 individer sett i et fuglefjell – TSW; 17/8 6 km fra bunnen av Rijpfjorden 1 reir, og muligens fantes det flere reir i bruk i dette området – ØF.

Hettemåke (*Larus ridibundus*). 1963 Hopen 1 eksemplar anføres observert – KT; 27/4 65 Bjørnøya 1 individ – OM; ellers mangler nærmere data. Bortsett fra et funn av hettemåke på Vestspitsbergen i 1963, gjort av britene M. A. OGILVIE og R. J. F. TAYLOR, kjennes ingen sikre observasjoner fra Svalbard. Ved observasjoner av måker med hette tar man ofte ikke med i betraktningen at sabinemåke har hette, men den er mer skifergrå. Dette har ført til at alle de hittil foreliggende «hettemåkeobservasjoner» fra Svalbard er usikre, fordi nærmere detaljer angående de observerte måkene mangler.

Rødnebbterne (*Sterna macrura*). Sett første gang i 1965: 28/5 Bjørnøya – OM; 4/6 Hornsund – E. SLETBAKK; 30/5 Isfjord Radio – I. KRISTOFFERSEN; 25/5 Longyearbyen – T. VEGGE; 22/5 Ny-Ålesund – A. BRYN; 19/6 Tjuvfjorden reir med 2 egg – OL. I juli/august 65 ble arten sett i større og mindre ansamlinger på Nordaustlandet, og særlig i Rijpfjordområdet så arten ut til å være relativt tallrik. Det var sparsomt med observasjoner av hekking.

Snøugle (*Nyctea scandiaca*). Slutten av februar 1959 Bjørnøya anført observert 1 individ – OM; 14/2 63 Hopen 1 individ – KT; 8/4 65 Tjuvfjorden 2 individer – OL; 4/8 65 Kapp Linné holdt 1 individ til i utkanten av ternekolonien – PO; 19/8 65 Fuglehuken 1 individ holdt til i fuglefjellet – O. NORDHUS.

Jordugle (*Asio flammeus*). Høsten 1962 Bjørnøya funnet 1 dødt individ etter snøfall – OM.

Ravn (*Corvus corax*). 1962 Hopen 1 individ oppgis observert – KT.

Kråke (*Corvus corone*). 1963 Hopen 1 individ oppgis observert – KT.

Gråtrost (*Turdus pilaris*). Høsten 61 og 63 Hopen, sett store flokker, men de døde da frosten satte inn; 7/4 64 Hopen sett 1 stk. – KT.

Rødvingetrost (*Turdus iliacus*). 22/4 65 Bjørnøya 3 stk. – OM; 11/10 64 Tjuvfjorden 1 stk. – OL; juli 65 Ny-Ålesund 1 dødt eksemplar – S. KAULBERG.

Svarttrost (*Turdus merula*). Fra Bjørnøya anføres denne arten å være første landfugl om våren og siste om høsten. De som kommer om høsten dør gjerne der. Treffes vanligvis som enkelte streifindivider, men opptil 4 stk. sett sammen. Tidligste observasjon 24/4 65 – OM.

Steinskvett (*Oenanthe oenanthe*). 7/6 65 Bjørnøya 1 individ – OM; i tiden 1961–63 angis observert på Hopen – KT; 18/7 65 Ariakammen, Hornsund – PO.

Buskskvett (*Saxicola rubetra*). Bjørnøya, et par anføres å ha hatt tilhold ved stasjonen (datoangivelse mangler) – OM.

Heipiplerke (*Anthus pratensis*). Bjørnøya, ved flere anledninger skal arten ha vært registrert ved Kapp Forsberg, hvor det er rikelig med gresstuer, opptil 3 individer sett samtidig (datoangivelse mangler) – OM.

Sidensvans (*Bombycilla garrulus*). Følgende observasjoner fra Bjørnøya i 1965: 21/4 2 stk., 22/4 4 stk., 24/4 5 stk., 25/4 7 stk. – OM.

Stær (*Sturnus vulgaris*). På Bjørnøya er av OM observert: våren 1959 4 stk., våren 1963 sang stær ved den meteorologiske stasjonen og besøkte fuglekassen

på Tobiassen-hytten, men ble ikke sett hekkende, i alt ble den våren sett 3 stk.; 19/4 65 1 ad. (sett første gang), 22/4 2 ad. og 24/4 3 ad.

Gråsisik? (*Carduelis flammea*). På Bjørnøya er av OM observert: våren 1963 småflokker av arten rundt stasjonen. Etter 10/6 såes bare noen få individer og de holdt til i steile fjellsider hvor det var rikelig med mose og småplanter. Det er ikke usannsynlig at de hekket der.

Bjørkefink (*Fringilla montifringilla*). Bjørnøya 1 ♂ sett klamre seg til vinduskarmen på stasjonen, for å sole seg (datoangivelse mangler) – OM.

Lappspurv (*Calcarius lapponicus*). 11/6 65 Bjørnøya 1 ♂ funnet død – OM.

Gulspurv (*Emberiza citrinella*). 24/4 65 Bjørnøya 1 ♀ – OM.

Tabell 1.

Observasjoner over rein (*Rangifer tarandus spitsbergensis*) sommeren 1965.

Lokalitet	Dato	Antall dyr	Observert av	Anmerkninger
Vårsolbukta, Bellsund	7–17/7	4–5 ♂♂, 2–3 ♀♀	SS	sett daglig
Akseløya	22–26/7	3 ♂♂, 2♀♀, 1 juv.	»	
Isfjord–Bellsund	7/8–8/8	5 ♂♂, 5 ♀♀, 1 juv.	PO	
Kjellstrømdalen ved Trollbotn	5/8	3 ad.	JN	
Kjellstrømdalen ved Langstakken	9/8	6 ad., 2 juv.	»	
Liljevalchneset	23/8	23 ad.	»	
Kjellstrømdalen ved Dalskuta	14/8	7 ad., 5 juv.	»	
Arnicadalen ytterst	»	4 ad	PO	
Arnicadalen–Brentskaret	»	30 ad.	»	i spredte flokker
Brentskaret–Longyearbyen	»	27 ad.	»	—»—
S og Ø for Siktefjellet	11/7	7 ad.	TH	spredt
Reinsdyrflya	»	3 ad., 1 juv.	»	
Rundt leir på Reinsdyrflya	12/7	12 ad., 3 juv.	»	spredt på forskjellige steder
Ø og S for Sørkollen	14/7	9 ad., 3 juv.	»	i to flokker
NV for Albertbreen	16/7	15 ad., 4 juv.	»	
Ø for Idabreen	24/7	1 ad.	»	
Mellom Lernerøy og Monacobreen	25/7	5 ad., 2 juv.	»	
Sørdalsbukta	31/7	16 ad., 4 juv.	»	
Andøyane	4/8	8 ad., 2 juv.	»	
Roosneset	5/8	22 ad., 5 juv. 8 ad., 1 juv.	»	to flokker
Måkeøyane	»	1 ad.	»	
Lady Franklinfjorden ved Norgekollen	20/7–2/8	7 ad., 3 juv.	BF	holdt seg i området
Innvika, Duvefjorden	4–20/8	4 ♂♂, 4♀♀, 4 juv.	»	i området
Planciusdalen	22/8	8 ad., 1 juv.	»	
Carolusbukta	22–23/8	1 ♂, 3 ad., 1 juv.	»	
V Floraberget, Murchisonfjorden	24/7	1 ♀	TSW	
Sørvika Ø	27/7	1 ♂, 1 ♀, 1 juv.	»	
Snaddvika	28/7	1 ♀	»	
N Claravågen	29/7	2 ♀♀, 2 juv.	»	
W Ahlmannisen, Rijpfjorden	5/8	1 ♀	»	
—»—	15/8	1 ♀, 1 juv.	»	
Ø Reinsdyrvidda, Oscar II Land	11/8	6 ♂♂, 1 ♀	»	
Thank God Bay mot S	17/8	7 ♂♂, 2 juv.	»	
Ø Bengtsenbukta	19/8	4 ♂♂	»	
Thank God Bay mot S	23/8	1 ♀, 1 juv.	»	
Sveanor	23/7	1 ♂	AHN	
N for Gimleneset	31/7	1 ♀, 1 juv.	»	
Bodleybukta	4/8	6 ♂♂, 5 ♀♀, 2 juv.	»	spredt, nær breen
NV Brodleybukta	7/8	6 ♀♀, 5 juv.	»	
Innvika	»	4 ♂♂, 5 ♀♀, 3 juv.	»	
Overgang Bygebukta–Brennevinsfjorden	25/7	1 ♀, 1 juv.	AH	
Bygebukta	28/7	1 ♀	ØF	meget mager
—»—	29/7	2 ♂♂, 1 ♀, 1 juv.	»	♀ liten, mager, ♂♂ kraftige
Sør for Bygebukta	»	2 ♂♂	»	
—»—	30/7	3 ♂♂, 1 ♀, 1 juv.	»	
Bygebukta	1/8	2 ♂♂, 3 ♀♀, 2 juv.	»	2 ♀♀ med 1 kalv hver, gode beiter
Oxfordhalvøya	3/8	20 ad, 5 juv.	»	sett fra helikopter
Rijpfjorden	4/8	1 ♂	»	
Østside av indre Rijpfjorden	6/8	4 ♂♂, 1 ♀, 1 juv.	»	1 ♀ med 1 kalv
Østside av midtre Rijpfjorden	7/8	1 ♂, 1 ♀, 1 juv.	»	—»—
Brinknuten, østside Rijpfjorden	8/8	1 ♂	»	

Tabell 1 (forts.)

Lokalitet	Dato	Antall dyr	Observert av	Anmerkninger
Sør for Lars Hansenfjellet	16/8	1 ♂	ØF	
Sør for Kræmerodden, Rijpfjellet	»	1 ♀, 1 juv.	»	
Bunnen av Rijpfjellet, østside	17/8	3 ♂♂, 2 ♀♀, 3 juv.	»	
Nordre Rijpdalen	18/8	2 ♂♂	»	
Sørøst bunnen av Rijpfjorden	19/8	4 ♂♂, 1 ♀, 1 juv.	»	
Bunnen av Rijpfjorden	20/8	1 ♂	»	ganske ung
Nordvestre Rijpdalen	24/8	1 ♂	»	sett fra helikopter

Tabell 2.
Observasjoner over isbjørn (*Thalarctos maritimus*) sommeren 1965

Lokalitet	Dato	Antall dyr	Observert av	Anmerkninger
Sorgfjorden	18/7	1 ad.	BF	
Lady Franklinfjorden	26/7	1 ♂, 1 ♀, 2 juv.	»	
Nilsenbreen, østside Duvefjorden	11/8	1 ad.	»	
Kapp Bruun	»	1 ad.	»	
Søre Repøya	19/8	1 ♀, 1 juv.	»	
Bangenhukhalvøya	12/7	1 ad.	NG	
Verlegenhuken	19/7	1 ad.	AHN	
Sorgfjorden	20/7	1 ad.	»	
NV i Bodleybukta	7/8	1 ad.	»	
Reinsdyrflya	16/7	1 ad.	TH	
Utenfor elvemunning i Bygebukta	26/7	1 ♀, 2 juv.	ØF	1 stor og 1 liten unge
Fra ytre Lady Franklinfjorden	»	1 ♂	»	stor
Murchisonfjorden	27/7	1 ♂	»	skutt, 2 års hann
På isen i ytre Rijpfjorden	12/8	1 ♂	AH	ung

Tabell 3.
Observasjoner av ærfugl (*Somateria mollissima*) sommeren 1965.

Lokalitet	Dato	Antall dyr/ kjønn	Observert av	Anmerkninger
Bjørnøya	1963–1965	ad.	OM	rundt øya sålenge isfritt eller råker Antagelig var der hele vinteren
Hornsund	våren	ad.	E. SLETBAKK	sett fra lyst om våren
Isfjord Radio	1964/65	ad.	I. KRISTOFFERSEN	holdt seg her hele vinteren
Longyearbyen	10/5 65	6 ♂♂	T. VEGGE	1 gang våren 1965
Ny-Ålesund	19/4 65	4 ad.	A. BRYN	—»—
»	4/6 65	4 ad.	»	ruget i området
Tjuvfjorden	2/4 65	2 ad.	OL	1. gang våren 1965
»	10/7 65	2 egg	»	
Burgerbukta	27/7	2 ♀♀, 2 juv.	JN	
»	18/7	18 ad.	»	
Hyrneodden	12/7	3 ♀♀, 1 rede m/ 4 egg	»	
Braganzavågen	5/8	12 ad.	»	
Sveasundet	6/8	18 ad., 10 juv.	»	
Liljevalchneset	23/8	9 ♀♀, 14 juv.	»	
Crednermorena	24/8	2 ♀♀, 5 juv.	»	
»	25/8	10 ♀♀, 22 juv.	»	
Bellsund	7–17/7	Få ♂♂ og ♀♀, ingen reder	SS	
Akseløya	22–26/7	Få ♂♂ og ♀♀, 1 rede m/ 3 egg	»	1 rev sett på Akseløya
Fuglehuken	7/8	5 ♂♂	KZL	
Kaldneset	30/8	150 ad.	»	
Ebeltoftgrunnen	22/8	Ca. 200 ad, noen juv.	»	noen store ungekull
Adventfjorden	17/6	4 ♂♂, 1 ♀	AHN	
Skansbukta	»	4 ♂♂, 1 ♀	»	
Gåsodden	19/6	9 ♂♂, 1 ♀	»	
Brucebyen	»	12 ♂♂, 4 ♀♀	»	
Kapp Ekholm	»	14 ♂♂, 2 ♀♀	»	
Bjørnehamna	1/7	13 ad.	»	
Moseøya	»		»	hekket langs kysten
Biskayerhuken	2/7	6 ad.	»	
Svenskesundet	4/7	8 ad.	»	
Klovningen	6/7	30 ad.	»	
Verlegenhuken	8/7	2 ad.	»	
Reinsdyrflya	/7	ca. 60 ad.	TH	begynnelsen av juli
Gråhuken	12/7	14 ♂♂; 9 ♂♂; 8 ♀♀, 4 ♀♀	HH	3 flokker
»	13/7	43 ♂♂, 2 ♀♀	»	på isen
»	»	1 rede m/ 4 egg	»	
»	14/7	3 ♂♂, 4♀♀	»	
»	15/7	6 ♂♂, 1 ♀	»	
Bjørnesholmen, innerst i Wijdefjorden	26/7	4 tomme reder, 2 reder m/ 3 egg	»	
Storøya	27/7	30 tomme reder, 7 reder m/ 4 egg, 4 reder m/ 3 egg, 4 reder m/ 2 egg, 2 reder m/ 1 egg	»	

Tabell 3 (forts.)

Lokalitet	Dato	Antall dyr/ kjønn	Observert av	Anmerkninger
Restadholmen	9/8	3 unge kull m/ 4, 3, 2 juv.; 3 reder m/ 3, 2, 1 egg	HH	
»	12/8	4 ♀, 7 juv.; 4 reder m/ 4, 3, 2, 1 egg	»	
Bjørneshytta, Wijdefjorden	22/8	4 ♀, 12 juv.	»	
Sorgfjorden	18/7	120 ♂♂, 40 ♀♀	BF	i to flokker på isen
Innvika	4/8	2 ♀♀, 4 juv.	»	
Vest for Nilsenbreen	11/8	11 ♀♀, 13 juv.	»	
Kapp Bruun	»	18 ♀♀	»	
Innvika	16/8	26 ♀♀	»	
Glennhalvøya	19/8	ca. 60 ♀♀	»	fordelt på to flokker
Carolusbukta	22/8	12 ♀♀	»	
Eolusneset	/7	1 ♀, rede m/ 4 egg	TSW	
»	»	1 ♀, rede m/ 4 egg	»	
Sorgfjorden	»	ca. 100 egg	»	lite ruget
N. Krossøya	»	ca. 30 egg fordelt på reder m/ fra 6–4 egg	»	
Murchisonheia, Rijpfjorden	9/8	50 ♀♀	»	
Ellingensenodden	15/7	7 ad.	AHN	
Lagunepynten	16/7	14 ♂♂, 23 ♀♀	»	
S. Russøya	23/7	7 ad.	»	
Triodalen	24/7	1 ♂, 2 ♀♀	»	hekket
Jäderinfjorden	25/7	20 ad.	»	
Depotodden	31/7	1 ♂, 15 ♀♀	»	
Russøya m/ Gimleodden	20–30/7	50 ad, 15 ♀♀	»	to flokker
Innvika	10–20/8	4 ♂♂, 20 ♀♀, 10 juv.	»	
Likholmen (ca. 2000 m²), Danskegattet	11/7	100–150 reir	ØF	fra 1–4 egg pr. rede, gj.sn. 2–3 egg; 1 rede pr. ca. 15–20 m²
Ø. Amsterdamøya	»	Mange ♂♂ og ♀♀, 5 juv.	»	2 kull
Danskegattet	13/7	2 juv.	»	
Albertøya (ca. 5000 m²)	»	20–40 reder	»	
Holme vest i Danskegattet	14/7	1 ♂, 3 ♀♀, 1 rede	»	
Eolusneset, Sorgfjorden	18/7	50 ♂♂, 30 ♀♀	»	spredte flokker
S. Velkomstpynten	»	ca. 40 ♂♂, ca. 20 ♀♀	»	
Russøya, Murchisonfjorden	20/7	1 ♀+rede 5 egg	»	
Ved Bygebukta	22/7	1 rede+4 egg	AH	
Bygebukta	23/7	ca. 20 ad.	ØF	
Brennevinsfjorden	30/7	1 ♀	»	
Carfaxhaugen, Bodleybukta	3/8	forlatt rede+ 4 kolde egg		
Ytre Rijpfjorden	8/8	flokker med ad.	»	
Øst midtre Rijpfjorden	9/8	flokker på 15–20 ♀♀	»	ingen juv. eller ♂♂
Langvatnet, SØ for Ahlmannfonna	11/8	18 ♀♀	»	
N. Wordieodden	12/8	2 ♂♂, 22 ♀♀	AH	
Gyllensköldholmane i Wijdefjorden	26/8	2 ♀♀, 6 juv.	ØF	

Tabell 4.

Observasjoner over kortnebbgås (*Anser fabalis brachyrhynchus*) sommeren 1965.

Lokalitet	Dato	Antall dyr/ kjønn	Observert av	Anmerkninger
Bjørnøya	23/5	3 ad.	OM	1. gang i 1965
»	31/5	16 ad.	»	på trekk
»	15/6	5 ad.	»	
Hopen	28/5 64	1 ad.	KT	skutt
Hornsund	21/5	—	E. SLETBAKK	sett første gang
Tjuvfjorden	30/5	2 ad.	OL	1 gang i 1965, etter denne dato vanlig å se i Tjuvfjorden
»	1/6	3 ad.	»	
Vårsolbukta, Bellsund	7–17/7	ca. 10 ad., 1 rede + 5 egg, senere 5 juv.	SS	
Akseløya	22–26/7	3 ♀♀, 9 juv.	»	3 kull
Vårsolbukta, Bellsund	17/8	ca. 20 ad.	»	fløy over.
Kjellstrømdalen	19/8	30 ad.	JN	
Liljevalchneset	23/8	30 ad.	»	
Isfjord Radio	21/5	4 ad.	I. KRISTOFFERSEN	1. gang i 1965
Ebeltoftlaguna	22/8	ca. 70 individer	KZL	mest juv., delvis flyvedyktige
Siktefjellet	11/7	3 ad., 1 juv.; 4 ad., 1 juv.	TH	to flokker
Andøyane	12/7	2 ad.	»	
Syd for Sørkollen	14/7	6 ad.	»	sett i luften
Øst for Siktefjellet	16/7	5 ad., 4 juv.; 3 ad., 2 juv.	»	to flokker
Siktefjellet	17/7	3 ad., 2 juv.; 2 ad., 1 juv.	»	to flokker
Reinsdyrflya	»	3 ad.	»	
Andøyane	4/8	15 ad.	»	
Sør for Kræmerodden	16/8	ad.	ØF	flokker på 1 + 4 ad. på trekk
SØ for bunnen av Rijpfj.	19/8	ad	»	flokker på trekk

Tabell 5.
Observasjoner over ringgås (*Branta bernicla*) sommeren 1965.

Lokalitet	Dato	Antall dyr/ kjønn	Observert av	Anmerkninger
Bjørnøya	23/5 65	3 ad.	OM	1. gang i 1965
»		opptil 15 ad.	»	på høst -og vårtrekk
Hopen	1963–64	—	KT	sett på trekk høst og vår
Hyttevika, Hornsund	29/4 65	5 ad.	E. SLETBAKK	1. gang i 1965
Dunøyane	august		PO	ca. 15 brukte reder lokalisert
Akseløya	25/7	ca. 5 ad.	SS	sett i flukt
V/ Holmungen, Nordenskiöldkysten	8/8	2 ad., 3 juv.	PO	
Isfjord Radio	21/5 65	8 ad.	I. KRISTOFFERSEN	
Tjuvfjorden	14/8 64	18 ad.	OL	beitet
Østsiden Negropynten	15/8	2 ad.	»	
Tjuvfjorden	12/9	ca. 50 ad.	»	
Tjuvfjordområdet	1/6 65	—	»	vanlig å se ringgås her
Tschermakfjellet	24/6	4 ad.	AHN	
Biskayerhuken	3/7	23 ad.	»	
Indre Norskøyane	1/7	2 ad.	»	
Mosselvannet	18/8	2 ad., 3 juv.	NG	
Sorgfjorden	8/7	2 ad.	AHN	
Bjørneshytten, Wijdefjorden	16/8	ca. 70–80 ad.	HH	en stor flokk
—»—	21/8	7 ad., 14 juv.	»	juv., ikke flyvedyktige
—»—	22/8	—	»	trekk av ringgjess
Ellingsenodden	15/7	3 ad.	AHN	
Snaddvika, Murchisonfjorden	28/7	1 ♂, 2 ♀♀	TSW	
Bunn av Innvika	4/8	9 ad.	BF	svømmende
—»—	7/8	1 ad.	»	flyvende
Vest for Innvika	10/8	1 ♀, 1 ♀, 3 juv.	»	i råk
Bunn av Innvika	12/8	5 ad.	»	
Bunnen av Rijpfjorden	24/8	noen ad.	ØF	på trekk

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FRA SVALBARDS DYREVERDEN 12

(On the Svalbard fauna 12)

Some observations on the birdfauna on Hopen, Svalbard

BY

HENRIK ÖSTERHOLM[1]

Contents

Abstract

This paper deals with some ornithological observations made on Hopen, Svalbard, during the second half of August and the first week of September in 1965. On the island 11 species were breeding. *Somateria mollissima* and *Fratercula arctica naumanni* have not been recorded as breeders earlier. Possibly also one pair of *Branta bernicla hrota* bred there. Out of these I observed 5 visitors. Of them *Calidris ferrugineus* was a new bird for the Svalbard area.

In the paper there are also statements as to the birds mentioned by LØVENSKIOLD and in the diary at the meteorological station on Hopen. According to these records and my own observations 38 bird species altogether have been seen on Hopen.

Introduction

As a member of a Swedish-Finnish geographical expedition to the island of Hopen, Svalbard, in 1965 I had possibility to study the birdfauna on the island. Unfortunately we did not arrive at Hopen until August 15th. Most of the young were fledlings at this time. The autumn migration had not begun, however. In the last week of August the migration generally started and when we left Hopen four weeks later only a fraction of the bird population was left.

There are only a few records of the birdfauna on Hopen from earlier years.

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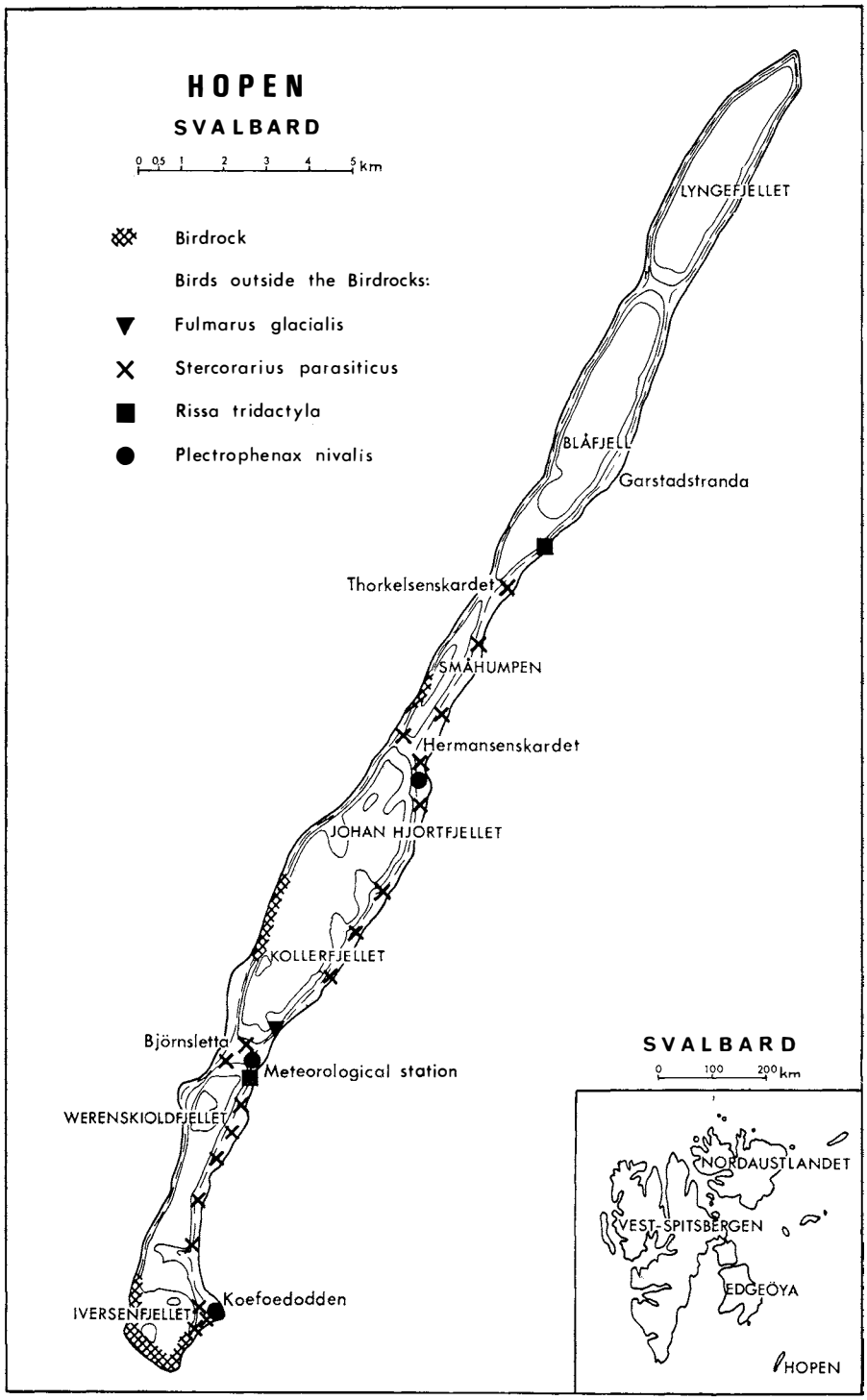

Fig. 1. *Map of Hopen. The main breeding places for some of the most common birds are indicated.*

The geographical circumstances on Hopen

Hopen is a part of Svalbard. It is about 600 km north of Norway. On the island there is a meteorological station (MSH i. e. Meteorological Station Hopen in my paper) which situation is 76° 30′ N lat and 25° 4′ E long. Hopen is 38 km long and only 2 km at the broadest place. At the southern end of the island there is the highest point, Iversenfjellet which is 370 m high. From this peak northwards there is a level and narrow about 250–300 m high plateau. At four places there are valleys cutting straight through the plateau. Specially the western and southern coasts are very steep. There is no possibility to walk along the western shore. On the eastern side there is a narrow coast plain between the shore and the steep mountain walls. But only at a few places you can climb up to the plateau from the coast plain. At some places steep cliffs descend abruptly into the sea on the eastern side, too. On the northernmost part of the island also the eastern coast is very steep. Unfortunately we had not the opportunity to visit this part of Hopen. (Figs. 1 and 2).

The vegetation is very sparse. In the valleys there are some mosses. In some places you can see *Papaver radicatum* and *Saxifraga oppositifolia*.

The climate is rather severe. The mean temperature in July is about +3°C. The summers are wet and foggy. Usually the sea gets ice free in July (LUNDE 1963), but during our visit the sea was not open until the first week of September.

Fig. 2. *The cliff south of the meteorological station. Iversenfjellet in the background.*

Since 1908 there have been polarbear hunters on the island some years. They have built three huts. After the Second World War "Vervarslinga for Nord-Norge" built a meteorological station in Husdalen, the southernmost of the valleys.

The birdlife on Hopen

The birdfauna is characterized by few species but many individuals. In the Svalbard area there are altogether 37 breeding species (LØVENSKIOLD 1964). On Hopen I found only 12 of them. Except these I saw 5 visitors. According to the diary on MSH and LØVENSKIOLD 21 birds have been observed in addition to these. From all the Svalbard area LØVENSKIOLD mentions 93 bird species. On Hopen the steep cliffs give fulmars, guillemots and seagulls very good breeding possibilities. These birds make up the bulk of the bird population. The arctic skua is also a common bird.

The birdlife on Hopen has not been studied earlier. However, some notes are made by IVERSEN (1926). LØVENSKIOLD (1964) mentions Hopen in his work about the birdfauna in the Svalbard area, but he has not visited the island.

Breeders

Fulmarus glacialis (L.). The fulmar breeds in colonies on the cliffs of Iversenfjellet and the western side of Kollerfjellet. There are small colonies on a steep cliff about 500 m north of MSH and on the western cliff of Småhumpen. Separate pairs breed along the eastern side of Werenskioldfjellet and Johan Hjortfjellet. One pair bred in a colony of kittiwakes about 500 m south of MSH.

All of the observed fulmars were of the dark phase. Extremely dark birds formed about 5–10 per cent of the population. This is in accordance with LØVENSKIOLD's opinion (1964 p. 74).

When we arrived at Hopen most of the young were still in their nests. Many of them had not fledged until the first week of September. When we left the island on September 11th all young had left their nests.

Somateria mollissima (L.). LØVENSKIOLD says (1964 p. 103), that in 1898 ducks and ducklings of eiders were seen off Hopen, but that trappers do not think that the eider breeds here. However, on August 15th I saw 2 females and 9 ducklings near the shore of Bjørnstranda west of Kollerfjellet. On August 19th I observed 1 male, 2 females and 5 ducklings in the bay east of Hermansenskardet. On August 26th there were 1 female and 4 ducklings on Koefoedodden. It seems probable that the eider breeds on Hopen. The staff of MSH was of the opinion that the eider breeds in the northern part of the island. According to LØVENSKIOLD (1964 p. 113) eiders usually breed on low level ground covered with grass and moss. In the northern part of Hopen such places are found only on Garstadstranda.

It was very surprising to find eiders on Hopen in the summer 1965 when the ice situation was so severe. But the narrow belt of open water between the shore and the ice was probably enough for the birds.

Calidris maritima (BRÜNN.). Two broods of purple sandpiper were seen on the shore east of Hermansenskardet on August 17th. On August 21st I saw two broods in the neighbourhood of MSH. During August and the first week of September a flock of about 30 purple sandpipers stayed on the shore at MSH and southwards. Probably they were non-breeding birds which, according to LØVENSKIOLD (1964 p. 186) can be found in big flocks as early as June and July. When we left Hopen only a few purple sandpipers remained.

Stercorarius parasiticus (L.). The arctic skua is a common breeder on Hopen. I found 19 breeding pairs altogether. East of Thorkelsenskardet there was 1 pair and between this valley and Hermansenskardet were 2 pairs breeding. In Hermansenskardet and on the coastplain east of the valley there bred 3 pairs. Between this place and MSH I observed 3 pairs. On Bjørnsletta west of MSH 2 pairs were breeding. Along the shore south of MSH I counted 5 pairs and on Koefododden 3 pairs.

The dark phase of the arctic skua is a rare bird in Svalbard (LØVENSKIOLD 1964 p. 218). In the eastern part it is more frequent, but the light birds make over 90 per cent of the population there, too. On Hopen 8 of the full-grown birds were dark, i. e. 21 per cent. In two cases both of the sexes were dark.

Usually there are several kilometres between the nests in the breeding grounds in the Svalbard area (LØVENSKIOLD 1964 p. 223). On Hopen the arctic skuas bred more closely together.

When we arrived we saw only a few fledged young. In the beginning of September all young were able to fly. In the first week of September all non-breeding arctic skuas disappeared from the island. About half the breeding pairs had left Hopen on September 11th.

I never saw arctic skuas trying to get food directly. They robbed their food chiefly from kittiwakes which are abundant on the island. They also attacked guillemots and little auks. RÖMER and SCHAUDIN (1900 p. 26) state, that the arctic skua does not pursue glaucous gulls. This is not in accordance with my observations, as in many cases I saw arctic skuas robbing their food from glaucous gulls.

Larus hyperboreus (GUNN.). The glaucous gull is a common breeder on Hopen. It breeds in small groups on the cliffs specially on Iversenfjellet, the western side of Werenskioldfjellet and Kollerfjellet. There were small groups also in the neighbourhood of Hermansenskardet and Thorkelsenskardet. Single pairs bred specially near by MSH. All the groups were among colonies of other cliff-breeding birds.

When we arrived at Hopen no fledged young were observed. After a few days the first ones appeared. On the first days in September I saw big flocks of fledged young. On September 8th I observed the last non-fledged young. According to LØVENSKIOLD (1964 p. 248) the normal time for the young glaucous gulls to fly is in the first three weeks of August.

Rissa tridactyla (L.). In the area we examined there were four big colonies of

kittiwakes. They were situated on the cliffs of Iversenfjellet and the western side of Kollerfjellet, on a cliff about 500 m south of MSH and between Thorkelsenskardet and Garstadstranda. There were small colonies on the western cliffs of Werenskioldfjellet, the eastern side of Johan Hjortfjellet and on the cliffs of the western side of Småhumpen. Small groups were observed on many places along the steep western coast. Some pairs bred among fulmars on a steep cliff north of MSH.

In the diary of MSH is mentioned, that on June 16th a nearly hatched egg of kittiwake was found. Probably it had been laid about May 25th (see LØVENSKIOLD 1964 p. 283). When we arrived at Hopen there were many young on the wing. In September very few were not able to fly, but when we left the island there were still some young sitting in their nests. RÖMER and SCHAUDIN (1900 p. 74) mention 3 to 4 eggs as a normal clutch in the Svalbard area. In SWENANDER's opinion (1900 p. 18) this is erroneous. He found clutches of two eggs to be normal on Bjørnøya. The same is generally valid on Hopen, too. In some nests I could see three young, but never four.

Plautus alle (L.). The little auk bred in great numbers on the steep cliffs of Iversenfjellet and the western side of Kollerfjellet. A small colony was found on the western cliffs of Werenskioldfjellet. Little auks were seen on the western side of Småhumpen, too. There were thousands of birds in the middle of August, but after that they disappeared very quickly. In September I saw no little auks any longer.

According to the diary of MSH the first little auks in 1964 were observed on April 8th.

Uria lomvia (L.). Brünnich's guillemots bred in enormous numbers on the same birdrocks as the little auks. This species left Hopen at the same time as the little auk. In September I could see no Brünnich's guillemot any longer.

In the diary of MSH there was mentioned that guillemots were seen in a lane on February 13th in 1965. One year the men on Hopen shot guillemots in December and January. According to LØVENSKIOLD (1964 p. 321) there are a few observations of wintering guillemots from Spitsbergen. The earliest observation of migrating guillemots in the spring is on March 3rd.

Cepphus grylle mandtii (MANDT). Isolated pairs of Mandt's guillemots bred on all birdrocks. In the colony of kittiwakes about 500 m south of MSH there were 2 pairs, each of them having 2 young. From one of the nests the young fled about August 20th. In the other the young birds were still there on August 26th, but on the 29th the nest was empty. According to LØVENSKIOLD (1964 p. 337) the majority of young of Mandt's guillemots are fully fledged in the last two-three weeks of August in the Svalbard area. In the first week of September there were still some Mandt's guillemots in the sea around Hopen.

Fratercula arctica naumanni (NORTON). On August 16th I observed 3 Spits-

bergen puffins swimming at the foot of the cliffs of Iversenfjellet. On September 8th I observed 1 fully grown puffin and 2 newly fledged ones in the same place. The staff of MSH had observed puffins many times in the neighbourhood of Iversenfjellet.

These observations are not in accordance with LØVENSKIOLD's statements. He says (1964 p. 341) that the puffin does not breed on Hopen and that there are only 3 records from this island. The nearest breeding ground on Spitsbergen is on Keilhaufjellet northeast of Sørkappøya. My observations from Hopen are also surprising because the young puffins usually do not appear on the water before the first week of October (LØVENSKIOLD 1964 p. 344). KOLTHOFF (1903 p. 88) records, however, that he saw a young bird on the water on August 29th 1898.

Plectrophenax nivalis (L). The snow-buntings were seen in three places. When we arrived at Hopen all the young had fledged and the birds were united in flocks. In the surroundings of the hut east of Hermansenskardet there was a flock consisting of 7 birds between August 17th and 20th. In the last week of August and the first week of September there was a flock consisting of 23 birds in the neighbourhood of MSH. On Koefoedodden I saw 10 birds on August 26th. 5 birds were about 2 km south of MSH on September 8th. Probably there had been 6 to 8 pairs in the area examined by me.

Snow-buntings will not build their nests in bogs or on the tundra where there are no stones under which the nests can be hidden. On Hopen, however, all the breeding grounds were tundras or solifluction soils with very sparse vegetation and few stones and boulders. The huts and old timber on the shores and the raised beaches give some shelter, though.

I cannot say for how long the flocks stayed on Hopen. The big flock in the station area was still there when we left the island. According to LØVENSKIOLD (1964 p. 367) the flocks will not go south until September. The autumn migration does go on even throughout October.

Possible breeders

Branta bernicla hrota (MÜLLER). On Koefoedodden I found an empty nest of a goose on August 16th. On August 26th there was a pale-breasted brent goose in the same place. Three days later the same species was observed grazing on Bjørnsletta. On August 30th I saw a pale-breasted brent goose swimming outside Koefoedodden. In the diary of MSH there is mentioned that 7 pale-breasted geese were seen on Koefoedodden in July 1963.

It seems probable that the nest I found was of a pale-breasted brent goose. The tundra on Koefoedodden is a typical breeding ground for a pale-breasted brent goose. The same applies to the pink-footed goose, but no member of this species has been seen on Hopen before September.

In the nest I found there were no remains of eggs. I think that the breeding had been destroyed by a glaucous gull, an arctic skua or by an arctic fox.

According to LØVENSKIOLD (1964 p. 138) pale-breasted brent geese have only

been seen on migration on Hopen. The migration starts towards the end of August. The nearest breeding place known so far is on Kong Ludvigøyane west of Tjuvfjorden.

Visitors

Anser fabilis brachyrhynchus (BAILLON). I observed 4 pinkfooted geese grazing on Bjørnstranda on September 11th. According to LØVENSKIOLD (1964 p. 128) the main part of this species migrates throughout September.

Branta leucopsis (BECHSTEIN). On August 16th I saw a barnacle goose passing MSH. On September 10th 3 barnacle geese were grazing on Bjørnstranda. This goose and the geese mentioned earlier visit Hopen every spring and autumn.

Very little is known about the migration of the barnacle goose in Svalbard. The earliest date is May 22nd (KRISTOFFERSEN 1931 p. 256). In 1964 barnacle geese were seen on Hopen on May 25th.

Calidris alpina (L.). Between August 23rd and 25th 2 dunlins were seen in the surroundings of MSH. This is the first record from Hopen.

Calidris ferrugineus (L.). I saw a curlew sandpiper on MSH on August 23rd. The weather was stormy with winds from the east. This bird has never earlier been observed in the Svalbard area.

Catharacta skua (BRÜNN.). On August 18th I saw a great skua at Hermansenskardet. This is the first record from Hopen.

Observations done by other persons

In addition to the pink-footed goose and the barnacle goose LØVENSKIOLD mentions the following visitors on Hopen in his work about the birdfauna in the Svalbard area: *Gavia stellata* (PONTOPP.), *Lagopus mutus hyperboreus* (SUNDEV.), *Arenaria interpres* (L.), *Stercorarius pomarinus* (TAMM.), *Pagophila eburnea* (PHIPPS.), *Xema sabini* (SABINE), *Nyctea scandiaca* (L.), *Hirundo rustica* (L.) and *Corvus corone cornix* (L.). To these records I only add some observations about the ivory gull and the hooded crow. LØVENSKIOLD says (1964 p. 263) that ivory gulls have been seen only a few times on Hopen. But according to the staff on MSH this gull species is often seen during spring and autumn. A hooded crow visited the island in the autumn of 1963. It was killed and eaten by glaucous gulls. About this bird LØVENSKIOLD mentions (1964 p. 353) that it has been observed there in 1954 and in 1956.

But the staff at MSH has seen the following bird species, too:

Anas crecca (L.). A teal was observed in 1962.

Clangula hyemalis (L.). According to KRISTIAN TORSVIK, the steward at MSH, a long tailed duck appeared on Hopen in 1963.

Cygnus cygnus (L.) or *C. bewickii* (YARR.). In the diary at MSH is a note about a swan having been shot in 1958. Unfortunately there are no reports about species or month.

Vanellus vanellus (L.). According to K. TORSVIK a lapwing has once been seen on Hopen, probably in 1962.

Charadrius hiaticula (L.). The same man told me that a ringed plover was observed on Hopen on May 30th 1963.

Charadrius squatarola (L.). K. TORSVIK also told me that a grey plover was seen in 1963. This is the first record from the Svalbard area.

Sterna paradisaea (PONTOPP.). The arctic tern has been found breeding in the whole Svalbard area, with the exception of Hopen. According to LØVENSKIOLD (1964 p. 287) the bird must at least have visited the island, but it has never been recorded there. According to K. TORSVIK the arctic tern is often seen on Hopen, however. It will probably sometimes breed there. We could not see any arctic tern on Hopen. Koefoedodden could be a good breeding ground for the bird. It is very curious that at least in 1965 there were no terns on Hopen. The sea is rich in food. The ice condition is hard, but not as hard as at Kong Karls Land where the species breeds. Glaucous gulls and arctic skuas are common on Hopen, but according to LØVENSKIOLD (1964 p. 290) the tern mercilessly drive them away from their territories.

Asio flammeus (L.). A short-eared owl was shot and stuffed on May 13th 1964. This is the first record from the Svalbard area.

Corvus corax (L.). A raven was observed in 1962.

Turdus pilaris (L.). In the autumn there have sometimes been seen flocks of fieldfares on Hopen. According to the diary at MSH a big flock was there for some days in 1961.

Oenanthe oenanthe (L.). According to K. TORSVIK a wheatear was seen on Hopen in 1964.

Sturnus vulgaris (L.). Some starlings visited Hopen in the autumn of 1963. One of the birds fled into the house and lived in the attic for some months. It died after eating salt meat.

Summary

On Hopen there bred 11 bird species in 1965: *Fulmarus glacialis, Somateria mollissima, Calidris maritima, Stercorarius parasiticus, Larus hyperboreus, Rissa tridactyla, Plautus alle, Uria lomvia, Cepphus grylle mandtii, Fratercula arctica naumanni* and *Plectrophenax nivalis*. The eider and the puffin have not been found breeding earlier. The others were common breeders. Possibly one pair of *Branta bernicla hrota* bred on the island. No nest of the pale-breasted goose has been found on Hopen earlier.

I observed the following visitors: *Anser fabalis brachyrhynchus, Branta leucopsis, Calidris alpina, Calidris ferrugineus* and *Catharacta skua*. The curlew sandpiper has not been observed in the Svalbard area earlier. The dunlin and the great skua are new species on Hopen. According to LØVENSKIOLD (1964) *Gavia stellata,*

Lagopus mutus hyperboreus, Arenaria interpres, Stercorarius pomarinus, Pagophila eburnea, Xema sabini, Nyctea scandiaca, Hirundo rustica and *Corvus corone cornix* have been seen on Hopen. Besides these the following species are mentioned in the diary at MSH: *Anas crecca, Clangula hyemalis, Cygnus cygnys* or *C. bewickii, Vanellus vanellus, Charadrius hiaticula, Charadrius squatarola, Sterna paradisaea, Asio flammeus, Corvus corax, Turdus pilaris, Oenanthe oenanthe* and *Sturnus vulgaris*. The grey plower and the short eared owl have not been observed in the Svalbard area earlier.

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Lokalt område med permafrost i Gudbrandsdalen

AV

OLAV LIESTØL

Abstract

In September 1965 permafrost was found in the neighbourhood of Otta in Gudbrandsdalen, Central-Norway, about 300 m above sea level and about 5 m under the surface. The frozen area occurs in a glaciofluvial deposit from the end of the glacial period, and consists of loosely piled coarse stones. The permafrost is not a relic from the glacial period, but is formed by cold air in winter sinking into the mass and cooling it, while the warmer lighter air in summer has no effect. In this way a "cold-trap" is formed which preserves the permafrost.

Similar phenomena on a smaller scale are known from several areas of Western Norway. Permafrost with ice is also found in large stone and slag heaps in several places in Norway.

Det vakte stor oppmerksomhet og forundring da det tidlig på høsten 1965 i et grustak syd for Otta på østsiden av dalen ved Sandbu ble funnet tele med isklumper ca. 5 m under overflaten.

Forfatteren besøkte stedet 5/9 mens det enda var drift i grustaket. Betegnelse grustak er ikke helt korrekt i dette tilfelle, da massen vesentlig består av grov, kantet stein. Den ble brukt som fyllings- og bærelag ved omlegging av riksveien like ved. Massen er ganske egenartet ved at sand- og leirfraksjonen fullstendig mangler samtidig som blokkene for det meste bare er kantet eller svakt kantslitt. Begrensingen mot sør er ganske skarp og står nærmest i en raskant mot en renspylt fjellgrunn som her skråner utover mot midten av dalen. Som rimelig kan være er vegetasjonsdekket meget sparsomt i et så tørt og veldrenert område. Over store flater finnes bare reinmose og litt lav på steinene. Spredt hist og her utover står det noen forkrøblete furutrær, mens det i området omkring er en ganske tett og frodig bestand (Fig. 1). Dannelsesmåten er meget vanskelig å bestemme. På en eller annen måte er materialet sortert, men på den annen side må transporten og behandlingen være meget moderat, noe de skarpkantede blokker tyder på. Noen slags talusdannelse eller ras av noen art utelukkes av form og beliggenhet. Det rimeligste er at man har å gjøre med et formelement fra isavsmeltingens sluttfase.

Fig. 2 viser et fotografi av grustaket. Den stiplede linje angir telens øvre grense som varierer fra 3 til 6 m under overflaten. Telen var for hard til at det lønte seg å bryte denne for å skaffe masse, men ved først å ta bort de overliggende massene

Fig. 1. *Bildet viser den sterile, blokkrike overflaten av permafrostområdet.*

The picture shows the sterile surface of the permanently frozen ground. Photo: O. LIESTØL.

og så vente noen dager kunne man få skrapt av et nytt opptint lag. Massen består som tidligere nevnt av blokker med en del grov grus imellom. Opplagringen virket meget løs med store åpninger mellom blokkene. Under telegrensen var åpningene fylt med is. Rene isklumper på opptil 1 dm^3 kunne brytes løs. En del isprøver ble tatt med til Vassdragsvesenets kuldelaboratorium og undersøkt med polarisert lys. Undersøkelsen tyder på at isen er dannet på stedet ved at krystallene er vokset ut fra de tilgrensende stenflater. Det kan således ikke være tale om rester av bre-is fra istiden. Man måtte da kunne vente større sammenhengende partier av is. Den ville også hatt en annen krystallstruktur.

På dette sted, ca. 300 m o. h., skulle det normalt ikke være betingelse for permafrost. Man måtte da eventuelt ha et årsmiddel på under 0°C i overflaten. Lufttemperaturen på de nærmest liggende stasjoner viser: Vinstra +2,3, Vågåmo +1,8 og Dovre +0,9. Lufttemperaturen ligger således ikke så langt fra 0°C, men jordens overflatetemperatur vil ligge høyere på grunn av innstrålingen om sommeren og snøens isolerende virkning om vinteren. En relikt fra en tidligere kaldere klimaperiode kan man heller ikke godt godta. Noen slik klimadepresjon av betydning er heller ikke kjent. Selv klimaforverringen på 1700-tallet ville ikke forårsake permafrost som kunne ha overlevet til nå. I et grustak like i nærheten med normal, litt sortert morenegrus var det heller ikke antydning til permafrost på ca. 7 m dyp.

Det må derfor være noe med strukturen i denne dannelse, og det materiale den er bygget opp av som er årsaken. Den hypotese som synes rimeligst er følgende:

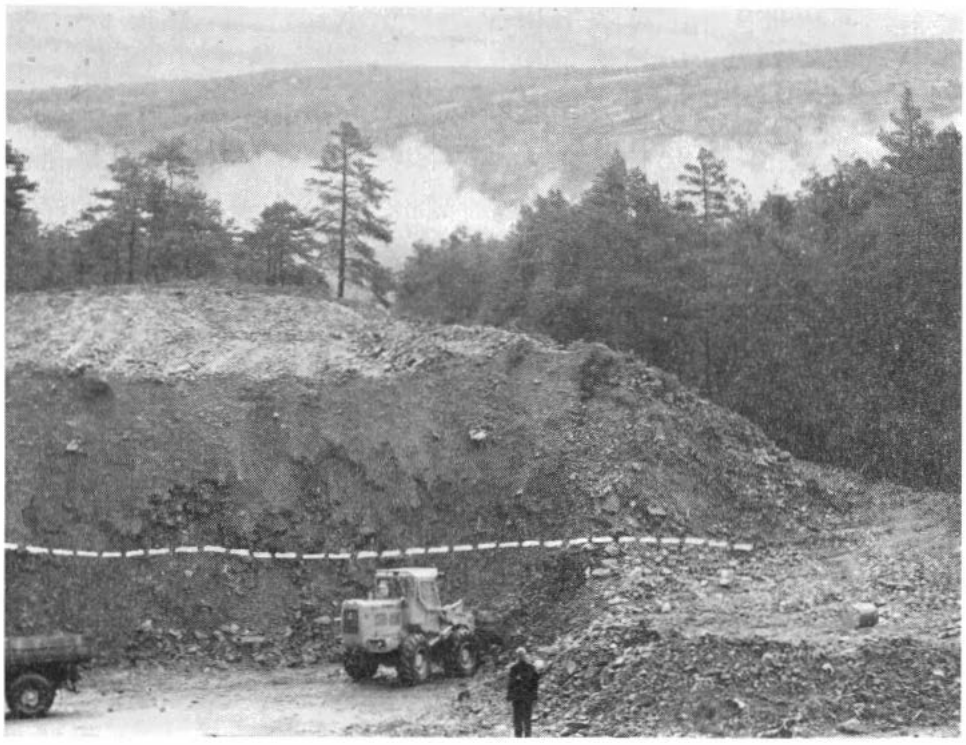

Fig. 2. *Fotografiet viser grustaket i den sørligste del av permafrostområdet.*

The photograph shows the gravel pit in the southern part of the permafrost area. Photo: O. LIESTØL.

Porerommet eller åpningene mellom steinene er så store at den kalde luften om vinteren kan sige ned til den tette horisont som telen danner, og fortrenge luft med høyere temperatur. Den varme sommerluften har derimot ingen mulighet for å fortrenge den tunge kaldluften som har lagret seg i hulrommene i løpet av vinteren. En del kaldluft vil selvfølgelig smått om senn sige ut på nedsiden av området om sommeren, og bli erstattet av varmere luft øverst. Imidlertid er nedkanten av dannelsen mer finkornig og dekket av vegetasjon slik at luften ikke så lett siger ut her. Det hele kommer derfor til å virke som en kuldefelle, der den kalde vinterluften blir liggende igjen. Denne luften blir selvfølgelig også etter hvert oppvarmet av den varme som avgis fra steinmassen for igjen å bli skiftet ut med kaldere luft. Dette vil gjenta seg til man ut på ettervinteren får massen såpass nedkjølt at det oppstår en likevekt mellom luften i steinmassen og luften over. Nedtrengingen av den kalde luften blir selvfølgelig til en viss grad hindret av snødekket. Men i denne forholdsvis tørre del av landet er dette meget sparsomt slik at det nesten alltid vil være åpninger. Om våren vil smeltevann fra overflaten sige ned og fryse i den avkjølte steinmassen. Derved frigjøres varme som til slutt har fått hele massen over telegrensen til å anta 0°C. Mot telegrensen vil det nedtrengende smeltevann og senere regnvann stoppe opp. Til å begynne med fryser en del av vannet og telegrensen heves. Senere på året vil imidlertid regnvann og delvis også varmeledning gjennom steinmassen presse telegrensen nedover igjen

til den ut på høsten når sitt laveste nivå. Fenomenet blir på denne måte en form for den såkalte «Balch Ventilation» som tidligere er beskrevet fra Nord-Amerika. (1962).

Hvor dyp denne telen er og hvor stor utstrekning den har, er vanskelig å si. Utstrekningen faller sannsynligvis sammen med denne spesielle geologiske dannelse og skulle da være ca. 50 dekar. Hadde man noen temperaturmålinger i massen, ville dybden så noenlunde kunne beregnes. Men i denne grove steinmassen er det meget vanskelig å bore hull for plasering av termometre.

Ifølge den foran nevnte hypotese skulle det således være helt spesielle geologiske forhold som forårsaker permafrost på dette stedet. Så helt ualminnelig er ikke dette fenomen som man skulle tro. På Vestlandet er det på flere steder fra gammelt av kjent urer med «kalde-hol» hvor man kunne oppbevare mat og hvor man kunne finne is til langt ut på sommeren. I veiskjæringer gjennom urer har vegvesenet enkelte steder kommet over tele sent på høsten. På nordsiden av Jølstervatnet ble det sommeren 1966 funnet en stor isklump i en ur ved utvidelse av vegen. Når gamle steinfyllinger fra gruver og tunneler blir tatt i bruk igjen, støter man også på denne form for tele. Dette er kjent blant annet fra de store berghallene ved Røros og Noreanleggene. På slike steder har man nettopp den løse oppbygging av stor stein som luften lett kan sirkulere gjennom.

Den forekomst som mest kan minne om forholdene ved Otta er beskrevet av I. LEIVISKÄ (1914) fra Åbo i Finnland. Her dreier det seg om et såkalt iskonglomerat som ble funnet i en dybde av ca. 20 m i en eskerlignende glasiofluvial dannelse. Etter beskrivelsen og fotografiene å dømme er materialet noenlunde av samme type som ved Otta. Mektigheten var ca. 3 m og utstrekningen i en retning oversteg i alle fall 45 m. LEIVISKÄ mener dette bare kan være en levning fra istiden, men forklaringen virker ikke overbevisende. Sannsynligvis kan man bruke samme forklaring her som for permafrostområdet ved Otta. I denne forbindelse kan oppmerksomheten henledes på en artikkel av V. OKKO (1957) som beskriver de termale forhold i noen eskere i Sør-Finnland. Han viser hvordan om vinteren luften i eskeren oppvarmes relativt i forhold til luften utenfor og drives opp gjennom grusmassene i en slik grad at overflaten på toppen delvis holdes snøbar gjennom hele vinteren. Om sommeren foregår den omvendte prosess, og kald luft siger ut ved eskerens fot. Avkjølingen var imidlertid her ikke så stor at evig tele ble dannet.

Under våre breer, selv de høyest beliggende, holder temperaturen seg alltid på 0°C. Imidlertid finner man permafrost med store ispartier i de resente ende- og sidemorener i til dels lave nivåer, f. eks. foran enkelte av Jostedalsbreens utløpere. Den beskrevne effekt er sikkert også her med til å vedlikeholde og danne denne form for evig tele.

Permafrost i vanlig forstand treffer man først på i høyfjellet og lengst nord i landet. Men heller ikke her vil man få store sammenhengende områder. Temperaturen i bakken er i høy grad bestemt av snødekkets tykkelse. Vegetasjonen og det øverste jordslags struktur spiller også en rolle.

Ved nøyere undersøkelser vil man sikkert kunne finne mange slike områder som her er beskrevet rundt omkring i landet.

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Bremålinger i Norge i 1965

Av
Olav Liestøl

Abstract

The regime measurement on Storbreen in the budget year 1964–65 shows an accumulation of 154 gr/cm², an ablation of 120 gr/cm², and a resultant positive material balance of 34 gr/cm². On Hardangerjøkulen they show respectively 205 gr/cm², 154 gr/cm², and a surplus of 51 gr/cm². The accumulation was a little above the normal and the ablation well below the normal.

The table gives the results of all regime measurements, which were carried out by Norges Vassdrags- og Elektrisitetsvesen and by Norsk Polarinstitutt. It can be seen that all the glaciers had a positive material balance. In relation to the normal budget, the glaciers in Jotunheimen and Nigardsbreen glacier had the highest positive balance. The results are also illustrated in Fig. 6.

Ice front fluctuations have been measured for 13 glaciers, and all except Åbrekkebreen are in retreat.

Storbreen

På Storbreen ble akkumulasjonen målt i slutten av april. Vinternedbøren var omtrent normal eller litt under, men stadige snøfall i løpet av hele ablasjonssesongen gjorde at den totale akkumulasjon ble 154 g/cm². Dette er mere enn gjennomsnittet for de årene målinger har vært foretatt på Storbreen. Av samme grunn ble også akkumulasjonen i de øvre områdene i forhold til de nedre større enn normalt. Likedan som sommeren 1964 var sommeren 1965 fuktig og kald, men gjennomsnittstemperaturen var likevel en del høyere. Dette resulterte i en ablasjon på 120 g/cm² mot 95 g/cm² året før og 170 g/cm² for de foregående 16 år.

Resultatet av materialbalansemålingene gir derfor et overskudd for breen som helhet på 34 g/cm².

I samarbeid med Norges Vassdrags- og Elektrisitetsvesen ble det i tillegg til de vanlige observasjoner foretatt spesielle undersøkelser. To studenter oppholdt seg størstedelen av ablasjonssesongen på breen. Det ble foretatt daglige målinger av ablasjonen på noen utvalgte staker og ukentlige målinger på samtlige ablasjonsstenger. Dessuten ble der foretatt rutinemessige meteorologiske observasjoner. Den tidligere oppsatte limnigraf i breelven ble også, så ofte som været tillot, kontrollert og elveløpet renset. Til kalibrering av limnigrafen ble det en rekke ganger foretatt vassføringsmålinger ved hjelp av saltmetoden. Alle disse målinger er et ledd i en undersøkelse av de glasihydrologiske forhold i området. Elven ved limnigrafen drenerer et område som er ca. 80% bredekket, og er derfor meget vel egnet til en slik spesialundersøkelse.

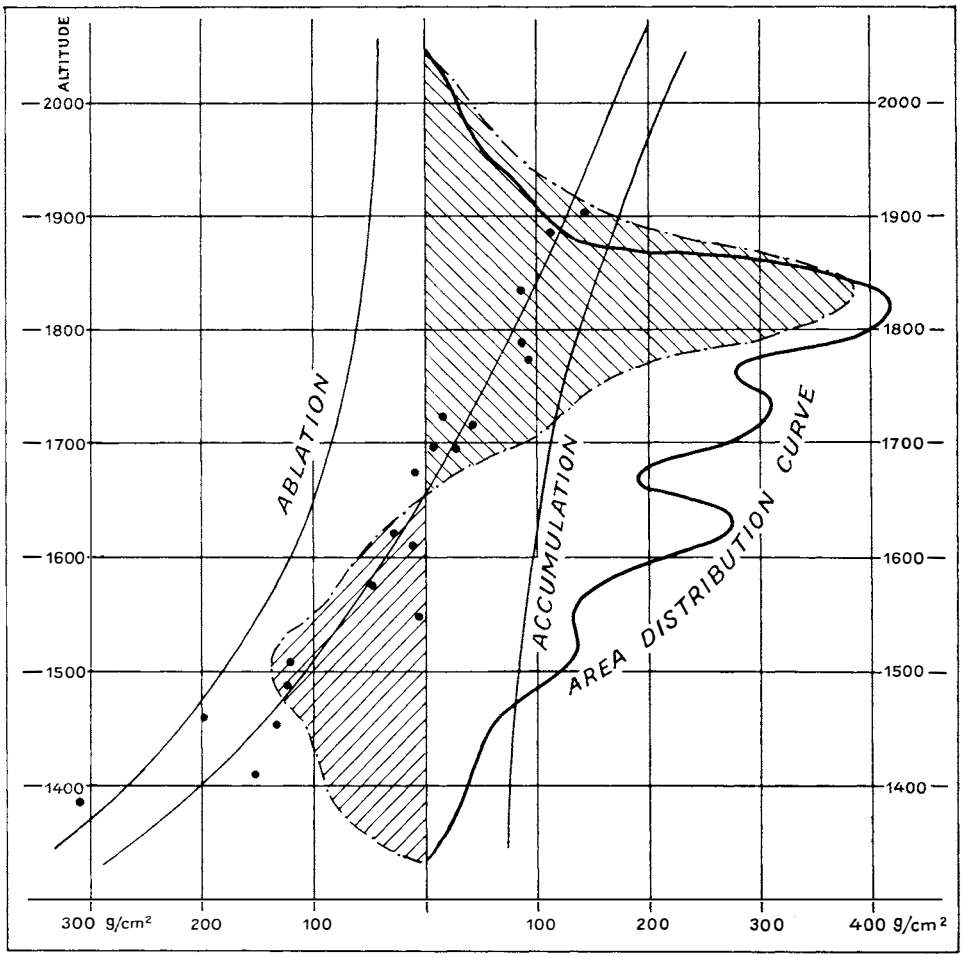


Fig. 1. *Diagrammet viser ablasjonen, akkumulasjonen og nettobudsjettet på Storbreen i forhold til høyden over havet.*

The diagram shows ablation, accumulation and the net budget on Storbreen in relation to the height above sea level.

Hardangerjøkulen

I 1965 ble breen besøkt første gang fra 10. til 14. mars. Stålstenger med diameter 42 mm og 53 mm ble fraktet opp på breen for å erstatte de stenger som var brukket ned eller blitt borte på annen måte. Man håper at disse stenger er kraftige nok til å klare vinterstormenes påkjenninger selv om de rager opptil 4 m over snøoverflaten. Ved det siste besøk på breen i oktober 1964 var vær- og siktbarheten så dårlig at bare noen få stenger i området over 1600 m o.h. ble funnet og dratt opp. Det var følgelig derfor også få stenger som kunne brukes som støtte for beregninger av akkumulasjonen. Imidlertid var høstens overflate relativ lett å ta igjen ved sondering. 12 stenger ble plassert i en rekke fra toppen av breen og ned til 1680 m o. h. Disse kunne da tjene til registrering av det tillegg i akkumulasjonen som man ville få om våren, og likeledes tjene som ablasjonsstenger inntil fjorårets

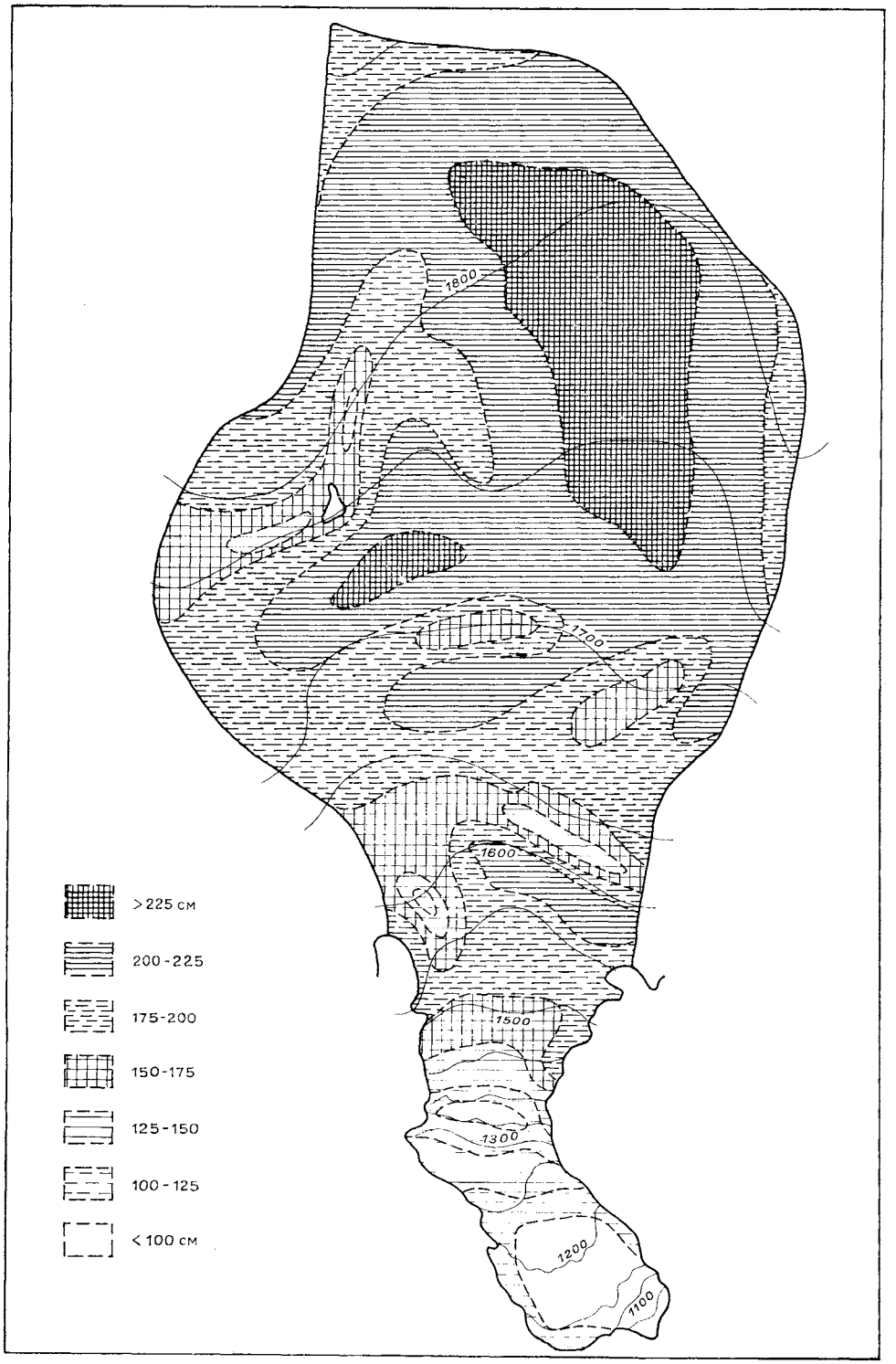


Fig. 2. *Kartet viser akkumulasjonen på den del av Hardangerjøkulen som dreneres til Rembesdalsskåki.*

The map shows the accumulation on the part of Hardangerjøkulen which drains into Rembesdalsskåki.

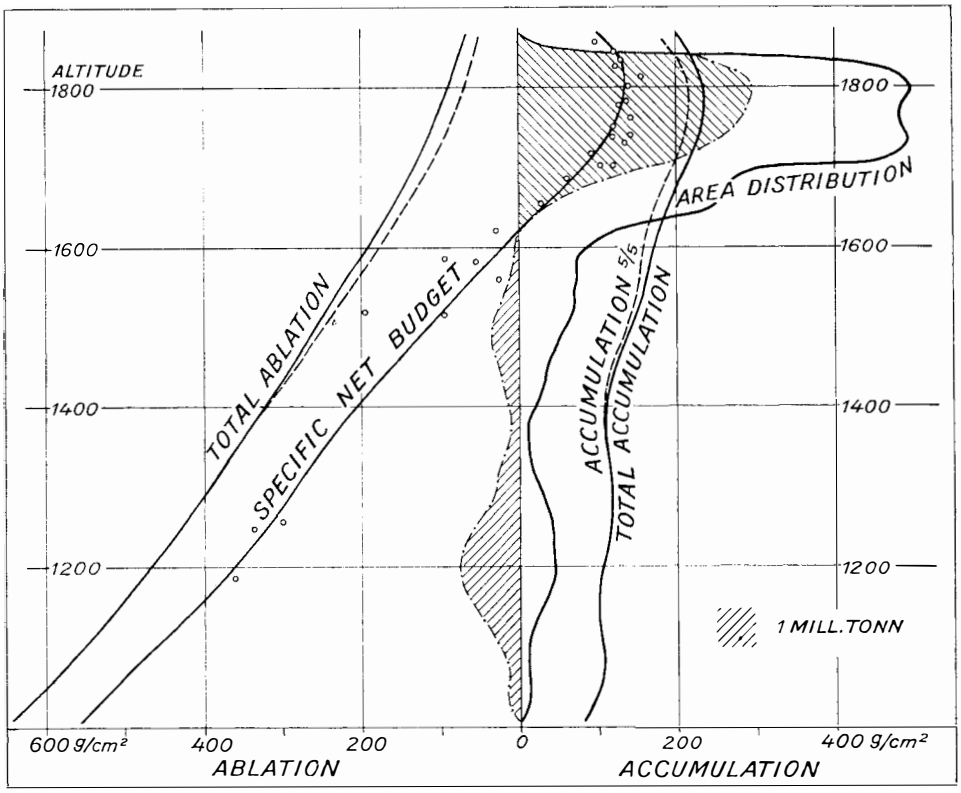


Fig. 3. *Diagrammet viser akkumulasjonens, ablasjonens og nettobudsjettets variasjon med høyden o. h.*

The diagram shows the accumulation, ablation and net budget variation with height above sea level.

stenger igjen smeltet fram. Ved det neste besøk på breen, fra 24. april til 2. mai, ble akkumulasjonen igjen målt. Det viste seg at man i dette tidsrom hadde fått et tillegg på 19 g/cm² i gjennomsnitt. Mønstret og fordelingen av akkumulasjonen i dette tidsrom følger ganske nøye det man fikk når den samlede akkumulasjonen ble målt (Fig. 6).

På den sist nevnte tur ble også ved velvillig hjelp av Forsvarets våpentekniske korps en ny observasjonshytte, innkjøpt av N.V.E., kjørt opp på breen. Den ble plassert på en liten nunatakk i Rembesdalsskåkis akkumulasjonsområde ca. 1765 m o. h. Denne hytten ble innkjøpt for å kunne utvide arbeidsprogrammet på Hardangerjøkulen. To studenter bodde her i størsteparten av ablasjonssesongen fra 23/6–1/9. T. VINJE, meteorolog ved Norsk Polarinstitutt, monterte den nødvendige apparatur og instruerte og satte i gang arbeidet. Breen ble besøkt siste gang fra 30/9–4/10. Det hadde vært en relativt stor ablasjon i september, men man kan av meteorologiske data slutte at det etter dette besøk ikke har vært smelting av betydning.

Observasjonene som de to studenter utførte besto først og fremst i en detaljert registrering av ablasjonen. En rekke stenger ble plassert fra hytta på skrå nedover og tvers over breen. Disse ble observert hver dag så sant været tillot det. Dessuten

ble alle ablasjonsstenger på breen målt minst en gang i uken. I tillegg til disse observasjoner ble en rekke meteorologiske data samlet inn. Disse var spesielt beregnet på å gi et bedre kjennskap til de faktorer som bestemmer ablasjonen. For å finne strålingens virkning ble en balansemåler og en aktinograf montert i nærheten av hytta. For bestemmelse av konveksjonens og kondensasjonens virkninger ble temperatur, fuktighet og vindstyrke registrert både ved automatiske instrumenter og ved 3 daglige ordinære målinger. Spesielle målinger ble også foretatt for å bestemme ved hvilken temperatur nedbøren går over fra snø til regn, eller rettere når nedbøren gir akkumulasjon. Resultatet ga en temperatur på +1.4°C. Et forsøk ble også gjort på å få målt kondensasjonen direkte. En aluminiumsfolie ble lagt ut på snøen og den kondenserte fuktighet samlet opp i et måleglass. Man

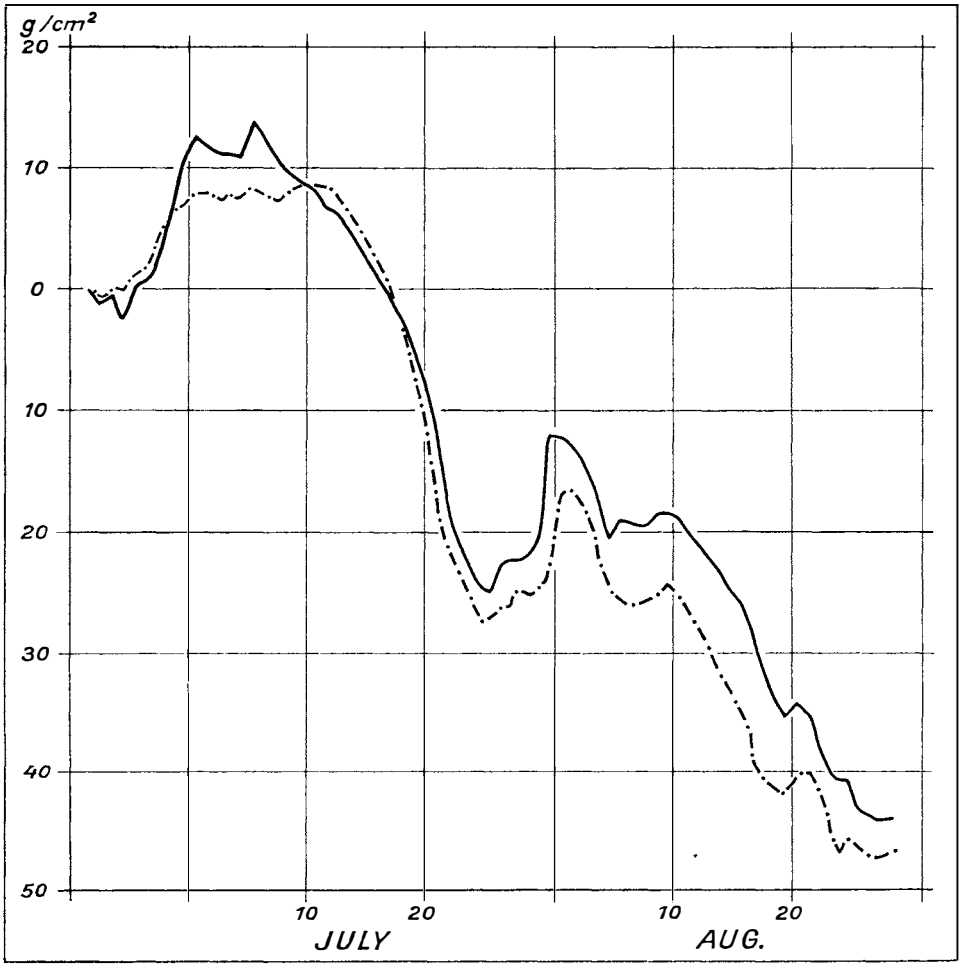


Fig. 4. *Diagrammet viser midlet av de daglige registreringene på 5 staker i 1700 m nivået omregnet i g/cm². Den stiplete kurve viser de beregnete verdier for akkumulasjonen og ablasjon basert på observasjoner på Slirå.*

The diagram shows the average of the daily measurements at five stakes at the 1700 m level converted to gr/cm². The dashed curve shows the calculated values for accumulation and ablation based on the observations at Slirå.

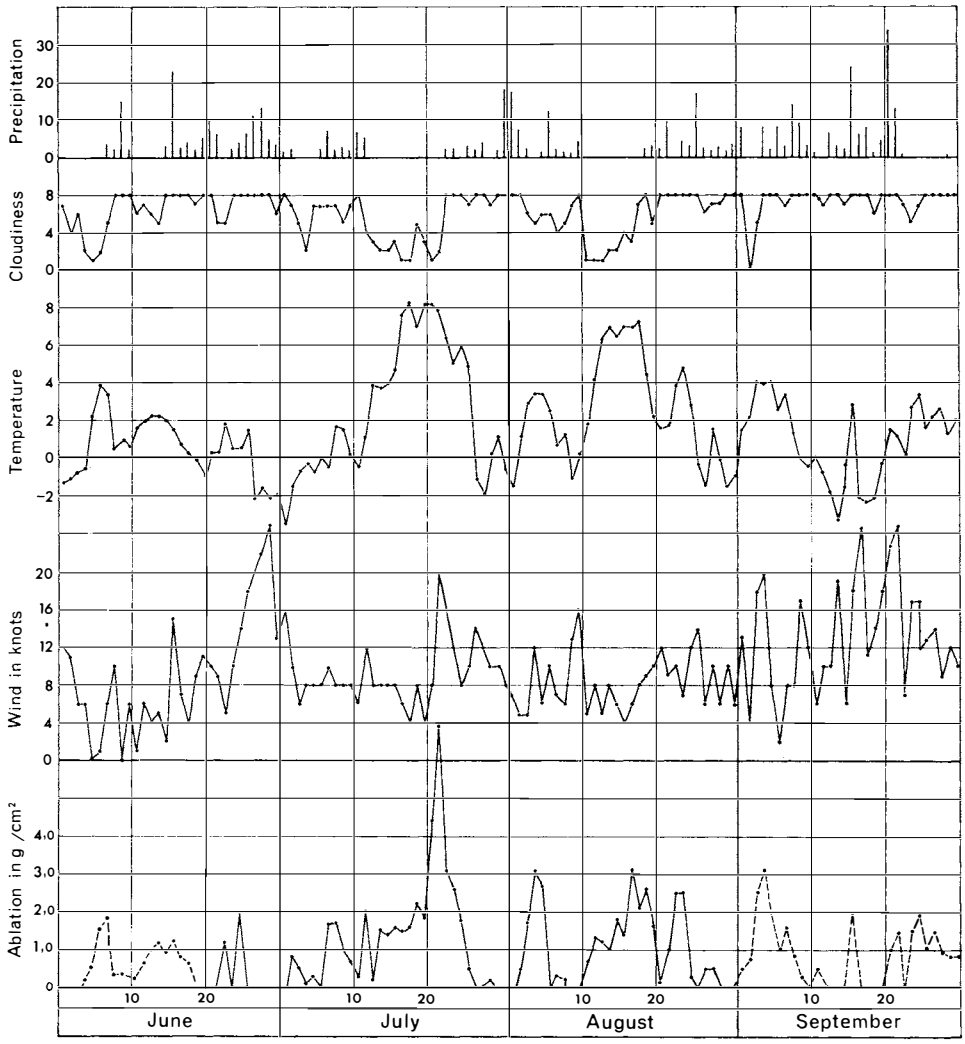


Fig. 5. *Diagrammet viser grafisk de meteorologiske observasjoner fra Slirå som har betydning for ablasjonen. Den heltrukne del av den nederste kurve viser direkte ablasjonen i g/cm². dag i gjennomsnitt for 5 staker plassert ca. 1700 m o.h. Den stiplete del er beregnete verdier. I grove trekk følger ablasjonen temperaturkurven, men man kan merke seg vindens betydning. F. eks. viser dagene 18. og 22. juli omtrent samme temperatur og skyforhold mens vinden er omtrent 5-doblet den siste dagen. Resultatet blir en 4-dobling av ablasjonen. I diagrammet kommer ikke kondensasjon og fordampning frem, noe som i enkelte situasjoner spiller stor rolle.*

This diagram shows plots of the meteorological parameters for Slirå which are significant for ablation. The solid part of the lowest curve shows the average measured ablation (gr/cm². day) for 5 stakes c. 1700 m a.s.l. The dashed portions are calculated values. The ablation roughly follows the temperature curve but the significance of the wind is noticeable. For example the days July 18 and July 22 show about the same temperature and cloud cover but the wind is about 5 times stronger on the latter day. The result is 4 times higher ablation. The diagram does not include condensation and evaporation which in individual situations play a large role.

gikk her ut fra at folien antok samme temperatur som snøen. Duggnedslaget på aluminiumsfolien gir også en god indikasjon på når det er kondensasjon eller sublimasjon. Alle disse målinger er ennå ikke ferdig bearbeidet, men man håper, når resultatet foreligger, å kunne bruke observasjoner fra nærliggende stasjoner til å bestemme forholdene på breen i de tider man her ikke har direkte observasjoner.

Av tabellen ser man resultatet av siste års målinger på Hardangerjøkulen. Akkumulasjonen var litt over normalen. Dette skyldes først og fremst en større akkumulasjon i nivåene over 1600 m o.h. I dette ligger også en del av forklaringen på at det er så meget større overskudd i balansen her enn på Folgefonni, hvor storparten av arealet ligger under 1600 m nivået. Ablasjonen ble på grunn av den relativt lave sommertemperaturen mindre enn normal. Stadige snøfall, spesielt i de øvre nivåer, gjorde også at albedoen hele tiden var meget høy, ca. 70%. Resultatet ble derfor et overskudd for breen som helhet. Overskuddet var også større enn året før på tross av at smeltingen i 1964 var lavere. Dette skyldes som tidligere nevnt den store akkumulasjon i de øverste nivåer, som igjen «skyldtes» at sommernedbøren kom i form av snø. Denne sommerakkumulasjon kommer tydelig fram på diagrammet på Fig. 3, som viser en daglig registrering på 5 staker i høyde 1690 til 1720 m o.h. Den stiplede kurve i Fig. 4 er tegnet på grunnlag av observasjoner på Slirå. Dette er en beregnet kurve hvor man på grunnlag av nedbør, vind og temperaturobservasjoner har prøvd ad teoretisk vei å kalkulere ablasjon og akkumulasjon på Hardangerjøkulen i samme høyde som de fem stakene. Beregningene var spesielt vanskelige denne sommeren på grunn av de tidligere nevnte stadige snøfall som forandret overflatens albedo og de øverste snølags egenvekt.

Ved siden av undersøkelsene som Norsk Polarinstitutt har gjort på Storbreen og Hardangerjøkulen, har Norges Vassdrags- og Elektrisitetsvesen foretatt målinger på syv andre breer; fem i Sør-Norge og to i Nord-Norge (Glasio-hydrologiske undersøkelser i Norge 1965, Norges Vassdrags- og Elektrisitetsvesen, Hydrologisk avdeling, Årsrapport). Nedenfor er alle undersøkelsene i Norge satt opp i tabell 1.

Tabell 1.

Bre	Akkumulasjon g/cm²	Ablasjon g/cm²	Balanse g/cm²
Folgefonni	237	233	+ 4
Hardangerjøkulen	205	154	+51
Ålfotbreen	364	316	+47
Nigardsbreen (Jostedalsbreen)	229	138	+91
Storbreen (Jotunheimen)	154	120	+34
Hellstugubreen –»–	129	77	+52
Gråsubreen –»–	77	36	+41
Blåisen (Nordland)	200	146	+54
Storsteinfjellbreen (Nordland)	169	125	+44

Skjematisk er forholdene ved de forskjellige breer satt opp i diagram Fig. 6. Til sammenligning er forholdene for de to foregående år tegnet inn. Målingene av breenes fram- eller tilbakerykking i meter ble målt ved i alt 11 breer og resultatet sees av nedenstående oppstilling:

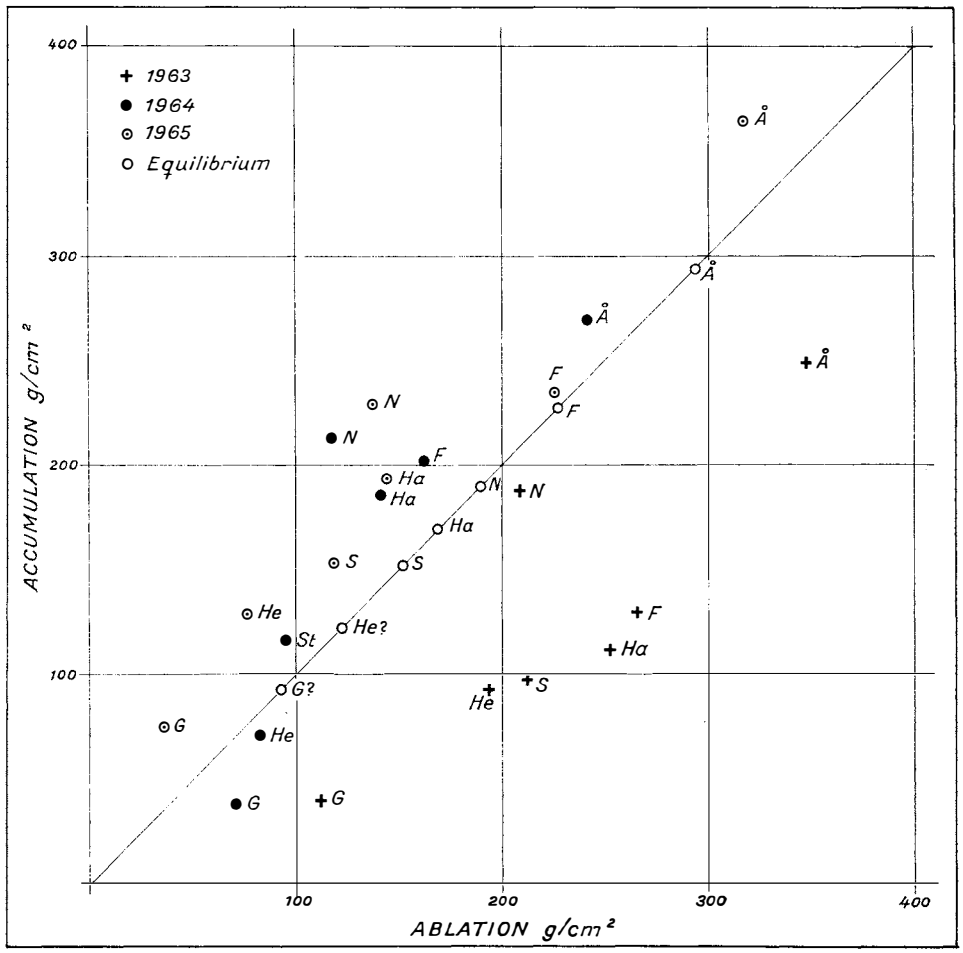


Fig. 6. *Diagrammet viser forholdet mellom brutto akkumulasjon og brutto ablasjon sett i relasjon til forholdene når breene er i likevekt og har «normal» materialomsetning. Å = Ålfotbreen, F = Folgefonni, N = Nigardsbreen, Ha = Hardangerjøkulen, S = Storbreen, He = Hellstugubreen og G = Gråsubreen.*

The diagram shows the ratio of gross accumulation to gross ablation in comparison to the conditions when the glaciers are in equilibrium and have «normal» material balance.

Jostedalsbreen	
Austerdalsbreen	÷ 8
Nigardsbreen	÷ 54
Fåbergstølbreen	÷103
Lodalsbreen	÷120
Stegholtbreen	÷ 67
Brikdalsbreen	÷ 2
Åbrekkebreen	+ 7
Tunsbergdalsbreen	÷ 28
Folgefonni	
Båndhusbreen	0
Jotunheimen	
Storbreen	÷8
Styggedalsbreen	÷3
Møre	
Finnebreen	0
Veslebreen	÷1
Trollkyrkjebreen	0

Besøk på Bouvetøya i 1958 og 1966

(Bouvetøya twice visited)

Av
Thore S. Winsnes

Abstract

Bouvetøya is the southernmost island on the Mid-Atlantic Ridge. In December 1958 the author, on board the Norwegian expedition-ship "Polarbjørn" on its way to Antarctica, passed Bouvetøya. However, poor weather-conditions made it impossible to get on shore that time, and while the ship only sailed around the island a series of radarpictures was taken (Fig. 2). In March 1966 the author, as glaciologist and Norwegian representative, joined a South-African expedition to Bouvetøya. The South-Africans are planning to try to put up a permanent meteorological station on Bouvetøya. Due to especially favourable weather-conditions, it was this time possible to get on shore several times, and a small hut was put up on the main glacier at the place where one is hoping perhaps it will be possible to build a permanent meteorological station. A series of oblique air photographs was taken from the helicopters, and it was carried out glaciological and geological investigations. Several of the highest points on the island were visited with the helicopters and the heights were measured with altimeter. On the basis of all the new information a preliminary map of Bouvetøya (Fig. 1) has been compiled. Several geological samples were also collected, mainly on Westwindstranda.

Bouvetøya, jordens ensomste øy, ligger sydligst på Den midtatlantiske rygg. Som en kuriositet kan nevnes at en annen norsk øy, Jan Mayen, er den nordligste øy på den samme ryggen. Begge er bredekket og består av en stor vulkan. Mens Jan Mayen er vel kartlagt, finnes det idag ikke noe godt kart over Bouvetøya. Et kart produsert av Syd-Afrika i 1956 viser tilnærmet riktig kystkontur, mens innlandet er mindre godt avbildet.

I desember 1958, på vei til Antarktis, foretok ingeniør B. Luncke og jeg en del observasjoner av øya. Været umuliggjorde en landing og lavt skydekke hindret en observasjon av de høyere partier av øya. Mens «Polarbjørn» langsomt sirklet øya i ca. to mils avstand, ble det tatt 32 bilder av radarskjermen (Fig. 2), mens klokke, kurs, dybde og antatt hastighet ble notert.

På grunnlag av dette materialet kunne man konstruere et kart i likhet med det syd-afrikanske. Kystkonturen lignet bortsett fra området syd for Kapp Circoncision hvor utrasninger, først observert 10. januar 1958 av et helikopter fra den amerikanske isbryter «Westwind», hadde dannet en ny kystlinje. Dette området ble også fotografert og det var mulig å få et inntrykk av landtungen.

Syd-Afrika har i flere år vist stor interesse for Bouvetøya, da den ligger i et område hvor meteorologiske observasjoner, viktige for værvarslingen for Syd-Afrika, mangler. Ved flere besøk, senest i mars–april 1964 (LUNDE 1964), har de forsøkt å finne en plass for en bemannet meteorologisk stasjon. Været har som regel hindret inngående undersøkelser, men man har fra meteorologhold antydet at den gunstigste posisjon ville være lavt nede på østsiden av øya.

Ved en ny ekspedisjon i februar–mars 1966 fikk jeg anledning til å være med som glasiolog og norsk representant.

Etter ni døgns seilas fra Cape Town i sterk motvind ankom ekspedisjonen 3. mars til Bouvetøya. Ekspedisjonen besto av to skip, og ca. 50 mann var engasjert i utforskningen av øya og omgivelsene. Den syd-afrikanske marines forskningsskip, jageren «Natal», tok seg av opploddingen av farvannet rundt øya. Ombord var dessuten med folk for å studere biologi, kosmisk stråling, ionosfære og «air glow». Forskningsskipet «R.S.A.» på ca. 740 tonn hadde ombord to turbinhelikoptere av typen «Wasp» med mannskap. Ombord var dessuten lederen for ekspedisjonen, orlogskaptein B. HAGERTY, D.F.C. og direktøren for Værvarslingen i Syd-Afrika, Mr. S. A. ENGELBRECHT som også var leder av det vitenskapelige programmet. Videre var med ombord meteorologer, geologer, glasiologer og topografer.

Da fartøyene ankom til øya fikk vi en usedvanlig gunstig værperiode, og i fem dager ble folk daglig landsatt flere steder på øya og det ble tatt en rekke fotografier av øya, blant annet også en rekke skråbilder fra helikopter.

Allerede første dag lyktes det å finne et område lavt nede på breen på østsiden av øya, som syntes brukbart for etablering av en bemannet stasjon. De følgende dager ble det satt opp og nøyaktig innmålt en rekke staker i dette området for senere å kunne måle isens bevegelse og snøtilveksten. Stakenes innbyrdes plassering ble målt igjen senere, men i løpet av de få dagene mellom målingene var det ikke mulig å spore noen bevegelser. Ved graving av tre dype hull og kjerneboring kom vi frem til at området synes å ha en årlig tilvekst på ca. 60 cm snø. Dette var rent lokalt i det svakt konkave området med et fall østover på ca. 6°. Både syd og nord er breoverflaten konveks, snauføket og full av sprekker. For senere å kunne se hvordan et hus ville klare seg i området, ble en liten bod satt ned på isen av helikopter og fast forankret på to store stokker. Det er ventet at fokksneen raskt vil samle seg rundt huset, men man vet ikke hvilke mengder det dreier seg om.

Mens vi lå ved øya var det lite av brefronten i øst som brakk av, og sydligst på Mowinckelkysten ser det ut som om det er en stor fonn foran brefronten. Dette tyder på meget liten bevegelse av isen i dette området.

Tykkelsen av isen langs fronten var nokså jevn, ca. 60–70 m.

Topografene arbeidet med tellurometere og teodolitt og fikk målt en linje fra stasjonen på isen og til Norvegiaodden. Undertegnede fikk også tatt noen sikt fra stasjonen mot toppene, og dessuten ved et besøk på Westwindstranda ble det tatt en del sikt i dette området. De topografiske stasjoner med beregnede høyder er avsatt på kartet, Fig. 1. Geologiske prøver ble samlet fra en rekke steder, og helikopterne landet også på de høyeste toppene slik at deres høyder kunne bli tilnærmet bestemt ved hjelp av høydemåleren. Det viste seg at høydene av fjelltoppene er noe mindre enn tidligere antatt.

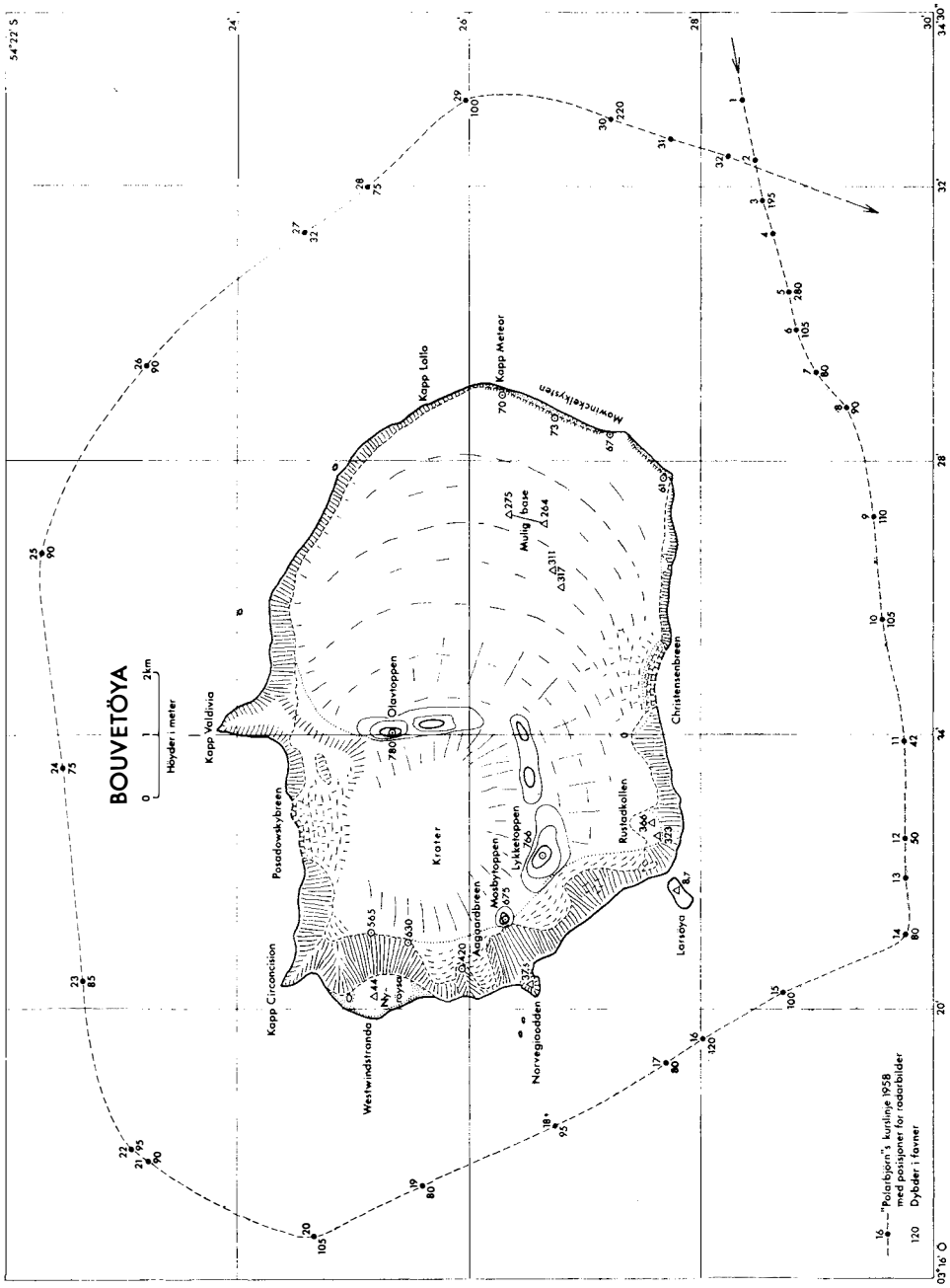


Fig. 1. *Kart over Bouvetøya, stilt sammen av* T. S. WINSNES *på grunnlag av radarbilder tatt i 1958 og observasjoner gjort i felten i 1966. Trekanter angir varder, rundinger med prikk i angir steder hvor høyder ble målt.*

Map of Bouvetøya, compiled by T. S. WINSNES on base of radarpictures taken in 1958 and observations made in the field in 1966.

På grunn av det til dels klare været var det mulig å se og fotografere toppene av øya slik at oppbyggingen av de høyere deler kan skisseres. Klarværet varte imidlertid aldri så lenge at en planlagt vertikalfotografering lot seg gjennomføre.

Under et besøk på Westwindstranda ble området rekognosert. Dette området ble også besøkt i 1964 og geologien her er beskrevet av BAKER og TOMBLIN (1964). Undertegnede føler seg ikke overbevist om at de beskrevne «tumuli» finnes og om

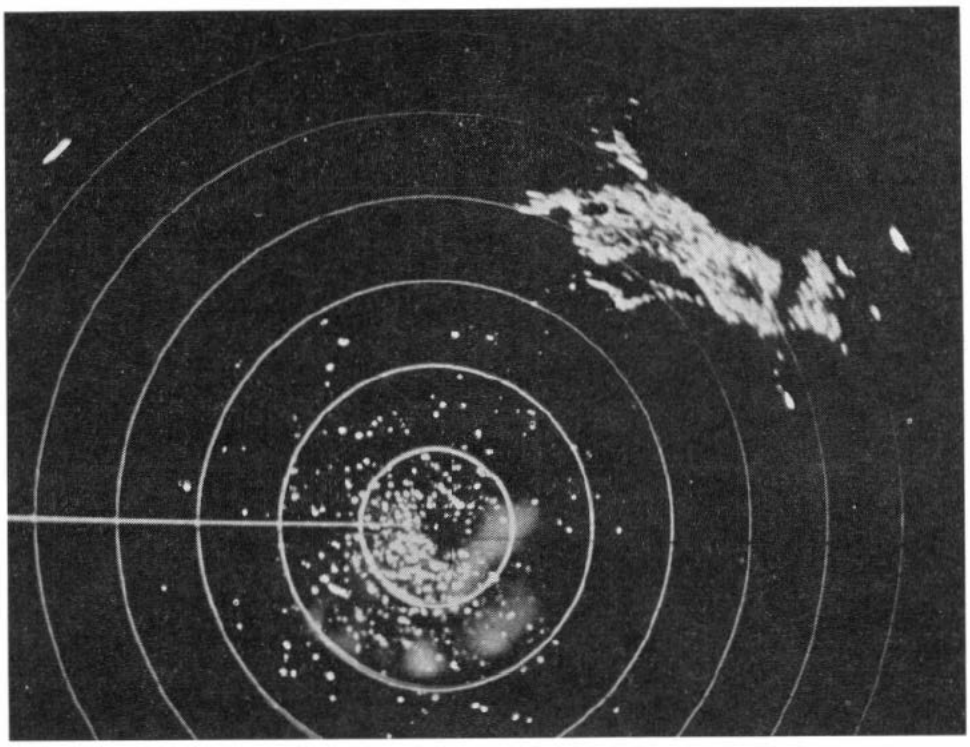


Fig. 2. *Radarbilde av vestkysten av Bouvetøya tatt fra stasjon 20, 9. desember 1958. Avstanden mellom distanseringene er ½ naut. mil. Westwindstranda kan tydelig sees (se kartet, Fig. 1).*

Radarpicture of the west coast of Bouvetøya taken from station 20 on December 9, 1958. The distance between the circles on the picture is ½ naut.mile. Westwindstranda can clearly be seen (see also map, Fig. 1).

den eruptive dannelse av området. Det synes mer sannsynlig at hele området er dannet ved en stor utrasning av fjellsiden. Deler av breen har også rast ut og har gitt opphav til typiske «grytehull» i området. En fumarole antydet på BAKER og TOMBLINS kart ble ikke funnet.

Ved hjelp av observasjonene fra 1958 og 1966 har jeg forsøkt å lage en skisse av øya. Bouvetøya består som nevnt av en vulkan, med et krater hvis rand er gjennombrutt i nord. Her velter Posadowskybreen ut. Langs kraterranden ligger Olavtoppen, Lykketoppen og Mosbytoppen. Erosjonen av vestsiden av øya har nådd helt inn til kraterranden. På sydsiden av øya, i en høyde av 320 til 365 m, er et bart område, Rustadkollen. Det består av et kollet område med rik lavvegetasjon og synes å være et sted hvor en stasjon kan plasseres. Sett fra meteorologisk synspunkt er stedet ikke så gunstig som på østsiden. Det ligger nemlig noe høyere, har et stort stup i syd og fjellene i nord vanskeliggjør radio-kommunikasjon med Syd-Afrika. Mannskapene og utstyr kan bare bringes til stedet med helikopter. Fra stasjonen på østsiden er det antagelig mulig å ta seg ned til en bred strand syd på Mowinkelkysten, slik at man kan få kontakt med stasjonen, selv med det vanlige lave skydekket.

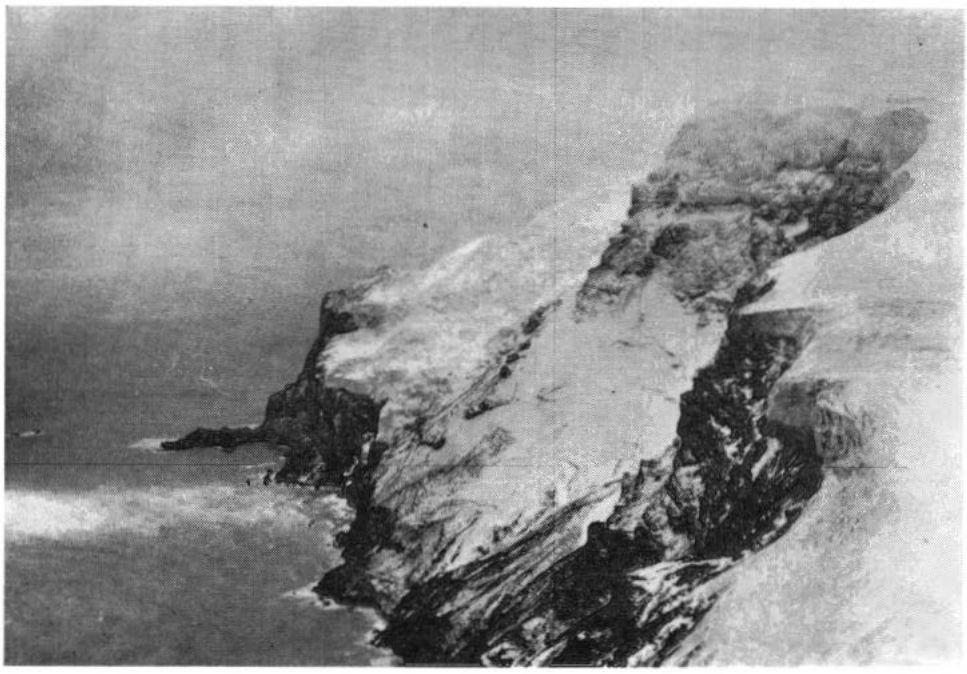


Fig. 3. *Utsyn fra Rustadkollen mot Norvegiaodden.*

The view from Rustadkollen towards Norvegiaodden. Foto: T. S. WINSNES.

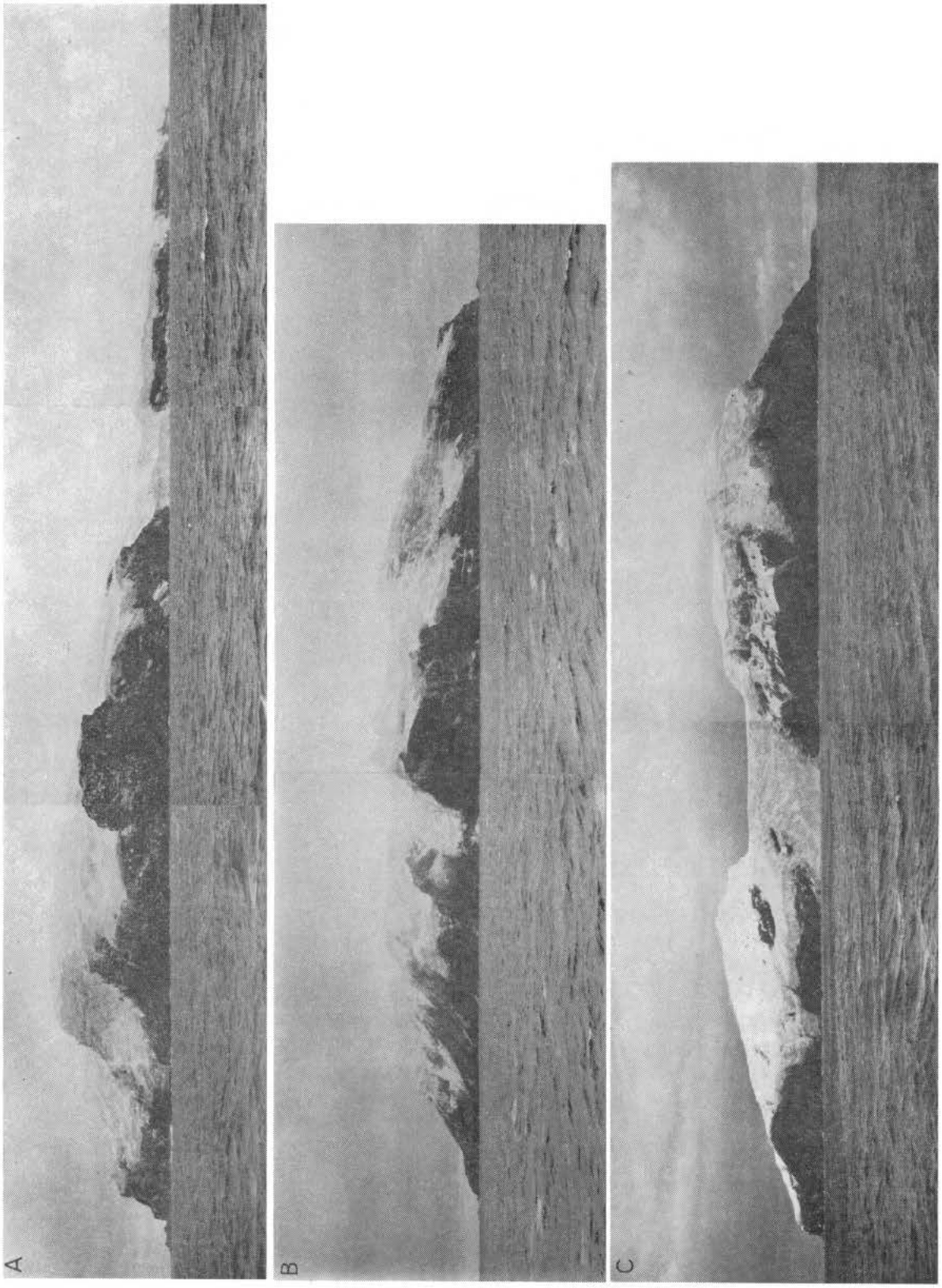
Kartskissen (Fig. 1) og panoramabildene (Fig. 4) gir forøvrig et inntrykk av dette lille norske bilandet.

Dyrelivet består som bekjent av fugl og sel. Av de første er det store kolonier av Adéliepingviner (*Pygoselis adeliae*) og gulltoppingviner (*Eudyptes chrysolophus*) flere steder. Det er særlig store kolonier på Larsøya og nordligst på Nyrøysa.

Foruten pelsselen (*Arcto cephalus tropicalis*) på Larsøya, er det nå også 500–600 pelssel nordligst på Westwindstranda. Det er her god plass for en stor økning av bestanden. 20-30 sjøelefanter (*Miræunga leonina*) har også tilhold her.

Av andre observasjoner av interesse kan nevnes en varm vanndamp som strømmer ut fra fjellet øst for Kapp Circoncision. Denne dampen ble også observert av «Norvegia»-ekspedisjonene i slutten av 1920-årene. Det ble også observert damputbrudd noe høyere oppe i fjellet.

Jeg håper at den norske virksomheten på Bouvetøya ikke har tatt slutt. Som en vil se har Syd-Afrika gjort en stor innsats i utforskningen av øya, og en kan regne med at det i nær fremtid vil foreligge nye kart over øya og farvannet rundt. Ennu er ikke en topografisk kartlegging av øya avsluttet, det kan også fortsettes med geologiske undersøkelser og studier av dyrelivet. Hvis det ikke snart blir en norsk innsats, vil også dette bli utført av andre.


A
B
C

Litteratur

BAKER, P. E. and J. F. TOMBLIN, 1964: A recent volcanic eruption on Bouvetøya, South Atlantic Ocean. *Nature*, **203**, 1055–56. London.

LUNDE, T., 1964: Et besøk på Bouvetøya. *Norsk Polarinstitutt Årbok 1963*. Oslo.

Fig. 4. *A. Bouvetøya sett fra syd, Norvegiaodden til venstre og Rustadkollen midt på bildet.*
B. Bouvetøya sett fra sydvest. Til venstre Kapp Circoncision, midt på bildet Aagaardbreen og Mosbytoppen og til høyre Larsøya.
C. Bouvetøya sett fra nord. Til venstre Kapp Valdivia, midt på bildet velter Posadowskybreen ut av krateret, til høyre sees Kapp Circoncision og lengere syd kan man skimte Westwindstranda og Nyrøysa.

A. Bouvetøya seen from south, to the left Norvegiaodden and in the centre of the picture Rustadkollen.

B. Bouvetøya seen from southwest. To the left Kapp Circoncision, in the centre Aagaardbreen and Mosbytoppen and to the right Larsøya.

C. Bouvetøya seen from north. To the left Kapp Valdivia, in the centre Posadowskybreen and to the right can be seen Kapp Circoncision, Westwindstranda and Nyrøysa. Foto: T. S. WINSNES.

The weather in Svalbard in 1965

BY
VIDAR HISDAL

The following description of some salient features of the large scale atmospheric circulation over the Svalbard area is based on a study of the weather maps for 1965. The pressure systems most closely connected with these curculation patterns and the character of the resulting air flow are briefly indicated. Words like cold, cool, normal and mild characterize the temperature conditions in relation to the average conditions for the period 1947–64, the basis of these indications being mainly the temperature observations from Isfjord Radio.

1965	
1–3 Jan.	Moderate to strong northeasterly winds between a depression to the south and a high pressure area over the Polar Basin. Cold.
4–15 Jan.	Cyclones pass to the south and east, while the circulation over Svalbard is governed by passages of high pressure ridges. Weak or moderate winds, and mostly temperatures below average.
16–20 Jan.	Low pressure centres move northeastwards between Norway and Svalbard. Northeasterly winds, and cold.
21–25 Jan.	Svalbard is situated near the boundary of an extensive anticyclone over northern Russia. Varying winds between south and east. Mild.
26–29 Jan.	A cyclone from the southwest passes. Southerly winds and mild in the front of the cyclone, a colder westerly to northerly air stream in the rear.
30 Jan.–12 Feb.	Cyclones pass close to or over the Svalbard area. Winds between east and north most of the time. Temperatures below average at the start of the period, milder towards the end.
13–15 Feb.	Northerly to easterly winds to the south of a high pressure area over the Polar Basin. About normal temperatures.
16–24 Feb.	A well-developed cyclonic system passes Svalbard from the southwest. Southerly winds, and above normal temperatures in the front of the system, northerly winds and colder in the rear.
25–28 Feb.	A cold air stream from the north between a polar high and a low pressure area towards the southeast.
1–5 March	Depressions are passing to the south. Northeasterly winds, and below normal temperatures.
6–15 March	Cyclonic centres move across the southern part of the area. Periods of strong winds. Comparatively mild air in the front of the cyclones, cold in the rear.
16–26 March	A high pressure ridge to the east gives northeasterly to northerly winds. Cold.
27–28 March	A high pressure ridge extends northwards to the Svalbard area. Weak, variable winds. Somewhat higher temperatures towards the end of the period.

29 March–8 Apr.	The circulation is governed by a high pressure area to the west and depressions to the east. Most of the time advection of cold air from the north.
9–25 Apr.	The passage of a series of cyclones from the southwest brings considerably milder air.
26–27 Apr.	A high pressure situation gives calms or weak winds. Mild.
28 Apr.–1 May	A cyclone approaches over Greenland and passes the islands. In the rear of the cyclone the temperature drops to about average values for the season.
2–12 May	A weak depression from the southwest, and later a weak depression from the northwest, move across the area. Cooler towards the end of the period.
13–22 May	The situation is dominated by an extensive high pressure area with centres towards the north and east. Weak winds or calms, and comparatively cold.
23–31 May	Weak depressions from the southwest and west pass. Light winds of variable direction, and about normal temperatures.
1–4 June	A high pressure ridge moves slowly over the Svalbard region. Weak winds, and average or somewhat below average temperatures.
5–10 June	Cyclones from the southwest again approach the area. Light winds or calms during the first part of the period, somewhat stronger, northwesterly winds towards the end. Temperature conditions about normal.
11–18 June	Svalbard lies near the eastern boundary of an extensive anticyclone over Greenland and the Polar Basin. Light winds or calms. The temperature continues to vary about the average for the season.
19–25 June	Cyclones from the south pass over or close to the area. Weak to moderate winds. Slightly below normal temperatures.
26 June–9 July	A northerly to easterly air flow between high pressure areas over the Polar Basin and (or) Greenland, and depressions moving farther south. Most of the time temperatures above normal.
10–23 July	Cyclones from the south, and later from the southeast, pass over or close to the region. Cool during the middle of the period.
24–29 July	A feeble pressure field with light, variable winds, and about normal temperatures.
30 July–3 Aug.	An anticyclone extends from Greenland towards the Polar Basin. Comparatively high temperatures.
4–9 Aug.	Svalbard is situated between a polar high and depressions farther south. Generally light winds, and temperatures about or above normal.
10–20 Aug.	A ridge of high pressure brings light winds or calms. Slightly cooler.
21 Aug.–4 Sept.	Depressions approach from the southwest, and the centres pass closely south of the islands. Weak to moderate winds of variable direction. Cool at the start of the period, about normal temperatures towards the end.
5–14 Sept.	Svalbard lies on the outer edge of a high pressure area towards the north and east. Weak winds or calms, and mostly cold.
15 Sept.–10 Oct.	Cyclones pass south of, and, later, over the Svalbard area. Easterly winds and close to normal temperatures during the first part of the period, northeasterly winds and temperatures below normal towards the end.
11–16 Oct.	An easterly air stream between an anticyclone to the north and depressions moving farther south. The temperatures continue to be below normal.
17–19 Oct.	A high pressure area that moves eastwards over Svalbard is accompanied by light westerly winds and somewhat higher temperatures.
20-26 Oct.	Well-developed cyclones from the southwest. Periods with mild, southerly winds, and cold, northerly winds alternate as the cyclones pass.
27 Oct.–3 Nov.	The cyclonic tracks are shifted southwards, and give place to a cold easterly to northeasterly air flow. Milder towards the end of the period.
4–8 Nov.	A low pressure system again approaches from the southwest, and becomes quasi-stationary over the Svalbard area. Temperatures above the average for the season.

9–28 Nov.	The pressure pattern is most of the time dominated by an anticyclone over Greenland and adjacent areas. Easterly to northerly winds predominate. Gradually colder.
29 Nov.–12 Dec.	Northerly to easterly winds between a polar high, that moves slowly towards northern Russia, and a low pressure area extending northwards from northwestern Europe. Comparatively mild at the start of the period, colder towards the end.
13–19 Dec.	A depression from the south passes east of Svalbard. Later a low pressure system from the southwest moves across the islands. Easterly winds and below normal temperatures at the start of the period, southerly winds and appreciably milder towards the end.
20–31 Dec.	Advection of cold air from the northeast between a high pressure area over Greenland and depressions to the south and east.

In the table below are given the monthly mean temperatures for Isfjord Radio for 1965, as well as their deviation from the means of the period 1947–64.

Temperature data for Isfjord Radio (°C)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1965 means	–12.7	–11.9	–16.9	–7.0	–4.2	1.4	4.1	3.4	0.3	–4.7	–6.1	–10.5
Deviation of 1965 means from 1947–64 means	–1.9	–0.7	–5.1	1.9	–0.9	–0.3	–0.4	–0.9	–0.8	–2.2	–0.1	–1.5

It appears that all months except April were colder than normal. The unusually low mean temperature of March is a result of the prevailing easterly to northerly flow of cold air over Svalbard during this month.

Norsk Polarinstitutts virksomhet i 1965

Av
Tore Gjelsvik

Organisasjon og administrasjon

Personale

Norsk Polarinstitutt hadde pr. 31. desember 29 faste stillinger. Instituttet hadde tatt opp forslag om opprettelse av følgende 4 nye stillinger: En sekretær eller konsulent, en biolog, en materialforvalter og en fotograf. Samtlige forslag ble avslått, men instituttet fikk senere tillatelse til å engasjere en materialforvalter for året 1965 og postere lønnsutgiftene til dette på ekspedisjonskapitlet.

I den ubesatte stillingen som geofysiker II tiltrådte 1. januar Torgny E. Vinje. Den ene geolog II-stillingen stod ubesatt i 2 måneder og ble fra 1. mars besatt av cand. real. Boye Flood. Innehaveren av geodet I-stillingen, jordskiftekandidat Einar Skirdal, hadde permisjon fra 1. august, og stillingen som topograf I ble ledig fra 1. desember, da jordskiftekandidat Johannes Hus fratrådte.

Stillingene som hydrograf I, hydrograf II og laborant I ble fra 1. april omgjort til henholdsvis førstehydrograf, hydrograf I og laborant i særklasse.

10 personer var midlertidig ansatt for kortere eller lengre tid, og 2 av disse var engasjert med bearbeidelse av ekspedisjonsmateriale fra Antarktis.

Midlertidig engasjerte

(hvor tidsrom ikke er angitt, varte engasjementet hele året):

Ingeniør Thor Askheim.
Bibliotekar Sigrid Rasmussen.
Fullmektig Eli Holmsen, timelønnet.
Materialforvalter Bjørn Reese, 11 mdr.
Cand. mag. Bjørn Geirr Harsson, 6 mdr.
Cand. mag. Olav Dybvadskog, 3 mdr.
Cand. mag. Olav Orheim, 3 mdr.
Assistent Hans Rudolf Fritsch, 3 mdr.
Mr. Roger G. Bennett, B. A., 2 mdr.
Cand. mag. Bjørn Wilmann, 1 md.

Stipendier og forskningsbidrag er ydet til:

Cand. mag. OLAV DYBVADSKOG, stipend til bearbeidelse av glasiologisk materiale.

Cand. mag. MAGNAR NORDERHAUG, stipend til bearbeidelse av ornitologisk materiale samlet inn på Svalbard.

Cand. mag. THOR LARSEN, bidrag til studier av isbjørn i Alaska.

Geolog DAVID G. GEE (Storbritannia), bidrag til bearbeidelse av geologisk materiale fra Svalbard.

Dr. STANISLAW SIEDLECKI (Polen), bidrag til bearbeidelse av geologisk materiale fra Svalbard.

Lektor THOM ASKILDSEN, bidrag til etnografiske studier av eskimoene ved Povŭgnituk, Canada.

Gjesteforsker:

Dr. STANISLAW SIEDLECKI, Geologisk laboratorium, Det Polske Vitenskapsakademi, Kraków, har, med stipend fra N.T.N.F., hatt arbeidsplass ved Norsk Polarinstitutt. Han deltok også i sommerens ekspedisjon til Svalbard.

Oppnevnelser:

Direktør TORE GJELSVIK ble 6. januar oppnevnt som medlem av Svalbardutvalget, med KAARE Z. LUNDQUIST som personlig varamann.

Videre er GJELSVIK oppnevnt som medlem av en komité som er nedsatt av Norges Almenvitenskapelige Forskningsråd, og som skal ta opp arbeidet med opprettelse av en fast vitenskapelig stasjon på Svalbard. Som varamann fungerer her THOR SIGGERUD.

REGNSKAPET FOR 1965

Kap. 950, Poster:	*Bevilget*	*Medgått*
1. Lønninger	kr. 942 800	kr. 944 669
9. Deltakelse i Antarktisekspedisjonen 1964/67	» 25 000	» 19 200
10. Kjøp av utstyr	» 18 000	» 18 207
15. Vedlikehold	» 9 000	» 9 580
20. Ekspedisjoner til Svalbard og Jan Mayen	» 747 000	» 678 330
21. Undersøkelser av statens kullfelter	» 50 000	» 49 274
26. Flytting til nye lokaler, bevilgning 1964, se komm.		
27. Antarktisekspedisjonen 1956–60	» 76 200	» 55 518
29. Andre driftsutgifter	» 242 000	» 237 489
70. Stipend	» 40 000	» 38 539
	kr. 2 150 000	kr. 2 050 806
Kap. 31. Fyr og radiofyr på Svalbard	kr. 27 000	» 20 800

Kap. 3950, Poster:	*Budsjettert*	Innkommet
1. Svalbard-budsjettet	kr. 300 000	kr. 300 000
2. Inntekter (salg m.m.)	» 11 000	» 17 590
	kr. 311 000	kr. 317 590

Kommentarer til regnskapet:

Kap. 950. Post 9. Deltakelse i Antarktisekspedisjonen 1964/67. – Mindreforbruket skyldes at den norske deltakeren i det amerikanske Antarktisprogrammet 1964/65 gjorde oppholdet i USA etter tilbakekomsten fra Antarktis kortere enn forutsatt, og at deltakeren i 1965/66 ikke kunne få sendt reiseregning så tidlig at den kom med i årsoppgjøret for 1965.

Post 20. Ekspedisjoner til Svalbard og Jan Mayen. – Mindreforbruket skyldes at Norsk Polarinstitutt fikk leie helikoptertjeneste hos Luftforsvaret i stedet for å måtte nytte private selskaper.

Post 26. Flytting til nye lokaler. – Kr. 275 000 ble bevilget for 1964 til innkjøp av utstyr i samband med flyttingen til nye lokaler. Alt utstyret kunne imidlertid ikke bli innkjøpt i 1964. En fikk derfor overført restbeløpet kr. 78 024 til 1965. Restbeløpet ble brukt og flyttingen avsluttet i 1965.

Post 27. Antarktisekspedisjonen 1956–60. – Mindreforbruket skyldes at den engasjerte meteorolog ble fast ansatt som geofysiker (isforsker). En del av det således innsparte beløp på nærværende post ble nyttet til engasjement av assistenter til bearbeidelse av meteorologisk materiale.

Kap. 3950. Post 2. – Økingen i salgsinntektene skyldes først og fremst den stigende interesse for Svalbard.

Ekspedisjonsvirksomheten

Svalbard

Isforholdene langs vestkysten av Vestspitsbergen var sommeren 1965 forholdsvis normale og skapte ikke noen særlige vanskeligheter. Derimot var forholdene vanskelige i området Sørkapp–Bjørnøya–Hopen, og dette var i enda høyere grad tilfelle i Storfjorden og rundt Nordaustlandet. Da den geologiske aktivitet var planlagt å være konsentrert på Nordaustlandet, og sjøopploddingen i det førstnevnte området, måtte arbeidsfeltene til dels skiftes og ekspedisjonsplanene endres på forskjellig vis. Værforholdene var særlig dårlige på Nordaustlandet, hvor det i juli var kaldt, delvis med nysnø og dannelse av nyis på vannet. I august var det mildere, men til gjengjeld mye lavt skydekke, tåke og stille. Ekspedisjonsdeltakerne klarte imidlertid å overvinne de problemer naturforholdene skapte, slik at resultatet ble tilfredsstillende.

Ekspedisjonen 1965, under ledelse av KAARE Z. LUNDQUIST, bestod av i alt 17 partier med til sammen 43 mann. I tillegg kom besetningen på 4 mann på de to helikopterne og et samlet mannskap på 18 mann på fartøyene «Signalhorn» og «H. U. Sverdrup», hvilket til sammen ble 65 mann. Av disse reiste ca. 25 mann opp med ekspedisjonsfartøyene. Videre dro operasjonssjef THOR SIGGERUD sammen med helikoptermannskapene og helikopterne med M/S «Bernes» fra Mo i Rana, og returnerte til Norge med samme fartøy i slutten av august. Resten av ekspedisjonsdeltakerne reiste nordover med M/S «Binny» og returnerte dels med «Steinvarg» og dels med «Binny».

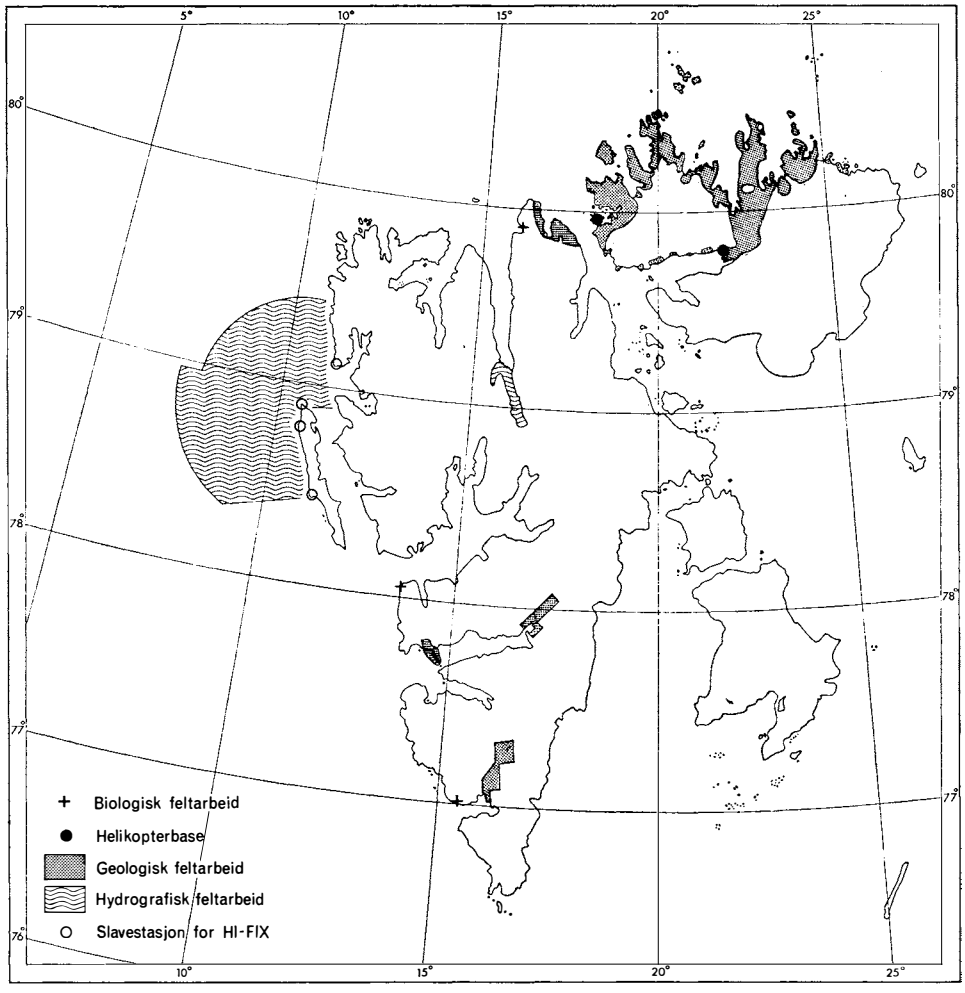


Fig. 1. *Kartet viser hvor Norsk Polarinstitutts feltpartier arbeidet sommeren 1965.*

Direktør TORE GJELSVIK reiste til Svalbard med ekspedisjonsfartøyet «H. U. Sverdrup» den 1. august og sluttet seg i Barentsburg til en delegasjon fra Det interdepartementale Svalbardutvalg under ledelse av statsråd O. C. GUNDERSEN, og var med dette på en ukes rundreise på Svalbard. Deretter forsøkte han med «Nordsyssel» å komme til østkysten av Nordaustlandet for å gjøre geologiske undersøkelser der. På veien tok han med det svenske partiet fra Kapp Linné til Hopen. Ytterst vanskelige isforhold hindret videre fremtrenging mot nordøst, og til og med et forsøk på å ta med to fangstgrupper fra Storfjorden mislyktes. Under denne reise foretok GJELSVIK detaljerte isobservasjoner. På tilbakeveien til Longyearbyen foretok han et par befaringer av mineraliserte områder i den sørlige del av Vestspitsbergen.

Den største gruppen av partier (geologpartiene 1–5 og botanikerpartiet) arbeidet på Nordaustlandet som en samlet operasjon, basert på bruk av de to helikopterne.

Ellers var partiene spredt rundt i områdene Hornsund, Van Mijenfjorden/Bellsund, Amsterdamøya, Danskøya, Reinsdyrflya/Liefdefjorden og Wijdefjorden.

Ekspedisjonsfartøyene. – M/S «Signalhorn» med BJARTE BRANDAL som fører ble overtatt av HELGE HORNBÆK, og gikk fra Åndalsnes 30. juni etter innlasting av utstyr som var kommet med jernbane fra Oslo. Båten returnerte til Åndalsnes 5. september.

På turen nordover ble to partier satt på land i Hornsund og ett parti i Bellsund. I Longyearbyen ble et par partier som skulle nordover tatt med og senere satt ut. HORNBÆK gikk fra borde 11. juli ved Gråhuken og kom ombord igjen 26. august og stod så for innsamling av de siste partiene og hjemreisen.

Fra 15. juli til 25. august ble «Signalhorn» brukt som base for helikopteroperasjonene på Nordaustlandet, bortsett fra tiden 9. til 14. august da den var på en provianteringsrunde til Longyearbyen og samtidig var innom alle partiene som lå nord for Isfjorden. EINAR NETELAND stod for ettersynet av fyrbelysningen. Dette ble dels utført fra «Signalhorn», dels fra «Nordsyssel», mens tenningen av fyrene ble gjort fra «H. U. Sverdrup».

Forskningsfartøyet «H. U. Sverdrup» ble overtatt av KAARE Z. LUNDQUIST i Harstad 31. juli og avlevert i Bodø 14. september. I den tiden det var i Svalbardfarvann, ble det i alt vesentlig benyttet til opplodding, og noen magnetiske målinger ble tatt. På tur nordover ble et svensk geografparti fra Geografiska Institutionen i Stockholm, bestående av A. HÄGGBLOM, P. BJÖRKLUND og H. ÖSTERHOLM, satt i land på Isfjord Radio. Det ble senere flyttet til Hopen og hentet der og tatt med tilbake til Norge.

Hydrografparti 1 og 2. – Leder KAARE Z. LUNDQUIST med løytnant GUNNAR SANDEN som assisterende hydrograf, EINAR NETELAND som teknisk leder, og assistenter DAG TORE FODSTAD, ERIK GUNDERSEN, FINN LILLEVIK og JOHAN H. WASSERFALL.

Toktet vai lagt relativt sent på sommeren for å sikre gode arbeidsmuligheter i området Sørkapp/Hopen/Bjørnøya. Imidlertid var isforholdene her i august så vanskelige at man ble nødt til å gi opp å lodde i dette området, og måtte isteden ta opp arbeidet på vestkysten av Vestspitsbergen i tilslutning til den opploddingen som ble foretatt der de to foregående årene. Det samlede resultat av loddingen, som foregikk i tiden 5. august til 7. september, var vel 3.300 nautiske mil med loddelinjer og dessuten over 300 n. mil med registreringer med et protonmagnetometer.

Det ble foretatt en del alminnelige ekspedisjonsarbeider med «H. U. SVERDRUP», og bl. a. stod partiet for tenning av fyrlyktene.

Hydrografparti 3. – Leder HELGE HORNBÆK med assistenter ARNE KILDAHL, JENS PETTER TAASEN og SIVERT UTHEIM. Opploddingen foregikk i den indre del av Wijdefjorden, men arbeidet kom sent i gang da Wijdefjorden først gikk opp 17. juli. Senere ble loddingen mye hindret av kraftig vind og sjø, men da fjorden er relativt ren og dyp, ble det likevel loddet omtrent så meget som planlagt. Dessuten fikk man loddet en del ved Reinsdyrflya og Gråhuken.

Fig. 2. *Helikopter på toppen av Ekstrømfjellet, sett mot øst sommeren 1965.*
Foto: A. Hjelle.

Helikopteroperasjonen. – Leder Thor Siggerud med Per Wendelbo som assistent. Helikopteroperasjonene var sommeren 1965 henlagt til Nordaustlandet, og planen var å ha en mobil hovedleir, idet M/S «Signalhorn» skulle tjene som base.

Fra Det Kgl. Norske Luftforsvar hadde man fått stilt to helikoptere av typen Bell 47-G til disposisjon. De ble ført av løytnantene Jarle Aune og Skjalg Mjånes og med sersjantene Arnold Henning og Harry Wådahl som mekanikere. Imidlertid var is- og værforholdene ualminnelig dårlige. Langs hele nordkysten av Nordaustlandet lå det fastis hele sommeren. Planen om å kunne ha en mobil base som suksessivt ble flyttet østover på nordkysten, måtte oppgis, men det lyktes å få etablert en første base ved Søre Russøya ved innløpet til Murchisonfjorden. Senere på sommeren gikk Wahlenbergfjorden opp, og basen kunne bli flyttet til Bodleybukta innerst i denne, hvorfra geologene kunne settes ut radiært nordover.

Helikopterne skulle sommeren 1965 så å si utelukkende brukes av geologene, i alt 5 partier, men et botanikerparti som skulle til Nordaustlandet måtte på grunn av is-situasjonen også gå inn i helikopteroperasjonen. I alt fløy helikopterne vel 250 effektive flytimer på Svalbard for Norsk Polarinstitutt. Dessuten ble det ytet helikopterassistanse til Bergmesteren for Svalbard to dager i den sørlige del av Vestspitsbergen.

På tross av de vanskelige vær- og isforholdene ble stort sett den oppsatte planen for en geologisk oversiktskartlegging av de nordligste 2 tredjedeler av Nordaustlandet gjennomført. Helikopteroperasjonene forløp uten noen uhell, ikke minst takket være dyktige flygere og mekanikere. Helikopterne var dessuten i meget god

stand og hadde godt med reservedeler. Endelig var vedlikeholdet i felten meget strengt og omfattende.

Geologparti 1. – Leder THORE S. WINSNES med J. CHRISTIAN KELLER som assistent. Den første del av feltsesongen ble arbeidet konsentrert i Murchisonfjord-området. Det ble utført noe mer detaljert kartlegging enn opprinnelig planlagt, og bl. a. lyktes det å påvise tilstedeværelsen av en tykk lagserie mellom de to seriene: Florakvartsitten og Kapp Hansteen-formasjonen, som tidligere er beskrevet av O. KULLING. Da basen ble flyttet til Bodleybukta, ble arbeidet henlagt til Prins Oscars Land. Her fant man bl. a. at det avmerkete granittområdet hadde en vesentlig større utbredelse enn tidligere antatt. Undersøkelsene av det sedimentære komplekset gjorde det bl. a. klart at mektigheten av Kapp Hansteen-formasjonen i dette området er mindre enn i Lady Franklinfjord-området. I begynnelsen av feltsesongen arbeidet WINSNES delvis sammen med D. G. GEE, mens han senere en viss tid hadde leir sammen med A. HJELLE.

Geologparti 2. – Leder AUDUN HJELLE med ØYSTEIN FÆSTØ som assistent. I tiden 9. til 17. juli hadde partiet base i Virgohamna og arbeidet på Amsterdamøya og den nordre del av Danskøya. Det ble funnet at det undersøkte området i alt vesentlig var bygget opp av paragneiser, utviklet som slire- eller åregneis med overgang til migmatitt av samme type som også er kjent fra søndre Danskøya. I disse gneisene observertes relikter, vesentlig av glimmerskifre. I andre gneistyper, f. eks. mere båndete gneiser, fantes relikter av kvartsitt, marmor og amfibolitt. Spor av primærstrukturer fantes.

I området Brennevinsfjorden–Sjuøyane–Sabinebukta ble et granitt-gneiskompleks med en noe forskjellig utvikling undersøkt. I vest og sør opptrådte porfyriske middelskornete feltspatporfyroblast-bergarter, mens det i nordøst forekom mere grove typer, som porfyriske granitter eller øyegranitter og delvis tydelig folierte bergarter. I Rijpfjord-området ble særlig en rødlig middelskornet intrusiv granitt, rik på muskovitt undersøkt. I høye punkter i terrenget fant man her rester av de overliggende bergartene, videre forekom mer basiske overgangstyper av granitten, hvor overliggende bergarter var blitt delvis assimilert i granitten. Dessuten fantes øyegneiser i kontakt med et gneiskompleks av suprakrustal opprinnelse, begge synes å være eldre enn granitten.

Det ble i de undersøkte områdene ikke funnet forekomster av mineraler eller bergarter som har umiddelbar økonomisk betydning.

Geologparti 3. – Leder BOYE FLOOD med EINAR TVETEN som assistent. Arbeidet på Nordaustlandet falt i tre avsnitt etter som hvor partiet hadde sin base. Fra en leir på Botniahalvøya ble de vulkanske bergartene som bygger opp den nordlige og østlige del av halvøya undersøkt. De er skilt fra en sedimentserie med et mektig kvartsitt-porfyrkonglomerat. Fra en leir i Innvika, Duvefjorden, ble området vestover til Ahlmannfonna og sydover til Østfonna undersøkt. Det ble funnet at hele den nordøstlige del av Nordaustlandet kan karakteriseres som et migmatittområde med grå vekselkornete gneiser, som ofte inneholder rester av

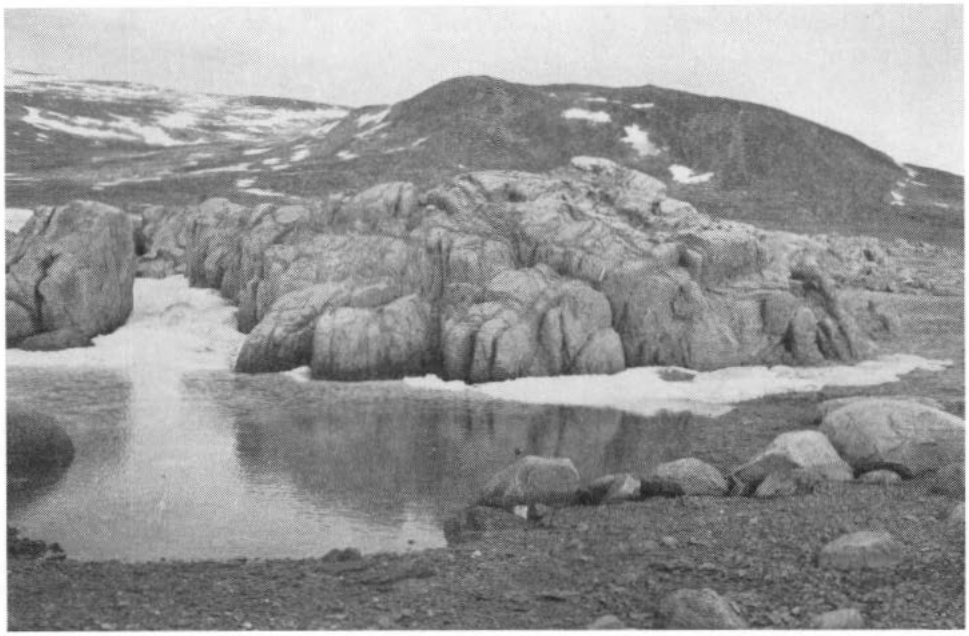


Fig. 3. «*Rijpfjord-granitt*» *fra indre østside av Rijpfjorden. Lars Hansenfjellet i bakgrunnen.* Foto: A. HJELLE.

de opprinnelige sedimentene. Det ble funnet inneslutninger av glimmerskifre, marmor, kvartsitt og amfibolitt i gneisene, men det ble ikke funnet noen markert litologisk variasjon i inneslutningene når en gikk fra vest mot øst i dette området. Fra den siste leiren i Planciusdalen ble det gått opp et profil fra Rijpfjorden til Carolusbukta, og her ble det funnet at det geologiske bildet var sterkt komplisert på grunn av at det opptrådte en rekke forkastninger. Området bygges opp av en stor synklinal, hvor det øverst ligger lyse og røde kvartsitter av Murchison Bay-formasjonen, mens under følger mørke skifre, antagelig av Kapp Hansteen-alder.

Geologparti 4. – Leder DAVID G. GEE (Storbritannia) med assistent LUDVIG J. BECKMAN. Første del av sommeren ble benyttet til en kartlegging av Murchisonfjorden og området mot Brennevinsfjorden, dels sammen med WINSNES. En ny lagserie under den tidligere laveste del av Murchison Bay-formasjonen ble påvist, og det ble lagt stor vekt på strukturelle undersøkelser. Det synes som KULLING's antagelse om en stor overfoldning med gjentagelse av lagrekken ikke lar seg opprettholde. Senere ble det kartlagt i Duvefjord-området sammen med FLOOD. Avslutningen på sommeren ble en undersøkelse sydover fra Duvefjorden mot Wahlenbergfjorden. Spesielt ble det lagt vekt på de strukturelle undersøkelser. Det ser ut som man her har to foldefaser.

Geologparti 5. – Leder THOR SIGGERUD. I den utstrekning det var mulig av hensyn til ledelsen av de felles operasjoner, arbeidet SIGGERUD også som geolog. Han fikk kartlagt et profil fra Murchisonfjordens nordside sydover langs kysten

til Wahlenbergfjorden og videre inn i denne og halvveis over til Duvefjorden. Han kunne bl. a. konstatere at det tidligere avsatte permokarbonfeltet på nordsiden av Wahlenbergfjorden bare fantes utviklet i Idunfjellet. Videre utførte han en del utfyllende undersøkelser i Sabinefjord-området, slik at man i dette området fikk bedre klarlagt aldersforholdene mellom sedimentene og porfyrene som gjennomsetter disse, og som igjen intruderes av granitter.

Geologparti 6. – Leder dr. STANISLAW SIEDLECKI (Polen) med assistenter HANS RUDOLF FRITSCH og ULF JØRGEN BORGEN. Partiet utførte fra 6. juli til 17. august detaljerte paleontologisk-stratigrafiske undersøkelser i områdene: 1) Ingeborgfjellet, Flynibba-Sundhøgda, 2) Sundodden og 3) Akseløya. I alt ble et område på ca. 40 km² kartlagt i målestokk 1:25 000, og en rekke profiler gjennom karbon-perm-triaslagene i disse områdene ble beskrevet. I alt ble det samlet ca. 150 litologiske og paleontologiske prøver, og av særlig interesse var funnet av et eksemplar av den permiske haien *Helicoprion*.

Under transport med dory gjennom Akselsundet inn til Van Mijenfjorden, hvorfra hjemreisen skulle finne sted, ble doryen knust av isflak. Partiet reddet seg og utstyret opp på et isflak og senere i land med en gummidingy og kom vel fra uhellet.

Geologparti 7. – Leder JENÖ NAGY med assistenter FINN FAYE KNUDSEN og TORBJØRN LJONES. Partiet var i tiden 6. juli til 2. august i Hornsund og Torell Land, og fra 4. til 28. august i områdene i og ved Kjellströmdalen. Mens man ventet på at isen skulle gå opp i den indre del av Hornsund, slik at det ble mulig å kjøre inn med snøscooter til Torell Land, ble følgende profiler detaljmålt: På Kruseryggen og Terskelen et profil fra midtre karbon til nedre trias, på Triasnuten fra øvre karbon til nedre jura og på Hyrneodden gjennom devonlagene. I Torell Land ble det foretatt omfattende undersøkelser i området Kvalfangerbreen, Harmensisen, Storbreen og dessuten på Isskiltoppane. Videre ble den sentrale del av Grimfjellantiklinalen studert, og det ble samlet en rekke fossilprøver. Partiet fant meget svak sulfidmineralisering et par steder.

Fra basen i Kjellströmdalen ble først området mellom Dalskuta og Kolhamaren undersøkt. Videre ble det arbeidet på Liljevalchfjellet, Ispallen og Snøvola. Alle disse stedene ble undersøkelsene konsentrert om studier av Ditrupa Skifer-serien og den nederste del av undre lyse sandsten-serien. Det ble samlet inn fossiler, vesentlig ammonitter, og målt 11 profiler gjennom Ditrupa Skifer-serien.

Biologparti 1. – Leder NIELS E. GULLESTAD med assistenter HANS PETTER GULLESTAD og GUNNAR GISNÅS. Partiet foretok undersøkelser av røye i elver og vann på østsiden av Wijdefjorden. P. g. a. den sene isløsning i vannene i dette området ble resultatet av fiskeundersøkelsene ikke så godt som ventet. Det ble dessuten funnet 10 eksemplarer av pukkellaks (*Onchorhynchus gorbuscha*), som er en østlig art og som for tiden ser ut til å trenge inn i Svalbardområdet. Det ble videre ringmerket ca. 300 fugler.

Biologparti 2. – Leder MAGNAR NORDERHAUG med assistenter LAGE LJØTERUD og ELDAR WRÅNES. I tiden 7. juli til 2. august ble ærfuglens produksjonsforhold i Hornsund undersøkt. Det ble lagt vekt på å følge klekkingsforløpet og få en oversikt over variasjonen i kullene og bestandens sammensetning. Uten tvil må under de nåværende forhold polarmåken betraktes som den primære årsaken til ærfuglenes svake ungeproduksjon i mange områder. Videre ble produksjonsforholdene hos ringgås, hvitkinngås og kortnebbgås undersøkt i Hornsundområdet, og i alle fall relativt sett hadde alle tre arter en god sesong. Når det gjaldt hvitkinngåsen, ser den fremdeles ut til å øke i antall på Svalbard, og i undersøkelsesområdet ble det funnet ca. 290 brukte reir. I tiden 3. til 11. august ble arbeidet fortsatt i området mellom Kapp Linné og Kapp Martin, hvor også produksjonsforholdene, først og fremst hos ærfugl, ble studert. I alt ble 3559 fugler merket, derav 3000 alkekonger, og 98 kontroller og/eller gjenfunn av tidligere merkete fugler ble gjort.

Botanikerparti. – Leder dr. ALASDAIR H. NEILSON (Storbritannia) med assistenter AKSEL ØDEGAARD og BJARNE FOSSØY. Det botaniske arbeidet måtte inngå i helikopteroperasjonen p. g. a. isvanskelighetene som umuliggjorde at man kom frem med annet enn helikopter. I alt ble det foretatt undersøkelser på 23 forskjellige stasjoner i Wahlenbergfjord-, Murchisonfjord-, Lady Franklinfjord-, Brennevinsfjord-, Rijpfjord- og Duvefjord-områdene. Det ble samlet omkring 1000 eksemplarer, vesentlig av slektene *Graminae* og *Draba*. Det ble funnet fire nye arter for Nordaustlandet og nye finnesteder for fem arter, som tidligere bare var kjent fra Wahlenbergfjorden. Videre ble det registrert ny nordgrense for fem arter av blomsterplanter. Det samlete resultat må sies å være meget tilfredsstillende, ikke minst på bakgrunn av at værforholdene sommeren 1965 var vanskelige og at planteveksten kom meget sent i gang.

Ekstraparti. – Leder JAN HOLTEDAHL med SVEIN BREEN, TROND HARSTAD og TORE SLYNGSTAD som assistenter. Dette partiet, som oppholdt seg på Reinsdyrhalvøya og Liefdefjordområdet i tiden 10. juli til 10. august, hadde som spesialoppgave å kveile sammen og grave ned ca. 20 km ledning, som fantes i området innenfor Sørdalsbukta i Liefdefjorden. Denne tråden var rester av telefonledninger fra tyske utposter under krigen, og i løpet av de siste tre årene var det funnet mer enn 60 reingevir viklet inn i denne tråden, noe som viste at mange rein var omkommet fordi denne tråden lå utover. I forbindelse med dette arbeidet ble det funnet et tysk ammunisjonsdepot fra siste krig. Dette ble rapportert, og folk fra minekommandoen i Nord-Norge kom opp i september og sprengte det.

Cand. real. REIDAR KANESTRØM fulgte ved sommerens begynnelse med «Signalhorn» for å foreta geofysiske undersøkelser når båten ikke var opptatt med andre oppdrag. På grunn av instrumentfeil og andre vanskeligheter lot programmet seg ikke gjennomføre.

Isrekognosering. – I slutten av juni foretok TORGNY E. VINJE en isrekognoseringstur med et albatrossfly fra Det Norske Luftforsvar. Turen gikk fra Bardufoss over

Bjørnøya og Kong Karls Land, videre nordenom Nordaustlandet og tilbake over Hinlopenstretet og Storfjorden. Det var for det meste 7 til 10/10 vinteris på strekningen fra Bjørnøya opp til Nordaustlandet. På nordaust- og nordvestsiden av denne øya var det svært brede kystråker utenfor årsgammel fastis langs land. Hinlopenstretet var farbart sydover til Wahlbergøya. Smeltingen var kommet dårlig i gang, og dette må være en av årsakene til at det senere på sommeren var forholdsvis mye is på østsiden av øygruppen.

Andre norske ekspedisjoner til Svalbard

Førstekonservator dr. OLAF I. RØNNING foretok botaniske undersøkelser ved Ny-Ålesund i august. Han fikk hjelp til transport og utstyr fra Norsk Polarinstitutt.

Norsk Polar Navigasjon A/S fortsatte sine oljeundersøkelser sommeren 1965. Leder var ing. YTRELAND.

A/S Berabo hadde to ekspedisjoner til Svalbard med henholdsvis M/K «Sydstrand» og M/S «Rundøy». Leder J. P. BALSTAD.

Marinekommando/DKN sendte i september en gruppe på 4 mann med løytnant SVEIN HØY som leder til Reinsdyrflya på den nordlige del av Vestspitsbergen, hvor det ble foretatt rydding av miner og andre sprenglegemer som var etterlatt av tyskerne i 1943/44. Sprenglegemene var funnet av Polarinstituttets ekspedisjon 1965. Marinekommandogruppen ble assistert av sysselmannsfullmektig FREDERIK BEICHMANN.

Utenlandske ekspedisjoner til Svalbard

American Overseas Petroleum Ltd. sendte i mai et mindre parti til Svalbard for å gjøre forberedelser til å sette i gang boring etter olje på Blåhuken ved Van Mijenfjorden. Hovedekspedisjonen kom til Blåhuken i siste halvdel av juni. Forlegning ble opprettet på Blåhuken og boringen satt i gang i slutten av juli. Ca. 40 mann var sysselsatt med oljeboringen, som pågikk ved årets slutt. Ekspedisjonens virksomhet ble ledet av drilling superintendant H. E. WEINER frem til desember, da han ble avløst av drilling superintendant PALCO.

Sovjetisk geologisk ekspedisjon, oppgitt til 16 deltakere fra Institutt for Arktisk Geologi i Leningrad, utførte prøvetaking og kartlegging på flere områder på den sydlige halvdel av Vestspitsbergen, vesentlig i samarbeid med det statseide gruveselskap Arcticugol. Til transport ble nyttet helikoptere og fartøy. Leder dr. V. N. SOLOKOV.

Sovjetisk glasiologisk ekspedisjon med 5 medlemmer fra Det Geografiske Institutt ved Vitenskapsakademiet i Moskva studerte breer og avleiringer fra kvartær-

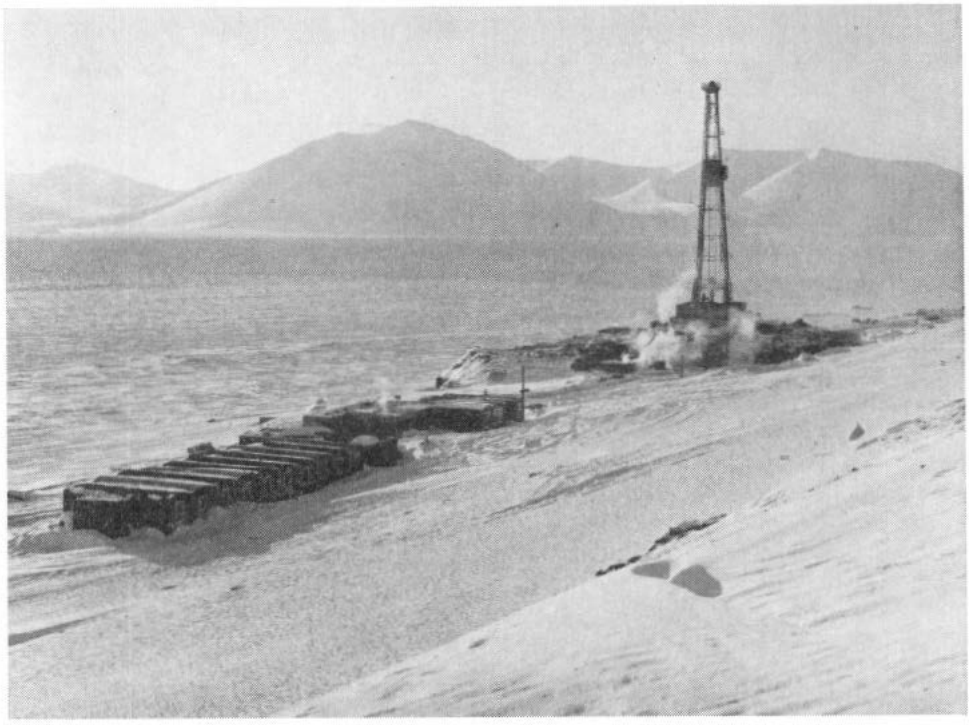


Fig. 4. *Oljeboringsleiren på Blåhuken, Van Mijenfjorden, Vestspitsbergen.*
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tiden. Ekspedisjonen fikk, etter introduksjon fra Sysselmannen, anledning til gjøre seg kjent med resultatene av meteorologiske observasjoner ved Svalbard Radio og Isfjord Radio. Leder dr. E. M. ZINGER.

Cambridge Spitsbergen Expedition 1965 med 21 deltakere, fordelt på 5 partier, drev vesentlig med geologiske og geofysiske studier på forskjellige områder på Vestspitsbergen. Ledere: R. H. WALLIS, M. MOODY-STUART, P. F. FRIEND, K. HOWELLS, D. W. HOLLIDAY og J. R. PARKER.

Øst-tysk ekspedisjon med 5 deltakere fra «Nationalkomitee für Geodäsie und Geophysik der Deutschen Demokratischen Republik bei der Deutschen Akademie der Wissenschaften zu Berlin» overvintret fra 1964, og drev glasiologiske, geografiske og geomagnetiske undersøkelser i området ved Ny-Ålesund. Leder Dipl. phys. U. VOIGT.

Fransk ekspedisjon med 14 deltakere og med J. CORBEL som leder utførte geologiske, glasiologiske og botaniske undersøkelser, vesentlig i Kongsfjord-området hvor det er etablert en permanent fransk base.

Finsk ekspedisjon med 3 deltakere under ledelse av dosent E. NYHOLM drev zoologiske og ornitologiske undersøkelser, vesentlig i områdene ved Longyearbyen. To av deltakerne fortsatte i juli til nordkysten av Vestspitsbergen i egen båt.

Leicester University Spitsbergen Expedition med 4 deltakere drev botaniske undersøkelser i området mellom Isfjorden og Van Mijenfjorden. Leder M. HALLIDAY.

Vest-tysk ekspedisjon bestående av H. WERNER og R. THUN drev ornitologiske og botaniske undersøkelser i Sassendalen og Rendalen.

Engelsk ekspedisjon, bestående av A. CULLINGFORD og T. ARCHER, foretok studier av kullgruvedriften og kullgruvesamfunnene ved Isfjorden.

Svensk geologisk studentekskursjon, bestående av 8 deltakere med K. KLEIN som leder, besøkte Isfjord-området og Ny-Ålesund.

To svenske ekspedisjoner fra Geografiska Institutionen i Stockholm foretok, dels med transportmessig støtte fra Norsk Polarinstitutt, kvartærgeologiske undersøkelser. Det ene partiet besøkte Bjørnøya i mai–juni, det andre var på Isfjord Radio og Hopen i august. Ledere var ing. S. R. EKMAN og amanuensis A. HÄGGBOM.

Ekspedisjonen fra The International Youth Federation for the Study and Conservation of Nature, med 8 deltakere fra Sverige, Nederland, Belgia og Storbritannia, utførte forskjellige studier i geologi, botanikk, zoologi og ornitologi. Leder med. cand. Å. BRUCE.

Svensk Skid- och Friluftsfremjandets ekspedisjon med 22 deltakere utførte studier i geologi, glasiologi, ornitologi og botanikk, og foretok fjellklatring og skiløping fra breene i områdene ved Longyearbyen og Ny-Ålesund. Leder gymnasdirektør G. BILLING.

Sveitsisk ekspedisjon med 3 deltakere har en få opplysninger om. Ekspedisjonen var trolig av turistmessig karakter.

Sveitsisk klatre-ekspedisjon med 6 deltakere og A. RYSER som leder kom til Svalbard for å bestige bl. a. Aurivillius- og Hornemantoppen.

Ekspedisjonen fra Polish Mountaineering Club, Poznan, med 10 deltakere, skulle etter planen landsettes ved den polske vitenskapelige stasjon i Isbjørnhamna, men måtte p. g. a. isforholdene fortsette til Longyearbyen. Da det heller ikke senere lyktes å bringe ekspedisjonen inn til Hornsund-området, ble den satt i land i Recherchefjorden. Ledere var W. SCHRAMM og J. MICHEJDA.

Vest-tysk ekspedisjon med 2 deltakere, U. og J. TROBITZCH, gjorde filmopptak for fjernsyn i Hiorthavn, Sassen, Dicksonfjorden og Wijdefjorden.

Belgisk-hollandsk fjernsynsekspedisjon med 3 deltakere og med J. COOLSAET som leder gjorde filmopptak i Longyearbyen, ved Isfjord Radio, ved Norsk Polar Navigasjon A/S' borevirksomhet i Grønnfjorden, i Ny-Ålesund og ved Smeerenburg.

En sveitsisk fjernsynsekspedisjon med A. ANDERSCH som leder besøkte Svalbard i ca. 3 uker med M/S «Havella» av Tromsø. Etter planene skulle det lages en omfattende og allsidig spillefilm om Svalbard, og det var forutsetningen at filmen skulle sendes over fjernsynsnettet i Tyskland, Østerrike og Sveits.

Dronning Maud Land, Antarktis

Den amerikanske «South Pole – Dronning Maud Land Traverse» startet i desember 1964 fra Sydpolen, og i løpet av den første etappen nådde man i slutten av februar 1965 fram til «Utilgjengelighetens pol» (The Pole of Inaccessibility). Cand. mag. OLAV DYBVADSKOG var med som norsk deltaker på denne traversen. Hans oppgave på turen var først og fremst å studere skavlenes form og dannelse. I den andre sesongen ble cand. mag. OLAV ORHEIM den norske deltaker, og han reiste via USA til Antarktis i november måned. Han skulle liksom DYBVADSKOG først og fremst ta seg av studier av skavlenes form og dannelse.

Utenlandske overvintringsekspedisjoner

1. SANAE, 70°19′S, 2°22′V, sørafrikansk ekspedisjon, 14 overvintrere.
2. Novolazarevskaja, 70°46′S, 11°49′Ø, russisk ekspedisjon, 14 overvintrere.
3. Roi Baudoin, 70°26′S, 24°19′Ø, belgisk-nederlandsk ekspedisjon med 10 belgiske og 6 nederlandske overvintrere.

Disse tre stasjonene drives helårlig og har til dels utvidet forskningsprogram om sommeren.

Breundersøkelser i Norge

De breundersøkelser som blir utført i Norge i Norsk Polarinstitutts regi, ble som tidligere år ledet av OLAV LIESTØL. Ekspedisjonsvirksomheten begynte i midten av mars med en tur til Hardangerjøkulen for måling av snøakkumulasjonen. I slutten av april ble både Hardangerjøkulen og Storbreen i Jotunheimen besøkt, og målinger viste at snøakkumulasjonen var omtrent normal. Sommerens undersøkelser var mer omfattende enn vanlig. I tiden 22/6–1/9 ble det på Hardangerjøkulen foretatt kontinuerlige glasiologiske og meteorologiske observasjoner, og etter et noe mindre program ble det på Storbreen i tiden 13/7–17/8 også foretatt kontinuerlige observasjoner. Feltarbeidet ble avsluttet med kortere besøk på begge breene i månedsskiftet september/oktober. Sommeren 1965 var kaldere og mer regnfull enn normalt, og en stor del av nedbøren kom hele sommeren som snø på de øvre deler av breene. Resultatet ble derfor et overskudd i materialbalansen, som for Hardangerjøkulen gjennomsnittlig lå på 51 g/cm² og for Storbreen på 26 g/cm².

Fra de faste observatørene har Polarinstituttet fått inn måleresultater fra 11 breer. Bortsett fra Åbrekkebreen i Olden, som har rykket frem ca. 5 m, viser målingene at alle de andre breene er i tilbakegang.

LIESTØL fungerte også som konsulent for Vassdragsvesenet ved deres elektriske isboringer på Rembesdalsskåki.

OLAV ORHEIM fikk støtte av Polarinstituttet til sine videre undersøkelser av Suphellebreen i Fjærland.

I forbindelse med breundersøkelser på Svartisen utførte topografer fra instituttet en avstandsmåling med tellurometer.

Bearbeidelse av materiale fra Svalbard

Hydrografisk avdeling

KAARE Z. LUNDQUIST stod for en del kartredigering, utførte beregninger og la til rette materiale i forbindelse med bruken av Hi-Fix-systemet til loddingen om sommeren.

HELGE HORNBÆK monterte de siste målingene på det nye sjøkartet nr. 516 over nordvesthjørnet av Svalbard, som nå er under arbeid. Videre pantograferte han brebegrensningene på samme kart og stod for korrekturlesingen av det. Han utførte beregninger og stod for opplegget av målebordsblad over Wijdefjorden, som forberedelse til feltsesongen 1965. Han beregnet middelvannstanden i Longyearbyen og utarbeidet en oppgave over tidevannsdata for Hopen. – Sjøkart nr. 516 er i løpet av året blitt rentegnet av karttegner BJARNE EVENSEN.

Topografisk-geodetisk avdeling

Arbeidet med å overføre triangel- og passpunkter fra gamle ekstrakter til nye kartotekkort ble fullført i løpet av våren. Det ble foretatt beregninger av observasjonsmaterialet fra Albert I Land, Haakon VII Land, Andrée Land og James I Land, som ble samlet inn sommeren 1964. Likeledes ble en del av 1963-materialet fra Ny Friesland og Olav V Land beregnet. Området mellom Monacobreen og Bockfjorden, samt kystkontur i indre del av Wijdefjorden ble konstruert i målestokk 1:50 000. Adskillige foreløpige navnekart i målestokk 1:100 000 ble gjort ferdige. Fem kartblad i konstruksjonsmålestokken 1:50 000 kom i nytt opplag. Arbeidet med et kart over Svalbard i målestokk 1:1 000 000 fortsatte.

Geologisk avdeling

HARALD MAJOR fortsatte arbeidet med beskrivelsen til det i 1964 ferdigtrykte geologiske kartet over Adventdalen. Han har videre utført kullpetrografiske studier av prøver fra gruve 5 og prøvestoller i gruve 7 i Longyearbyen. Han har utført et omfattende konsulentarbeid i forbindelse med de nye kullfelter i Adventdalen, og utmålssaker og råstoffspørsmål i forbindelse med Norsk Koksverk i Mo i Rana. Han har med bistand av MAGNE GALÅEN utarbeidet en rekke utmålskart over Svalbard i forskjellige målestokker.

THORE S. WINSNES skrev i løpet av våren ferdig en avhandling med tittelen «Observations on the Carboniferous and Permian rocks of Vestspitsbergen», som ble trykt i Norsk Polarinstitutt's Årbok 1964. Han utførte også en del arbeid som medforfatter i en publikasjon vedrørende radiometriske aldersbestemmelser av bergarter fra Svalbard (Skrifter Nr. 137, trykt 1966). Etter sommerens ekspedisjon tok han så fatt på bearbeidelsen og beskrivelsen av de innsamlete prøver av sedimentære bergarter fra Nordaustlandet.

THOR SIGGERUD stod for koordineringen av utarbeidelsen av et geologisk kart i 1:250 000, og bearbeidelsen av det geologiske materialet innsamlet på Nordaustlandet sommeren 1965. Det ble nedlagt et stort arbeid med å få utarbeidet en standardisert terminologi for klassifiseringen av sedimentene og de metamorfe bergartene fra Nordaustlandet, og å få klarhet i hva de moderne engelske geologiske termene egentlig innebærer i relasjon til norsk ordbruk. Et foredrag om «Nordaustlandets geologi» ble gjort ferdig til Det VII Nordiske Geologiske Vintermøte.

AUDUN HJELLE bearbeidet i løpet av våren og forsommeren det innsamlete geologiske materialet fra nordvesthjørnet av Vestspitsbergen, og skrev sammen med DAVID G. GEE en oversikt over geologien i dette området, trykt i Norsk Polarinstitutt Årbok 1964. Videre mikroskoperte han en del bergarter innsamlet på Danskøya og Amsterdamøya. Høsten ble vesentlig benyttet til å bearbeide det innsamlete materialet fra Nordaustlandet og til sammen med GEE, FLOOD, SIGGERUD og WINSNES å sette sammen et geologisk kart over den nordlige halvdel av Nordaustlandet i målestokk 1:250 000. HJELLE har også spesielt arbeidet med de granittoide bergartene fra Nordaustlandet og har i den forbindelse foretatt volum-%-tellinger i slip og håndstykker av granittoide bergarter fra Vestspitsbergen. Han har lagt opp til et program for behandling av volum-%-tellinger og modalanalyser i datamaskin.

BOYE FLOOD arbeidet i løpet av våren med gjennomgåelse av tidligere litteratur fra Nordaustlandet og studerte prøvemateriale og ikke publiserte data innsamlet på Norsk Polarinstitutts tidligere ekspedisjoner til dette området. På grunnlag av dette tegnet han sammen et foreløpig geologisk kart over Nordaustlandet i målestokk 1:400 000. I løpet av høsten ble materiale innsamlet sommeren 1965 på Nordaustlandet bearbeidet, og et foredrag om de foreløpige resultatene av studiene av vulkanittene på Nordaustlandet ble skrevet for Det VII Nordiske Geologiske Vintermøte.

JENÖ NAGY har skrevet en avhandling med en kort geologisk kartbeskrivelse til den østlige delen av kartbladet Markhambreen (Torell Land), trykt i Norsk Polarinstitutt Årbok 1964. Videre har han skrevet en kort oversikt over oljeundersøkelsene på Svalbard for tidsskriftet «Polar Record». NAGY har i 1965 arbeidet med en oversikt over de strukturelle forholdene i den østlige del av Wedel Jarlsberg Land og har i den forbindelse tegnet en del geologiske profiler, basert delvis på fotogeologisk arbeid. Han har også arbeidet med de stratigrafiske forholdene innen Ditrupa-lagene i undre kritt og gjennomført en bestemmelse av det innsamlete ammonittmateriale fra dette laget. NAGY har videre tilrettelagt materiale i forbindelse med oljeutmålssaker.

Den polske geologen dr. STANISLAW SIEDLECKI fortsatte i 1965 bearbeidelse av det materialet han samlet inn på Sørkappøya og de omliggende områdene sommeren 1964. Om høsten tok han også opp studier av sitt materiale fra Bellsund og arbeidet bl. a. med beskrivelse av en funnet hai, *Helicoprion*, fra permtiden.

Den engelske geologen DAVID G. GEE hadde arbeidsplass på Norsk Polarinstitutt den største del av 1965. Han bearbeidet bl. a. sammen med HJELLE materiale de samlet inn i nordvesthjørnet av Vestspitsbergen sommeren 1964 (se ovenfor).

Om høsten deltok han i utarbeidelsen av det geologiske kartet over Nordaustlandet (se ovenfor), og videre var han medforfatter i Skrifter nr. 137 (trykt 1966). I Årbok 1964 hadde han dessuten skrevet en artikkel sammen med M. MOODY-STUART angående «The base of the Old Red Sandstone in central north Haakon VII Land, Vestspitsbergen» og en notis om opptreden av eklogitt på Vestspitsbergen.

WILLY INGEBRETSEN har laget geologiske preparater og slip og foretatt analyser av de geokjemiske prøvene som ble samlet inn sommeren 1964.

Geofysisk avdeling

OLAV LIESTØL har fortsatt bearbeidelsen av det innsamlete glasiologiske materialet fra Svalbard og Norge. Kortere oversikter er trykt, og rapporter utarbeidet for Norges Vassdrags- og Elektrisitetsvesen for undersøkelser i forbindelse med kraftprosjekter.

VIDAR HISDAL har beregnet tidevannets harmoniske komponenter for Van Keulenfjorden og Longyearbyen (kontrollmateriale) ved hjelp av en metode spesielt egnet for korte avlesningsserier av vannstanden, og med uregelmessige tidsintervaller mellom de enkelte avlesningene. Han har videre påbegynt arbeidet med to andre undersøkelser, en påvisning av visse statistiske fellestrekk ved skymengdens hyppighetsfordeling for så vel polare stasjoner som stasjoner på lavere bredder, og en undersøkelse av spektralfordelingen av den diffuse himmelstrålingen på grunnlag av målinger fra Svalbard og Oslo. Han gjorde også ferdig en beskrivelse av været på Svalbard i 1964 for Norsk Polarinstitutt Årbok 1964.

TORGNY E. VINJE overtok 1. januar stillingen som havisforsker, og en vesentlig del av året har således gått med til å sette seg inn i litteraturen om dette emnet. Han har videre organisert og samlet inn ismeldinger, plottet dem inn på kart for for hver ¼ måned og sørget for videre forsendelse av ismeldingene til London, København og Norsk Caltex.

Biologisk arbeid

NATASCHA HEINTZ og MAGNAR NORDERHAUG utarbeidet et nytt, utvidet observasjonsskjema for biologi, som ble sendt nordover med alle partiene sommeren 1965. De innkomne data fra året før ble ordnet, og en artikkel om dette ble trykt i Årbok 1964. Det innkomne plantemateriale ble bearbeidet av cand. real. PER SUNDING, og han skrev en kort artikkel om dette, som ble trykt i Årbok 1964. Både N. HEINTZ og M. NORDERHAUG besvarte i løpet av året en rekke forespørsler angående dyreliv og fredning på Svalbard.

MAGNAR NORDERHAUG har, utenom det han har samarbeidet med N. HEINTZ om, fortsatt bearbeidelsen av alkekongematerialet fra Svalbard. Arbeidet ventes avsluttet i 1966. Videre har han avsluttet arbeidet med «Utredning om aktuelle tiltak vedrørende viltstell og naturvern på Svalbard». Utredningen tar sikte på å trekke opp retningslinjer for arbeidet innen naturvern- og viltstellsektoren på Svalbard i de kommende år.

NORDERHAUG har i 1965 arbeidet mye med isbjørnsaken. En bibliografi over isbjørnlitteratur i de siste 25 år, «The Polar Bear. List of literature», er utarbeidet og distribuert. Et forslag til endring av de gjeldende bestemmelser for isbjørn ble

gjort ferdig og sendt forskjellige personer og institusjoner til uttalelse. Saken ble imidlertid stillet i bero da instituttet ble meddelt at Fiskeridirektoratet, som hadde fått forslaget oversendt, ville fremme et eget forslag for Fiskeridepartementet.

I september deltok NORDERHAUG i den internasjonale konferanse om isbjørnspørsmål i Fairbanks, Alaska. Sammen med den andre norske deltaker, cand. real. T. ØRITSLAND, Bergen, hadde NORDERHAUG utarbeidet en oversikt, «The Polar Bear, Norwegian Hunt and Management». Denne ble fremlagt på konferansen.

I oktober deltok NORDERHAUG i et viltbiologisk seminar ved Universitetet i Lund.

Sammen med T. LARSEN og N. A. ØRITSLAND har NORDERHAUG fortsatt planleggingen av den biologiske overvintringsekspedisjonen.

Bearbeidelse av materiale fra Antarktis

Kartarbeider

Arbeidet med konstruksjon av kart over Sør-Rondane fortsatte, og i den forbindelse ble det også utført en del beregninger. Kartene J 5 Mühlig-Hofmannfjella Nord og K 5 Filchnerfjella Nord ble levert til reproduksjon og trykking, mens kartene L 5 og M 5 ble ført fram til korrekturlesning.

Meteorologi

VIDAR HISDAL har arbeidet med en undersøkelse av vindens daglige variasjon på is-shelfen i Antarktis. Observasjonsresultatene er blitt sammenlignet med resultatene av de teoretiske beregninger av de variasjoner som ville oppstå på grunn av en land- og sjøbriseffekt.

De meteorologiske stasjonene ombord på de norske hvalkokeriene ble som vanlig inspisert i løpet av høsten.

TORGNY E. VINJE fortsatte bearbeidelsen av data fra det meteorologiske tårnet på Norway Station, og materialet er nå sendt til elektronisk databehandling.

Cand. mag. BJØRN GEIRR HARSSON har påbegynt en bearbeidelse av radiosondematerialet fra Norway Station, og det er meningen at han skal nytte dette materialet til en hovedfagsoppgave.

Biblioteket

I løpet av 1965 ble det registrert innkommet ca. 3000 bøker, tidsskrifter og småtrykk som tilvekst til biblioteket. Instituttet kjøpte inn 71 bøker, abonnerte på 21 tidsskriftserier og fikk ca. 90 serier på regulær byttebasis.

I samarbeid med bibliotekskonsulent TORBORG COLLIN har SIGRID RASMUSSEN fortsatt registreringen av biblioteket, men det er et omfattende og tidskrevende arbeid, som man ennå må regne med vil ta megen tid.

Konsulent- og informasjonsvirksomhet

Det er fortsatt stor interesse for polarområdene. Norsk Polarinstitutt har også i 1965 fått tallrike spørsmål vedrørende disse områder fra presse, kringkasting, forlag, skoler og privatpersoner i inn- og utland. Instituttet er ikke bygget opp slik at det kan utføre tilfredsstillende informasjonsvirksomhet uten at det går ut over instituttets hovedoppgave: utforskningen av norske polarområder.

Våren 1965 ble situasjonen så vanskelig at instituttet ble nødt til å gå til en vesentlig innskrenkning av informasjonstjenesten. Senere fikk en godkjenning på å opprette en ny stilling for sekretær I fra 1966. Forøvrig har en søkt å utføre det mest presserende informasjonsarbeid med det personell instituttet har.

Direktøren, i noen grad også andre ved instituttet, har besvart en rekke spørsmål fra offentlige myndigheter, presse, kringkasting og fjernsyn vedrørende Svalbardforhold. SØREN RICHTER har besvart mange spørsmål vedrørende arktiske forhold, og har dessuten vært behjelpelig med å skaffe materiale og opplysninger til forskjellige interesserte. KAARE Z. LUNDQUIST har svart på spørsmål vesentlig om Arktis og ekspedisjonsvirksomhet på Svalbard. SIGURD HELLE har særlig behandlet saker vedrørende Antarktis, og han har dessuten tatt seg av spørsmål om kart og flyfotografier.

NATASCHA HEINTZ har gjennomgått innkommen russisk faglitteratur og oversatt et ganske stort antall artikler for instituttets medarbeidere, vesentlig av geologisk karakter. Hun har redigert Årbok 1964, og bistått ved andre trykningsarbeider. VIDAR HISDAL har delvis tatt seg av redigeringen av Norsk Polarinstitutt Skrifter. Ellers har arbeidet med trykning av Norsk Polarinstitutts publikasjoner vært forestått av ELI HOLMSEN. NATASCHA HEINTZ og THOR SIGGERUD ajourførte sitt skrift fra 1963: «Svalbard, en kort oversikt».

THOR SIGGERUD har hatt en del kontakt med Norges Teknisk-Naturvitenskapelige Forskningsråd angående byggingen av ESRO-stasjonen i Ny-Ålesund, og har dessuten vært med i Norges Almenvitenskapelige Forskningsråds kontinentalsokkel-komité.

Forelesnings- og foredragsvirksomhet

TORE GJELSVIK foreleste i vårsemesteret i malmgeologi ved Universitetet i Oslo.

TORE GJELSVIK og SØREN RICHTER holdt i desember et par forelesninger om Svalbard og andre norske interesseområder i Arktis på Forsvarets Høgskole. Videre holdt GJELSVIK i november et foredrag i Oslo Militære Samfund om «Svalbard i utvikling eller avvikling?». Foredraget ble gitt bred omtale i presse og kringkasting.

NATASCHA HEINTZ holdt i vårsemesteret forelesningene i paleontologi ved Universitetet i Oslo.

AUDUN HJELLE holdt foredrag i Norsk Geologisk Forening med tittelen «Om gneis og granitt på Svalbard».

OLAV LIESTØL holdt i vårsemesteret kollokvier for hovedfagsstudenter i geofysikk, i høstsemesteret forelesninger i glasiologi ved Universitetet i Oslo, samt

et foredrag om «Brevariasjoner og klima» i Det Norske Videnskaps-Akademi i Oslo.

SØREN RICHTER holdt foredrag i Norsk-Britisk Forening om «Amundsen-Scott-ekspedisjonene til Sydpolen 1911–12».

Reiser, kongress-, møte- og kursvirksomhet

VIDAR HISDAL gjennomgikk i tiden 23.–27. august et kurs i programmering av elektroniske regnemaskiner. Kurset var arrangert av Vassdragsvesenet.

TORGNY VINJE deltok fra 29. september til 3. oktober i «Polartagung», arrangert av Die deutsche Gesellschaft für Polarforschung, Hamburg.

NATASCHA HEINTZ gjennomgikk i tiden 21.–28. november et kurs i terrestrisk økologi ved Den landbiologiske stasjonen ved Lunds Universitet.

EINAR NETELAND deltok i tiden 8.–10. desember i et kurs vedrørende bruk av Proton-magnetometer i Trondheim.

Besøk

Blant dem som i det forløpne året har besøkt Norsk Polarinstitutt var: Professor G. HOPPE og docent V. SCHYTT, Sverige; kaptein R. SOKOLOV, fører av atomisbryteren «Lenin», SSSR; J. GOMEZ, generalsekretær for Instituto Antartico, Argentina; H. O. BARFOD, Canada; THOR HEYERDAHL; professor O. H. SELLING, Sverige; P. DOYEN, Belgia; oberst J. O. FLETCHER, Rand Corporation, USA; R. M. IVERSEN, Army Map Service, USA; professor A. OSTENSO, Geophysical & Polar Research Centre, University of Wisconsin, USA; professor GIRS, Arctic and Antarctic Institute, Leningrad, SSSR; professor D. C. NUTT, Arctic Institute of North America, USA; Professor I. KETIN, Istanbul, Tyrkia; dr. S. THORARINSSON, Island; dr. R. NUMELIN, Finland; L. A. LE SCHACK, EXPO-67, Canada; dr. U. VOIGT, Dresden, DDR.

Publikasjoner

Skrifter:

Nr. 133 – VIDAR HISDAL: On the tides at Norway Station. (Scientific Results No. 9).

Nr. 134 – OLAF I. RØNNING: Studies in Dryadion of Svalbard.

Nr. 135 – S. H. BUCHAN, A. CHALLIONOR, W. B. HARLAND, and J. R. PARKER: The Triassic stratigraphy of Svalbard.

Meddelelser:

Nr. 93 – ROLF W. FEYLING-HANSSEN: Shoreline displacement in central Vestspitsbergen and a marine section from the Holocene of Talavera on Barentsøya in Spitsbergen. (Reprints from "Vorträge des Fridtjof-Nansen-Gedächtnis-Symposions über Spitzbergen").

Årbok:

Årbok 1963.

Instituttets medarbeidere har dessuten i andre serier publisert:

OLAV LIESTØL: Breundersøkelser på Hardangerjøkulen i 1964. Norges Vassdrags- og Elektrisitetsvesen, Meddelelse nr. 14 fra Hydrografisk avdeling.

JENÖ NAGY: Oil exploration in Spitsbergen. Polar Record, Vol. 12, No. 81, Sept. 1965.

SØREN RICHTER: Otto Sverdrup. Norsk biografisk leksikon. S. 431–438. Oslo.

THORE S. WINSNES: The Precambrian of Spitsbergen and Bjørnøya. The Geologic Systems, The Precambrian. Vol. 2. Editor: Kalervo Rankama.

The activities of Norsk Polarinstitutt in 1965

Extract of the annual report

BY

TORE GJELSVIK

Staff

There was no change in the number of people permanently employed by the institute during 1965. Two vacancies were filled, as Cand. real TORGNY E. VINJE and Cand. real. BOYE FLOOD joined the staff to work in the fields of sea ice research and geology, respectively. Topographer JOHANNES HUS resigned. 10 people were temporarily engaged, two of them working up data collected by the Norwegian expeditions to Antarctica before 1960.

Professor Dr. STANISLAW SIEDLECKI, Geologic Laboratory of the Polish Academy of Science, has been a visiting scientist at the institute, working on geological material from Svalbard.

Expeditions to Svalbard

Ice conditions in the Svalbard waters differed very much during the season. On the west coast of Vestspitsbergen conditions were fairly good, whereas in the east and northeast severe ice difficulties were encountered. Some field plans for the work had to be changed; nevertheless, the expedition succeeded in carrying out most of its objectives.

The expedition, headed by K. Z. LUNDQUIST, numbered 65 men, including the crews of two helicopters from the Norwegian Royal Airforce and two chartered ships "H. U. Sverdrup" and "Signalhorn". The expedition left Norway in the last days of June and the first days of July, and it returned at the end of August. "Signalhorn" reached the western coast of Norway on the 5th of September. "H. U. Sverdrup" was taken over at Harstad on the 31st of July and was delivered at Bodø on the 14th of September.

Hydrography

The hydrographical survey by "H. U. Sverdrup", in which K. Z. LUNDQUIST, G. SANDEN and E. NETELAND took part, was planned to take place in the Storfjorden area. Therefore the vessel was chartered as late as possible in the season. However, the survey still had to be transferred to the waters off the west coast of Vestspitsbergen because of the ice conditions in Storfjorden. 3,300 nautical

miles of echograms were obtained as well as 300 nautical miles of protonmagnetometer runs.

H. HORNBÆK, using the hydrographical surveying-boat "Svalis", was delayed for some time by the fjord ice in Wijdefjorden, but the survey was carried out according to plan.

Geology

The main task of the geologists during the 1965 season was to make a survey of the island of Nordaustlandet. The original plan was to base the geologists in the expedition ship "Signalhorn", moving her from one fjord to the other on the north coast, and to carry the geologists out daily by the two small Bell 47 G helicopters. This would have meant the most economic use of the short range helicopters. However, the land-fast ice in the fiords of Nordaustlandet did not go away at all, and the expedition had to erect a temporary base at the island of Søre Russøya at the entrance of Murchisonfjorden. Later, when Wahlenbergfjorden opened up, it was possible to move "Signalhorn" into Bodleybukta at the head of the fiord and to fly the geologists out from there. The survey was carried out by a team consisting of the geologists B. FLOOD, D. G. GEE, A. HJELLE and TH. S. WINSNES. TH. SIGGERUD was in charge of the operations, and also made geological investigations himself when possible. From the base at Søre Russøya, the geologists made a detailed survey of an area formerly studied by O. KULLING, with the result that a new sediment series between the Flora quartzite and the Kapp Hansteen formation was established. When working out from the head of Wahlenbergfjorden, most of the work was carried out on the north coast of Nordaustlandet from about 21° to 26°E. It was *i.a.* found that the granite area was considerably larger on Prins Oscars Land than shown on earlier geological maps. The team succeeded in making a rather extensive geological reconnaissance, the result of which in the form of a geological map with description will appear shortly in Skrifter.

Before taking part in the Nordaustlandet survey, A. HJELLE worked on the islands of Danskøya and Amsterdamøya in Vestspitsbergen.

Professor Dr. S. SIEDLECKI carried out stratigraphical and paleontological studies in the Bellsund area, particularly of the Permo-Carboniferous and Triassic series near the entrance of Van Mijenfjorden.

J. NAGY, using a snowscooter, carried out a paleontological-stratigraphical study in Torell Land and in Kjellströmdalen. While waiting for the ice in Burgerbukta to open, he also made detailed measurements of profiles on Hyrneodden and Treskelodden.

Biology

N. E. GULLESTAD continued his investigations of the Spitsbergen char, this year on the east side of the Wijdefjorden area. The ice of the lakes in this area melted very late, however, and the investigations were seriously hampered. He observed 10 chars (*Onchorhynchus gorbuscha*) which now seems to migrate to the Svalbard waters from the east. He also ringed 300 birds.

M. NORDERHAUG investigated the productivity conditions of eider ducks and various geese species in the Hornsund area. Later he studied the productivity of eider ducks on the coast between Kapp Linné and Kapp Martin. He ringed more than 3 500 birds, most of which were little auks (*Plautus alle*).

A. H. NEILSON joined the Nordaustlandet geology team in order to make botanical studies. He was able to visit a number of places from Murchisonfjorden in the west to Duvefjorden in the east, and collected around 1 000 samples of flowers, in particular of the families Draba and Graminae, among which were four species not earlier observed on the island.

Other expedition activity

E. NETELAND inspected and carried out maintenance of the lighthouses and beacons.

A party of rover scouts, under the leadership of J. HOLTEDAHL, collected a more than 20 km long cable left by a German meteorological party during the second world war. This cable, lying on the ground, had caused the death of more than 60 reindeer in the past years. During its work, the party discovered a German ammunition depot, which was reported to the Sysselmann.

T. GJELSVIK, on board the governor's ship "Nordsyssel", tried in vain to penetrate the ice in the eastern part of Spitsbergen, in order to make geological investigations on the east coast of Nordaustlandet and Kvitøya. Instead, he made ice observations in the Storfjorden area.

T. VINJE, at the end of June, made an ice reconnaissance flight over the eastern part of Svalbard with an Albatross plane from Andøya.

In March, H. MAJOR visited the coal deposits of Adventdalen in order to inspect some new exploration adits.

Other Norwegian expeditions to Svalbard

Dr. O. I. RØNNING undertook botanical investigations at Ny-Ålesund. He was supported by Norsk Polarinstitutt.

Norsk Polar Navigasjon A/S continued its drilling operations, this year only in the Grønfjorden area.

A/S Berabo – a private company – sent 2 expeditions to Svalbard.

An expedition sent by the Mine Command D.K.N. in September inspected and destroyed the ammunition depot found by Norsk Polarinstitutt at Reinsdyrflya.

Foreign expeditions

In all 21 foreign expeditions were reported to have visited Svalbard in 1965, 8 of them were sport and film expeditions, 2 were oil exploration expeditions and the rest had a purely scientific programme.

American Overseas Petroleum Ltd. started a major drilling operation at Blåhuken in Van Mijenfjorden (see Fig. 4, p. 166). It was the first deep hole to be drilled in Svalbard. Owing to ice difficulties and technical delays, the hole was not completed before the onset of the winter, and the drilling had to be continued during the winter.

An expedition from the Institute of Arctic Geology, Leningrad, working for Trust Arctikugol, continued exploration for oil as well as other geological investigations.

Cambridge Spitsbergen expedition, consisting of 5 parties and 21 members, made geological and geophysical studies in various places.

A glaciological expedition from the Institute of Geography, Akademia Nauk SSSR, made an extensive glaciological study in central Vestspitsbergen.

An expedition of 5 men from the National Committee for Geodesy and Geophysics, DDR, wintering in Ny-Ålesund, continued glaciological and geophysical studies carried out by a larger group in the summer of 1964.

A French expedition of 14 members made geomorphological, glaciological, botanical and marine biological studies in the Kongsfjorden area, Vestspitsbergen.

Two expeditions from Geografiska Institutionen, University of Stockholm, made investigations of Pleistocene geology at Bjørnøya and Hopen islands.

Expeditions to Dronning Maud Land, Antarctica

No Norwegian expedition worked in Antarctica in 1965. On the American "Queen Maud Land Traverse", glaciologist OLAV ORHEIM took part, in order to continue the studies of glaciologist OLAV DYBVADSKOG, who participated in 1964.

One South African, one Russian, and one Belgic/Dutch expedition wintered in Dronning Maud Land.

Glaciological studies in Norway

OLAV LIESTØL continued the extensive studies of the glaciers Hardangerjøkulen near Finse and Storbreen in Jotunheimen, and OLAV ORHEIM made studies on Suphellebreen in Sogn. Reports of fluctuation of 11 other glaciers were received from observers.

The summer in Norway was colder and rainier than normal, and much of the precipitation on the glaciers was snow. The balance of material, therefore, showed a surplus for most of the glaciers. Still, with the exception of one glacier, the retreat of the glacier fronts continued.

Preparation of data from Svalbard

Hydrography

The work continued on a new chart covering the north-west corner of Vestspitsbergen, which is expected to be published in a years time. A new edition of chart No. 503 (Isfjord–Bellsund) was also in preparation.

Topography – geodesy

Observations from the 1964 survey of Albert I Land, Haakon VII Land, Andrée Land and James I Land were calculated. Furthermore was part of the 1963 observations from Ny Friesland and Olav V Land worked out.

The area between Monacobreen and Bockfjorden as well as coast lines of the inner part of Wijdefjorden were constructed (1:50,000), as were also several pre-

liminary maps for naming purposes (1:100,000). Work on a map of Svalbard in the scale of 1:1 mill. continued.

Geology

H. MAJOR worked on a description of the geological map of Adventdalen and made coal petrology studies of samples from the mines and exploration adits. He was frequently consulted on problems related to future coal mining in Adventdalen, and had to prepare claim maps of various kinds.

J. NAGY wrote a paper on the geology of eastern Torell Land, printed in the yearbook of 1964, as well as a paper in "Polar Record" on the oil exploration in Spitsbergen, worked out structural features of eastern Wedel Jarlsberg Land, and made detailed studies of stratigraphy and paleontology of the Ditrupa beds (upper part of Lower Cretaceous in Vestspitsbergen). He has also prepared much material in connection with oil claims based on geological indications.

S. SIEDLECKI prepared his material from Sørkappøya and Bellsund, and described a new fish fossil find, *Helicoprion*, from Permian.

TH. SIGGERUD coordinated the work of a team consisting of himself, B. FLOOD, D. G. GEE, A. HJELLE and TH. WINSNES, who took part in the helicopter-supported geological survey of Nordaustlandet during the 1965 field season. They prepared a geological map in the scale of 1:250,000, A. HJELLE particularly studied the material of granitic rocks, FLOOD the volcanic series of the Kapp Hansteen formation, GEE structural problems, and WINSNES the stratigraphy. SIGGERUD, FLOOD, and GEE prepared individual papers on their study for the VII Nordic Geology Winter Meeting in Åbo. Before the expedition FLOOD collected and put down on maps all available information on the geology of Nordaustlandet, whereas HJELLE and GEE prepared the data collected during the geological survey of the Hecla Hoek rocks in the north-west part of Vestspitsbergen, and produced a map and a paper which was printed in the 1964 yearbook. HJELLE, furthermore, made detailed investigations of thin sections and slabs of granitic rocks from Vestspitsbergen and Nordaustlandet. In the spring, WINSNES completed a paper on the Carboniferous and Permian rocks of Vestspitsbergen (Årbok 1964), and was co-author of the paper on the geochronology of Svalbard rocks (Skrifter Nr. 137). D. G. GEE worked up data from various parts of Vestspitsbergen, and was co-author of Skrifter Nr. 137 and of another paper, together with M. MOODY-STUART: The base of the Old Red Sandstone in central north Haakon VII Land (Årbok 1964).

Geophysics

O. LIESTØL prepared glaciological data from Svalbard and Norway, some of which were collected for hydro-electrical schemes. A paper on the results of 15 years' investigations of the Storbreen glacier in Jotunheimen was about to be completed.

V. HISDAL calculated the harmonic tidal components for two places in Svalbard, using a special method for short and irregular observation series. He initiated a statistical study of the frequency of cloud amount for polar and lower latitude sta-

tions, and an investigation of the spectral distribution of the diffuse radiation at Svalbard and Oslo. A note on the weather in Svalbard in 1964 was published in the yearbook.

T. VINJE took up his new job as a sea-ice scientist at the beginning of the year. He organized further the ice report service by ships and airplanes, and plotted the ice situation for the Svalbard area on maps which were distributed to interested organizations.

Biology

N. HEINTZ and M. NORDERHAUG prepared a new observation form for the expedition parties, to be used during the 1965 field season in Svalbard.

The data from the preceding season were prepared and a paper published in the yearbook.

The plant material was prepared for publication, also in the yearbook, by P. SUNDING.

M. NORDERHAUG continued his investigations of little auk material from Svalbard, and finished a paper on wildlife and conservation in Svalbard. In addition, he worked with the polar bear problem and published a literature list called: "The Polar Bear. List of Literature", which contained papers on this subject published during the last 25 years. In September he took part in the International polar bear conference in Fairbanks, Alaska, as a member of the Norwegian delegation.

Preparation of data from Antarctica

Topography

Construction of maps from Sør-Rondane continued. The maps J 5 Mühlig-Hofmannfjella Nord and K 5 Filchnerfjella Nord (scale 1:250,000) were submitted for print, and proofs of two new sheets were read.

Meteorology

V. HISDAL studied diurnal wind variations on the shelf ice, and compared the observed facts with theoretical calculations based on the land–sea breeze effect.

T. VINJE continued to prepare data from the meteorological tower at Norway Station.

B. S. HARSSON took up a study of the secondary tropopause, based on radiosonde data from Norway Station.

Notiser

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On the Svalbard fauna 13

Ringmerking av fugl på Svalbard 1962–1965

(Bird banding in Svalbard 1962-1965)

Abstract. The results of Norsk Polarinstitutt's ringing activity in Svalbard in the years 1962–1965 are summarized. Different biological parties have been occupied with bird banding in connection with other field work in Svalbard (Table 1). Table 2 gives the number of ringed birds of the different species. 12,528 out of 14,150 individuals were ringed as adults. Trapping methods are briefly described. Fulmars (*Fulmarus glacialis*), kittiwakes (*Rissa tridactyla*), Brünnich's guillemots (*Uria lomvia*) and little auks (*Plautus alle*) were taken with different types of "fleygja-stong". Some of the best results are mentioned: 57 adult fulmars were ringed by two men in $2^1/_2$ hours and 1,000 adult little auks were ringed by two men in $2^1/_2$ days. Some preliminary recoveries are mentioned: Fulmar (1) from North-Norway, Brünnich's guillemots (3) and little auks (8) from West Greenland, barnacle geese from Scotland and snow buntings (3) from Arkhangelsk, USSR.

Innledning

I årene 1962–1965 er ringmerking av fugl blitt utført på Svalbard i sammenheng med Norsk Polarinstitutts ekspedisjonsvirksomhet. Merkingene er utført for Stavanger Museum og Statens viltundersøkelser.

Også tidligere er fugl merket på Svalbard i samband med ornitologekspedisjoner til dette området. Av disse er de britiske ringmerkingene av kortnebbgås (*Anser fabalis brachyrhynchus*) og ringgås (*Branta bernicla hrota*) for Stavanger Museum i 1950-årene av størst betydning (HOLGERSEN 1960). Ringmerkingene på Svalbard har hittil gitt flere verdifulle og til dels uventede resultater. Det er å håpe at arbeidet kan fortsette i årene framover, og helst komme i fastere former. Av flere grunner vil imidlertid Svalbardmerkingene i de nærmeste sesonger bli av mindre omfang enn i perioden 1962–1965. Nedenfor er gitt en oversikt over resultatene i nevnte tidsrom, med en del bemerkninger.

Ringmerkingsvirksomheten

I 1962 organiserte 7 studenter ved universitetet i Oslo i samarbeid med Norsk Polarinstitutt en ornitologisk ekspedisjon (NOSE–62) til Hornsund (BANG *et al.* 1963), og vel 3000 fugl ble da ringmerket. Erfaringene fra denne sesongen dannet grunnlaget for merkingene i de påfølgende sesonger. Disse ringmerkinger ble utført av Norsk Polarinstitutts biologpartier med deltagere fra 1962-ekspedisjonen som partiledere. I denne sammenheng skal anføres at merkingene i alle tilfelle har vært sekundært arbeid i forbindelse med annen biologisk feltvirksomhet på Svalbard. Resultatene av merkingene er gitt i tabell 1 og 2.

Med hensyn til antall merkete hvitkinngjess skal anføres at ytterligere 222 individer ble merket i nevnte tidsrom. Det gjelder ringmerkinger utført av «The Wildfowl Trust» i stammens vinterkvarter ved Firth of Solway, Skottland (BOYD 1964). Ved utgangen av 1964 var således over 1000 av Svalbards hvitkinngjess merket, d.v.s. mellom $^1/_3$ og $^1/_4$ av hele bestanden.

Av de totale 14 150 individer av 17 arter som ble merket var 12 528 fanget som voksne. Årsaken er at unger av de fleste arter vanskelig kan nåes i større antall. Merkingene måtte derfor baseres på utprøving av effektive fangstmetoder for voksne individer.

Tabell 1.
Ringmerking av fugl på Svalbard i årene 1962-65.
Bird banding activity in Svalbard in the years 1962-65

År *Year*	Merket av *Banded by*	Antall deltagere *Number of men*	Lokalitet *Locality*	Antall fugl merket *Number of bird ringed*
1962	Norsk Ornit. Spitsbergen Ekspedisjon	7	Hornsund	3 135
1963	Reingruppe: leder T. LARSEN	3	Nordvest Spitsbergen	1 097
	Ornitologgruppe: leder M. NORDERHAUG	3	Hornsund	2 686
1964	Ferskvanns biologgr.: leder N. GULLESTAD	2	Hornsund	500
	Ornitologgruppe: leder M. NORDERHAUG	3	Hornsund	2 828
1965	Ferskvanns biologgr.: leder N. GULLESTAD	3	Bangenhuk	342
	Ornitologgruppe: leder M. NORDERHAUG	3	Hornsund	3 562
		Totalt for årene 1962–65 *Total in the years 1962–65*		14 150

Tabell 2.
Ringmerking på Svalbard 1962-65, fordelt etter art.
Number of different species banded in Svalbard 1962-65.

Art (*Species*)	Antall merket (*Number ringed*)				
	1962	1963	1964	1965	Total 1962–1965
Havhest (*Fulmarus glacialis)*	118	320	25	278	741
Ærfugl (*Somateria mollissima*)	–	7	1	–	8
Ringgås (*Branta bernicla*)	–	1	–	–	1
Hvitkinngås (*Branta leucopsis*)	685	21	102	–	808
Spitsbergenrype (*Lagopus mutus*)	–	–	–	1	1
Sandlo (*Charadrius hiaticula*)	–	–	–	2	2
Fjæreplytt (*Calidris maritima*)	6	23	9	11	49
Polarsvømmesnipe (*Phalaropus fulicarius*)	2	3	2	1	8
Tyvjo (*Stercorarius parasiticus*)	3	8	5	1	17
Polarmåke (*Larus hyperboreus*)	–	33	–	92	125
Krykkje (*Rissa tridactyla*)	22	100	77	140	339
Rødnebbterne (*Sterna macrura*)	5	163	19	249	436
Alkekonge (*Plautus alle*)	2 100	2 901	3 010	3 001	11 012
Polarlomvi (*Uria lomvia*)	125	106	20	97	348
Svalbardteiste (*Cepphus grylle*)	3	–	–	6	9
Polarlunde (*Fratercula arctica*)	–	10	–	–	10
Snøspurv (*Plectrophenax nivalis*)	66	87	58	25	236

Fangstmetoder

De metoder som erfaringsvis viste seg effektive skal kort nevnes:

Hovfangst. Voksne havhester, krykkjer, polarlomvi, alkekonger, samt i visse tilfelle tyvjo og rødnebbterner, ble tatt med langskaftede bambushover. Form og nett-type ble avpasset for hver art. Som en illustrasjon av hvor effektiv denne fangstmetode kan bli under optimale forhold med erfarne fangere og riktige hovtyper, kan nevnes noen eksempler fra ornitologpartiets arbeid i Hornsund. 6/8 1963 tok to mann 57 havhest for ringmerking på $2^1/_2$ time ved Hyttevika nord for Hornsund. I polarlomvikolonien i Sofiakammen, Hornsund, fanget og merket tre mann (en hov) 25 individer på 20 minutter. I juli samme år merket to mann 1000 alkekonger på $2^1/_2$ dag i Gulliksenfjellet, Hornsund.

Gåsefangst. All ringmerking av hvitkinngjess er basert på fangst av voksne, mytende individer ved hjelp av ledegjerder i kileform og bruk av gummibåter (LARSEN & NORDERHAUG 1963).

Fellefangst. Voksne snøspurv ble fanget ved hjelp av trådutløste feller med havregryn. Der bestanden var tett ble resultatene brukbare fordi fangsten foregikk under opphold i leiren.

Ungefangst. For arter der hovfangsten var ineffektiv (rødnebbternene) og hvor felle/ruse-fangst ikke var brukbart (fjæreplytt) eller arter som bare fantes spredt (polarsvømmesnipe og tyvjo) ble merkingen basert på ungefangst. Hos polarlomvi kan for øvrig ungemerking være effektiv i de tilfelle det er mulig å oppholde seg ved koloniene når ungene forlater hyllene (i midten av august). I vindstille kvelder lander da et betydelig antall på land.

Foreløpige gjenfunn

Bare noen viktigere gjenfunn skal foreløpig nevnes:

Av 741 merkede havhest er hittil bare to gjenmeldt, og bare en av dem utenfor Svalbard. En merket i Hornsund i juli 1963 ble funnet ved Loppa, Finnmark, i januar 1964.

Av alkekonger ringmerket i Hornsund foreligger 8 gjenfunn fra Vest-Grønland. Dette viser hittil ukjente sider ved artens vintervandringer. Svalbards polarlomvier har muligens et tilsvarende trekk. Hittil foreligger tre vinterfunn som tyder på det. Av 236 ringmerkede snøspurv er hittil tre gjenfunnet, alle fra Arkangelsk-området i Sovjet-Samveldet. Kontroll- og gjenfunnsmaterialet av hvitkinngjess skal ikke behandles her. Imidlertid ser det i alle fall hittil ut til at artens vinterkvarter i sin helhet ligger ved Firth of Solway i Skottland. Funn fra selve trekkveiene er mer sparsomme (LARSEN & NORDERHAUG 1964).

Litteratur

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Annen etappe av Dronning Maud Land Traversen

Abstract. During the Antarctic summer of 1965–66 the author joined the U. S. Antarctic Research Programme in the second part of a traverse through Dronning Maud Land. This time the distance from the "Pole of Inaccessibility" to the new American "Plateau Station" was covered. The scientific programme for the expedition covered the fields of seismology, gravimetry, magnetism, glaciology and meteorology, and the author was responsible for the daily meteorological observations and for the study of the surface features of the snow, particularly the sastrugis.

Fra november 1965 til januar 1966 ble den andre etappen av den amerikanske Dronning Maud Land Traversen gjennomført. Som året før fikk Norsk Polarinstitutt innbydelse fra National Science Foundation i USA til å sende med en deltaker ved ekspedisjonen, og jeg fikk anledning til å bli med. Da O. DYBVADSKOG har gitt en utførlig beskrivelse av den første delen av traversen fra Sydpolen til Utilgjengelighetens Pol i NPI Årbok 1964, vil jeg her bare nevne noen av de mer spesielle trekk ved årets ekspedisjon.

Vi ble fløyet inn til Utilgjengelighetens Pol (det punkt på det antarktiske kontinent som ligger lengst fra havet) 22. november 1965. Lederen for ekspedisjonen var professor E. PICCIOTTO fra Belgia, og dessuten var det med seks amerikanske vitenskapsmenn og fire mekanikere, foruten meg. Utilgjengelighetens Pol ligger på vel 3700 m o. h., så mekanikerne som kom direkte fra McMurdo Station, den amerikanske hovedbasen ved Rossisen, lå syke i flere dager p. g. a. høydeforskjellen. Vi andre derimot slapp slike problemer, da vi tilbragte vel en uke på Amundsen-Scott Sydpol stasjonen (2800 m o. h.) og ble akklimatisert til store høyder der.

På Utilgjengelighetens Pol ble vi liggende i vel tre uker for å gjøre kjøretøyene, de tre såkalte sno-cat'ene, kjøreklare. Sno-cat'ene ble etterlatt der da den første etappen av traversen ble avsluttet her i februar 1965 og mye reparasjonsarbeid måtte gjøres, da de ble kjørt hardt det siste stykket inn til Utilgjengelighetens Pol. Selve overvintringen med temperaturer helt under -88°C hadde de klart fint.

Arbeidsforholdene var ikke de beste, luften var tynn og kald, så det var umulig å arbeide hurtig på grunn av pusten. Temperaturen kom seg endel mens vi lå der, døgnmiddelet steg fra -46°C til -34°C, og så lenge vindstyrken var lav gikk det fint. Men ved et par anledninger hadde vi imidlertid 20 knops vind og -40°C og da måtte alt utearbeid stort sett innstilles.

Den 15. desember kjørte vi, i alt 11 mann, ut fra Utilgjengelighetens Pol (en av mekanikerne hadde da returnert med et forsyningsfly) med omtrent samme opplegg som på første del av traversen. Vi kjørte 40 nautiske mil i løpet av et døgn, så lå vi stille det neste døgn og foretok forskjellige geofysiske målinger. Som DYBVADSKOG sto jeg for de meteorologiske rutineobservasjonene hver 6. time og for overflatestudiene av snøen, herunder spesielt sastrugiene.

Vi hadde bløtere snø og mindre sastrugier enn på den første del av traversen og det gjorde sitt til at lite tid gikk tapt med reparasjonsarbeid på kjøretøyene. På den annen side ble farten lavere i den bløte snøen og enkelte dager tok det oss over 30 timer å kjøre 40 nautiske mil.

Stort sett forløp ekspedisjonen uten nevneverdige opplevelser. Men etter to uker mistet vi en del borseksjoner, og vi måtte grave en sjakt 15 m ned for å hente dem opp igjen.

Vi boret et hull vel 40 m dypt ved hver hovedstopp, så temperatur og egenvekt kunne måles på forskjellige snødyp, og seismologene kunne få fyrt av sprengladningene tilfredsstillende langt under snøoverflaten. Det var under boringen av et slikt hull at en del seksjoner ble sluppet ned, og det tok oss 4 dager å få dem opp igjen.

Like før vendepunktet kom vi inn i et uventet sprekkeområde som antagelig skyldtes en høy, skarp subglasial fjellkjede. Sprekkene var nokså godt gjenfylt med

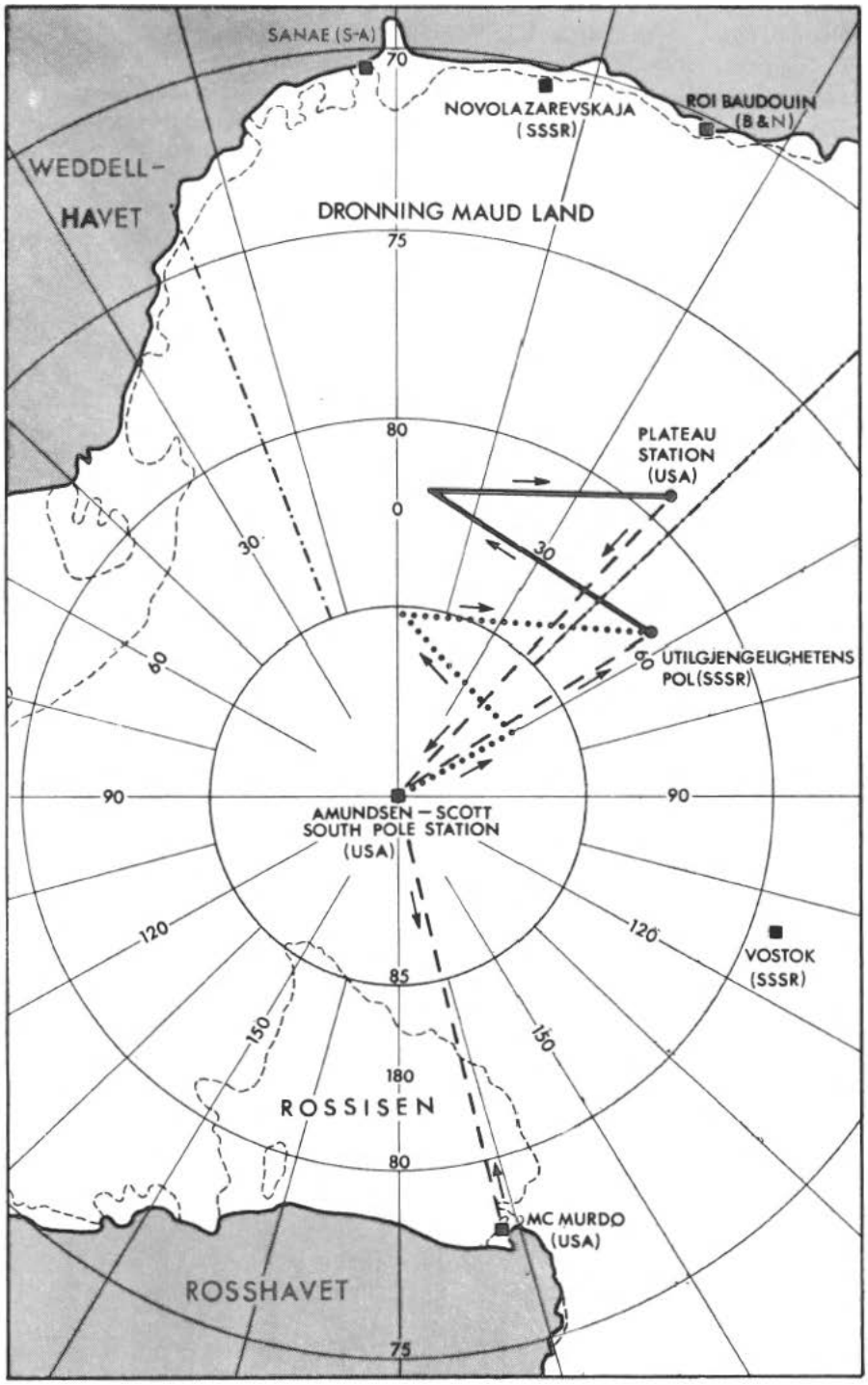

Fig. 1. *Kart over Antarktis med ruten til den amerikanske Dronning Maud Land Traversen inntegnet. Den prikkete linjen angir første etappe gjennomført i 1964/65, den helt opptrukne linjen viser annen etappe fra Utilgjengelighetens Pol til den nye Plateau Station, og den stiplete linjen viser flyruten.*

Map of Antarctica with the route of the American Dronning Maud Land traverse indicated. The dotted line shows the first part of the traverse covered during the Antarctic summer of 1964–65, the solid line gives the second part of the journey from "The Pole of Inaccessibility" to the new American base "Plateau Station", and the broken line shows the distances travelled by air.

Fig. 2. *Sastrugier er en form for skavler som kan bli opptil et par meter høye, og de er ofte svært hårde. Tommestokken på bildet er 1 m lang.*

Sastrugis are a special form of steep snow-drifts. They can be up to a couple of metres high, and often quite compact. The stick lying on the top of the sastrugi is 1 m long.
Photo: O. ORHEIM.

vindblåst snø, så til tross for at vi kjørte nedi et par ganger, var det ingen alvorlig fare.

I løpet av januar ble en ny base, Plateau Station, bygget ved endepunktet for vår del av traversen, og da vi kom frem 29. januar sto den klar til innviing. Vi ble der ikke lengere enn høyst nødvendig, temperaturen falt raskt, men noen dager gikk med til å dele opp kjøretøyene så de kunne flys tilbake til McMurdo Station. Derfra skulle motorene sendes med båt til USA og overhales før tredje etappen på traversen starter fra Plateau Station i november 1967.

Ekspedisjonen var strabasiøs, og mye ble ensformig, men Antarktis gav likevel mersmak.

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