DET KONGELIGE DEPARTEMENT
FOR INDUSTRI OG HÅNDVERK

NORSK POLARINSTITUTT

SKRIFTER

Nr. 109

THE QUATERNARY GEOLOGY OF BRAGENESET, NORDAUST-LANDET, SPITSBERGEN

BY

J. J. DONNER AND R. G. WEST

WITH 9 TEXT FIGURES, 1 TABLE AND 5 PLATES

I KOMMISJON HOS
FABRITIUS & SØNNERS FORLAG
OSLO 1957

NORSK POLARINSTITUTT
(Formerly Norges Svalbard- og Ishavs-undersøkelser.)
Observatoriegaten 1, Oslo

SKRIFTER

Skrifter 1—50, see numbers of Skrifter previous to No. 100.

Resultater av De Norske statsunderstøttede Spitsbergenekspeditioner.

Nr. 51. BIRKELAND, B. J. et GEORG SCHOU, *Le climat de l'Eirik-Raudes-Land.* 1932. Kr. 2,00
„ 52. KIÆR, J. †, *The Downtonian and Devonian Vertebr. of Spitsb.* IV. Suborder *Cyatha spida.* 1932. Kr. 5,50.
„ 53. 1. MALAISE, R., *Eine neue Blattwespe.* 2. A. ROMAN, *Schlupfwespen.* 3. O. RINGDAHL, *Tachiniden und Musciden.* 4. M. GOETGHEBUER, *Chironomides du Groenland oriental, du Svalbard et de la Terre de François Joseph. — Zool. Res. Norw. Sc. Exp. to East-Greenland. II.* 1933. Kr. 4,00.
„ 54. VARTDAL, H., *Bibliographie des ouvrages norvégiens relatifs au Grœnland (Y compris les ouvrages islandais antérieurs à l'an 1814).* 1935. Kr. 12,00.
„ 55. OMANG, S. O. F., *Übersicht über die Hieraciumflora Ost-Grönlands.* 1933. Kr. 2,50.
„ 56. DEVOLD, J. and P. F. SCHOLANDER, *Flowering Plants and Ferns of Southeast Greenland.* 1933. Kr. 20,00.
„ 57. ORVIN, A. K., *Geology of The Kings Bay Region, Spitsbergen.* 1934. Kr. 20,00.
„ 58. JELSTRUP, H. S., *Détermination astronomique à Sabine-Øya.* 1933. Kr. 2,50.
„ 59. LYNGE, B. *On Dufourea and Dactylina. Three Arctic Lichens.* 1933. Kr. 5,00.
„ 60. VOGT, TH., *Late-Quaternary Oscillations of Level in S. E. Greenland.* 1933. Kr. 5,00.
„ 61. 1. BURTON, M., M. SC., *Report on the Sponges.* 2. ZIMMER, C., *Die Cumaceen. — Zool. Res. Norw. Sc. Exp. to East-Greenland. III.* 1934. Kr. 2,50.
„ 62. SCHOLANDER, P. F., *Vascular Plants from Northern Svalbard.* 1934. Kr. 15,00.
„ 63. RICHTER, S, *A Contr. to the Archæology of North-East Greenland.* 1934. Kr. 25,00.
„ 64. SOLLE, G., *Die devonischen Ostracoden Spitzbergens.* 1935. Kr. 5,50.
„ 65. 1. FRIESE, H., *Apiden.* 2. LINDBERG, H., *Hemiptera.* 3. LINNANIEMI, W. M., *Collembolen. Zool. Res. Norw. Sc. Exp. to East-Greenland. IV.* 1935. Kr. 2,50.
„ 66. 1. NORDENSTAM, Å., *The Isopoda.* 2. SCHELLENBERG, A., *Die Amphipoden.* 3. SIVERTSEN, E., *Crustacea Decapoda, Auphausidacea,* and *Mysidacea. Zool. Res. Norw. Sc. Exp. to East-Greenland. V.* 1935. Kr. 5,00.
„ 67. JAKHELLN, A., *Oceanographic Investigations in East Greenland Waters in the Summers of 1930—1932.* 1936. Kr. 7,00.
„ 68. FREBOLD, H. und E. STOLL, *Das Festungsprofil auf Spitzbergen.* III. *Stratigraphie und Fauna des Jura und der Unterkreide.* 1937. Kr. 5,50.
„ 69. FREBOLD, HANS, *Das Festungsprofil auf Spitzbergen.* IV. *Die Brachiopoden- und Lamellibranchiatenfauna des Oberkarbons und Unterperms.* 1937. Kr. 10,00.
„ 70. DAHL, EILIF, B. LYNGE, and P. F. SCHOLANDER, *Lichens from Southeast Greenland.* 1937. Kr. 4,50.
„ 71. 1. KNABEN, NILS, *Makrolepidopteren aus Nordostgrönland.* 2. BARCA, EMIL, *Mikrolepidopteren aus Nordostgrönland. Zool. Res. Norw. Sc. Exp. to East-Greenland. VI.* 1937. Kr. 3,50.
„ 72. HEINTZ, A., *Die Downtonischen und Devonischen Vertebraten von Spitzbergen. VI. Lunaspis-Arten aus dem Devon Spitzbergens.* 1937. Kr. 2,00.
„ 73. *Report on the Activities of Norges Svalbard- og Ishavs-undersøkelser 1927—1936.* 1937. Kr. 10,00.
„ 74. HØYGAARD, ARNE, *Some Investigations into the Physiology and Nosology of Eskimos from Angmagssalik in Greenland.* 1937. Kr. 1,50.
„ 75. DAHL, EILIF, *On the Vascular Plants of Eastern Svalbard.* 1937. Kr. 3,50.
„ 76. LYNGE, B., *Lichens from Jan Mayen.* 1939. Kr. 4,50.
„ 77. FREBOLD, HANS, *Das Festungsprofil auf Spitzbergen. V. Stratigraphie und Invertebratenfauna der älteren Eotrias.* 1939. Kr. 5,00.

DET KONGELIGE DEPARTEMENT
FOR INDUSTRI OG HÅNDVERK

NORSK POLARINSTITUTT

SKRIFTER

Nr. 109

THE QUATERNARY GEOLOGY OF BRAGENESET, NORDAUSTLANDET, SPITSBERGEN

BY

J. J. DONNER AND R. G. WEST

WITH 9 TEXT FIGURES, 1 TABLE AND 5 PLATES

I KOMMISJON HOS
FABRITIUS & SØNNERS FORLAG
OSLO 1957

A. W. BRØGGERS BOKTRYKKERI A/S

Contents.

	Page
Preface	5
Introduction	7
Stone orientation measurements of tills in the margin of Bragebreen, Vestfonna	9
Sections and directions of preferred orientation	11
The results	14
The raised beaches of Brageneset and the neighbouring parts of Hinlopenstretet	16
Marine shells from the tills and raised beaches	24
The Quaternary history of Brageneset	26
References	29
Plates	31

Preface.

The investigations described here were made during the Oxford University Expedition to Nordaustlandet in the summer of 1955. They had as their object, first, to investigate the Quaternary history of a small area, Brageneset, where the Expedition was based; secondly, to make observations on glacial geology which might be of use in the interpretation of Pleistocene deposits.

We acknowledge gratefully the great assistance given to us by the other members of the Expedition and by the Oxford University Exploration Club. One of us (R. G. W.) is indebted to the Geological Society of London for the encouragement of the research described here by the award of the Edmund Johnston Garwood Fund. We also thank Mr. D. F. W. Baden-Powell and Mr. G. L. Wilkins for their help in the identification of the shells.

J. J. Donner and R. G. West.

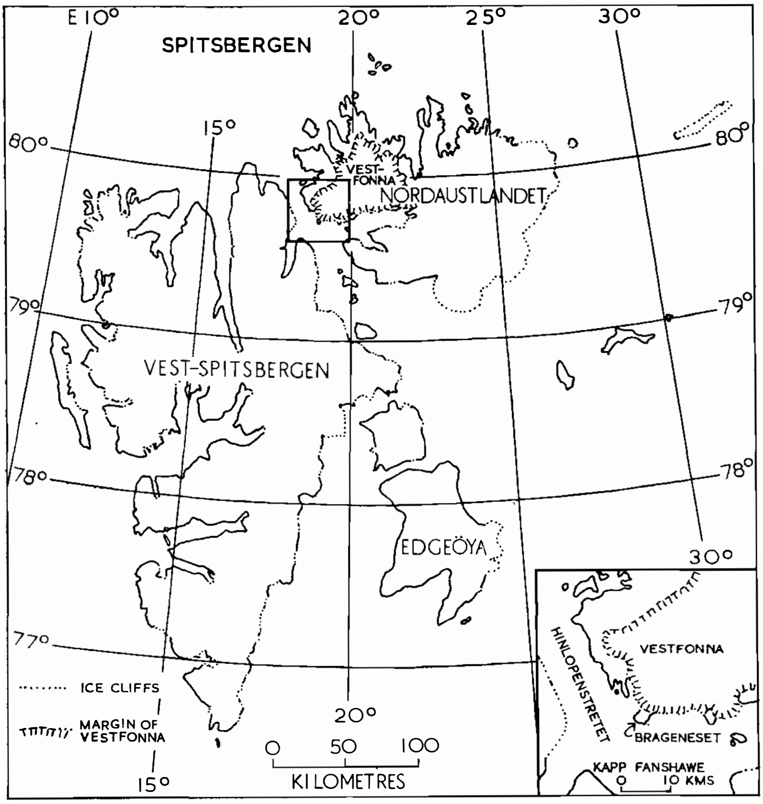

Fig. 1. Map of Spitsbergen showing the position of Brageneset.

Introduction.

The position of Brageneset is shown on the map, Figure 1. It lies at the most south-westerly extension of Vestfonna. The map, Figure 2, gives an outline of the topography of Brageneset and the adjacent parts of Vestfonna. This map does not pretend to be accurate. The positions of the Camp, South, Middle and West Cairns were fixed accurately by Dr. D. Masson-Smith. The secondary points were fixed by angles taken with a highway level, as were the positions of the stone measurement sites. The positions of other features on the map were fixed by compass.

Brageneset is an inconspicuous promontory, the surface of which is composed almost entirely of raised beach shingles, till and dolerite. The dolerite, probably of Cretaceous age (Orvin 1940), lies in weathered lumps over about a third of the surface. The outcrops of this rock are usually surrounded by sandy areas formed by its disintegration under the severe weather conditions. These outcrops are separated by a series of raised beach shingles (Plate 1, Fig. 1) which rise from the present sea level to 46.5 m a. s. l. near the West Cairn. The raised beach shingle is frequently very thin and barely mantles the glacial deposits, chiefly till, which are found in the depressions between the dolerite outcrops.

In the north and north-east parts of Brageneset the dolerite and raised beaches are concealed by fresh, often hummocky, moraines (Plate 1, Fig. 2). These moraines mark a former advance and standstill of the Vestfonna ice-front, the present position of which is shown in the map, Figure 2. Between the moraines and the foreland towards which the ice advanced are two moraine-dammed lakes and one large ice-dammed lake (Plate 1, Figs. 1 and 2). An old overflow channel of the largest lake and the present outflows of the lakes are also shown on the map.

Bragebreen, the lobe of Vestfonna which reaches Brageneset, gradually slopes to an inconspicuous edge where it meets Brageneset, as seen in the photographs, Plate 1, Figs. 1 and 2, and Plate 4, Fig. 1. Where the edge is seaward, however, the ice forms abrupt cliffs (Plate 2, Fig. 1), which are receding as erosion by the sea causes the calving of bergs.

Where the surface deposits of Brageneset are unconsolidated, and where a clay and sand or gravel interface occurs near the surface, the

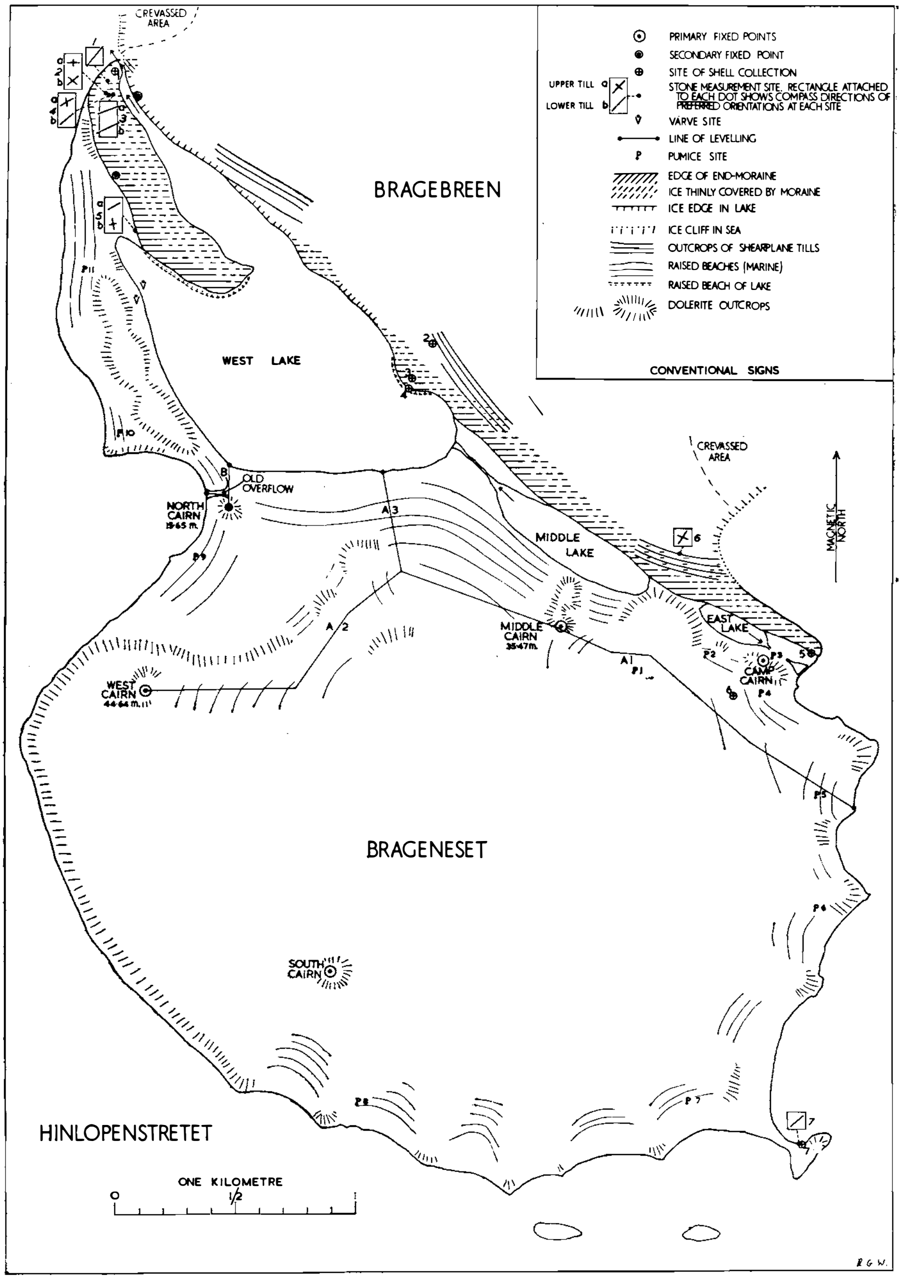

Fig. 2. Map of Brageneset.

effects of alternate freezing and thawing are seen in the presence of patterned ground. On level ground polygons and polyhedral frost-cracks are often found, while on sloping gound stone stripes from 15 to 150 cm width are common. The presence of patterned ground is no doubt enhanced by the rapid splitting of rocks by frost action and by the very sparse plant cover (the barren vegetation type of Summerhayes and Elton (1928)) formed under the extreme conditions of climate obtaining at Brageneset. We may mention that, according to Eriksson (1933), who has described the climate of the northern part of Hinlopenstretet in some detail, in this region the mean temperature of the coldest winter months (February-March) is about —22°C., and that of the warmest summer months (July-August) is about +3°C.

Stone orientation measurements of tills in the margin of Bragebreen, Vestfonna.

It has long been known that the long axes of stones in lodgement tills may have a preferred orientation parallel to the direction of movement of the ice which deposited the tills (Richter 1932, Holmes 1941). Preferred orientation was first inferred from studies of Pleistocene tills, for example, by the relation of the preferred direction to such oriented features as drumlins and striae. The few measurements made by Richter (1936) of tills of Norwegian valley glaciers in the process of deposition or formed recently confirm the relation of the direction of preferred orientation of till stones to the direction of ice flow. Hoppe (1953) made two measurements of tills of ground-moraine flats outside Icelandic glaciers and found the parallel relation to hold. The results described here of stone orientation measurements of tills in or closely related to the decaying margin of the ice sheet of Vestfonna give a further basis for the use of such measurements for the determination of ice movement directions in the Pleistocene epoch.

The moraines exposed during the decay of the ice margin are of various kinds. Ablation moraine is not very common, nearly all the moraine being formed of till of the boulder clay type. The outermost moraines (Plate 1, Fig. 2) form a band of hummocks of till which are larger and more rounded than the hummocks of the moraines inside them. These large hummocks must have been formed at the time of the maximum extension of the ice, possibly as ground moraine pushed up at the base of the advancing ice. Between the outer band of moraines and the ice edge is a zone of inner moraines with very irregular angular hummocks, numerous kettle holes and areas of ground-moraine flat (Plate 1, Fig. 2 and Plate 2, Fig. 2). Sections exposed by erosion in both the inner and outer zone of moraines show that much of the area is underlain by ice, in which occur narrow bands of till (Plate 2, Fig. 2). Contortions present in the dead ice suggest that the moraines are partly push-moraines. The last type of moraine to note is found directly on the ice of the ice-sheet itself near the margin. Here moraine appears because of ablation in areas where thrustplanes bring narrow bands of till to the surface of the ice. Thus lines of till stick up nearly vertically out of the ice, the lines following the strike of the thrustplanes parallel to the ice margin. The thrustplane tills are seen in Plate 2, Fig. 1 and Plate 3, Figs. 1 and 2.

The measurements described here are of tills from the ground-moraine flats which rest on the dolerite foreland and on ice, from narrow bands of till in the dead ice of the margin and from a band of till exposed by ablation on the ice-sheet itself.

Eleven tills at seven sites were investigated. The positions of the sites are shown on the map, Figure 2. Details of the sections exposed at these places are given below. All the tills studied were of the boulder clay lodgement type.

The directions and dips of the long axes of 100 stones (of size 1—15 cm) were measured in each till examined except at Site 7, where only 50 stones were measured. The results of these counts are presented on polar co-ordinate paper in the following way:

a. A diagram is made showing the dip and direction of the long axes of the stones, as in Figure 3. Each stone is represented by one dot; the direction (to the nearest 10°) of the long axis is shown by the direction of the radius on which the dot lies, and its dip by the distance of the dot from the outermost circle of the diagram, the concentric circles representing 10° intervals of angle of dip, increasing from 0° at the outermost circle to 80° at the innermost. Half the number of horizontally-lying stones in each 10° class of direction are placed on opposite sides of the diagram.

b. A rose diagram is made showing the directions, in 10° classes, of the long axes of the stones, as in Figure 4. The number of stones in each class is shown by the distance of each peak from the innermost circle, each concentric circle representing one stone when 100 stones were counted and half a stone when 50 were counted, with half the number of stones in each class being placed on opposite sides of the diagram.

Thus for each count two diagrams are obtained, the first showing the dip and the direction of the long axis of each stone, the second the number of stones in each 10° class of direction. The directions are based on the magnetic North point. The results of the counts are given in Figures 3 and 4. The directions of preferred orientation for each count, estimated visually from the diagrams, are given with the descriptions of the sections.

Sections and directions of preferred orientation.

Site 1.

0—60 cm. Red-brown shelly till (forming ground-moraine flat).
60—90 cm. Dolerite.
Measured at a depth of 45 cm.
Direction of preferred orientation: 40°

Site 2.

0—60 cm. Red-brown shelly till (forming ground-moraine flat).
60—110 cm. Ice.
110—115 cm. Red-brown till.
115—415 cm. Ice with thin dirt bands.
Orientation of interface between upper till and ice: apparently level.
Orientation of interfaces between lower till and ice: strike 350°
dip 10° E

a. Measurement of upper till at depth of 45 cm; direction of preferred orientation: 90°
b. Measurement of lower band of till; two directions of preferred orientation: major 50°
minor 130°

Site 3.

0—200 cm. Red-brown shelly till (hummock of ground-moraine flat isolated by erosion)
200—210 cm. Ice.
210—211 cm. Dirt in ice.
211—221 cm. Ice.
221—227 cm. Red-brown till.
227—375 cm. Ice with thin dirt bands.
Orientation of ice and till interfaces: strike 285°
dip 10°N

a. Measurement of upper till at depth of 180 cm; direction of preferred orientation: 70°
b. Measurement of lower band of till; direction of preferred orientation: 65°

Site 4.

0—100 cm. Red-brown shelly till (forming ground-moraine flat).
100—130 cm. Ice with thin dirt bands (contorted in this area).
130—140 cm. Clean ice (contorted in thie area).
140—146 cm. Red-brown till.
146—446 cm. Ice with thin dirt bands.
Orientation of interface betwen upper till and contorted ice: strike 250°
dip 10°N
Orientation of interface between contorted ice and lower band of till: strike 250°
dip 40°N

a. Measurement of upper till at depth of 70 cm; two directions of preferred orientation: major 60°
minor 350°
b. Measurement of lower band of till; direction of preferred orientation: 50°

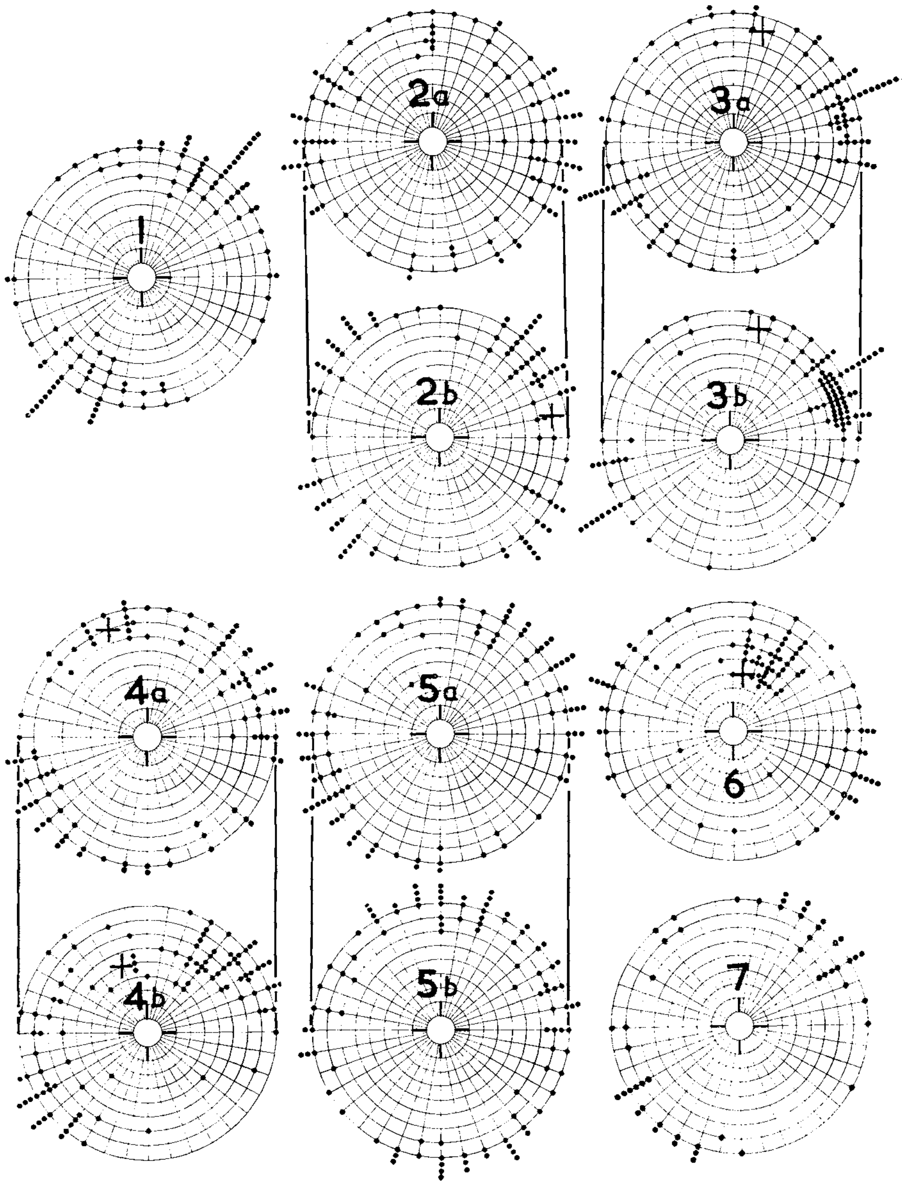

Fig. 3. Dip diagrams of stone orientation in tills; numbers refer to the sites. Pairs of tills from Sites 2, 3, 4 and 5 are shown together. The four cardinal points of the compass are marked by lines at the edges of the diagrams, with Magnetic North at the top (Crosses show the orientation of the till interfaces where they are not level).

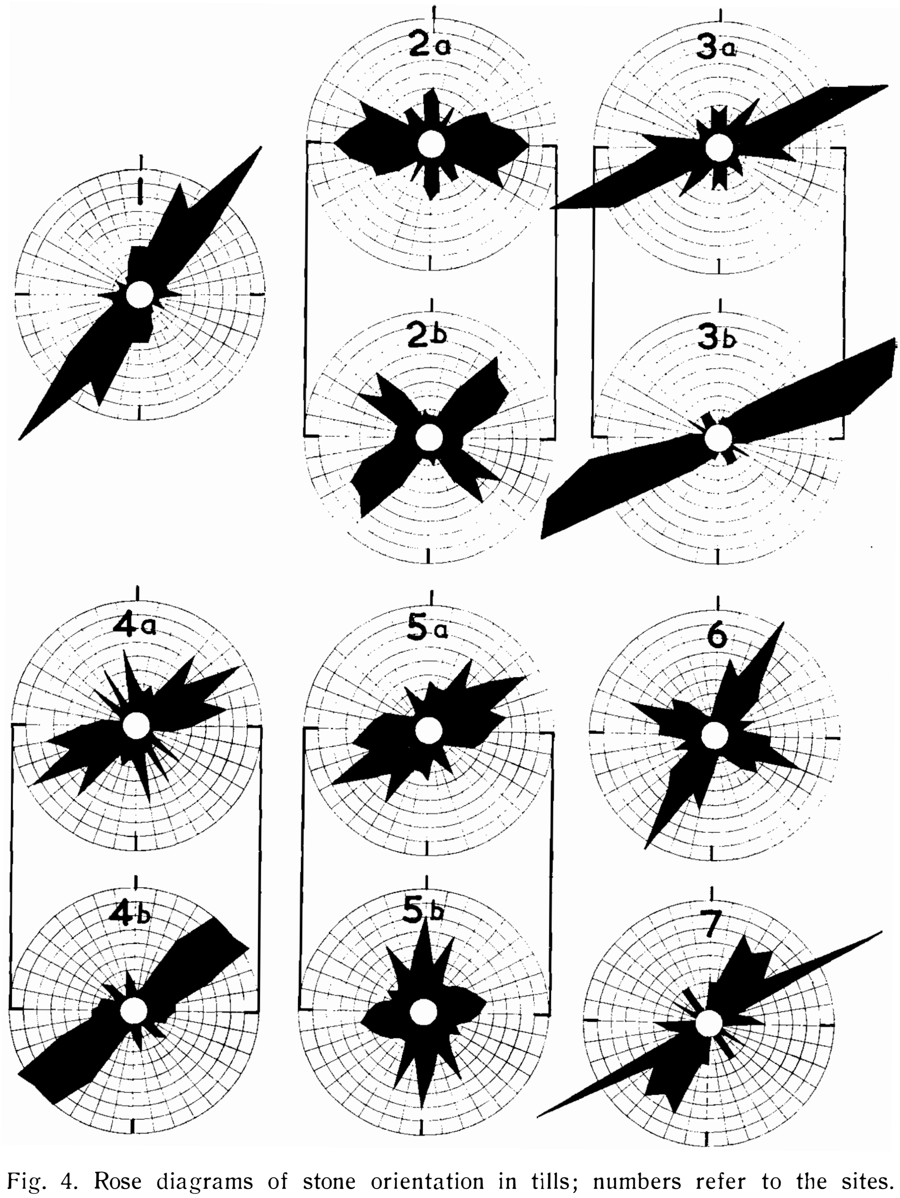

Fig. 4. Rose diagrams of stone orientation in tills; numbers refer to the sites. Pairs of tills from Sites 2, 3, 4, and 5 are shown together. The four cardinal ponts of the compass are marked by lines at the edges of the diagrams, with Magnetic North at the top.

Site 5.

0—140 cm. Red-brown shelly till (forming ground-moraine flat).
140—165 cm. Ice.
165—190 cm. Red-brown till.
190—390 cm. Ice.

Orientation of till and ice interfaces: apparently level.

a. Measurement of upper till at depth of 80 cm; direction of preferred orientation: 60°
b. Measurement of lower band of till; two directions of preferred orientation: major 170°, minor 80°

Site 6.

Measurement in band of till issuing from ice and exposed by ablation of the ice sheet, 140 cm above the level of the ice surface.

Orientation of till and ice interfaces: strike 280°, dip 50°N

Two directions of preferred orientation: major 30°, minor 290°

Site 7.

0—220 cm. Sandy beach shingle, coarser at the top, with many shell fragments, sometimes sorted into banks.
220—250 cm. Green shelly sand; many shells with valves united; *Mya truncata* in position of life at base.
250—350 cm. Red-brown till without shells, except where *Mya truncata* has bored into the top 10 cm; mean sea level about 100 cm below the bottom visible limit of the till.

Measurement of till at 30 cm from its top; direction of preferred orientation: 50°

The results.

All the rose diagrams (Fig. 4) show the existence of preferred orientations of long axes of stones in the tills. The directions are very conspicuous, except in No. 5 b, where, although present, they are not so clear. The directions of preferred orientation are placed on the map, Figure 2, the length of each line in the symbols used being proportional to the magnitude of the maxima on the rose diagrams.

The measurements at Sites 1—6, all inside the border of the young end-moraines, are considered first. All these measurements give approximately a similar direction for the most prominent peak of preferred orientation, except for No. 5 b, where the most important direction of preferred orientation is approximately transverse to this direction.

The direction of movement of the ice advance must be known if we wish to relate this direction to the main direction of preferred orientation. The topography of the inland ice, the relation of the ice margin and the end-moraines to each other and to the foreland (shown in the maps, Figures 1, 2 and 9), and the orientation of thrustplanes in the ice near its edge (shown in the map, Figure 2) all point to the conclusion that the ice advanced on Brageneset from a north-easterly direction. If this conclusion be accepted, then it is clear that the main direction of preferred orientation is parallel to the direction of ice movement, except in No. 5 b, where, though there is a small peak in this direction, the largest peak is transverse to it. This parallel relation of the preferred direction to the direction of ice movement is, as described above, the one generally accepted.

Except in No. 5 b, the parallel relation is common both to the tills of the ground-moraine flats which rest on the dolerite foreland (no. 1) and on ice (Nos. 2 a, 3 a, 4 a and 5 a) and to the tills in bands in the ice (Nos. 2 b, 3 b, 4 b and 6). Conspicuous transverse peaks are confined to certain of the narrow-band tills (Nos. 2 b, 5 b, 6). It will be seen in the dip diagrams in Figure 3 that this transverse orientation is most marked where the direction of dip of the ice and till interface (shown by a cross in the diagrams) is close to the most prominent direction of preferred orientation; also, the amount of dip in this direction corresponds approximately with the dip of many stones lying in that direction. In No. 5 b the ice and till interface is horizontal. The other narrow bands of till (Nos. 3 b and 4 b) are those which have only one prominent direction of preferred orientation, and here the directions of dip of the ice and till interfaces are distinctly different from the directions of preferred orientation.

Thus transverse orientation seems to be associated with the bands of till in ice, which are themselves usually associated with thrustplanes in the ice. As mentioned above, the large transverse peaks occur where the direction of dip of the ice and till interface corresponds with the direction of preferred orientation. Where these differ no prominent transverse peak is seen. In these instances the forces causing orientation next to the thrustplanes may not have remained sufficiently long in any one direction to produce the marked transverse orientation.

The last measurement to discuss is the one at the till at Site 7. This site is on the southern shore of Brageneset, well outside the limit of the young end-moraines, and the till belongs to an older ice advance. The direction of preferred orientation in the till is similar to the others, so the direction of movement of the older advance appears to have been the same as that of the more recent advance.

The results described here confirm the generally-held view that the long axes of stones in lodgement till have a preferred orientation parallel to the direction of movement of the ice which deposited the till. But it is apparent that this parallel orientation may sometimes be complicated by a transverse one. It seems that transverse orientation will be liable to occur in the narrow-band tills, which may be associated with thrustplanes. Such planes may be identified in certain Pleistocene glacial deposits (particularly those of old end-moraine areas), where the ice has melted away leaving bands of till. In these tills transverse may even predominate over parallel orientation, and the interpretation of orientation diagrams from them should be made with care.

The dip diagrams show that a preferred degree of dip of till stones may occur in tills found near ice and till interfaces, the preferred dips being related to the dips of the interfaces. If the surrounding ice melted then the preferred dip would presumably remain, but would be altered. This contrasts with the dip orientation found in the majority of thick lodgement tills, where the long axes of many stones are level. A preferred dip of stones is also found in solifluction deposits, where the dip is related to the angle of slope (as described by Hoppe (1952), for example). The relation of the measured deposit to its surrounding sediments should normally allow thin bands of till to be distinguished from solifluction deposits.

The raised beaches of Brageneset and the neighbouring parts of Hinlopenstretet.

Between the dolerite outcrops at Brageneset there is a series of raised beaches at very close intervals, forming shingle bars and terraces (Plate 1, Fig. 1). The material consists of re-deposited till or sand and gravel from frost-shattered rock. Some of the beaches have rather a coarse surface from which the finer materials have been removed by wind and water. Very often the beach material has been disturbed by frost action forming stone stripes on sloping ground and polygons and frost-cracks on level ground, as described in the introduction.

The beaches were levelled[1] along the lines A 1, A 2, A 3 and B, which are marked on the map, Figure 2. The profiles of the lines and the heights of the levelled beaches are shown in Figure 5. On the right hand side all the marine beach levels from the different profiles are put together. It is evident that there are no clear stages which can be demonstrated in the shore-line displacement. There must have been a continuous relative uplift of Brageneset which has left the well-developed but small raised beaches at different heights on the slopes. There are more than fifty beach levels between the present sea-level and the highest part of Brageneset, the highest beach being at 46.5 m a. s. l. The marine limit cannot be determined because the whole peninsula (or island) has been submerged. As the beaches are very close to each other it is naturally impossible to follow a particular beach for more than a few hundred metres and the levelled heights for the beaches do not exactly correspond to each other in different parts of Brageneset. A relatively clear and

[1] The heights are based on estimated mean sea level. A large error is unlikely as the tidal range is small (1—2 m).

consistent level is the raised beach at 8.8 m of West Lake (Plate 4, Fig. 1), the lake at present being 4.4 m a. s. l. The height of the old lake-level was levelled in three places and it corresponds to the height of the overflow through the old shore-bar immediately north of North Cairn (Figure 2 and Plate 5, Fig. 1).

The dating of the raised beaches at Brageneset is rather difficult. As described in Part IV the till is rich in shells, which are also present in the beach gravels, which are largely re-deposited till. As the beaches have these derived shells it is impossible to know whether there are any shells which are not of secondary origin. It was therefore not possible to use the shells on the beaches for establishing a sequence which could be used in describing the different beach levels, or in correlating them with beaches in other areas.

It is possible to get some idea of the rate of uplift from the drift-wood found on some beaches. The present beach is in some places very rich in drift-wood and on some storm beaches the upper limit of the drift-wood is about 1 m above the high water mark.[1] South of West Lake, at nearly 10 m a. s. l., just above the old lake level (profile A 3, Figure 5) the beach was rich in drift-wood with pieces of barrel and other worked wood, including a large piece probably from a boat. There can be no doubt that the drift-wood at this level is from the period when the sea-level was about 9—10 m higher than at present. It is very likely, but by no means certain, that the drift-wood was transported from Vestspitsbergen along the north coast and then south down Hinlopenstretet by the Gulf Stream, which is known to take this course. If the worked drift-wood is locally derived or is from Vestspitsbergen it is unlikely to be older than about 350 years, because the whaling activity did not start until the beginning of the 17th century. It can be concluded that if the worked drift-wood is local or came from Vestspitsbergen the relative uplift of land at Brageneset must have been nearly 3 m in a hundred years, a shore-line displacement which has been surprisingly rapid.

Even if the raised beaches at Brageneset cannot be grouped into any stages on the basis of the morphology or of the marine shells found in their deposits. there are two shore levels which can be distinguished because of the pumice found on them. Pieces of pumice up to 10 cm across and dark brown in colour were found at various sites. At some levels the pumice was abundant along a particular beach but in other places only occasional pieces were found. The pumice must have been

[1] On the higher beaches there are occasionally pieces of wood, and between Middle Cairn and West Lake a nearly complete barrel was found at 17 m a. s.l. This barrel was rather well preserved and is more likely to have been left there by some previous visitors to Brageneset than thrown up on this beach when the sea was at this level. No other traces of drift-wood were found at this level.

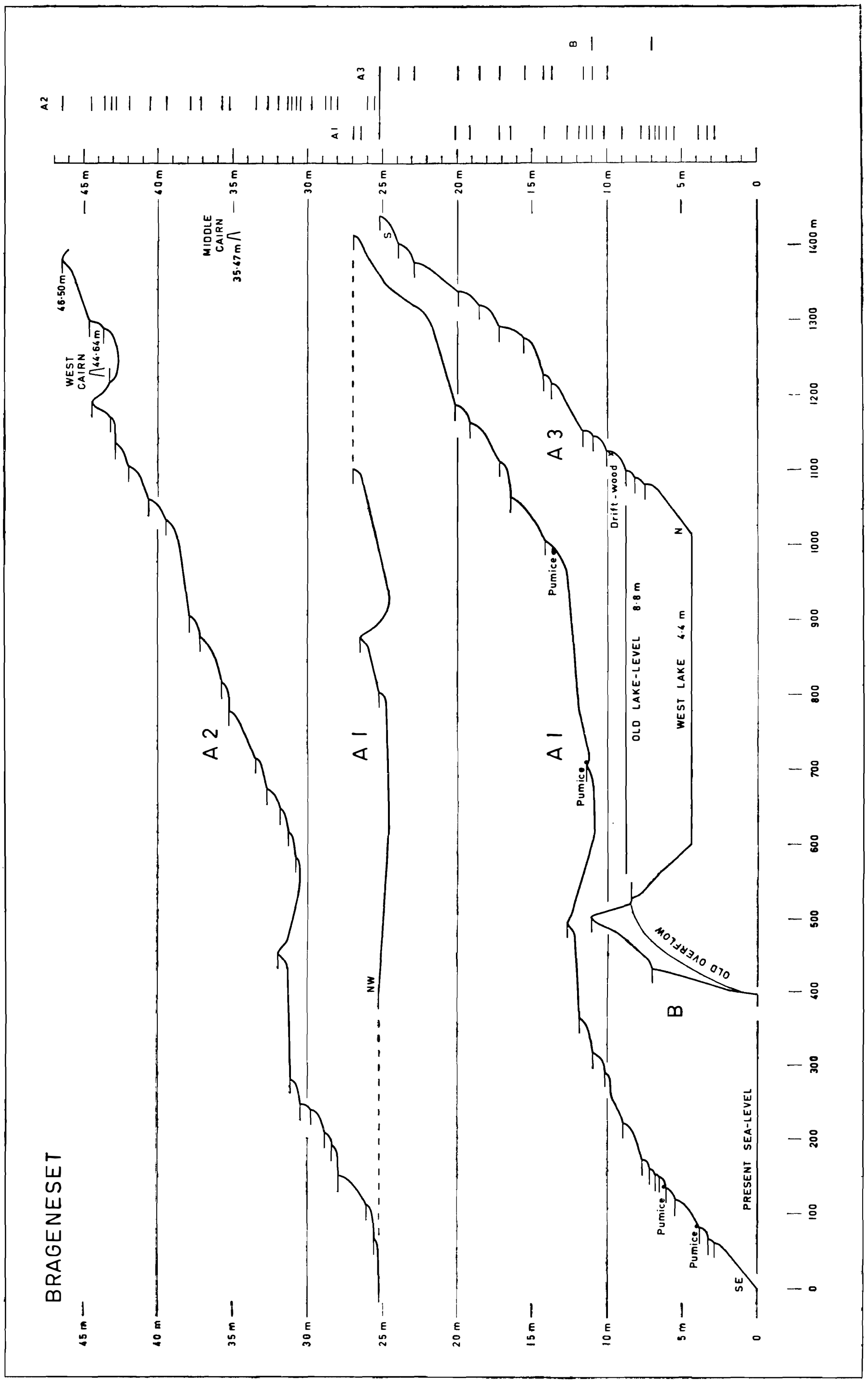

Fig. 5. Levelled profiles of raised beaches at Brageneset. For positions and numbers of the profiles see Figure 2.

deposited on the beaches when they were formed and a beach where the pumice is abundant is, of course, an important level for correlating the beaches with those in other areas. The occasional pieces of pumice have less value for this purpose. They may have been moved down a slope from a higher level by streams and solifluction or thrown up by storms. Therefore the original level at which they were deposited cannot exactly be determined. All the 11 sites at Brageneset where pumice was found were levelled. The heights (above mean sea level) and the relative frequency of pumice from the different sites are given below. The sites are marked on the map, Figure 2.

Pumice found at Brageneset:

Site 1	Abundant	13.6 m	profile A 1, Figure 5
	1 piece	11.4 «	
Site 2	Abundant	13.5 «	
	2 pieces	12.2 «	
Site 3	2 pieces	6.1 «	
	1 piece	5.7 «	
Site 4	1 piece	6.8 «	
Site 5	1 piece	6.1 «	profile A 1, Figure 5
	1 piece	3.8 «	
Site 6	Abundant	6.2 «	
Site 7	Abundant	13.9 «	
	2 pieces	11.6 «	
	1 piece	10.6 «	
	Abundant	6.4 «	
Site 8	Abundant	6.3 «	
	1 piece	5.2 «	
Site 9	A few pieces	6.5 «	
Site 10	1 piece	4.4 «	
Site 11	1 piece	15.0 «	
	Abundant	13.8 «	

The heights at which pumice was found and its frequency at each site are shown in Figure 6. It is clearly seen that pumice is abundant at two levels, at 13.8 m and 6.4 m, the variations between the different sites at each of these levels being very small. The diagram also shows that the occasional pieces of pumice are scattered at various heights and not concentrated at any particular level.

The tracing of the two above-mentioned pumice levels at Brageneset gave a method for comparing the raised beaches with those in the northern part of Hinlopenstretet with a view to getting an idea of the nature of the relative uplift of the land. Only a few sites along the coast were visited, but some of them had clear beach levels with pumice. Pumice was found at the following sites, the positions of which are shown in Figure 7:

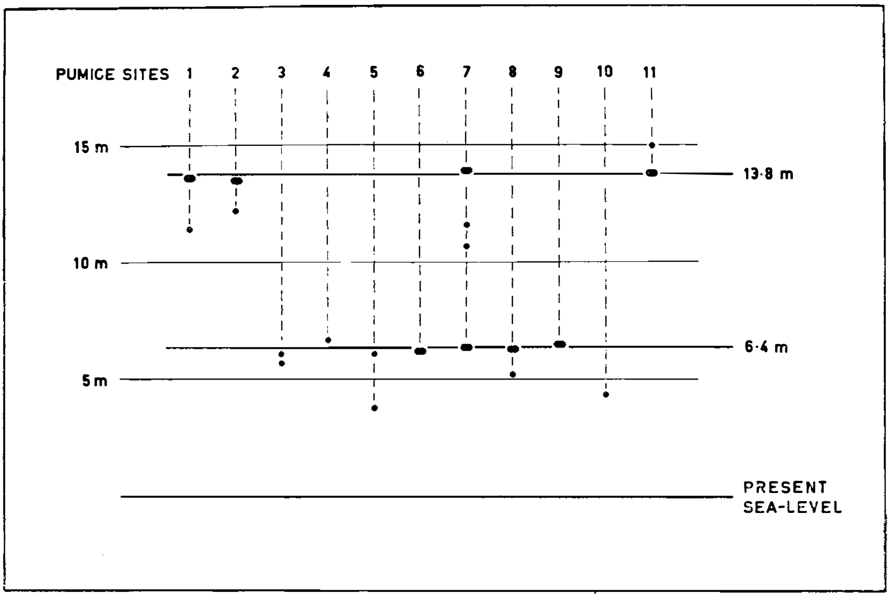

Fig. 6. Heights of pumice found at Brageneset. Large dots — pumice abundant; small dots — 1—3 pieces of pumice.

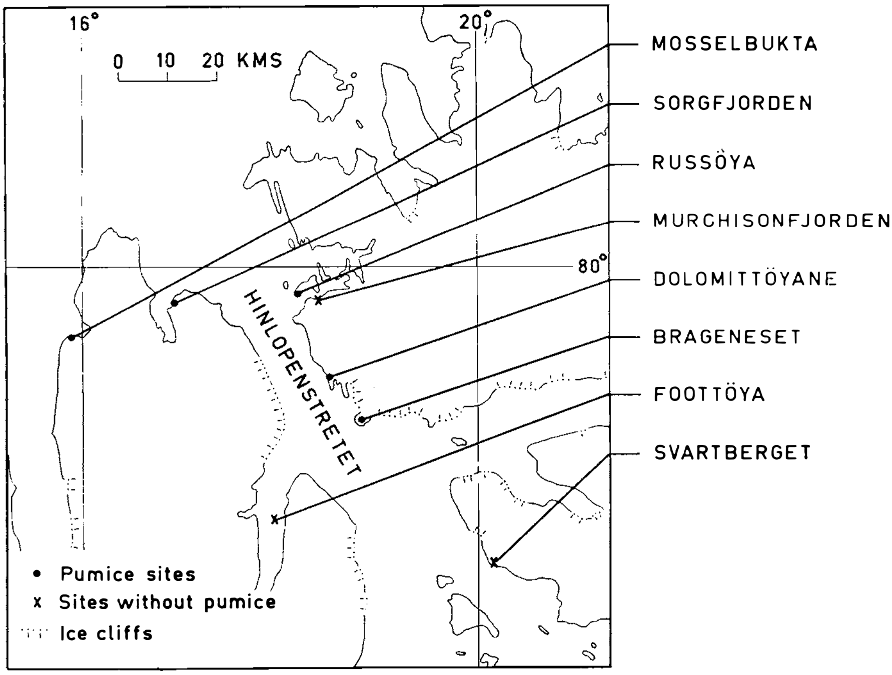

Fig. 7. Map of sites studied in the northern part of Hinlopenstretet.

Mosselbukta, 200 m south-west of the hut on Bangenhuk

	Abundant	3.0 m
	Abundant	1.5 «

Sorgfjorden, 500 m north of the hut on the eastern shore

	Abundant	5.6 m
	Abundant	3.2 «
	2 pieces	2.2 «
	A few pieces	1.4 «

Russøya, south-western part

	2 pieces	11.2 m
	1 piece	9.4 «
	Abundant	8.7 «
	1 piece	8.4 «
	Abundant	4.4 «
	1 piece	3.7 «

Dolomittøyane (see map, Figure 7)

	Abundant	12.4 m

On the map, Figure 7, the sites where no pumice level was found are also shown. Around Sveanor in Murchisonfjorden no pumice was found, nor on the small island Foottøya (about 15 m high) in Lomfjorden. At Svartberget there is a large area with a series of well-developed beaches up to about 35 m, but only one piece of pumice was found at 3.2 m, this single piece being of no great significance for the present study except that it shows that pumice can also be present in the southern part of Hinlopenstretet, although it is not so abundant as farther north.

By assuming that the pumice levels in the northern part of Hinlopenstretet represent synchronous stages in shore-line displacement, a shoreline diagram can be constructed on the basis of the present material. If the heights for the lower pumice level at Mosselbukta, Sorgfjorden, Russøya and Brageneset are put on a straight tilting reference level (Figure 8) the heights for the upper pumice level form a practically straight shore-line which is even more tilted. As seen from the diagram in Figure 8, the deviation of the measured heights are surprisingly small for the upper shore-line. The pumice level at 12 · 4 m from Dolomittøyane is, because of the closeness of the site to Brageneset, considered to represent the upper level. From the shore-line diagram it can be concluded that there is a clear tilt towards the north-west in the relative uplift of land in the northern part of Hinlopenstretet, the upper pumice level going down from 13 · 8 m at Brageneset to 3 · 0 m at Mosselbukta in a distance of about 60 km, the lower pumice level falling in the same distance from 6 · 4 m to 1 · 5 m. A tilt of the raised beaches of Spitsbergen has not been demonstrated previously by tracing pumice levels or by any other method. As it was not possible to find out the direction of the isobases a distance diagram of the pumice levels could not be drawn.

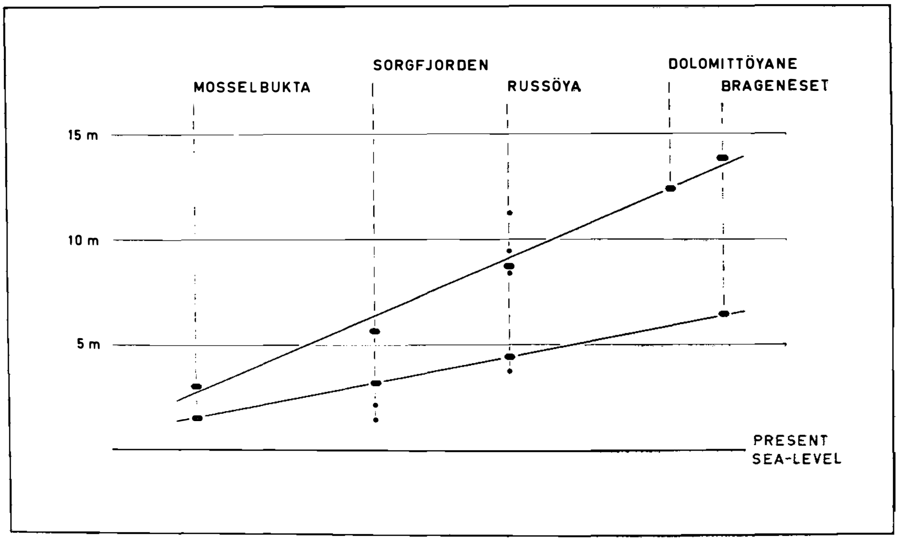

Fig. 8. Shore-line diagram of pumice levels in the northern part of Hinlopenstretet. Symbols as in Fig. 6.

Thus possible irregularities in the relative uplift of the land could not be demonstrated even if they may occur.

The pumice found in the northern part of Hinlopenstretet must have been carried by the Gulf Stream to this region. As the Gulf Stream comes along the northern coast of Vestspitsbergen eastwards to the mouth of Hinlopenstretet it is understandable that the pumice is abundant only on exposed shores in the northern part of Hinlopenstretet and not found in the narrow waters of Murchisonfjorden or further south on Foottøya or Svartberget (except occasional pieces). In the account of the Swedish Expedition to Spitsbergen in 1861 Chydenius (1865) has already mentioned that the Gulf Stream reaches Hinlopenstretet and brings with it pumice from Iceland. It is most likely that the pumice found in Spitsbergen comes from Iceland. The two pumice levels demonstrated can represent two periods of eruption, but for the pumice to reach as far north as northern Spitsbergen the sea current and the ice conditions must be favourable.

As seen at Brageneset the relative uplift of the land has been extremely rapid and the pumice levels are young, the higher probably being only about 500 years old. If this estimate is correct it is clear that this higher pumice level cannot be correlated with the highest pumice level along the Norwegian coast, where it is from the time when the Tapes shore-lines were formed (Holtedahl 1953). In Iceland Thorarinsson (1944) has dated eight eruptions of Hekla or other volcanoes, the oldest of these eruptions being from 1300. Each of these eruptions can be identified on the basis of the mineralogical composition of the products, this composition being shown by the colour. The basic products are darker than the more acid, but, as pointed out by Thorarinsson, one eruption can produce different kinds of volcanic rock-types. No attempt is made here to correlate the two pumice levels in Spitsbergen with certain eruptions in Iceland, but the dark brown and rather basic pumice found in Spitsbergen very probably originates from eruptions in Iceland, where pumice of the same kind is common. So not only the course of the Gulf Stream but also the composition of the pumice supports the assumption that it has been transported from Iceland to Spitsbergen.

The results from study of the raised beaches in the northern part of Hinlopenstretet, especially the pumice levels, form an independent system which is limited to the younger and lower raised beaches. The previous observations by other workers around Hinlopenstretet cannot yet be used for establishing a general sequence which could, by correlation with other areas, be tied to the absolute chronology. The material on marine shells found in the raised beaches is still too scarce to permit any general conclusions. It must be pointed out that even if the shells found in the drift at Brageneset to a large extent are of secondary origin, there certainly are raised beaches in other parts which have shells *in situ,* not re-deposited old shells (Kulling and Ahlmann 1936).

Some information about the highest marine limit is given by previous workers. Thompson (1953) mentions that it is about 107—122 m (350—400 ft) in south-western Nordaustlandet and Sandford (1929) mentions about 60 m (200 ft) for Wahlenbergfjorden. These values give some idea of the amount of the relative uplift, and they also show that the pumice levels demonstrated are at relatively low altitudes compared with the whole amount of uplift, which also shows that these levels are comparatively young.

In a detailed study of the vertical distribution of marine invertebrates, mainly Mollusca. found in the raised beach deposits of inner Isfjorden, Vestspitsbergen, Feyling-Hanssen (1955) has been able to establish a sequence for the raised beaches from the marine limit at 90—96 m a. s. l. down to the present sea-level, and to correlate the stratigraphy of the Late- and Post-Glacial periods of inner Isfjorden with the stratigraphy of Greenland, Iceland and Scandinavia. The few observations on the raised beaches of the northern part of Hinlopenstretet do not allow a correlation of the beaches from that area with those Feyling-Hanssen has described, but on the basis of the pumice levels it can be concluded that the rate of relative uplift in the area around Brageneset has probably been greater than in Vestspitsbergen. Even in Ny Friesland (Mosselbukta and Sorgfjorden) the negative shift on the shore-line has been comparatively small, at least in more recent time. It is not yet known how large an area around Brageneset has been undergoing rather rapid uplift and for how long a time this has been going on.

Marine shells from the tills and raised beaches.

The objects of this section are to put on record the Brageneset finds of Mollusca and Brachiopoda and to make some observations on their relation to the raised beaches. The paucity of finds of shells *in situ* in beach material prevent any useful comparison with faunas recorded from elsewhere in Spitsbergen.

Collections of shells were made from deposits at seven sites, the positions of which are shown on the map, Figure 2. Descriptions of the shelly deposits at these sites follow:

Site 1. Till of young end-moraine next to northern outflow of West Lake.
Site 2. Ablation till formed from till outcropping next to a thrustplane in the central part of the marginal ice.
Site 3. Till of the young end-moraine on the east side of West Lake.
Site 4. Raised beach cut into till of Site 3.
Site 5. Till of young end-moraine near Camp Cairn.
Site 6. Till of old ground-moraine west of Camp Cairn.
Site 7. Marine sand at 2 m a. s. l., overlying till of old ground-moraine and covered by beach gravel, on south coast of Brageneset (see Section at Site 7 described in Part II).

Table 1 lists the species found at each site. In the lists from Sites 1—6 only the relative abundance of the species is recorded, as the faunas are entirely derived and re-deposited as erratics in the till (Plate 4, Figure 2). In the list from Site 7, the only place where *in situ* marine deposits were observed, the numbers are the totals of individuals of each species occurring in the sample taken (numbers refer to whole shells of univalves and half the number of valves of bivalves). Fragments of *Balanus* sp. and *Lithothamnion* spp. were recorded from all sites and are not shown in the table.

In addition to the Brageneset finds we also recorded that two valves of *Mytilus edulis* (Linné) were found at a height of 4 · 5 m a. s. l. at the top of a disturbed section next to an outwash stream at Idunneset.

The following recent shells were found on the shore in the localities named:

Brageneset: *Musculus discors laevigatus* (Gray)
Saxicava arctica (Linné)
Margarites helicinus (Phipps)
Natica clausa Broderip and Sowerby
Buccinum glaciale Linné
Dolomittøyane: *Pyrulofusus deformis* (Reeve)

Table 1.

Shells found at Brageneset.

Species	Site 1	2	3	4	5	6	7
Leda minuta Müller	-	-	-	R	-	-	-
Chlamys islandica (Müller)	R	-	R	-	R	-	-
Astarte borealis (Chemnitz)	-	-	R	O	A	R	-
Astarte montagui (Dillwyn)	-	-	-	R	-	-	-
Astarte elliptica (Brown)	O	-	O	R	O	O	-
Serripes groenlandicus (Chemnitz)	-	-	-	-	R	-	-
Macoma calcarea (Chemnitz)	-	-	R	-	R	-	1·5
Saxicava arctica (Linné)	A	-	A	A	A	A	20
Mya truncata (Linné)	A	-	A	A	A	A	10
Puncturella noachina (Linné)	-	R	-	-	-	-	1
Lepeta coeca (Müller)	-	R	-	R	-	-	1
Trichotropis borealis Broderip and Sowerby	-	-	-	R	-	-	-
Natica clausa Broderip and Sowerby	-	-	R	R	-	-	-
Trophon truncatus (Ström)	-	-	-	R	-	-	1
Buccinum glaciale Linné	R	R	R	-	-	-	-
Hemithyris psittacea (Gmelin)	-	-	R	R	-	-	-
"Terebratella" spitzbergensis Davidson	-	-	-	R	-	-	-

A — abundant, O — occasional, R — rare.

Only one section was found in the marine beaches of Brageneset which showed marine sand with a shell fauna. This was at Site 7. In a few other places (e. g. Site 6) shells were exposed on the marine beaches, but here they came not from the beach material itself but from shelly till underlying it, the shells from the till being brought to the surface by weathering and cryoturbation. It is clear that in an area like Brageneset care has to be exercised in deciding whether a particular fauna is of the same age as the beach in which it occurs.

In general, however, the marine beaches were markedly unfossiliferous. This condition may be contrasted with the raised beach of the fresh-water West Lake (Plate 4, Figure 1), the surface of which was covered with shells, so much so that it appeared white at a distance. The shells were derived from the shelly till in which the beach was cut. The condition of the shells was no guide to their being derived, for both on the beach and in the shelly till shells were sometimes found to be in a perfect state of preservation, with both valves united and with periostraca present.

In Brageneset, therefore, there is the curious situation that the marine beaches are very poor in marine shells while the fresh-water beach abounds in them. It is evident that in regions with shelly till or where an ice-sheet may have over-ridden marine deposits we should be careful in the interpretation of shelly deposits (e. g. outwash gravels) associated with the glacial deposits. The shells may be derived by the processes now operative in Brageneset, that is, by the washing of till deposited by ice which has passed over marine deposits. Moreover, the state of preservation of the shells appears to be of uncertain significance for the interpretation of the deposits.

The Quaternary history of Brageneset.

The oldest of the Quaternary events recorded from Brageneset is the ice advance (or advances), presumably of the Vestfonna ice, which deposited the till found on the surface or beneath the raised beach material in many places on the promontory. An indication of the direction of this advance is given by the south-west to north-east direction of stone orientation in till at Site 7 in the southern part of Brageneset (Figure 2). The extent of this older till suggests that the ice advance extended south-west of the present coast.

After this early ice advance the ice must have retreated and then uplift of the land relative to the sea took place, so that a series of raised beaches were formed. An emergence is indicated of at least 46.5 m, which is the height of the highest raised beach on Brageneset. The rate of this uplift was discussed in Part III, where a rate of at least nearly 3 m in a hundred years was suggested.

The raised beaches found on all sides of Brageneset, including the side facing the ice-front (Figure 2 and Plate 1, Fig. 1), indicate that Brageneset was an island during the uplift.

Later than the uplift occurred the advance of the Vestfonna (Bragebreen) ice which deposited the young end-moraines now seen along the north-eastern border of Brageneset. The abundance of marine shells in the till indicates that the ice advanced across a marine basin. The advance must have been halted by the obstacle presented by the rising ground of Brageneset. The thurstplanes in the marginal ice (Plate 1, Fig. 1 and Plate 3, Figs. 1 and 2) and the contortions in the dead ice of the end-moraine show that thrusting followed the halt of the ice front.

Although it is not possible to date the earliest Quaternary events seen in Brageneset, some estimate of the date of the young ice advance may be made by a study of maps of Hinlopenstretet. In the map compiled by Dunér and Nordenskiöld (1865) Brageneset is shown as an island and named Hyperitön. Nordenskiöld landed there in 1861 and made observations to determine the latitude and longitude of the place. It may be presumed that Nordenskiöld had observational reasons for naming it -ön and not -neset. Similarly, an island is placed in the position of Brageneset in the map published by van Keulen in about 1710 (described by Conway 1906). Of course, no such confidence is to be placed in the accuracy of this map as may be placed in the map of Dunér and Nordenskiöld, but it should be noted that a series of crosses are placed round the island, presumably showing that observations on navigability were made around it.

It seems reasonable to conclude that Brageneset was an island at the time of Nordenskiöld's visit in 1861. However, the map produced by the Russo-Swedish Arc-of-Meridian Expedition of 1899—1902 (De Geer 1923) shows Brageneset, named by De Geer, as a promontory emerging from the inland ice of Vestfonna. Thus the young ice advance appears to have taken place between 1861 and 1899.

The advance of the ice ponded up three lakes between the ice-front and Brageneset. Whilst the ice stood at its maximum extent the outflow of the two northernmost lakes took place through the old overflow channel Plate 5, Fig. 1), as indicated in Figures 2 and 5. The water-level of West Lake at this time is marked by the 8.8 m raised beach found around the lake. The height of the overflow corresponds to this level (Figure 5).

On the retreat of the ice-front a new and lower outflow for the two northernmost lakes was found between the ice and the foreland at the north end of Brageneset, and as a result, the lake level dropped to its present height of 4.4 m a. s. l.

An attempt was made to measure the life of West Lake by varve counts of its sediments. Cores were taken through sediments exposed at the edge of the lake by the drop in water-level and through the sediments at the bottom of the present lake. The positions of the varve samples are shown in the map, Figure 2. Varves of thickness averaging about 1—2 mm were found at both sites, but their thinness and irregularity made it difficult to interpret the cores. At least 25 varves were counted in the lake-edge site and 35 in the lake site. The results signify that the lake has lasted for at least 35 years and the drop to its present position started at least 10 years ago. From the other evidence described here it seems that the lake has been in existence for about 60—90 years, and that, as shown below, the drop in water-level occurred after 1924. In respect of varve formation it may be of interest to note that the time between the break-up of the lake ice and its reforming, as suggested by observations made in August 1955 and by the climatic information of Eriksson (1933), would not be much more than the two months July and August, and also that the distance of these varves from the ice-front is about half a kilometre at the present time.

The relation of the end-moraine features to the raised beaches gives little exact information of the age of the advance in terms of the uplift, except that the old overflow channel cuts through a raised shore-bar at 11 m a. s. l. and therefore the lake was ponded up after the formation of this bar. On the other hand, no marine beaches have been cut in the end-moraines where they meet the sea, so uplift since the retreat began

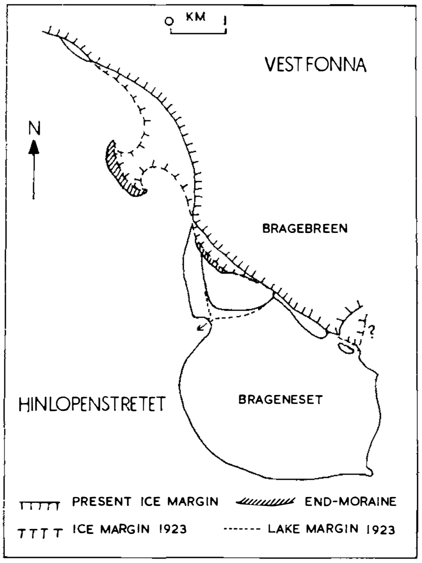

Fig. 9. The recent retreat of the Bragerbreen ice-front.

has not exceeded the range of the tides. It is shown below that the retreat had already begun by 1923, so no clear uplift since that date can be demonstrated.

We may also use as evidence bearing on the rate of retreat from the young outer end-moraines aerial photographs published by Mittelholzer (1925) and Binney (1925). The sketch-map, Figure 9, shows approximately the positions of the outer young end-moraines as seen in the photographs and in 1955. The positions of the ice-edge in 1923—4 as shown by the aerial photographs and its position in 1955 are also shown in the sketch-map. The ice, after its advance and period of outer end-moraine formation, had already started to melt down and form an edge tapering out on to the land when the aerial photographs were taken in 1923—4, although retreat had not proceeded far enough for the old overflow to be abandoned. The sea was already eating into the ice-front to form the bays shown in Figure 9. If present conditions continue the seaward ice-cliffs of Bragebreen will recede till Brageneset again becomes an island.

Thus the following events can be distinguished in the Quaternary history of Brageneset: an early ice advance and retreat, then uplift, then a second ice advance. The retreat of the ice from the end-moraines formed by the younger advance is going on at the present day. Although it has been possible to make some attempt at dating the later of these events, unfortunately nothing can be said of the climatic changes which may have accompanied them.

References.

Binney, G. 1925. With Seaplane and Sledge in the Arctic. London: Hutchinson and Co.

Chydenius, K. 1865. Svenska Expeditionen till Spetsbergen år 1861. Stockholm: P. A. Norstedt & söner.

Conway, M. 1906. No Man's Land. Cambridge University Press.

De Geer, G. 1923. Mission Suédoise pour la Mesure d'un Arc de Méridien au Spitzberg: Vol. 2, pt. 9. Topographie et Geologie. Stockholm.

Dunér, N., and Nordenskiöld, A. E. 1865. Anteckningar till Spetsbergens geografi. Kungl. Svenska Vetensk. Akad. Handlingar, *6,* No. 5.

Eriksson, B. E. 1933. Scientific Results of the Swedish-Norwegian Arctic Expedition in the Summer of 1931. VI. Climatology and Meteorology. Geogr. Ann. Stockh., *15,* 117.

Feyling-Hanssen, R. W. 1955. Stratigraphy of the marine Late-Pleistocene of Billefjorden, Vestspitsbergen. Norsk Polarinstitutt, Skrifter Nr. 107. Oslo.

Holmes, C. D. 1941. Till Fabric. Bull. Geol. Soc. Amer., *52,* 1299.

Holtedahl, O. 1953. Norges Geologi. Bind II. Norges Geol. Unders., No. 164.

Hoppe, G. 1952. Hummocky Moraine Regions. Geogr. Ann. Stockh., *34,* 1.

Hoppe, G. 1953. Några iakttagelser vid isländska jöklar sommaren 1952. Ymer 1953 (4), 241.

Kulling, O. and Ahlmann, H. W. 1936. Scientific Results of the Swedish-Norwegian Arctic Expedition in the Summer of 1931. XII. Observations on Raised Beaches and their Faunas. Surface Markings. Geogr. Ann. Stockh. *18,* 1.

Mittelholzer, W. 1925. By Airplane towards the North Pole. London: George Allen and Unwin Ltd.

Orvin, A. K. 1940. Outline of the geological history of Spitsbergen. Skrifter Svalbard og Ishavet, Nr. 78. Oslo.

Richter, K. 1932. Die Bewegungsrichtung des Islandeises rekonstruiert aus den Kritzen und Längenachsen der Geschiebe. Zeitsch. Geschierbeforsch., *8,* 62.

Richter, K. 1936. Gefügestudien im Engebrae, Fondalsbrae und ihren Vorlandsedimenten. Zeitschr. Gletschrk., *24,* 22.

Sandford, K. S. 1929. The Glacial Conditions and Quaternary History of North-East Land. Geogr. J., *74,* 451 and 543.

Summerhayes, V. S. and Elton, C. S. 1928. Further contributions to the ecology of Spitsbergen. J. Ecology, *16,* 193.

Thompson, H. R. 1953. Geology and Geomorphology in Southern Nordaustlandet (North-East Land), Spitsbergen. Proc. Geol. Assoc. Lond., *64, 293.*

Thorarinsson, S. 1944. Tefrokronologiska studier på Island. Geogr. Ann. Stockh., *26,* 1.

Printed August 1957.

PLATES

Plate 1.

Fig. 1. Brageneset; view looking north across the south-eastern corner of West Lake. Marine beaches in the foreground. Young end-moraine and ice-edge (Bragebreen) with thrustplanes in the background.

Fig. 2. Brageneset; view looking south-east from the secondary fixed point at the edge of the young end-moraine north of West Lake. Young end-moraine in the foreground; West Lake and marine raised beaches in the background. On the horizon are the cliffs on the southern side of Wahlenbergfjorden.

Fig. 1. Cliff section at the eastern edge of Bragebreen; thrustplanes carrying till are rising nearly vertically from the base of the cliff.

Fig. 2. Brageneset; section in young end-moraine at its northern end, about 5 m from stone measurement Sites 2 and 4. Thick lodgement till at the top of the section, with ice enclosing narrow-band tills below.

Plate 3.

Fig. 1. Brageneset; lines of till brought up in thrustplanes to the surface, with wet ablation till between the lines.

Fig. 2. Brageneset; lines of till brought up in thrustplanes to the surface. More ablation has taken place than in the previous figure and hummocks of till 1—1½ m high stand out.

Fig. 1. Brageneset; north-western corner of West Lake. Dolerite foreland and raised beach gravel in the foreground. In the middle distance is West Lake with its 8 · 8 m raised beach cut in the young end-moraine. Bragebreen in the background.

Fig. 2. Shelly till of the young end-moraine.

Plate 5.

Fig. 1. Brageneset, old overflow channel cut in a raised shore-bar at the south-western corner of West Lake. Old levels of West Lake made the beaches in the foreground.

Nr. 78. ORVIN, ANDERS K., *Outline of the Geological History of Spitsbergen.* 1940. Kr. 7,00.
„ 79. LYNGE, B., *Et bidrag til Spitsbergens lavflora.* 1940. Kr. 1.50.
„ 80. *The Place-Names of Svalbard.* 1942. Kr. 50,00.
„ 81. LYNGE, B., *Lichens from North East Greenland.* 1940. Kr. 14,00.

Norges Svalbard- og Ishavs-undersøkelser. Skrifter.

„ 82. NILSSON, TAGE, *The Downtonian and Devonian Vertebrates of Spitsbergen. VII. Order Antiarchi.* 1941. Kr. 11,50.
„ 83. HØEG, OVE ARBO, *The Downt. and Devonian Flora of Spitsbergen.* 1942. Kr. 33,00.
„ 84. FREBOLD, HANS, *Über die Productiden des Brachiopodenkalkes.* 1942. Kr. 6,00.
„ 85. FØYN, SVEN and ANATOL HEINTZ, *The Downtonian and Devonian Vertebrates of Spitsbergen. VIII.* 1943. Kr. 5,00.
„ 86. *The Survey of Bjørnøya (Bear Island) 1922—1931.* 1944. Kr. 9,00.
„ 87. HADAČ, EMIL, *Die Gefäßpflanzen des „Sassengebietes“ Vestspitsbergen.* 1944. Kr. 6,00.
„ 88. *Report on the Activities of Norges Svalbard- og Ishavs-undersøkelser 1936—1944.* 1945. Kr. 6,50.
„ 89. ORVIN, ANDERS K., *Bibliography of Literature about the Geology, Physical Geography, Useful Minerals, and Mining of Svalbard.* 1947. Kr. 12,00.

Norsk Polarinstitutt. Skrifter.

„ 90. HENIE, HANS, *Astronomical Observations on Hopen.* 1948. Kr. 3,00.
„ 91. RODAHL, KÅRE, *Vitamin Sources in Arctic Regions.* 1949. Kr. 6,00.
„ 92. RODAHL, KÅRE, *The Toxic Effect of Polar Bear Liver.* 1949. Kr. 12,50.
„ 93. HAGEN, ASBJØRN, *Notes on Arctic Fungi. I. Fungi from Jan Mayen. II. Fungi collected by Dr. P. F. Scholander on the Swedish-Norwegian Arctic Expedition 1931.* 1950. Kr. 2,00.
„ 94. FEYLING-HANSSEN, ROLF W. and FINN A. JØRSTAD, *Quaternary Fossils.* 1950. Kr. 8,25.
„ 95. RODAHL, KÅRE, *Hypervitaminosis A.* 1950. Kr. 22,50.
„ 96. BUTLER J. R., *Geochemical Affinities of some Coals from Svalbard.* 1953. Kr. 3,00.
„ 97. WÄNGSJÖ, GUSTAV, *The Downtonian and Devonian Vertebrates of Spitsbergen.* Part IX. *Morphologic and Systematic Studies of the Spitsbergen Cephalaspids.* A. Text, and B. Plates. 1952. Kr. 75.00.
„ 98. FEYLING-HANSSEN, ROLF W., *The Barnacle Balanus Balanoides (Linné, 1766) in Spitsbergen.* 1953. Kr. 8,00.
„ 99. RODAHL, KÅRE, *Eskimo Metabolism.* 1954. Kr. 10,00.
„ 100. PADGET, PETER, *Notes on some Corals from Late Paleozoic Rocks of Inner Isfjorden, Spitsbergen.* 1954. Kr. 1,00.
„ 101. MATHISEN, TRYGVE, *Svalbard in International Politics 1871—1925.* 1954. Kr. 18,00.
„ 102. RODAHL, KÅRE, *Studies on the Blood and Blood Pressure in the Eskimo and the Significance of Ketosis under Arctic Conditions.* 1954. Kr. 10,00.
„ 103. LØVENSKIOLD, H. L., *Studies on the Avifauna of Spitsbergen.* 1954. Kr. 16,00.
„ 104. HORNBÆK, HELGE, *Tidal Observations in the Arctic* 1946—52. Kr. 2,50.
„ 105. ABS, OTTO und HANS WALTER SCHMIDT, *Die arktische Trichinose und ihr Verbreitungsweg.* 1954. Kr. 4,00.
„ 106. MAJOR, HARALD and THORE S. WINSNES, *Cambrian and Ordovician Fossils from Sørkapp Land, Spitsbergen.* 1955. Kr. 4,00.
„ 107. FEYLING-HANSSEN, ROLF W., *Stratigraphy of the Marine Late-Pleistocene of Billefjorden, Vestspitsbergen.* 1955. Kr. 22,00.
„ 108. FEYLING-HANSSEN, ROLF W., *Late-Pleistocene Deposits at Kapp Wijk, Vestspitsbergen.* 1955. Kr. 3,00.
„ 109. J. J. DONNER AND R. G. WEST, *The Quaternary Geology of Brageneset, Nordaustlandet, Spitsbergen.* 1957. Kr. 5,00.
„ 110. KAARE Z. LUNDQUIST, *Magnetic Observations in Svalbard 1596—1953.* 1957. Kr. 6,00.
„ 111. H. U. SVERDRUP, *The Stress of the Wind on the Ice of the Polar Sea.* 1957. Kr. 2,00

MAPS AND CHARTS

The following topographical maps and charts have been published separately:

Maps:

Bjørnøya. 1:25 000. 1925. New edition 1944. Kr. 3,00.
Bjørnøya. 1:10 000. [In six sheets.] 1925. Kr. 30,00.
Adventfjorden—Braganzavågen. 1:100 000. 1941. Kr. 2,00.
Svalbard. 1:2 000 000. 1937. New edition 1944. Kr. 1,00.
Topografisk kart over Svalbard. Blad C 13. Sørkapp. 1:100 000. 1947. Kr. 3,00.
Topografisk kart over Svalbard. Blad B 10. Van Mijenfjorden. 1:100 000. 1948. Kr. 3,00.
Topografisk kart over Svalbard. Blad C 9. Adventdalen. 1:100 000. 1950. Kr. 3,00.
Topografisk kart over Svalbard. Blad B 11. Van Keulenfjorden. 1:100 000. 1952. Kr. 3,00.
Topografisk kart over Svalbard. Blad B 12. Torellbreen. 1:100 000. 1953. Kr. 3,00.
Austgrønland. Eirik Raudes Land frå Sofiasund til Youngsund. 1:200 000. 1932. Kr. 2,00.

Preliminary topographical maps [1:50 000] covering claims to land in Svalbard and a preliminary map of Hopen 1 : 100 000 may be obtained separately.

In addition, Norsk Polarinstitutt has prepared a wall map: Norden og Norskehavet, in 4 sheets. This map is to be obtained through H. Aschehoug & Co. (W. Nygaard), Oslo, at a price of kr. 27,80.

Charts

No. 501. Bjørnøya. 1:40 000. 1932. Kr. 4,00.
„ 502. Bjørnøyfarvatnet. 1:350 000. 1937. Kr. 4,00.
„ 503. Frå Bellsund til Forlandsrevet med Isfjorden. 1:200 000. 1932. Kr. 5,00.
„ 504. Frå Sørkapp til Bellsund. 1:200 000. 1938. Kr. 5,00.
„ 505. Norge—Svalbard, nordre blad. 1:750 000. 1933. Kr. 4,00.
„ 506. Norge—Svalbard, søre blad. 1:750000. 1933. Kr. 4,00.
„ 507. Nordsvalbard. 1:600000. 1934. Kr. 4,00.
„ 508. Kongsfjorden og Krossfjorden. 1:100 000. 1934. Kr. 4,00.
„ 509. Frå Storfjordrenna til Forlandsrevet med Isfjorden. 1:350 000. 1946. Kr. 4,00.
„ 510. Frå Kapp Linné med Isfjorden til Sorgfjorden. 1:350 000. 1946. Kr. 4,00.
„ 511. Austgrønland, frå Liverpoolkysten til Store Koldeweyøya. 1:600000. 1937. Kr. 4,00.

Prices above do not include purchase tax.

Norsk Polarinstitutt. Skrifter. Nr. 109. J. J. Donner and R. G. West: The Quaternary Geology of Brageneset, Spitsbergen.