DET KONGELIGE INDUSTRI-, HÅNDVERK-
OG SKIPSFARTSDEPARTEMENT

NORSK POLARINSTITUTT

SKRIFTER

Nr. 107

STRATIGRAPHY OF THE MARINE LATE-PLEISTOCENE OF BILLEFJORDEN, VESTSPITSBERGEN

BY

ROLF W. FEYLING-HANSSEN

WITH 57 TEXT FIGURES, 3 TABLES AND 27 PLATES

I KOMMISJON HOS
BRØGGERS BOKTRYKKERIS FORLAG
OSLO 1955

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 *Cyathaspida.* 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 INDUSTRI-, HÅNDVERK-
OG SKIPSFARTSDEPARTEMENT

NORSK POLARINSTITUTT

SKRIFTER

Nr. 107

STRATIGRAPHY
OF THE MARINE LATE-PLEISTOCENE
OF BILLEFJORDEN, VESTSPITSBERGEN

BY
ROLF W. FEYLING-HANSSEN

WITH 57 TEXT FIGURES, 3 TABLES AND 27 PLATES

I KOMMISJON HOS
BRØGGERS BOKTRYKKERIS FORLAG
OSLO 1955

A. W. BRØGGERS BOKTRYKKERI A/S

CONTENTS

ILLUSTRATIONS

Text figures.

Plates.

Tables.

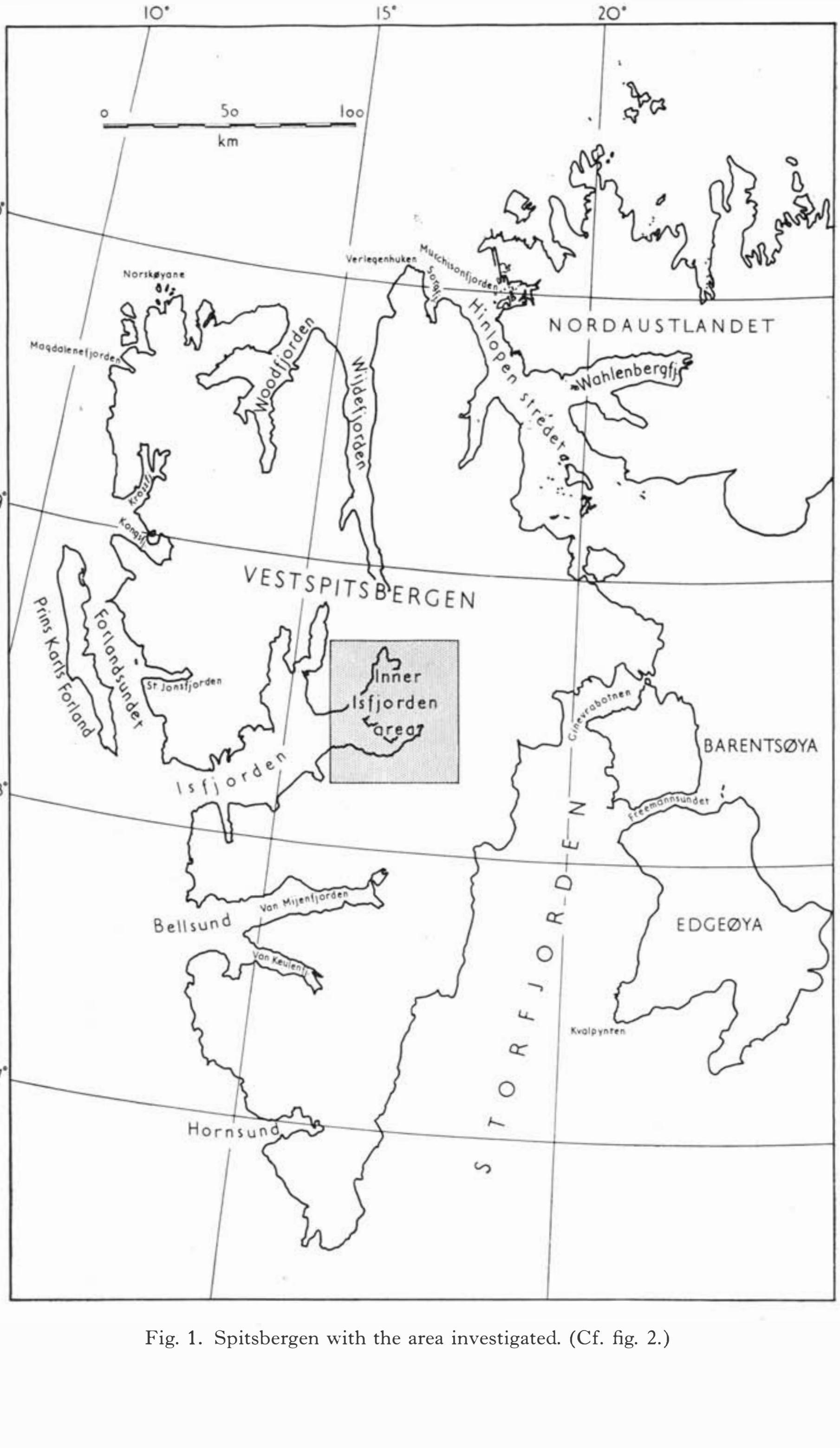


Fig. 1. Spitsbergen with the area investigated. (Cf. fig. 2.)

PREFACE

Billefjorden is located at the inner, eastern end of Isfjorden in Vestspitsbergen, between 78°27′ N. lat. and 78°43′ N. lat., and 16°2′ E. long. and 16°53′ E. long., branching off from Isfjorden towards the NNE (figs. 1 and 2). Its length from Gåsøyane to the head of Petuniabukta is 32 km, its smallest breadth 5 km. Four bays branch out from the fjord, viz. Adolfbukta, Petuniabukta, Mimerbukta and Skansbukta, to which may be added the bights of Anservika, Phantomvika and Ekholmvika. The greatest depth, 188 m, was found 2.6 km off the front of Nordenskiöldbreen which is the only glacier in the Billefjorden area with its front in the sea (fig. 47). Steep mountain sides rise to an average height of 600 m on both sides of the fjord, the highest mountains being De Geerfjellet, 1023 m a.s.l. and situated north of the front of Nordenskiöldbreen, and Pyramiden, 935 m a.s.l. at the junction of Petuniabukta and Mimerbukta. The rocks of the region are mainly Carboniferous limestones and sandstones with gypsum beds; Permian rocks have a more scattered occurrence and Devonian rocks outcrop only to the west of the area (ORVIN 1940, HARLAND 1952).

The present work is a continuation of the study of the raised, marine, Late-Pleistocene deposits of Spitsbergen which was started in the Sassen area of Isfjorden in 1948 (FEYLING-HANSSEN and JØRSTAD 1950). The field work was carried out during the summer of 1950 when the author together with JOHN A. S. ADAMS, Ph. D., and Cand. philol. ODD CHR. FEYLING-HANSSEN, all members of the Svalbard expedition of Norsk Polarinstitutt, disembarked at Skansbukta. I want to express my sincere thanks to my two companions who greatly facilitated the field investigations.

The work on the collections has been carried out at the Paleontologisk Museum of the University of Oslo. I am greatly indepted to the Head of Norsk Polarinstitutt, Professor dr. phil. H. U. SVERDRUP, and to the Deputy Director, dr. phil. A. K. ORVIN, who provided a grant from Norsk Polarinstitutt, and also to the head of Paleontologisk Museum, Professor dr. phil. A. HEINTZ, for placing laboratory facilities at my disposal.

Technical assistance has been given by Mrs. ALFHILD HORN, Magister S. RICHTER, Cand. mag. H. SKÅLVOLL and Mr. J. WILHELMSEN to whom I render grateful acknowledgment. I am especially indepted to the Faculty artist, Miss RANDI GULLIKSEN, who prepared all the drawings, and to the Faculty photographer, Miss BERGLIOT MAURITZ, who prepared the photographs. The air photographs have been taken by topographer B. LUNCKE of Norsk Polarinstitutt and generously placed at my disposal by the institute. Finally, I would like to thank Mr. W. T. DEAN who corrected the English of the manuscript.

Paleontologisk Museum, Oslo, October, 1954.

Rolf W. Feyling-Hanssen.

ABSTRACT

59 species of marine invertebrates (mainly mollusks) were found in the raised, Late-Pleistocene deposits of Billefjorden; 26 of them have not previously been recorded from this region, and 5 are new from the Pleistocene of Svalbard as a whole (p. 21). In the discussion of the fossil fauna Billefjorden and the Sassen area (FEYLING-HANSSEN and JØRSTAD 1950) have been taken together under the designation of the Inner Isfjorden Area, the total number of marine Pleistocene fossils from this region now amounting to 76 (table I).

In order to facilitate a classification of the fossil species, with reference to their thermic requirements, a regional division of the European seas has been discussed (p. 24), and three main elements distinguished within the fossil fauna, viz. a high-arctic, a mid-arctic, and a low-arctic element. The high-arctic element comprises the majority of the species, many of them being distributed southwards, even into the lusitanian region. The mid-arctic element comprises 9 species (p. 30), 3 of which, *Mytilus edulis, Lacuna vincta* and *Omalogyra atomus,* seem now to be extinct in Spitsbergen waters. The low-arctic element comprises 6 species, viz. *Heteranomia squamula, Volsella modiola, Cyprina islandica, Zirfaea crispata, Emarginula fissura* and *Littorina littorea,* which are all extinct in Spitsbergen to-day.

The vertical distribution of the fossil species in the Late-Pleistocene deposits of Billefjorden has been illustrated in table II, and in the region of Inner Isfjorden as a whole, in table III. At the level of the marine limit of Billefjorden, 90 (96) m a.s.l., no fossils were found, and between 84.5 and 60 m a.s.l. only *Saxicava arctica* and *Mya truncata* occurred. The corresponding period has been called the Late-Glacial Cold period. Between 60 and 38—40 m a.s.l. 14 more species appeared in the deposits, among them being three of the mid-arctic element, viz. *Mytilus edulis, Lacuna vincta* and *Littorina saxatilis* (p. 31). The corresponding period has been called the Post-Glacial Temperate period (p. 38). Between 38—40 and 3 m a.s.l. a quite large number of invertebrate species were found in the deposits of Inner Isfjorden; six of these are now extinct in Spitsbergen as they require a decidedly better climate for their existence there than that of the present-day (p. 33). The corresponding period has been called the Post-Glacial Warm period. Below a level of approx. 3 m a.s.l. the low-arctic and also, partly, the mid-arctic element of the fossil fauna have disappeared from the littoral

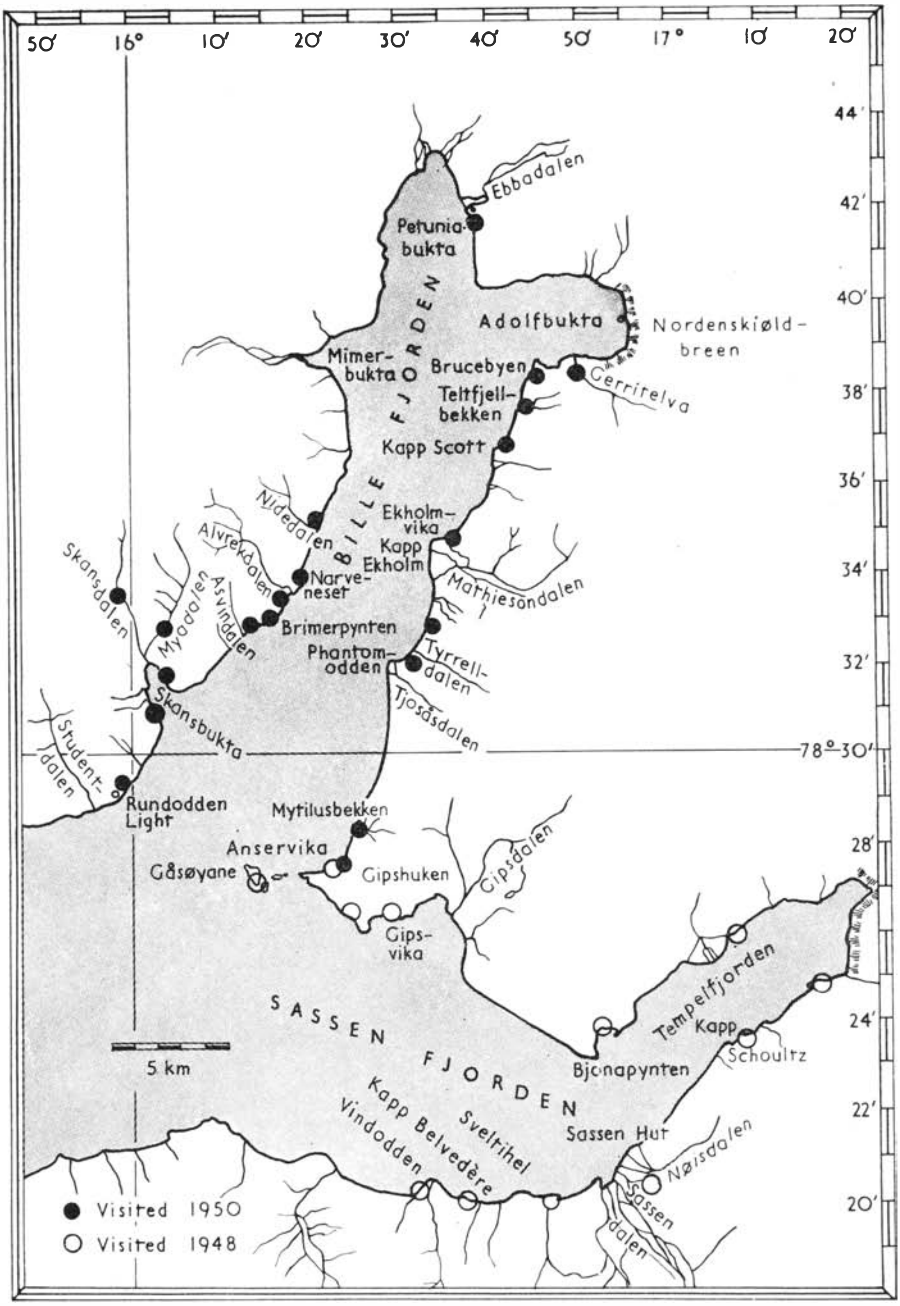


Fig. 2. The Inner Isfjorden Area (Billefjorden and Sassenfjorden with Tempelfjorden) with the localities investigated in 1948 and 1950.

deposits. The corresponding period has been called the Sub-Recent period. These periods have been correlated with the Late-Pleistocene stratigraphy of Greenland (p. 54).

The large cuspate forelands, being the most characteristic features of shore topography along the coasts of Billefjorden, have been discussed; they are prograded in a NNE direction by the addition of successive beach ridges (p. 15). When prograded during periods of constant sea level the result will be horizontal beach plains; when, on the other hand, the progradation is continuing during a period of negative shift of the shoreline the resulting beach plains will slope in the direction in which the forelands prograde. These sloping beach plains have falsely been interpreted as evidence of Pleistocene warping of the land mass (p. 17).

There seems to be evidence of a minor positive shift of the shoreline in Recent times (p. 48), and discontinuity in the formation of the sloping beach plains of Billefjorden, and in the faunas, suggests a temporary positive shift of the shoreline to have probably taken place at the transition between the Post-Glacial Temperate and the Post-Glacial Warm period,

The different localities investigated in Billefjorden have been described (p. 58) together with the collections, measurements and analyses. The fossil species from the area, their Late-Pleistocene and Recent occurrences within arctic and sub-arctic regions, have been dealt with on pp. 125—175, and an index of the species has been inserted at the end of the chapter (p. 176). Some of the species are illustrated in plates 17—27.

I. GENERAL PART

Introduction.

Cuspate Forelands.

A good description of the physiographic conditions of Billefjorden was given by BALCHIN (1941) who carefully mapped its shore topography (cf. also HARLAND 1952, with the Cambridge Spitsbergen Expedition map of Central Vestspitsbergen), so that only a few remarks need here be added.

The large cuspate forelands are the most characteristic features of shore topography along the coasts of Billefjorden. There are four of them along the east coast, viz. Phantomodden, Kapp Ekholm, Kapp Scott and Kapp Napier. They are more or less triangular, or cuspate, in shape and are prograded in a NNE direction by the addition of successive beach ridges. The ridges are generally close-set with narrow swales in between. Erosion is affecting the west and southwest sides of these forelands so that practically no ridges and swales remain parallel to those sides (fig. 3). Such forelands were termed truncated cuspate forelands (JOHNSON 1919, p. 325). An exception is a low beach plain to the west of the main formation at Brucebyen, where a seaward progradation takes place both to the WNW and the N.

The great fetch of southwesterly winds entering Isfjorden produces a dominant longshore beach drifting to the north in Billefjorden (BALCHIN 1941), such shore drifting necessarily being most prominent along the east side of Billefjorden. Accordingly there is only one cuspate foreland on the west coast of the fjord, viz. Narveneset, which is on a scale comparable with those on the east coast. This is also prograded in an in-fjord direction.

Wave currents produce the shore drifting, or littoral transport, by which beach material is, more or less constantly, being transported along the shoreline to accumulate on its leeward side[1]. The material is derived partly from neighbouring cliffs and partly from streams which carry great quantities of fluvio-glacial material seawards during the summer (BALCHIN 1941).

When these processes act during periods of constant sea level, i.e. periods with no vertical shift in the position of the shoreline, the result will be horizontal beach plains, more or less cuspate in outline. These surfaces

---

[1] For details of these processes the reader is referred to the excellent treatise by D. W. JOHNSON (1919), and papers issued by the Beach Erosion Board (e.g. Special Issue No. 2).

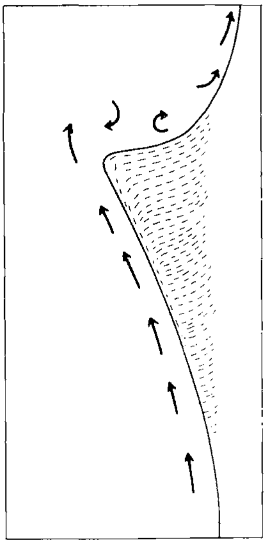


Fig. 3. Truncated cuspate foreland with successively added beach ridges; beach material is being transported along the shoreline by shore drifting to accumulate on its leeward side, thus causing an extensive forward building of the shore into the sea.

will be occupied by parallel or sub-parallel, generally curved, beach ridges of approximately equal crest altitudes, each beach ridge marking a temporary position of the shoreline during the progradation of the shore.

When, on the other hand, the same processes are continuing during a period of emergence, i.e. during a period of negative shift of the shoreline, the resulting beach plains will no longer be horizontal, but will slope in the direction in which the forelands prograde, the older ridges being more elevated than the younger ones. The gradient of the slope depends on the rate of emergence and the rate of progradation. Every new beach ridge had to form at a lower level than its predecessor and every new lamina in the growing sequence was deposited under a lower sea level than the previous lamina. The beach ridges still mark the temporary positions of the shoreline, but now they record its vertical, as well as its horizontal, movements.

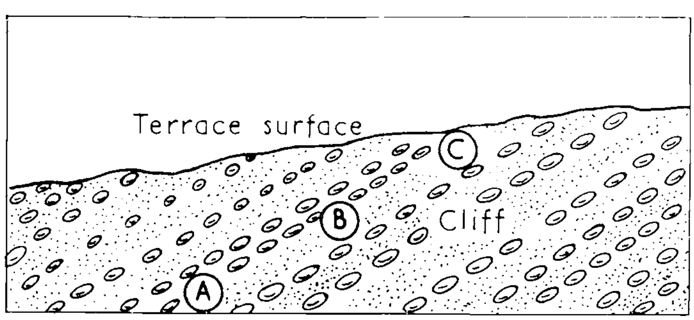


Fig. 4. Fossils found at A, B, or C, in the cliff of a raised beach plain, have generally been associated with the same terrace surface because they were once deposited on the same sloping beach face.

Along the eastern shores of Billefjorden such raised sloping beach plains, or sloping wave built terraces, have been cliffed by wave erosion. The cliffs, which cut the plains at approx. right angles to the direction of the beach ridges, reveal continuous incline bedding with alternating coarser- and finer-grained strata (p. 78, figs. 30—33; pl. 5, fig. 2, and pl. 6, figs. 2, 3). The material consists of gravel, the thicker strata with sandy gravel alternating with thinner strata containing silty gravel (p. 79). The strata have a true northerly dip of 20—25°, i.e. they dip in the same direction as the terrace surface above, and continue through the cliff up to the ridged surface (cf. also BALCHIN 1941)[1].

Wherever longshore drifting brings to the shore more débris than can be removed by the waves operating there, the shore must be prograded (JOHNSON 1919, p. 407). On the other hand, wherever wave and current action remove more than is supplied by littoral drifting, retrograding takes place. The first case is operative on the leeward, i.e. northern, sides of the forelands of Billefjorden, whereas their southwestern sides, in many places, are subject to erosion. Consequently these truncated cuspate forelands migrate in the direction of the dominant shore drifting[2]. Raised remnants of wave built terraces record earlier positions of such forelands, especially along the east shore of Billefjorden.

These sloping beach plains, so characteristic of the raised marine features of Billefjorden and many other fjords of Spitsbergen, were falsely interpreted as evidence of Pleistocene warping of the land mass (BALCHIN 1941)[3]. They have nothing to do with tilted shorelines, but are merely constructional features formed during periods of negative shift of the shoreline.

The sublittoral facies of the sediments of the beach plains are silty and partly clayey deposits. In the lower part of the raised sequence of Billefjorden, they are generally very rich in *Lithothamnion* (p. 44), whereas in the upper part they are characterized by *Mya truncata* (p. 40).

[1] BALCHIN (1941, p. 370) writes that the alternation of fine and coarse sediments is either a seasonal feature or related to the frequency of storms coupled with the supply of material. However, any variation in the longshore drifting will cause variation in the particle size of the material actually being deposited. If the alternation of sandy and silty gravel is seasonal we would, in this phenomenon, have an excellent method of age determination, but this would require closer examination of the texture and structure of the deposits. The thicker strata with sandy gravel could very well turn out to be summer layers deposited under free wave action, whereas the silty gravel might represent winter layers deposited when sea ice restricted wave action (cf. footnote p. 79).

[2] For details of these processes the reader is again referred to JOHNSON (1919).

[3] The present writer (1950) called attention to the improbability of the results reached by BALCHIN. Not having visited Billefjorden at that time, he (the writer) held the view that BALCHIN must have misinterpreted the slope of rudimentary delta plains, but this only partly covers the facts, the misinterpretation of the ridged beach plains having to be added.

Raised delta plains, or delta terraces, occur at Phantomvika (p. 69) and at Kapp Ekholm; these are rudiments of raised deltas and have therefore a supramarine as well as a marine facies. From their mode of formation, such plains will slope towards the sea in all directions from the centre of accumulation or apex of the delta (FEYLING-HANSSEN 1950).

At Nidedalen there occurs a series of beach ridges composed of very coarse material comparable with the boulder ridges of the coastal plain at Gipshuken (FEYLING-HANSSEN 1952).

Methods.

Topographical measurements in the field were made using a tachymeter. They were initially referred to local high-water mark and later corrected to an approximate half-tide level so that all heights given refer to mean tide level.

In general the heights of both the front and rear edges of each terrace were determined, though in many cases solifluction had obliterated the upper termination of the terrace. On extended beach plains the altitudes of several points on the surface were determined.

In collecting fossil mollusks, specimens from littoral deposits were, as far as possible, kept duly apart from those from sublittoral sediments. Fossils from deposits which had been disturbed by glacial advance were not considered in the discussion of delimitation of fossil horizons.

It was always attempted to collect a number of fossils great enough to give an estimate of the faunal composition, though scarcity of fossils prevented this in some localities. The frequency of the different species was indicated by the number of specimens in the sample. Of gastropods whole shells and summits of broken shells were counted, and of pelecypods valves and umbonal fragments, whose number was divided by two. Of balanids carinae or rostra were counted. Chitonids and echinids were not calculated, and microfossils were, in general, not considered (FEYLING-HANSSEN and JØRSTAD 1950, p. 12). In order to facilitate comparison of different faunal assemblages the frequency of each species was also expressed as a percentage of the total number of specimens in the sample.

Fossils from the cliff of a prograded, raised beach plain were generally associated with the same terrace level even if they were found at different heights above sea level (fig. 4). In fact, they were once deposited on the same sloping beach face or bottom of nearshore zone.

Fossils were considered to have remained in situ when the size and weight of the biogenic particles (size of fossil specimens or fragments thereof) were of an order of magnitude other than that of the particles of the minerogenic matrix. If, on the other hand, biogenic and minerogenic particles are of approximately equal size this may, in many cases, prove to indicate that one and the same agency brought them together (cf. FEYLING-HANSSEN and JØRSTAD 1950, p. 22, table I).

Errors.

Some of the measured altitudes of raised, marine features may be inaccurate on account of the base-line chosen. In Billefjorden the high-water line is marked neither by *Fucus* nor by the white lining of *Balanus balanoides* found so commonly elsewhere. The position of latest high-water is generally marked by a small sand ridge or by flotsam, this mark varying, however, from day to day with the tidal range. Approximate corrections had to be made for this and for occasional heavy seas and exceptional exposure. Compared with the heights of the raised marine features, however, the variations in the position of the chosen base-line are generally small, the tidal range being on the average, 1 m within the region.

As to the fossils, the various factors tending to diminish the accuracy of their indication were discussed by FEYLING-HANSSEN and JØRSTAD (1950, p. 10). The most serious one is redeposition of fossils by streams, waves, currents, or even by solifluction and glacial advance. Such factors are considered under the description of the localities (p. 58).

LEMCHE (cf. LAURSEN 1946 b) stated that at depths less than approx. 23 m there is in Greenland waters a relatively warmth-loving fauna, whereas a cold-loving one appears below this depth. An uplift of land in such an area would, accordingly, appear to be accompanied by a climatic change from high-arctic to milder conditions, as part of the hitherto high-arctic bottom will be raised into a zone with more temperate water. This would constitute a serious source of error in evaluation of the fossil fauna in correlation with change of levels, but LAURSEN (1950, pp. 111—117) has shown, however, that LEMCHE's theory is hardly in keeping with reality. LAURSEN (l.c.) also entered upon the problem of relict forms (cf. also JENSEN 1942).

Geographical Names.

The terms Vestspitsbergen, Spitsbergen and Svalbard have been used in accordance with „The Place-Names of Svalbard" (1942), viz. as follows:

Vestspitsbergen is the name of the greatest island in the Svalbard group.

Spitsbergen signifies Vestspitsbergen, Prins Karls Forland, Nordaustlandet, Barentsøya and Edgeøya.

Svalbard comprises Kvitøya, Kong Karls Land, Hopen and Bjørnøya in addition to the islands mentioned above.

Some of the investigated localities in the Billefjorden area had no names, so that in order to simplify the account of the present paper the following new names are proposed:

Mytilusbekken, stream north of Anservika (fig. 2, pl. 2).
Phantomvika, bight north of Phantomodden (figs. 2, 23).
Tjosåsdalen, valley SW of Tjosåsfjellet (figs. 2, 23).

Tjosåselva, the river of Tjosåsdalen (fig. 23).
Tyrrelldalen, valley between Tjosåsfjellet and Tyrrellfjellet (figs. 2, 23).
Tyrrellelva, the river of Tyrrelldalen (fig. 23).
Ekholmvika, bight north of Kapp Ekholm (figs. 2, 23; pl. 4).
Scottvika, bight north of Kapp Scott (p. 81).
Teltfjellbekken, stream at the foot of Teltfjellet, between Kapp Scott and Brucebyen (figs. 2, 34).
Sørdammen, pond at Brucebyen (fig. 34).
Norddammen, pond at Brucebyen (fig. 34).
Nidedalen, valley south of Mimerbukta (figs. 2, 48).
Nidedalselva, the river of Nidedalen (figs. 2, 48).
Narveneset, cuspate foreland south of Nidedalen (fig. 48).
Alvrekdalen, valley southwest of Narveneset (figs. 2, 48).
Alvrekelva, the river of Alvrekdalen (fig. 48).
Brimerpynten, point southwest of Alvrekdalen (figs. 2, 48).
Asvindalen[1], small valley southwest of Brimerpynten (fig. 48).
Myadalen, valley north of Skansbukta (figs. 2, 48).
Myadalselva, the river of Myadalen (fig. 48).
Skansdalselva, the river of Skansdalen (fig. 48).
Skansdalsbreen, the glacier at the head of Skansdalen (pl. 11, fig. 1).

The Inner Isfjorden Area (fig. 1) comprises Billefjorden, Sassenfjorden and Tempelfjorden.

The Fossil Fauna.

Faunistic Remarks.

In the present survey 59 species of marine invertebrates[2] are enumerated as occurring in the Pleistocene of Billefjorden, viz. 3 chitonids, 23 pelecypods, 28 gastropods, 4 cirripeds and 1 echinid[3]. Of these species 53 were found by the author, and 6 were recorded only by other investigators, viz.

Thyasira flexuosa	*Sipho togatus*
Sipho islandicus	*Buccinum ciliatum*
Sipho kroeyeri	*Buccinum finmarchianum.*

[1] In Norse mythology Nide, Narve, Alvrek, Brimer and Asvin are synonyms for the god Mimer.

[2] Foraminifera, Ostracoda and Polychaeta are not considered; coralline algae have been collected (p. 174).

[3] *Mya truncata ovata* JENSEN (= *M. pseudoarenaria* SCHLESCH) and *M. truncata uddevallensis* HANCOCK are here included in *Mya truncata* LINNÉ. Four of the mollusks were probably of Recent origin, viz. *Musculus discors substriatus, Liocyma fluctuosa, Pandora glacialis* and *Pyrulofusus deformis.*

26 of the species are here recorded from the Pleistocene of Billefjorden for the first time, viz.

Tonicella marmorea	*Moelleria costulata*
Trachydermon albus	*Cingula castanea*
Trachydermon ruber	*Omalogyra atomus*
Volsella modiola	*Trophon clathratus*
Musculus discors substriatus	*Pyrulofusus deformis*
Astarte crenata	*Buccinum undatum*
Thyasira croulinensis	*Buccinum totteni*
Thyasira sarsii	*Lora bicarinata*
Liocyma fluctuosa	*Verruca stroemia*
Zirfaea crispata	*Balanus balanus*
Emarginula fissura	*Balanus crenatus*
Acmaea rubella	*Balanus balanoides*
Margarites cinereus	*Strongylocentrotus* cf. *droebachiensis.*

In addition worn fragments of *Thracia* sp. and *Cyclostrema* sp. were found.

Five of these species, 4 mollusks and 1 cirriped, are here recorded from the Pleistocene of Svalbard for the first time, viz.

Thyasira croulinensis	*Omalogyra atomus*
Thyasira sarsii	*Verruca stroemia.*
Emarginula fissura	

In the raised Pleistocene deposits of the Sassen area (FEYLING-HANSSEN and JØRSTAD 1950) 60 species of marine invertebrates were found, 17 of which were not found in the Pleistoceene of the Billefjorden area, viz.

Nucula tenuis	*Thracia myopsis*
Leda pernula	*Siphonodentalium vitreum*
Yoldiella frigida	*Cingula aculea*
Bathyarca glacialis	*Lunatia pallida*
Musculus discors laevigatus	*Neptunea despecta*
Axinopsis orbiculata	*Buccinum tenue*
Turtonia minuta	*Buccinium ovum*
Macoma torelli	*Admete viridula.*
Thracia septentrionalis	

On the other hand, 16 of the species collected in the Billefjorden area were not found in the Sassen area, viz.

Trachydermon albus	*Thyasira croulinensis*
Tracydermon ruber	*Thyasira sarsii*
Thyasira flexuosa	*Emarginula fissura*

Acmaea rubella
Margarites cinereus
Cyclostrema sp.
Omalogyra atomus
Sipho kroeyeri
Buccinum ciliatum
Buccinum finmarchianum
Buccinum totteni
Lora bicarinata
Verruca stroemia.

Billefjorden and Sassenfjorden with Tempelfjorden constitute the innermost and easternmost branches of Isfjorden. The physiographic conditions and the development of the Late-Pleistocene being similar in both areas, the Billefjorden area and the Sassen area can be treated together under the designation of the Inner Isfjorden Area. If these two areas are taken together, the total number of marine invertebrate species recorded from the Pleistocene of the Inner Isfjorden Area amounts to 76, which are enumerated in table I. The occurrences at different parts of Spitsbergen are marked with an ×, but if the occurrence is supposed to be of Recent origin this mark has been put in brackets, (×). In the „West coast region" is included Isfjorden west of the Inner Isfjorden Area. The *Thracia* sp. found in the Billefjorden area is supposed to be *T. devexa,* this species being listed as occurring there in the table.

Table I.

No.	The marine invertebrates in the Pleistocene of the Inner Isfjorden Area.	Billefjorden area	Sassen area	West coast region	North coast region	East coast region
1	*Tonicella marmorea* (FABRICIUS)	×	×	×	.	×
2	*Trachydermon albus* (LINNÉ)	×	.	×	.	.
3	*Trachydermon ruber* (LINNÉ)	×	.	×	.	.
4	*Nucula tenuis* (MONTAGU)	.	×	×	.	×
5	*Leda pernula* (MÜLLER)	.	×	×	×	×
6	*Yoldiella frigida* (TORELL)	.	×	.	.	.
7	*Bathyarca glacialis* (GRAY)	.	×	.	.	.
8	*Heteranomia squamula* (LINNÉ)	×	×	×	.	.
9	*Chlamys islandica* (MÜLLER)	×	×	×	×	×
10	*Crenella decussata* (MONTAGU)	×	×	×	.	.
11	*Mytilus edulis* (LINNÉ)	×	×	×	×	×
12	*Volsella modiola* (LINNÉ)	×	×	×	.	.
13	*Musculus discors laevigatus* (GRAY)	.	×	×	.	×
14	*Musculus discors substriatus* (GRAY)	×	×	×	.	×
15	*Astarte boralis* (CHEMNITZ)	×	×	×	×	×
16	*Astarte montagui* (DILLWYN)	×	×	×	×	×
17	*Astarte elliptica* (BROWN)	×	×	×	×	×
18	*Astarte crenata* (GRAY)	×	×	×	.	.
19	*Axinopsis orbiculata* G. O. SARS	.	×	×	.	×
20	*Thyasira flexuosa* (MONTAGU)	×	.	×	.	×
21	*Thyasira crouliensis* (JEFFREYS)	×	.	.	.	.
22	*Thyasira sarsii* (PHILIPPI)	×	.	.	.	.
23	*Turtonia minuta* (FABRICIUS)	.	×	.	×	.
24	*Clinocardium ciliatum* (FABRICIUS)	.	×	×	.	×

No.	The marine invertebrates in the Pleistocene of the Inner Isfjorden Area.	Billefjorden area	Sassen area	West coast region	North coast region	East coast region
25	*Serripes groenlandicus* (CHEMNITZ)	×	×	×	.	×
26	*Cyprina islandica* (LINNÉ)	×	×	×	.	×
27	*Macoma calcarea* (CHEMNITZ)	×	×	×	×	×
28	*Macoma torelli* (STENSTRUP) JENSEN	.	×	.	.	.
29	*Liocyma fluctuosa* (GOULD)	(×)	×	×	.	×
30	*Saxicava arctica* (LINNÉ)	×	×	×	×	×
31	*Mya truncata* LINNÉ	×	×	×	×	×
32	*Zirfaea crispata* (LINNÉ)	×	×	×	.	.
33	*Pandora glacialis* LEACH	(×)	(×)	(×)	.	.
34	*Thracia septentrionalis* JEFFREYS	.	×	.	.	.
35	*Thracia myopsis* (MÖLLER)	.	×	×	×	×
36	*Thracia devexa* G. O. SARS	×	×	.	.	.
37	*Siphonodentalium vitreum* M. SARS	.	×	.	.	.
38	*Emarginula fissura* (LINNÉ)	×	.	.	.	.
39	*Puncturella noachina* (LINNÉ)	×	×	×	.	×
40	*Acmaea rubella* (FABRICIUS)	×	.	×	.	×
41	*Lepeta coeca* (MÜLLER)	×	×	×	×	×
42	*Margarites groenlandicus* (CHEMNITZ)	×	×	×	×	×
43	*Margarites helicinus* (PHIPPS)	×	×	×	.	×
44	*Margarites cinereus* (COUTHOUY)	×	.	×	.	×
45	*Moelleria costulata* (MÖLLER)	×	×	×	.	×
46	*Cyclostrema* sp.	×	.	.	.	.
47	*Lacuna vincta* (MONTAGU)	×	×	×	×	.
48	*Littorina saxatilis* (OLIVI)	×	×	×	.	.
49	*Littorina littorea* (LINNÉ)	×	×	×	×	.
50	*Cingula castanea* (MÖLLER)	×	×	×	.	.
51	*Cingula aculea* (GOULD)	.	×	×	.	.
52	*Omalogyra atomus* (PHILIPPI)	×	.	.	.	.
53	*Lunatia pallida* (BRODERIP and SOWERBY)	.	×	×	.	×
54	*Natica clausa* BRODERIP and SOWERBY	×	×	×	.	×
55	*Trophon clathratus* (LINNÉ)	×	×	×	×	×
56	*Trophon truncatus* (STRÖM)	×	×	.	.	.
57	*Sipho islandicus* (CHEMNITZ)	×	×	.	.	.
58	*Sipho kroeyeri* (MÖLLER)	×	.	×	×	×
59	*Sipho togatus* (MÖRCH)	×	×	.	.	.
60	*Neptunea despecta* (LINNÉ)	.	×	.	.	.
61	*Pyrulofusus deformis* (REEVE)	(×)	(×)	(×)	.	.
62	*Buccinum undatum* LINNÉ	×	×	×	.	.
63	*Buccinum groenlandicum* CHEMNITZ	×	×	×	.	×
64	*Buccinium ciliatum* (FABRICIUS)	×	.	.	.	×
65	*Buccinum finmarchianum* VERKRÜZEN	×	.	.	.	.
66	*Buccinum glaciale* LINNÉ	×	×	×	×	×
67	*Buccinum tenue* GRAY	.	×	×	.	×
68	*Buccinum ovum* MIDDENDORFF	.	×	.	.	×
69	*Buccinum totteni* STIMPSON	×	.	.	.	.
70	*Admete viridula* (FABRICIUS)	.	×	.	.	×
71	*Lora bicarinata* (COUTHOUY)	×	.	×	.	×
72	*Verruca stroemia* (MÜLLER)	×	.	.	.	.
73	*Balanus balanus* (LINNÉ)	×	×	×	×	×
74	*Balanus crenatus* BRUGUIÈRE	×	×	×	.	.
75	*Balanus balanoides* (LINNÉ)	×	×	.	.	.
76	*Strongylocentrotus* cf. *droebachiensis* (MÜLLER)	×	×	×	.	×

The total number of mollusk species now known from the whole of the Pleistocene of Svalbard, has been augmented to 95[1].

The majority of the species from the Pleistocene of Inner Isfjorden are still living in the fjords and along the coasts of Vestspitsbergen to-day. 9 of them, however, are now extinct there (pp. 127—161), viz.:

Heteranomia squamula	*Emarginula fissura*
Mytulis edulis	*Lacuna vincta*
Volsella modiola	*Littorina littorea*
Cyprina islandica	*Omalogyra atomus.*
Zirfaea crispata	

This fact points to changing thermic conditions in the sea during the period of deposition of the Pleistocene strata within the area, and in an insular region like Svalbard the temperature of the sea water will have a decisive influence on the climate. In order to extract the climatic evidence of the fossil fauna as completely as possible, it will be necessary to discuss the Recent geographical distribution of certain groups of species.

Regional Division of the European Seas.

A large number of climatological and zoögeographical delimitations of the European seas has been proposed by various authors; for details about the different regions and subregions, as to water temperature, currents, depths and organic life, the reader is referred to papers by APPELLÖF (1912), GURJANOVA, SACHS, and USCHAKOV (1925), ANTEVS (1928), BROCH (1933), EKMAN (1935), MADSEN (1936), and others. A simple regional division which will serve as a practical aid in the classification of our fossils from the Pleistocene of Inner Isfjorden and their paleoclimatic indications is found in ANTEVS (1928, p. 482). His classification is based on the old zoögeographical division of arctic, boreal and lusitanian provinces, the arctic province being sub-divided into a high-arctic and a low-arctic subregion, and the boreal into a high-boreal, a mid-boreal and a low-boreal subregion. (Cf. HESSLAND 1943.)

ANTEVS' regional division has here been altered a little, a mid-arctic subregion being inserted between the high-arctic and the low-arctic. This was necessary to make possible a distinction, in the diagram (table III), between species with different geographical occurrences, and different paleoclimatic indications which would, in ANTEVS' scheme, fall within the same geographical region. *Littorina saxatilis* var. *groenlandica* and *Cyprina islandica* would both, according to ANTEVS' scheme, be classified as low-arctic species with reference to their northern limit of distribution. However, *L. saxatilis* occurs in Spitsbergen, whereas *C. islandica* is distributed northwards only to the White Sea. Their vertical distribution in the Pleistocene of Inner Is-

[1] Cf. KNIPOWITSCH 1902 III, HOEL 1914, FEYLING-HANSSEN and JØRSTAD 1950, HÄGG 1950, 1951.

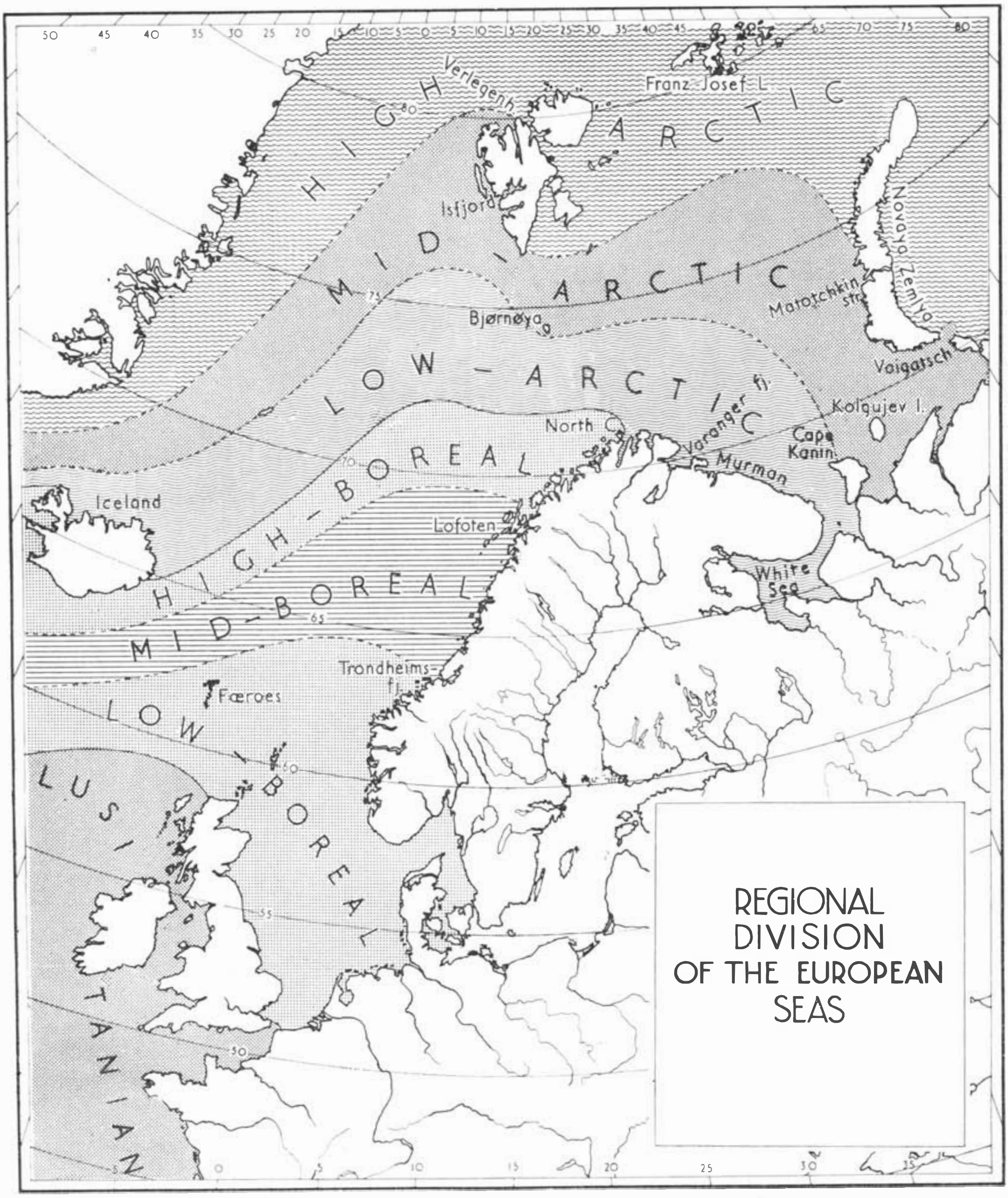


Fig. 5. Zoögeographical division of the northern European seas; the boundaries in the sea have been estimated, taking into consideration the effect of the Gulf Stream. The zoögeographical conditions in the Baltic have not been considered.

fjorden shows that they immigrated there at different times after the latest glaciation, *L. saxatilis* occurring at 45 m a.s.l., whereas *C. islandica* is found up to 31 m a.s.l. In accordance with the present altered regional division of the European seas the distribution of *L. saxatilis* extends into the mid-arctic subregion, whereas *C. islandica* reaches only into the low-arctic one.

The different regions are briefly defined below (fig. 5).

The high-arctic subregion is, on the whole, identical with MADSEN's arctic region (1936, pp. 64—67), and is devoid of littoral mollusks (cf. the high-arctic province of GURJANOVA, SACHS, and USCHAKOV 1925) and *Balanus balanoides*. It comprises the seas east of Vaigatsh and Novaya Zemlya, together with the seas of Franz Josef Land and eastern and north-eastern Spitsbergen, East Greenland north of 66—67°N.lat., i.e. slightly north of Angmagssalik, and West Greenland north of Prøven.

The mid-arctic subregion is delimited to the north by the northern limit of distribution of *Balanus balanoides* (FEYLING-HANSSEN 1953, p. 12). In it are counted parts of the Barents Sea, the west and north coast of Vest-spitsbergen as far east as Verlegenhuken (80°3.7′ N. lat.), the East Greenland coast south of Angmagssalik and the West Greenland coast south of Upernivik, or rather, south of Prøven, 72°25′N.lat. (MADSEN 1940). The southern delimitation of this subregion should be drawn northwestwards from Cape Kanin (GURJANOVA, SACHS, and USCHAKOV 1925); whether north or south of Bjørnøya (Bear Island) cannot be decided until the shore fauna of this island becomes better known. The mid-arctic subregion comprises arctic waters which are slightly influenced by the Gulf Stream.

The low-arctic subregion is distinguished by a rich littoral fauna. It includes the White Sea, the Murman coast, East Finnmarken, the northern and eastern shores of Iceland (ANTEVS 1928, p. 483). The low-arctic subregion comprises arctic waters which are strongly influenced by the Gulf Stream.

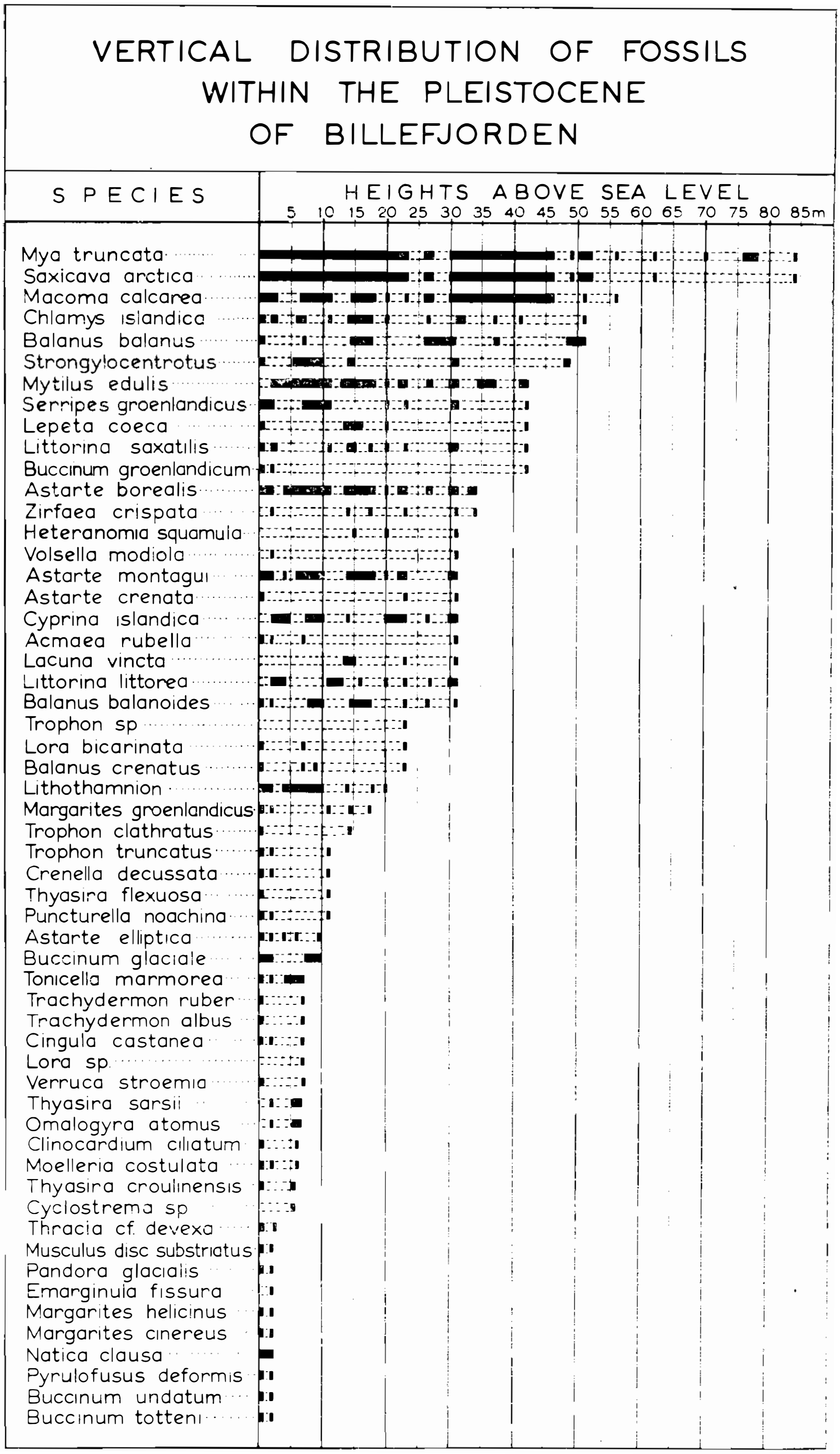
The high-boreal subregion extends from Nordkapp (North Cape) to north of Lofoten, between Vesterålen and Lofoten on the coast of northern Norway, and includes also the southern and western coasts of Iceland (ANTEVS l.c.).

The mid-boreal subregion extends from north of Lofoten to south of Trondheimsfjorden on the Norwegian west coast.

The low-boreal subregion extends from south of Trondheimsfjorden to the eastern part of the English Channel. It includes the North Sea and the Faroes (ANTEVS l.c.).

The lusitanian region comprises the shallow seas south and west of the Scotland-Faroe Ridge and the eastern part of the English Channel, the coasts of France, Portugal and Spain and the Mediterranean.

Table II.


VERTICAL DISTRIBUTION OF FOSSILS WITHIN THE PLEISTOCENE OF BILLEFJORDEN
SPECIES
HEIGHTS ABOVE SEA LEVEL
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85m
Mya truncata
Saxicava arctica
Macoma calcarea
Chlamys islandica
Balanus balanus
Strongylocentrotus
Mytilus edulis
Serripes groenlandicus
Lepeta coeca
Littorina saxatilis
Buccinum groenlandicum
Astarte borealis
Zirfaea crispata
Heteranomia squamula
Volsella modiola
Astarte montagui
Astarte crenata
Cyprina islandica
Acmaea rubella
Lacuna vincta
Littorina littorea
Balanus balanoides
Trophon sp
Lora bicarinata
Balanus crenatus
Lithothamnion
Margarites groenlandicus
Trophon clathratus
Trophon truncatus
Crenella decussata
Thyasira flexuosa
Puncturella noachina
Astarte elliptica
Buccinum glaciale
Tonicella marmorea
Trachydermon ruber
Trachydermon albus
Cingula castanea
Lora sp.
Verruca stroemia
Thyasira sarsii
Omalogyra atomus
Clinocardium ciliatum
Moelleria costulata
Thyasira croulinensis
Cyclostrema sp
Thracia cf. devexa
Musculus disc substriatus
Pandora glacialis
Emarginula fissura
Margarites helicinus
Margarites cinereus
Natica clausa
Pyrulofusus deformis
Buccinum undatum
Buccinum totteni

Vertical Distribution of the Fossils.

The fossil species from the Pleistocene of Billefjorden were found at different heights above present sea level, as illustrated in table II. The results of a survey of all the finds, with recorded elevation, from the region of Inner Isfjorden as a whole have been illustrated in the diagram, table III. Shell collections from deposits which had been disturbed by glacier movements, or had been incorporated in moraines, have been omitted from the diagrams.

The elevations at which the different species were found have been plotted to the right in the diagrams, and the species have been arranged in order of their first appearance in the deposits, i.e. those found at the greatest elevation are listed first. To the left in the diagram, table III, the Recent geographical distribution, as far as known, for the different species has been indicated in accordance with the regional division just proposed.

We have in this way obtained a graphical connection between the Recent geographical distribution of the species and their fossil occurrence in the deposits of the area, i.e. we have a picture of the types of species, from the point of view of thermic requirements, which occur at the different heights within the marine Late-Pleistocene. All species which occur at present in Isfjorden are plotted down to the zero line in the diagram, which makes possible a comparison between the Recent fauna there and the faunas of different ages back in the Late-Pleistocene, as represented by the succession of ancient sea levels.

Only two species occur at the highest levels, viz. *Mya truncata* and *Saxicava arctica,* but later, i.e. at lower levels, *Macoma calcarea* appears, and then more and more species immigrate to the area, though some of them disappear again in fairly Recent times. The majority of them, however, were able to sustain life in the area, even under deterioration of the climate, when once they had arrived there, so that the number of species has, on the whole, been increasing during Post-Glacial time.

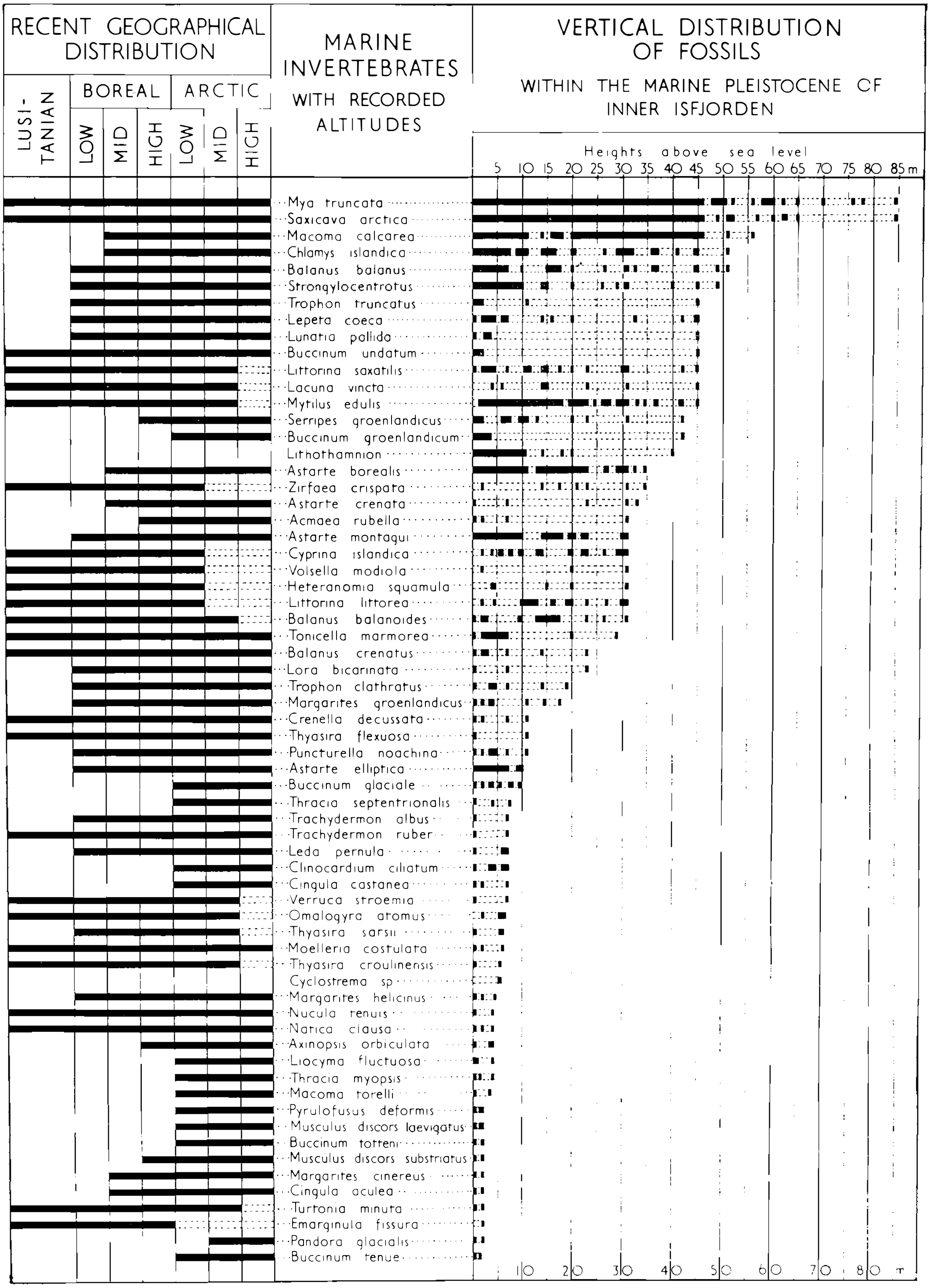
Provided the ecological characters of a species were the same during Late-Pleistocene times as they are to-day, the occurrence of the species at certain heights in the deposits indicates changes in the environmental conditions of Inner Isfjorden during Late-Pleistocene time[1]. It is reasonable to assume that these changes were caused mainly by changes in the climate of the area, so that the more finds, with recorded altitudes, that can be obtained from the area, the more completely the climatic changes can be interpreted from the deposits.

As to zoögeographical types three main components can be distinguished among the 65 species enumerated in the diagram, table III, viz.:

---

[1] The delimitation of this method is discussed on p. 19.

Table III.


RECENT GEOGRAPHICAL DISTRIBUTION
LUSI-TANIAN
BOREAL
ARCTIC
LOW
MID
HIGH
LOW
MID
HIGH
MARINE INVERTEBRATES
WITH RECORDED ALTITUDES
VERTICAL DISTRIBUTION OF FOSSILS
WITHIN THE MARINE PLEISTOCENE OF INNER ISFJORDEN
Heights above sea level
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 m
Mya truncata
Saxicava arctica
Macoma calcarea
Chlamys islandica
Balanus balanus
Strongylocentrotus
Trophon truncatus
Lepeta coeca
Lunatia pallida
Buccinum undatum
Littorina saxatilis
Lacuna vincta
Mytilus edulis
Serripes groenlandicus
Buccinum groenlandicum
Lithothamnion
Astarte borealis
Zirfaea crispata
Astarte crenata
Acmaea rubella
Astarte montagui
Cyprina islandica
Volsella modiola
Heteranomia squamula
Littorina littorea
Balanus balanoides
Tonicella marmorea
Balanus crenatus
Lora bicarinata
Trophon clathratus
Margarites groenlandicus
Crenella decussata
Thyasira flexuosa
Puncturella noachina
Astarte elliptica
Buccinum glaciale
Thracia septentrionalis
Trachydermon albus
Trachydermon ruber
Leda pernula
Clinocardium ciliatum
Cingula castanea
Verruca stroemia
Omalogyra atomus
Thyasira sarsii
Moelleria costulata
Thyasira croulinensis
Cyclostrema sp
Margarites helicinus
Nucula tenuis
Natica clausa
Axinopsis orbiculata
Liocyma fluctuosa
Thracia myopsis
Macoma torelli
Pyrulofusus deformis
Musculus discors laevigatus
Buccinum totteni
Musculus discors substriatus
Margarites cinereus
Cingula aculea
Turtonia minuta
Emarginula fissura
Pandora glacialis
Buccinum tenue
10 20 30 40 50 60 70 80 m

1) A high-arctic (high-arctic—boreal—lusitanian) element, 2) a mid-arctic (mid-arctic—boreal—lusitanian) element and 3) a low-arctic (low-arctic—boreal—lusitanian) element.

The high-arctic element comprises 47 species, 10 of which are distributed southwards, even into the lusitanian region, viz.

Tonicella marmorea	*Saxicava arctica*
Trachydermon ruber	*Mya truncata*
Nucula tenuis	*Moelleria costulata*
Crenella decussata	*Natica clausa*
Thyasira flexuosa	*Buccinum undatum.*

Taken alone these are, therefore, of little value as climatological indicators in the area. 14 of the other species are of an arctic-boreal, and 6 of an arctic-mid-boreal distribution[1]. 5 of the species do not occur south of the high-boreal subregion, viz.

Musculus discors substriatus	*Acmaea rubella*
Axinopsis orbiculata	*Buccinum totteni,*
Serripes groenlandicus	

and 11 of the species do not occur outside the arctic region:

Musculus discors laevigatus	*Cingula castanea*
Clinocardium ciliatum	*Pyrulofusus deformis*
Macoma torelli	*Buccinum groenlandicum*
Liocyma fluctuosa	*Buccinum glaciale*
Thracia septentrionalis	*Buccinum tenue.*
Thracia myopsis	

One species, viz. *Pandora glacialis* is distributed only in the high-arctic and mid-arctic subregions.

The mid-arctic element comprises 9 species, viz.

Mytilus edulis	*Littorina saxatilis*
Thyasira croulinensis	*Omalogyra atomus*
Thyasira sarsii	*Verruca stroemia*
Turtonia minuta	*Balanus balanoides,*
Lacuna vincta	

[1] Hägg (1951, pp. 245, 247) classified *Cingula aculea* as a boreal species, being now extinct at Spitsbergen. Thorson (1944, p. 35) found it to be a panarctic species, and recorded it both from Franz Joseph Fjord in East Greenland and from Spitsbergen.

which at present are distributed northwards into the mid-arctic subregion. Three of these species seem now to be extinct in Spitsbergen waters, viz.

Mytilus edulis *Omalogyra atomus.*
Lacuna vincta

The low-arctic element comprises 6 species, viz.

Heteranomia squamula *Zirfaea crispata*
Volsella modiola *Emarginula fissura*
Cyprina islandica *Littorina littorea,*

though *Emarginula fissura* has probably a boreal distribution. All these species are now extinct in Spitsbergen waters.

Paleoclimatic Evidence of the Fossil Fauna.

At the highest levels, up to 84.5 m a.s.l., only two species were found in the raised deposits, viz.

Saxicava arctica *Mya truncata.*

They are both eurytherme forms and do not indicate anything particular about the climate of the corresponding period. On the other hand, the fact that only two species occurred between 84.5 and 60 m a.s.l. points to rather severe environmental conditions, a view which is supported also by the scarcity of specimens at these levels, in general only some fragments being found.

This period at which *Saxicava arctica* and *Mya truncata* immigrated to Inner Isfjorden, where they were probably the only species present, has here been called the *Late-Glacial Cold period.*

At 56 m a.s.l. *Macoma calcarea* appeared in the deposits (cf. diagram, table III) followed by *Chlamys islandica* and *Balanus balanus* at 51 m and *Strongylocentrotus* cf. *droebachiensis* at 49 m. At present all these extend into the high-arctic subregion, but they occur also southwards in the boreal region. At 45 m a.s.l. 7 additional species were found in the deposits, viz.

Mytilus edulis *Lunatia pallida*
Lepeta coeca *Trophon truncatus*
Lacuna vincta *Buccinum undatum.*
Littorina saxatilis

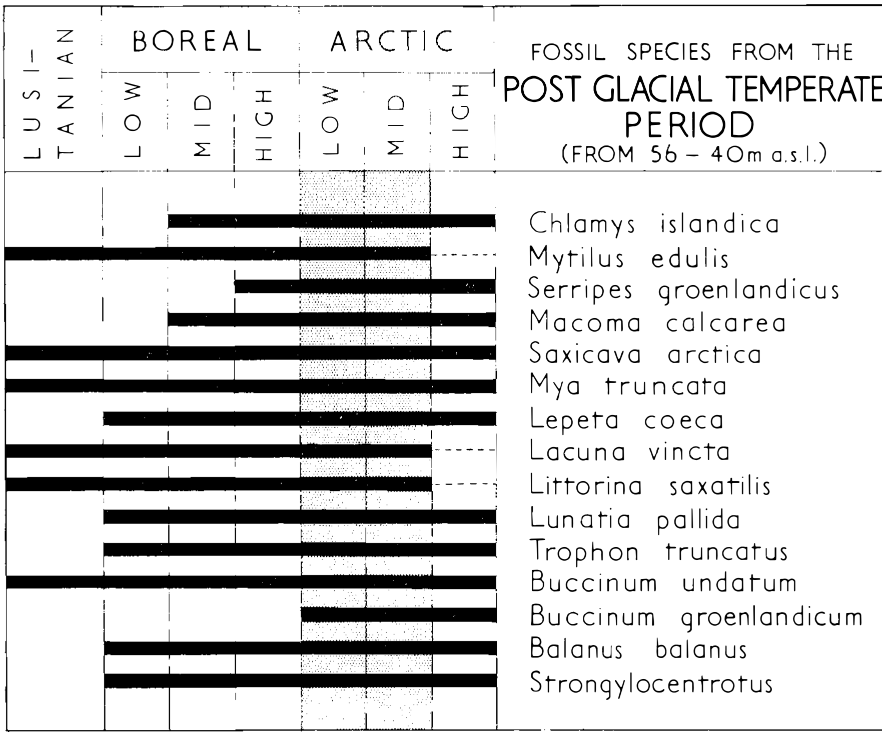


Fig. 6. Fossil species from the Post-Glacial Temperate period of Inner Isfjorden; their Recent geographical distribution indicates that the climate of the Temperate period of the area was no worse than that of the mid-arctic subregion of to-day and, at all events, no better than that of the low-arctic.

Three of these, *Mytilus edulis, Lacuna vincta* and *Littorina saxatilis,* belong to the mid-arctic element in the fossil fauna and indicate a distinct amelioration of the climate. *Littorina saxatilis* lives at present along the west coast, and occasionally also on the north coast of Vestspitsbergen (p. 159), whereas *Mytilus edulis* and *Lacuna vincta* occur at Novaya Zemlya (pp. 132 and 158). The period at which these species immigrated to the area of Inner Isfjorden has here been called the *Post-Glacial Temperate period.*

Serripes groenlandicus and *Buccinum groenlandicum* appeared at 42 m a.s.l., and *Lithothamnion* at 40 m; their immigration to the area should also be referred to this period.

The species from the Post-Glacial Temperate period have been listed in fig. 6 together with their Recent geographical distribution. The Recent distribution of *Mytilus edulis, Lacuna vincta* and *Littorina saxatilis,* and their presence in the deposits, indicates that the climate of the Post-Glacial Temperate period of Inner Isfjorden was no worse than that of the mid-arctic subregion of to-day, as these species could live there. On the other hand, the presence of *Serripes groenlandicus* and, especially, of *Buccinum groenlandi-*

cum indicates that the climatic conditions were still severe, at all events no better than those of the low-arctic subregion of to-day. In other words, the fossil fauna suggests that the Temperate period had a climate slightly more favourable than that prevailing in the area to-day.

At 34.5 m a.s.l. *Astarte borealis* and *Zirfaea crispata* appeared for the first time; at 33 m *Astarte crenata* was found; at 31 m a.s.l. 7 new species occured in the deposits, viz.

Heteranomia squamula	*Acmaea rubella*
Volsella modiola	*Littorina littorea*
Astarte montagui	*Balanus balanoides,*
Cyprina islandica	

and at 29 m a.s.l. was found *Tonicella marmorea.* Among these species are 5 with a low-arctic distribution, viz.

Heteranomia squamula	*Zirfaea crispata*
Volsella modiola	*Littorina littorea.*
Cyprina islandica	

These are now extinct in Spitsbergen as they require a decidedly better climate for their existence than that of the present-day.

The period at which these species first immigrated to the Inner Isfjorden Area after the latest great glaciation has here been called the *Post-Glacial Warm period.*

The species from 34.5 to 29.0 m a.s.l. have been listed in fig. 7 together with their Recent distribution, and as the result it appears that the climate of Inner Isfjorden at the beginning of the Post-Glacial Warm period was no worse than that of the low-arctic subregion of to-day and, any way, no better than that of the high-boreal. It was most probably similar to that prevailing at present at the coasts of Finnmarken and Iceland.

These favourable conditions lasted during continued lowering of the shoreline down to approx. 3 m above present sea level, and a number of new species immigrated to Inner Isfjorden during this period, amongst them being 5 species with a mid-arctic Recent distribution, viz.:

Thyasira croulinensis	*Omalogyra atomus*
Thyasira sarsii	*Verruca stroemia*
Turtonia minuta	

and one with a boreal distribution, viz.

Emarginula fissura.

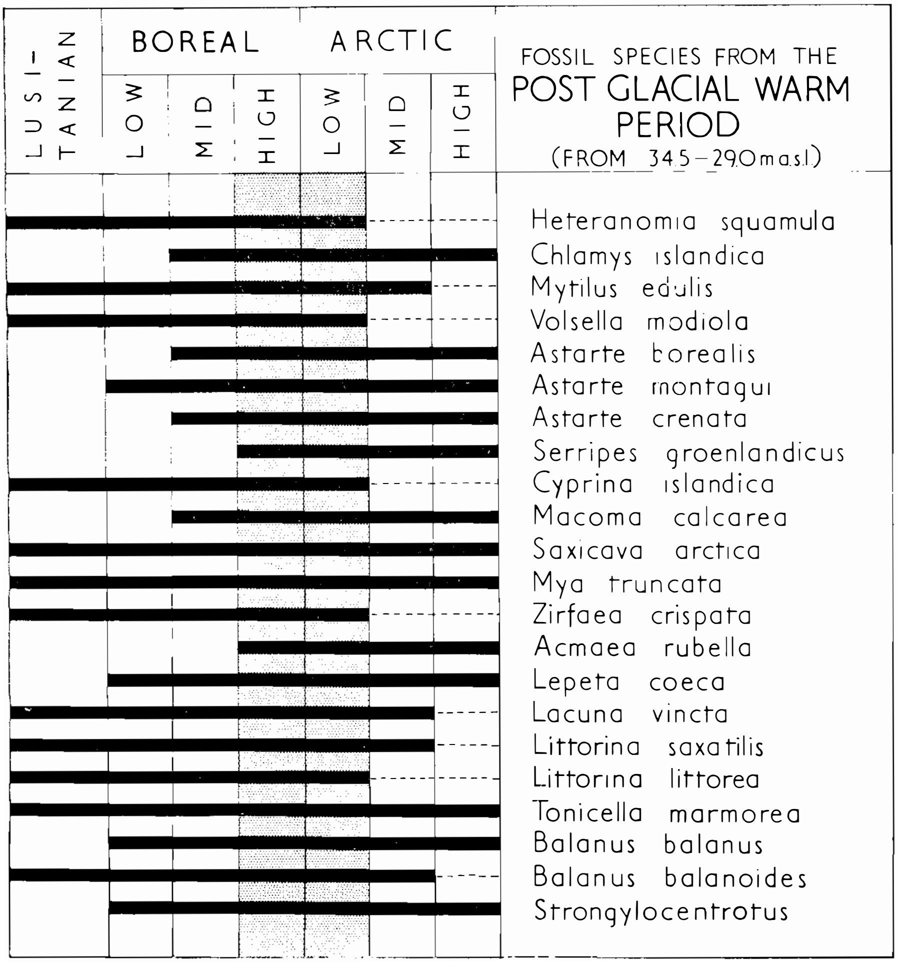


Fig. 7. Fossil species from the earlier part of the Post-Glacial Warm period of Inner Isfjorden; their Recent geographical distribution indicates that the climate of the Warm period of the area was no worse than that of the low-arctic subregion of to-day and, at all events, no better than that of the high-boreal.

All were found from 7 to 2 m a.s.l., but those at lower levels occurred in cliffs of higher terraces or in deposits referable to higher levels. The contemporary shoreline is probably to be found at 7 m a.s.l. or somewhat higher. Further investigations will probably prove these species to be distributed higher up in the deposits from the Post-Glacial Warm period.

Most of the other species which immigrated during the lowering of the shoreline from 30 m to approx. 3 m a.s.l. have an arctic distribution, and some of them do not at present occur outside the arctic region. These are:

Musculus discors laevigatus
Clinocardium ciliatum
Macoma torelli
Liocyma fluctuosa
Thracia septentrionalis
Thracia myopsis
Cingula castanea
Pyrulofusus deformis
Buccinum glaciale.

This suggests that the climatic conditions were probably more favourable at the beginning of the Post-Glacial Warm period than they were later in the same period. Most probably climatic oscillations took place. The occurrence of *Mytilus* beds at 6 to 3 m a.s.l., with abundance of *Mytilus edulis,* indicates the latest slight improvement of the climate before the decisive decline of the Post-Glacial Warm period.

Below a level of approx. 3 m above the present sea level the Warm-period-indicators, the low-arctic and also, partly, the mid-arctic element of the fauna have disappeared from the littoral deposits. The arctic element prevails together with some species of the mid-arctic one, such as:

Thyasira croulinensis
Thyasira sarsii
Turtonia minuta
Littorina saxatilis
Verruca stroemia
Balanus balanoides.

The arctic gastropod *Buccinum tenue* and the pelecypod *Pandora glacialis,* of high-arctic—mid-arctic distribution, probably did not immigrate to the area until Recent times. *Pyrulofusus deformis,* of arctic distribution, probably behaved in the same way (pp. 151, 166).

With regard to the climate of Inner Isfjorden, the present-day conditions may be considered as being slightly less favourable than in the Post-Glacial-Temperate period, when *Mytilus edulis* first immigrated to Spitsbergen after the latest glaciation.

Ancient Sea Levels and their Characteristic Fossils.

The Late-Glacial Cold Period.

The upper marine limit as measured in Billefjorden is situated 90 m a.s.l. It was determined at Ekholmvika (p. 80) where it forms the rear edge of the highest terrace (pl. 5, fig. 3). No fossils were found, but the minerogenic surface material consisted of beach gravel with sand and pebbles. A distinct level in unconsolidated material at the mountain side north of Phantomodden was found to be situated at an altitude of 96 m a.s.l. (pl. 3, fig. 3), but this showed no evidence of marine origin. It was probably the surface of an old lateral moraine (cf. p. 76).

At Kapp Belvedere, on the south side of Sassenfjorden, there is a shoreline cut in bedrock 96.2 m a.s.l.; at Sveltihel, E of Kapp Belvedere, there is one at 85.7 m a.s.l. (FEYLING-HANSSEN and JØRSTAD 1950, p. 41), and in a beautiful illustration of the shore topography at Bjonahamna by STEN DE GEER in 1908 (published in „Guide de l'Excursion au Spitzberg", G. DE GEER 1910a, and reproduced in the present paper, fig. 8) there is marked a level of 89 m a.s.l.

The upper marine limit of Inner Isfjorden was previously considered to be situated at 60—70 m a.s.l. (DE GEER 1910a) or 70—80 m a.s.l. (HÖGBOM 1911).

Below the 90 m level at Ekholmvika in Billefjorden there is a terrace plain sloping from 84.5 to 77.0 m a.s.l. on the surface of which fragments of *Mya truncata* and *Saxicava arctica* were observed. The highest marine level at Teltfjellbekken was found at 76 m a.s.l., and at Gerritelva at 77.8 m a.s.l., *Mya truncata* being observed at these levels in both localities.

The best developed and best preserved feature representative of the next step in the process of recovery occurs on the SW side of Skansbukta, where a large ridged beach plain was found sloping from 73.5 (rear edge) to 62.1 m a.s.l. (front edge). Contemporaneous with this feature is the highest delta terrace at Tjosåsdalen (T and S on fig. 24), 68.0 and 60.6 m a.s.l. with *Saxicava arctica* and *Mya truncata*. The highest level at Alvrekdalen, 62 m a.s.l., probably also belongs to this stage. These terraces correspond to the highest delta terrace of Nøiselva at the Sassen Hut, 65.5—63.1 m a.s.l., and, further, to the terraces at 67.3 and 62.2 m a.s.l. in the same locality. At Sveltihel there was a marine level at 70.5 m a.s.l., in the east side of Blomedalen there was one at 63 m, and at Bjonahamna terraces were found at 70 and 65 m a.s.l. (FEYLING-HANSSEN and JØRSTAD 1950, pp. 40, 41). The same levels are represented by beach ridges 69 m a.s.l. in STEN DE GEER's illustration of the shore topography at Bjonahamna (fig. 8), and GUNNAR HOLMSEN (unpublished) measured a terrace surface 74.5—60.2 m a.s.l. at Bjonahamna.

All these levels, from 90 (96) to approx. 61 m a.s.l., represent stages in the position of the sea level during the Late-Glacial Cold period. The features are very often deformed by solifluction and snow patch erosion at their upper terminations, and by development of structural ground patterns on their surfaces; they have also usually been severely eroded. Fossils are extremely rare at these levels, *Saxicava arctica* and *Mya truncata* being the only species found, and of these only a few shells and some scattered fragments occur.

The scarcity of fossils makes it difficult to deduce anything definite about the climatic conditions of the period, except that this same scarcity points to severe conditions. On the other hand, the occurrence of high shorelines far into Billefjorden suggests an extension of the glaciers not very different from the present. This does not, however, contradict the assumption that the Late-Glacial Cold period had a climate more severe than the present, because in fact the higher sea level constitutes in itself a limiting factor to the advance of glaciers.

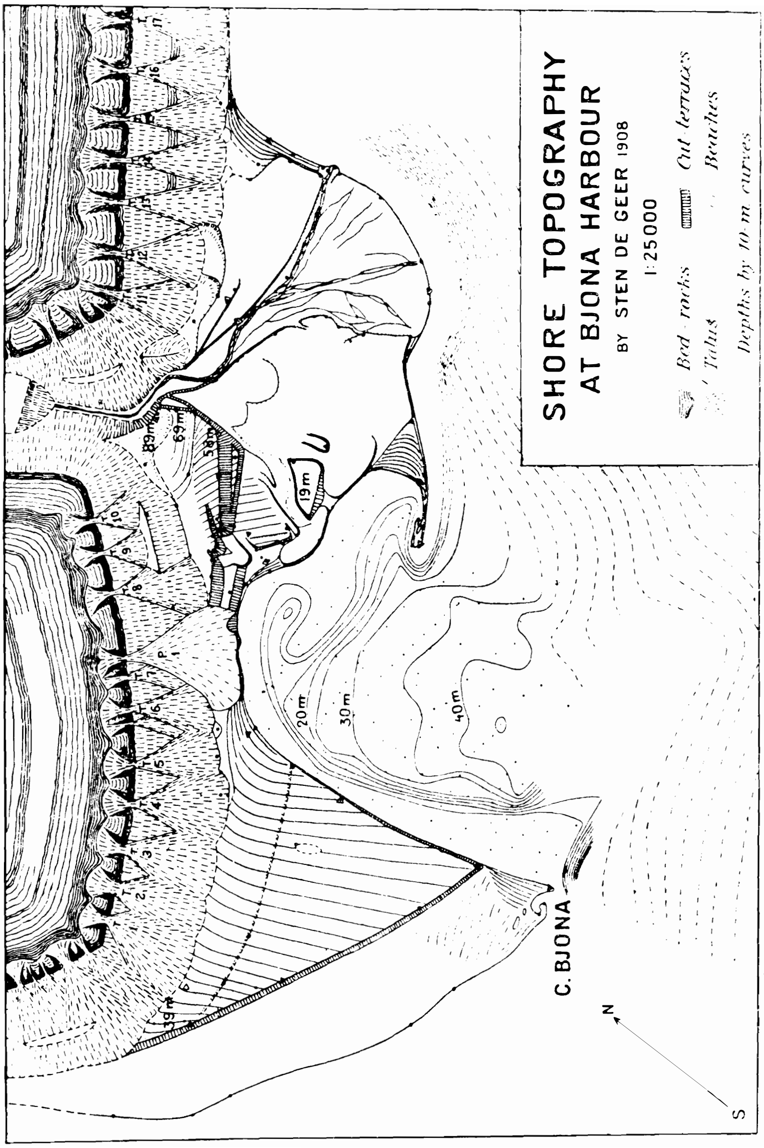


Fig. 8. (From G. de Geer: Guide de l'Excursion au Spitzberg, Stockholm 1910.)

The Post-Glacial Temperate Period.

The dominant littoral features of this period are the ridged beach plains sloping from approx. 60 m a.s.l. to approx. 38—40 m a.s.l., and usually carrying vast numbers of *Mya truncata.*

The large delta terrace at Tjosåsdalen (RPU on fig. 24), sloping from 60.1 to 51.9 m a.s.l., belongs to this period, as does the higher delta terrace of Tyrrelldalen (FGN on fig. 24), sloping from its undetermined apex to 46.2—43.4—35.4 m a.s.l. The *Mya* terrace (D on fig. 24) rising from 36.1 m, and the small terrace (E, fig. 24) at 41.8 m a.s.l. may also be referred to this period. The *Mya* level is beautifully developed between Phantomodden and Ekholmvika (fig. 23), forming the surface of a prominent terrace remnant which, north of Phantomvika, was situated 50.7 m a.s.l. (p. 73 and pl. 3, fig. 3). At Ekholmvika there is a large ridged beach plain sloping from 60 to 43 m a.s.l. (figs. 23 and 30). The corresponding terrace at Teltfjellbekken (figs. 34 and 35) has a surface sloping steeply from approx. 63 to 55.4 m a.s.l., the rear edge of which has been partly obliterated by solifluction. At Gerritelva *Mya* terraces were found at 59.7, 45.0, 40.0 and 36.5 m a.s.l., and at Petuniabukta (pl. 8) there is one at 41.3 m a.s.l. On the west side of Billefjorden corresponding levels were observed at Nidedalen, 54 m a.s.l., *Mya truncata* and *Macoma calcarea* being found in muddy material there at 36.4 m a.s.l.; at Alvrekdalen, 52 m; and at Myadalen (fig. 56), a large terrace there sloping from 51.8 to 41.2 m a.s.l. The lower terraces at 35.5 and 31.8 m a.s.l. of this locality also contained the typical *Mya* fauna of the Temperate period. In Skansdalen (fig. 48) there occurred terrace remnants with *Mya* fauna at 46—44 m a.s.l., and on the southwest side of Skansbukta a marked shoreline at 43.4 m.

These levels correspond to numerous marine levels measured in the Sassen area (FEYLING-HANSSEN and JØRSTAD 1950, p. 40), the most prominent being that at Gipsvika (l.c. p. 32), sloping from 56.5 to 45.0 m a.s.l., from which a large collection of fossils was made. On STEN DE GEER's illustration from Bjonahamna (fig. 8) this level is represented by a ridged beach plain at 58 m a.s.l., and GUNNAR HOLMSEN measured a sloping terrace (probably the same) 61.3—54.8 m a.s.l. (by courtesy from his diary).

The fossil fauna of these terraces is usually dominated by *Mya truncata,* hence they have been called *Mya terraces.*

In the littoral sediments, viz. sand and gravel, *Mya truncata* is associated with *Saxicava arctica, Macoma calcarea, Chlamys islandica* and *Littorina saxatilis;* usually a few valves or some fragments of *Mytilus edulis* occur, as do *Lepeta coeca* and some other species (p. 32), and *Balanus balanus* is not rare.

The average frequencies of the most common species in the littoral part of the *Mya terraces* of Inner Isfjorden are (fig. 9):

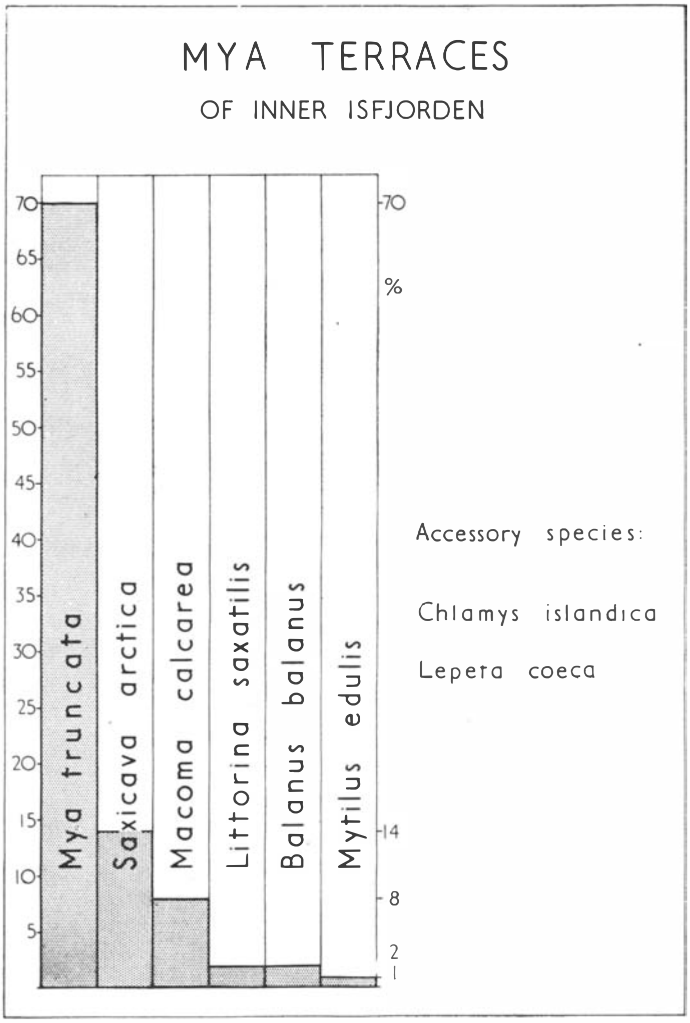


Fig. 9. The average frequency of six characteristic species from the littoral deposits of the *Mya terraces* of the Inner Isfjorden Area.

Mya truncata LINNÉ	70	per cent
Saxicava arctica (LINNÉ)	14	» »
Macoma calcarea (CHEMNITZ)	8	» »
Littorina saxatilis (OLIVI)	2	» »
Balanus balanus (LINNÉ)	2	» »
Mytilus edulis LINNEÉ	1	» »

Variations occur with different environments at the various localities. At Gipsvika (FEYLING-HANSSEN and JØRSTAD 1950, p. 32) the frequencies of *Mya truncata* and *Saxicava arctica* were almost equal.

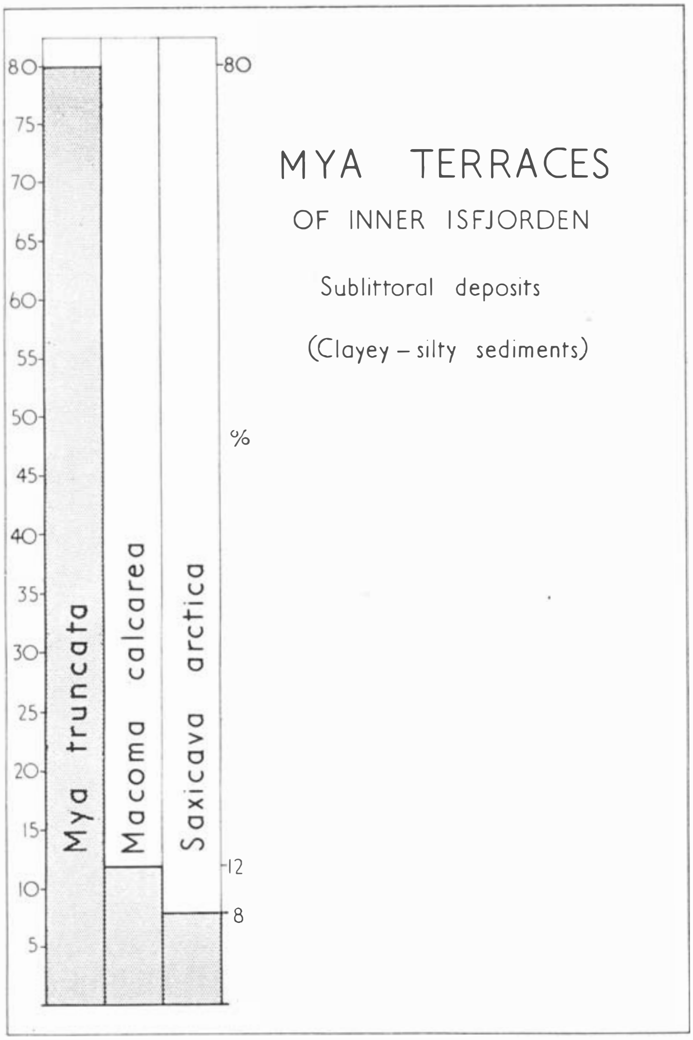


Fig. 10. The average frequency of the three species from the sublittoral deposits of the *Mya terraces* of the Inner Isfjorden Area.

The sublittoral deposits of the *Mya* terraces, clayey and silty sediments, contain a more homogeneous fossil fauna, in general composed only of the three species, *Mya truncata, Saxicava arctica* and *Macoma calcarea*. Their average frequencies in Inner Isfjorden are (fig. 10):

Mya truncata LINNÉ	80	per cent
Macoma calcarea (CHEMNITZ)	12	" "
Saxicava arctica (LINNÉ)	8	" "

The specimens of *Saxicava arctica* and *Mya truncata* were generally large and thick-shelled in these deposits.

The Post-Glacial Warm Period.

The dominant littoral formations of this period are the ridged beach plains sloping from approx. 38—40 m a.s.l. to approx. 3 m a.s.l. with rich fossil faunas dominated by *Astarte borealis*.

Numerous terraces dating from this period were found in Billefjorden as well as in Sassenfjorden, most of them being fragmentary formations with surfaces at various elevations within the height range mentioned. They have all been termed *Astarte terraces*.

The beach plain was found in continuous development at Ekholmvika (p. 76) where its ridge patterned surface slopes from 37.2 m a.s.l. to 12.7 m a.s.l. at the sea cliff. Further to the east it reaches the sea (fig. 30). A similar plain is sloping northwards from Kapp Scott until it reaches present-day sea level at Kapp Napier. No heights were determined at Kapp Scott. At Teltfjellbekken the surface of the plain was situated at 12.5 m a.s.l., but at the mountain side just south of Teltfjellbekken *Astarte* terraces were found at 20 and 32.7 m a.s.l., the latter having its rear edge 37—38 m a.s.l. (fig. 35). At Petuniabukta the corresponding terrace was also fragmentary, sloping from 34.5 to 29.7 m a.s.l. At Alvrekdalen a large ridged beach plain slopes northwestward from 37.8 to 26.5 m a.s.l. (p. 106). Alvrekelva has carried away a great part of the deposits, but a continuation of the beach plain is found on the northeast side of the river, at Narveneset (p. 106) where its surface slopes from 22 m and is cut by erosion on all sides. These features constitute a beautiful counterpart to the *Astarte* plain at Ekholmvika across the fjord. On the northeast side of Skansbukta there is a terrace complex from the Post-Glacial Warm period with a highest level of 37.4 m a.s.l.

The most magnificent littoral formation from the Post-Glacial Warm period within the Inner Isfjorden Area is, however, the triangular ridged beach plain at Bjonapynten on the north side of the entrance to Tempelfjorden. It is beautifully illustrated by STEN DE GEER (fig. 8, cf. also airphoto, pl. 1). S. DE GEER determined the elevation of the highest point of the plain to be 39 m a.s.l. (FEYLING-HANSSEN and JØRSTAD 1950, p. 40, found it to be 40 m a.s.l.) It slopes towards the ESE with curved beach ridges at approx. right angles to this direction, reaching sea level at the inner part of Bjonahamna[1].

The formation of marine features, both of progradation and degradation, can take place at any time whatsoever during a period of recovery of the land mass, where and when depending on local factors at the different places along the coast, e.g. wind, waves, exposure, currents, source and transportation of sediments. Thus retrograding or prograding starts whenever these conditions permit. On the other hand, most raised features will be found at

[1] At the very point of Bjonapynten progradation has taken place between the years 1908 (S. DE GEER) and 1936 (airphoto).

those levels where the shoreline paused, or where its negative shift was retarded, for longer periods.

In the slope of the uninterrupted beach plains (p. 47) we have a record of the movement of the shoreline during the Post-Glacial Warm period. From the height measurements of the plains at Ekholmvika and Brucebyen (figs. 31 and 38) it appears that the smallest slopes occur at approx. 20 m, between 15 and 10 m, at 7—6 m, and at 3—2 m a.s.l., the negative shift of the shoreline being retarded at these levels. Consequently numerous raised marine features are found at about these altitudes.

At Anservika there is a plain sloping from 14.8 to 9.7 m a.s.l., whilst at Phantomvika there is one at 13.4 m and another sloping from 10.1 to 8.2 m a.s.l. The lower delta terrace at the mouth of Tyrrellelva, Phantomvika (KJLMH on fig. 24), sloping from 31.4 to 7.8 m a.s.l., was also formed during this period. The benches in the cliff of the *Mya* terrace north of Phantomvika (fig. 25), at 32.3—30.5 and at 20.3—15.3 m a.s.l., where eroded during parts of the Warm period, as was the small *Astarte* terrace at 13.5 m a.s.l. at Ekholmvika (fig. 30). At Gerritelva *Astarte* terraces were found at 30.1, 23.2, 18.0, and at 14.0, 11.3 and 6.5 m a.s.l., and at Petuniabukta there is a terrace at 8 m a.s.l. A Swedish expedition found Warm period deposits 20 m a.s.l. at Mimerbukta. At Nidedalen there is a succession of coarse beach ridges from 27.2 m down to Recent sea level on the north side of the river, and a beach plain at approx. 27 m a.s.l. on the south side; another terrace was found at 18.6 m a.s.l. and one at 12.2 m. At Narveneset a terrace has been cut into the remnant of the large beach plain, previously mentioned, at 14.7 m a.s.l., and a similar feature was found 16.5 m a.s.l. at Alvrekdalen. At Brimerpynten there is one terrace surface sloping from 28.1 to 26.2 m a.s.l., and another at 24.2—17.6 m a.s.l. Indistinct marine features on the northeast side of Skansbukta are situated at 24.5 and at 18.3—13.8 m a.s.l. (fig. 51, p. 110), and on the southwest side of Skansbukta there is one terrace surface sloping from 23.7 to 20.4 m a.s.l., and another sloping from 18.4 to 14.8 m a.s.l. Beach ridges were found there at 8.1, 6.7, and 4.6 m a.s.l. At Rundodden Light there is a beach plain at approx. 7 m a.s.l. sloping toward the sea cliff which is between 3 and 5 m high there.

In the Sassen area terraces from the Post-Glacial Warm period were found at 32.9—31.5 m, 29.5—25.7 m, 24 m, 22.3—19.6 m, 14 m, 10.5—9.2 m, and 8.3—5.3 m a.s.l. (FEYLING-HANSSEN and JØRSTAD 1950, pp. 41, 42).

The fossil fauna of the littoral deposits between 38—40 and 6 m a.s.l. is characterised by the dominent occurrence of *Astarte borealis* and the simultaneous appearance of a low-arctic faunal element now extinct in Svalbard. Such terraces have, therefore, here been termed *Astarte terraces*. They have been further divided into *Upper Astarte terraces* from 40 to 17 m a.s.l., and *Lower Astarte terraces,* from 17 to 6 m a.s.l. (These terms were used with a different delimitation by FEYLING-HANSSEN and JØRSTAD 1950).

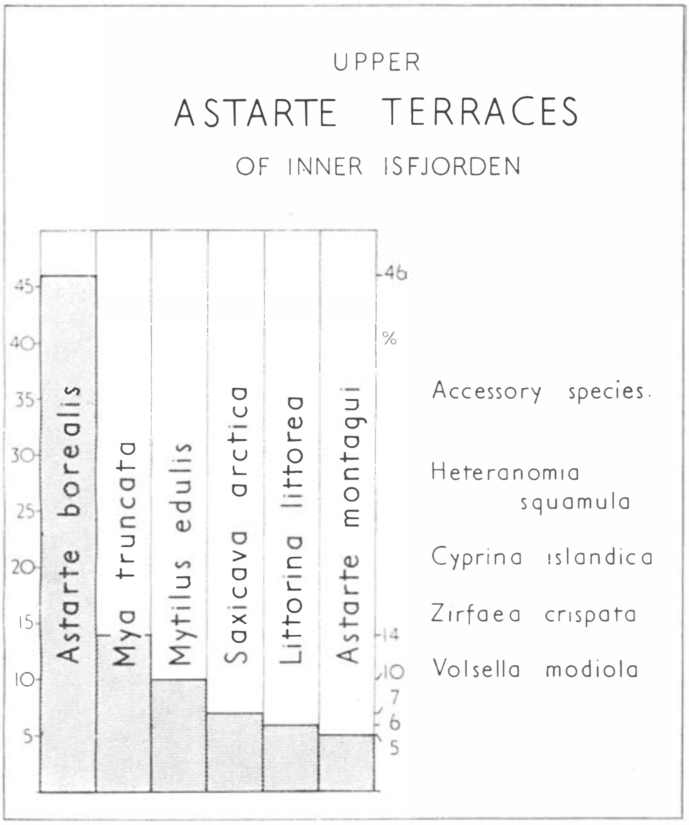


Fig. 11. The average frequency of six characteristic species from the *Upper Astarte terraces* of the Inner Isfjorden Area.

27 species were found in the *Upper Astarte terraces* of Inner Isfjorden (table III), *Astarte borealis* dominating all samples from these parts of the deposits except two from Petuniabukta, 31 m a.s.l., one of which was dominated by *Mya truncata* and the other by *Mytilus edulis*. The Warm period deposits on the northeast side of Skansbukta also contained more specimens of *Mya truncata* than of *Astarte borealis*.

The average frequencies of the most common and most characteristic species from the *Upper Astarte terraces* of Inner Isfjorden are (fig. 11):

Astarte borealis (CHEMNITZ)	46	per cent
Mya truncata LINNÉ	14	" "
Mytilus edulis LINNÉ	10	" "
Saxicava arctica (LINNÉ)	7	" "
Littorina littorea (LINNÉ)	6	" "
Astarte montagui (DILLWYN)	5	" "

Among the accessory species were the Warm period indicators: *Heteranomia squamula, Cyprina islandica, Zirfaea crispata* and *Volsella modiola. Heteranomia squamula* was quite common in the deposits at Petuniabukta (8 per cent), otherwise the average frequencies of these species were less than 1 per cent. *Lacuna vincta, Littorina saxatilis* and *Balanus balanoides* had an intermittent occurrence in the *Upper Astarte terraces.*

In the *Lower Astarte terraces* of Inner Isfjorden, found at levels between 17 and 6 m a.s.l., more species have been added to the fossil fauna, the total number of marine invertebrates (exclusive of Foraminifera, Ostracoda and Polychaeta) recorded from these deposits now being 37.

Astarte borealis was predominant in all samples from the *Lower Astarte terraces,* accounting for 49—96 per cent of the faunas. *Astarte montagui* and *Mytilus edulis* were common, and *Saxicava arctica* and *Mya truncata* occurred in most samples. A few valves of *Astarte elliptica* were found in some of them.

The average frequencies of these six species from the *Lower Astarte terraces* of Inner Isfjorden are (fig. 12):

Astarte borealis (CHEMNITZ)	70 per cent
Astarte montagui (DILLWYN)	9 » »
Mytilus edulis LINNÉ	8 » »
Saxicava arctica (LINNÉ)	6 » »
Mya truncata LINNÉ	4 » »
Astarte elliptica (BROWN)	1 » »

Among the accessory species were *Chlamys islandica, Cyprina islandica, Macoma calcarea* and *Littorina saxatilis.*

The *Lithothamnion silt* underlies the littoral deposits of the Lower *Astarte* terraces (fig. 35, p. 84). It is a sublittoral deposit containing vast quantities of *Lithothamnion,* together with numerous Foraminifera and Ostracoda, and was found from 14 m a.s.l. (Teltfjellbekken) down to present sea level (Sentabukta). Only three samples of this sediment were treated, namely from Teltfjellbekken, Brucebyen and Sentabukta. *Astarte borealis* dominated the fauna of the sample from Sentabukta, 2 m a.s.l. (p. 91); *Mytilus edulis, Saxicava arctica, Astarte montagui* and *Astarte elliptica* were common, and numerous small gastropods occurred, among them being *Emarginula fissura* and *Omalogyra atomus. Verruca stroemia* occurred in the sample from Sørdammen, Brucebyen.

A similar sediment, with great masses of *Lithothamnion,* was found, at 7.0—4.6 m a.s.l., on the south side of Nøiselva at the Sassen Hut (FEYLING-HANSSEN and JØRSTAD 1950, pp. 66—67), *Astarte elliptica* being very frequent in two of the samples from that deposit.

Another deposit from this period was the clayey-silty sediment, 6—0 m a.s.l., at Ledalen (l.c. p. 64), containing numerous large valves of *Cyprina islandica.*

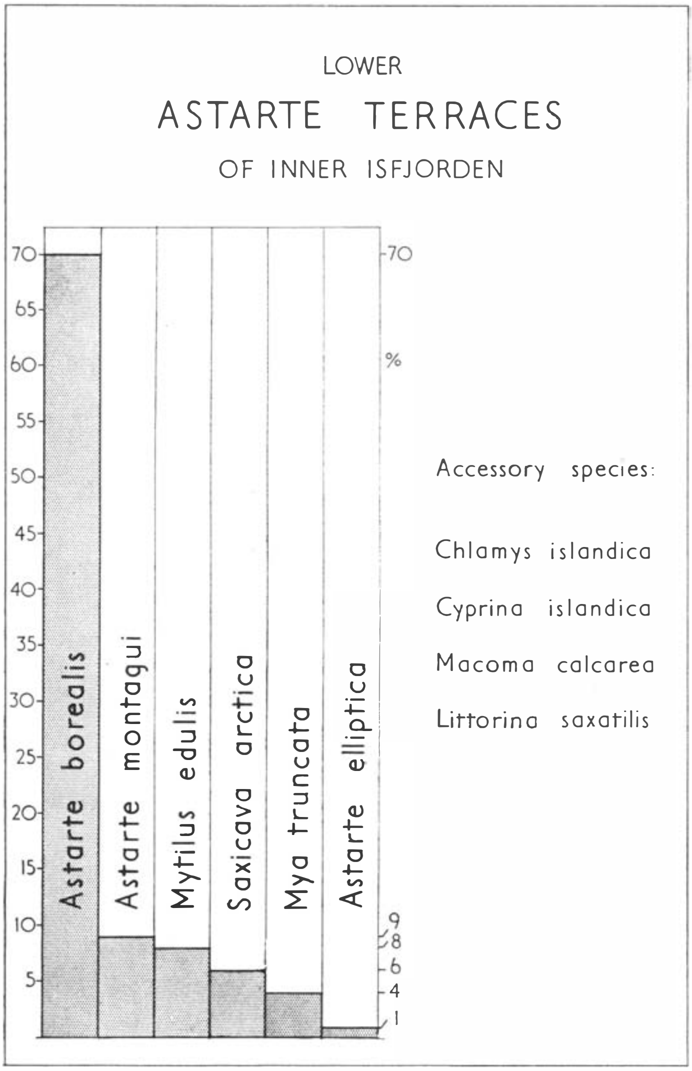


Fig. 12. The average frequency of six characteristic species from the *Lower Astarte terraces* of the Inner Isfjorden Area.

Between 6 and 3 m a.s.l. there occur some littoral features which have been termed *Mytilus terraces,* because *Mytilus edulis* dominates the fauna in most of them. At Mytilusbekken there is a terrace 5.8 m a.s.l., at Ekholmvika one at 4.3 m, at Petuniabukta 4.3 m, at Nidedalen 4.8 m, and at Asvindalen 6.2 m a.s.l. In the Sassen area similar terraces were found at 3.6, 3.0, 5.2, 3.9, and 3.2 m a.s.l.

Mytilus edulis dominated the fauna of most of these formations, accounting for 32.1—93.9 per cent. A sample from Brucebyen and one from

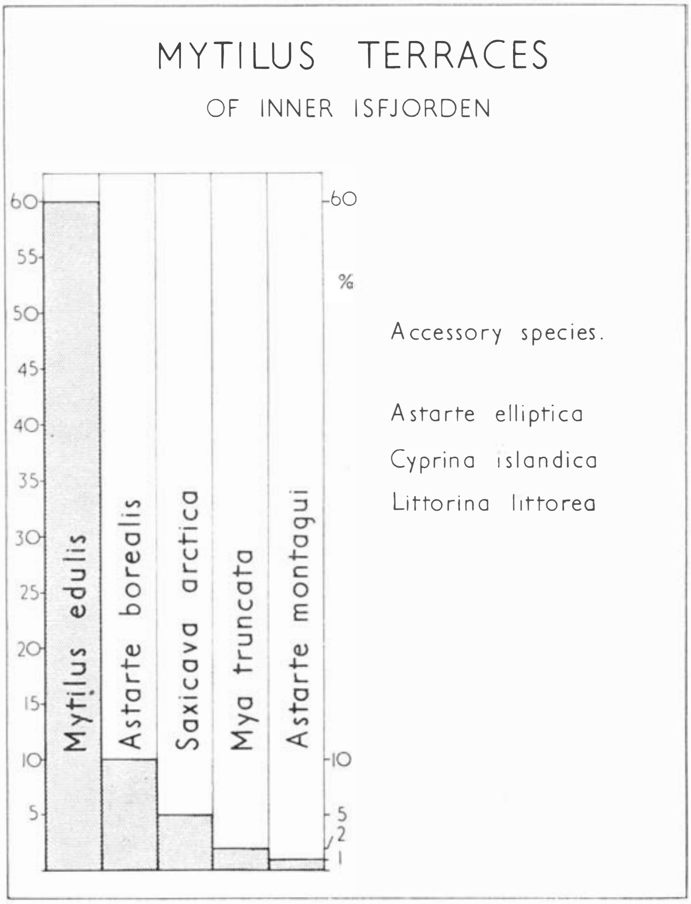


Fig. 13. The average frequency of five characteristic species from the *Mytilus terraces* of the Inner Isfjorden Area.

Petuniabukta contained more specimens of *Astarte borealis* than of *Mytilus edulis*. *Saxicava arctica* and *Mya truncata* occurred in most of the samples and *Astarte montagui* in some.

The average frequencies of these five species in the *Mytilus terraces* of Inner Isfjorden were found to be (fig. 13):

Mytilus edulis LINNÉ	60	per cent
Astarte borealis (CHEMNITZ)	10	» »
Saxicava arctica (LINNÉ)	5	» »
Mya truncata LINNÉ	2	» »
Astarte montagui (DILLWYN)	1	» »

An intermittent occurrence had *Astarte elliptica, Cyprina islandica* and *Littorina littorea.*

There are no sudden changes in the composition of the fauna from littoral deposits at different levels within the sequence of the Post-Glacial Warm period. The dominance of *Astarte borealis* is, on the average, most pronounced in the middle parts of the deposits; the frequency of *Mya truncata* decreases towards the lower levels, and *Mytilus edulis* becomes dominant in most of the deposits from the youngest part of the period. An illustration of the relative change in frequency of *Mytilus edulis* and *Astarte borealis* from the lower part of the sloping beach plain at Brucebyen (p. 88) is given in fig. 40. Four collections were made from the sea cliff and surface of this plain, I at 2.3 m, II at 4.0 m, III at 6.0 m, and IV at 7—8 m a.s.l. The frequency of *Mytilus edulis* was greatest in sample II, 4 m a.s.l.

The Sub-Recent Period.

Raised littoral deposits below 3 m a.s.l. were found at Brucebyen and at Skansbukta. At both sides of Skansbukta beach plains with low ridges were developed at 2.0 and 2.2 m a.s.l., their surfaces sloping very gently inland (p. 108). In the Sassen area low beach plains were found at Sveltihel, 2.3 m a.s.l., and at Gipsvika, 1.9 m a.s.l. In both localities the height of the crest of the Recent storm ridge excedes that of the plains behind.

At these low levels the Warm-period-indicators have disappeared from the fossil fauna. Even *Mytilus edulis* seems to have abandoned the Spitsbergen waters at the corresponding time. The scattered and often worn fragments of this species which may be found at these lower levels have most probably been washed down from *Mytilus* deposits above. The presence of two fragments of *Cyprina islandica* on the low beach plain on the southwest side of Skansbukta is explained in the same way. Some of the gastropods on the low plain on the northeast side of Skansbukta have been washed up unto the plain from the shore in Recent times (p. 108).

This period, during which a severe deterioration of the climate took place, has been termed the *Sub-Recent period.* It involved a sudden change in the composition of the fauna, and extends into Recent times. *Astarte borealis* and *Saxicava arctica* are very common in these low deposits, and *Serripes groenlandicus* is more frequent than in older formations.

Movements of the Shoreline.

The main movement of the shoreline in Billefjorden, and at Inner Isfjorden as a whole, during Late- and Post-Glacial time has been a negative shift from the upper marine limit, 90—96 m a.s.l., down to Recent sea level. This shift took place at a variable rate, sometimes faster, sometimes slower;

standstills occurred for shorter periods and there were even some slight positive shifts. The trend of the recovery is beautifully illustrated in the sloping ridged beach plains (pp. 79, 88), the beach ridges representing successive stages in the position of the shoreline. Retardations or slight positive shifts have supported the formation of ponds and lakelets in the larger swales (cf. Brucebyen, p. 87).

There is always a break between the beach plains of the Post-Glacial Temperate and the Post-Glacial Warm period. Nowhere within Billefjorden or in the Sassen area the beach plains of the Temperate period pass conformably into those of the Warm period; the latter are always developed as new formations, and are nowhere found as continuations of the first.

A similar break occurs in the fauna of the two periods, there is a sudden change in its composition at the border between the Temperate and the Warm periods. A pure sample could always with certainty be referred to one of the periods, and would never represent a little of each.

These conditions might be explained as resulting from a positive movement of the shoreline, interrupting its general negative shift, at the transition between the Post-Glacial Temperate and the Post-Glacial Warm period, or rather, after the beginning of the Post-Glacial Warm period, as the amelioration of the climate was probably able to cause a eustatic rise of sea level sufficiently great to overcome the isostatic rise of the land mass. If there had been an uninterrupted, continuous, negative shift of the shoreline at the transition between the two periods the beach plains of the Temperate period should be expected, at least at some places, to continue into the beach plains of the Warm period. The occurrence of such a transgression within the Post-Glacial of Inner Isfjorden has, however, not been proved by any certain finding[1].

At present sea level there seems to be evidence of a positive shift of the shoreline in Recent times. At the base of the western sea cliff of the large *Astarte* plain of Brucebyen (p. 87) a lower plain has been formed in Sub-Recent and Recent times. As described on p. 88, height measurements of the beach ridges on this plain (figs. 34 and 39) revealed that the later ridges are higher than the preceding ones, the height of the modern ridge being 1.8 m a.s.l. whereas the heights of the crests of the older ridges decreased landwards to approx. 1 m a.s.l. Similar conditions were found at Kapp Napier (p. 88) where the general slope of the large Brucebyen beach

---

[1] The upper limit of the *Astarte* plains, of the Post-Glacial Warm period, was found to be approx. 37.5—38 m in Billefjorden (Ekholmvika, Teltfjellbekken, Alvrekdalen) and 39—40 m at Bjonapynten. In some places littoral deposits from the Temperate period (*Mya* terraces) were found below these levels, viz. 35.4 and 36.1 m a.s.l. at Phantomvika, 36.5 m at Gerritelva, 35.5 and probably 31.8 m at Myadalen. These may probably represent coarse-grained sublittoral extensions of the beach plains, their formation depending upon local factors during the sedimentation.

plain lessens towards modern sea level and from approx. 1 m a.s.l. is transformed into a rise towards the Recent beach ridge. The difference in altitudes between the Recent ridge and the lower of the older ones was there 0.5 m. These conditions are again repeated at Skansbukta where the lowest ridged beach plains, on both sides of the bay, slope gently landwards (p. 108). The later beach ridges thus seem to be formed at successively higher sea levels, suggesting a positive shift of the shoreline to have been taking place in Recent times. Considering the amount of progradation since this lowest position of the sea level and comparing it with the previous progradation, this positive shift can only have lasted for a short period compared with the duration of the preceding Post-Glacial Warm period.

A few beach ridges exhibiting a landward decrease in crest altitude do not necessarily indicate coastal submergence or positive shift of the shoreline. Successive beach ridges normally differ from each other in altitude of crest line because the factors involved in their formation are variable, e.g. progradation of the beach may lead to greater exposure to wind and waves, supporting the formation of higher ridges. The greater weathering to which the older ridges have been subjected may probably constitute another cause of normal decrease in altitude in a landward direction (JOHNSON 1919).

On the other hand, the beaches of Kapp Napier and along the line B—B on fig. 34 prograde into sheltered waters, and the effect of weathering in the course of some hundred years must be very small. The great porosity of the beach material makes the ridges very resistant also to deformation by solifluction (BALCHIN 1941)[1].

HOEL (1910) assumed that the shoreline of Svalbard has remained stationary for a long time along the present coast (cf. DE GEER 1910a, HÖGBOM 1911), and in the numerous lagoons he recognized evidence of a Recent positive oscillation in the movement of the shoreline. VOGT (1927) summed up various formations and phenomena which he considered to be indicative of a Recent subsidence of the Spitsbergen land mass[2]. According to VOGT (1927) this subsidence was caused by the increased weight of the ice mass after the Post-Glacial mild period.

The glaciers are very sensitive to climatic variations. They undergo long-period oscillations controlled by fluctuations in the climate[3]. At the end

---

[1] Several large blocks have fallen from the mountain side down on to the beach plain of Bjonapynten. Some of them have rolled far out on the plain having left distinct traces of their paths on the surface of the plain. These are still discernible even on airphotos (pl. 1).

[2] In the present low position of ruins of oil-cookeries from the whaling industri in the 17th century VOGT (1932) found another evidence of subsidence. FEYLING-HANSSEN (1954) explained their present position as a result of wave erosion and shore drifting.

[3] Beside these climatically controlled oscillations it is known that probably all Spitsbergen glaciers „are subject to spasmodic fits of rapid and tumultuous advance, alternating with longer intervals of retreat and ablation during which they become relatively stag-

of the Post-Glacial Warm period, approx. 2500 years ago, a general advance of glaciers took place (AHLMANN 1954)[1]. The accumulation of snow and the consequent advance of glaciers retarded the general elevation which has been going on ever since the ice cover of the latest glaciation vanished, and probably caused a slight subsidence. Due to the inertia of the land mass this retardation was not asserted until some time after the glacial advance, and it lasted through parts of the subsequent period of amelioration.

In consequence of the climatic amelioration in Recent times, a regional recession of the glaciers has been taking place for approx. 200 years, having been especially pronounced during the latest 50 years (AHLMANN 1954). The recession of the glaciers in Svalbard has been even greater than in Scandinavia during this period (HOEL 1953; cf. i.a. HARLAND 1952, HEINTZ 1953). The consequence of the improving climate is a eustatic rise of sea level caused by the surplus of water being carried to the oceans.

Both an isostatic and a eustatic component are involved in these processes. The isostatic retardation of the general elevation of the land mass and the eustatic rise of sea level operate almost simultaneously, thus mutually emphasising their effect which is a positive shift of the shoreline. These conditions will last until the new climate is stabilized. The rise of sea level will then come to an end, and the isostatic component will once again overtake the eustatic.

Correlation.

Vestspitsbergen.

Ever since the first scientific observations of the marine Pleistocene of Svalbard at the end of the 19th and the beginning of the 20th century, the occurrence of molluskan shells of species no longer living in Spitsbergen waters was recognized (BLOMSTRAND 1864, CHYDENIUS 1865, HEER 1870, KNIPOWITSCH 1902 III, 1903 IV, HOEL 1910, ELTON and BADEN-POWELL 1934). Whereas HEER (1870) considered the associated warm period to be of Inter-Glacial age, NORDENSKIÖLD (1874—1875, p. 372) and NATHORST (1883, p. 66) found it to be of Post-Glacial age. DE GEER (1896) regarded the presence of *Mytilus edulis* in Spitsbergen to be contemporaneous with

nant." (LAMPLUGH 1911, l.c. p. 221; cf. also DE GEER 1910 a and b). Such individual oscillations of the glaciers had already been recognized by MATTHES (1900, pp. 181—190). The accumulated load of several years' snowfall „may be required to overcome the rigidity of the ice; but when the limit is overpassed, a phase of active movement is started, and may go on vigorously until the extra load is wholly discharged and the stage of quiescence is again reached." (LAMPLUGH 1911, l.c.). Sefströmbreen in Ekmanfjorden has provided excellent demonstrations of this kind of oscillations (DE GEER 1910a, LAMPLUGH 1911, GRIPP 1929).

[1] Some of the shelly moraines with Warm period species (HOEL 1914, FEYLING-HANSSEN and JØRSTAD 1950) should probably be ascribed to this general advance.

STRATIGRAPHY OF INNER ISFJORDEN

PERIOD	FORMATION: LITTORAL	FORMATION: SUBLITTORAL	CHARACTERISTIC FOSSILS: LITTORAL	CHARACTERISTIC FOSSILS: SUBLITTORAL	SHORE LINE m a.s.l.
SUB-RECENT	LOWEST TERRACES		Astarte, Serripes		
POST-GLACIAL WARM PERIOD	MYTILUS TERRACES		Mytilus edulis		5
	LOWER ASTARTE TERRACES UPPER ASTARTE TERRACES	LITHOTHAMNION SILT	Astarte borealis Heteranomia squamula Cyprina islandica Zirfaea crispata Littorina littorea	Astarte elliptica Cyprina islandica Lithothamnion	10, 15, 20, 25, 30, 35, 40
POST-GLACIAL TEMPERATE PERIOD	MYA TERRACES	MYA SILT	Mya truncata Saxicava arctica Chlamys islandica Mytilus edulis Littorina saxatilis	Mya truncata Macoma calcarea Saxicava arctica	45, 50, 55, 60
LATE-GLACIAL COLD PERIOD	SCATTERED MYA and SAXICAVA		SCATTERED Mya truncata and Saxicava arctica		65, 70, 75, 80, 85, 90

Fig. 14.

the neolithic man in Scandinavia, and GRØNLIE (1924, p. 112) and NOE-NYGAARD (1932, p. 20) accordingly correlated the appearance of this species with the *Tapes* period in Scandinavia.

ANDERSSON (1910) correlated the climatic optimum of Svalbard with the later part of the *Ancylus* time in Sweden (cf. also BALCHIN 1941, p. 375). BADEN-POWELL (1939, p. 345) found it possible that there is a „cold" type of raised beach fauna in Spitsbergen as well as a „warm" type, and HÖGBOM (1913) considered the warm period („the *Mytilus* period") to have been a late portion of the Post-Glacial age.

HOEL (1914), on the contrary, concluded that the whole epoch during which the raised beaches were formed had a more genial climate than the present. He considered the marine limit to be 60—70 m above present sea level, and the fossil fauna through the whole series of subsequent levels to have had a warmer character than the present, in consequence, suggesting a great difference between the development of climatic circumstances in Svalbard and in Scandinavia. He assumed, however, that the period of raised fossil-bearing beaches in Spitsbergen could probably be correlated with the periods of *Mactra* and *Tapes* in southern Norway. KULLING (KULLING and AHLMANN 1936) assumed, in accordance with HOEL (l.c.), that the climate of Spitsbergen was probably more favourable during a greater part of the Post-Glacial period than at the present day, or that more favourable periods alternated with less favourable ones.

The stratigraphical division of the Late-Pleistocene of Inner Isfjorden (Billefjorden and the Sassen area) resulting from the present research have been illustrated in fig. 14. The Late-Glacial Cold period is very poor in fossils, *Mya truncata* and *Saxicava arctica* being the only species found, the Post-Glacial Temperate period is characterized by the first appearance of *Mytilus edulis* and *Littorina saxatilis,* and the Post-Glacial Warm period by the appearance of several species of the low-arctic element (p. 31) which are now extinct in Spitsbergen waters.

This scheme, which was erected upon observations made in the Inner Isfjorden Area, is, in its present form, restricted to this area ,but future investigations may probably prove it to be of some service in the Late-Pleistocene geology of Vestspitsbergen as a whole. DINELEY (1954) found *Mytilus* terraces, with dominance of *Mytilus edulis* in the included fauna, between 3.6 and 6.4 m a.s.l. near Müllerneset and around Eidembukta, Forlandsundet on the west coast. He found *Mytilus edulis* and *Astarte borealis* up to 30—36 m a.s.l. in marine deposits there, but only *Mya truncata* and *Saxicava arctica* above this level.

West Greenland.

Investigations by JENSEN and HARDER in West Greenland resulted in the establishment of a stratigraphic division for the marine Pleistocene of Orpigsoq and Sydostbugten. This scheme was presented in a preliminary report of 1910, and appeared as follows:

Horizon	Orpigsoq	Sydostbugten
F	Beach gravel with *Zirfaea*	———
E	Clayey sand with *Chlamys islandica*	———
D	Clay with *Portlandia arctica*	Clay with *Portlandia arctica*
C	Clay with *Mya truncata ovata*	Sandy clay with *Balanus hameri* etc.
B	Fine clayey sand with *Balanus hameri*	———
A	Glacial formations	Sandy clay with *Portlandia arctica*

By further preparation of HARDER's and JENSEN's notes and collections, this scheme was elaborated and partly altered by JENSEN and LAURSEN (HARDER †, JENSEN, and LAURSEN 1946, p. 94) the modified form being:

Horizon	Orpigsoq	Kangersuneq	Sydostbugten	Lerbugten
F	Beach gravel with *Zirfaea crispata*	Clay with *Mytilus edulis*	——	?Clay and sand with *Mytilus edulis*
E	Clayey sand with *Chlamys islandica*	Sediments with *Chlamys islandica*	——	?Clay and sand with *Chlamys islandica*
D	Clay with *Portlandia arctica*	Clay with *Portlandia arctica*	Clay with *Portlandia arctica*	Clay with *Portlandia arctica*
C	Clay with *Mya truncata ovata*	——	——	——
B	Clayey sand with *Balanus hameri*	Clayey sand with *Macoma calcarea*	Sandy clay with *Balanus hameri*	——
A	Delta sediments Clay with *Portlandia arctica*	——	Sandy clay with *Portlandia arctica*	——

In his important work on the stratigraphy of the marine Pleistocene of West Greenland DAN LAURSEN (1950) made this stratigraphic division applicable to the whole coast of West Greenland.

Horizon A is described as a high-arctic deposit characterized by the occurrence of *Portlandia arctica.* Horizon B is an arctic one, the occurrence of *Balanus hameri* indicating a climate somewhat milder than the previous. Horizon C is not always easily distinguishable from B. Its climate was arctic, probably with a temperature somewhat lower than during the time of horizon B. In horizon D the high-arctic climate appeared once again, its very poor fossil fauna being dominated by *Portlandia arctica.* Horizon E is characterized by *Chlamys islandica* and by the first appearance of *Mytilus edulis* in the Late-Pleistocene deposits of Greenland. The number of species and specimens increased remarkably with this horizon, and among the other species were *Serripes groenlandicus, Macoma calcarea, Saxicava arctica, Mya truncata* (with varieties *uddevallensis* and *ovata*), *Lepeta coeca, Littorina saxatilis* var. *groenlandica, Lunatia pallida, Trophon truncatus, Balanus balanus, Strongylocentrotus droebachiensis ; Astarte borealis* and *Astarte montagui* also occurred in this horizon. There are reasons to belive that *Chlamys islandica* immigrated before *Mytilus edulis* (LAURSEN 1950, p. 107). The climatic conditions of horizon E were arctic and hardly differed from those prevailing in West Greenland to-day (l.c. p. 108).

Horizon F „is characterized by the presence of boreal forms which do not occur in any other horizons" (LAURSEN 1950, p. 108). It is extraordinarily rich in shells, containing species which are now extinct in Greenland, viz.:

Heteranomia squamula, Macoma baltica, Cyprina islandica, Zirfaea crispata, Acmaea virginea, Emarginula fissura and *Alvania jeffreysi; Mytilus edulis* occurs in vast quantities and *Littorina obtusata* is present. Among the other species are *Astarte borealis, Astarte montagui, Macoma calcarea, Saxicava arctica, Mya truncata, Thracia myopsis, Puncturella noachina, Acmaea rubella, Margarites groenlandicus, M. helicinus, M. cinereus, Littorina saxatilis* var. *groenlandica*. The climate of horizon F was more favourable than the present at the coasts of West Greenland.

The Inner Isfjorden Area and Greenland.

The area of West Greenland in which LAURSEN (1950) carried out his investigations lies within the same zoögeographical subregion as the Isfjorden area of Vestspitsbergen, viz. the mid-arctic subregion (cf. i.a. the Recent distribution of *Balanus balanoides* in West Greenland, FEYLING-HANSSEN 1953, pp. 11—12, MADSEN 1936, 1940), a circumstance which facilitates a comparison of the Late- and Post-Glacial conditions in the two areas.

It is at once evident that the *Post-Glacial Warm period* of Inner Isfjorden corresponsd to the *horizon F* in West Greenland. This is proved by the appearance of warm period indicators in the fossil faunas of the two areas. *Heteranomia squamula, Cyprina islandica, Zirfaea crispata* and *Emarginula fissura* the Warm period in Vestspitsbergen and the horizon F in West Greenland have in common. In addition *Volsella modiola, Lacuna vincta, Littorina littorea* and *Omalogyra atomus* occur in the Warm period deposits of Inner Isfjorden whereas *Macoma baltica, Acmaea virginea* and *Alvania jeffreysi* are found in the horizon F deposits of West Greenland. *Mytilus edulis* is abundant in these deposits in both regions.

In King Oscar Fjord, East Greenland, even low *Mytilus* beds occur, being of the same character as the low *Mytilus* terraces of Inner Isfjorden. The East Greenland deposits with *Mytilus edulis,* together with *Astarte borealis, A. montagui* and *A. elliptica* (NOE-NYGAARD 1932), probably correspond to the Warm period deposits of Inner Isfjorden in Vestspitsbergen.

The Post-Glacial Temperate period of Inner Isfjorden corresponds with the *horizon E* of West Greenland. In both regions *Mytilus edulis* appears for the first time in these deposits. Another species of the mid-arctic element (p. 30) which these deposits of the two regions have in common is *Littorina saxatilis groenlandica,* this species also having its first appearance in these deposits. *Chlamys islandica* occurs in both regions and so do *Macoma calcarea, Saxicava arctica* and *Mya truncata. Chlamys islandica* is very abundant in the horizon E deposits of West Greenland, whereas *Mya truncata* is the most common species in deposits from the Post-Glacial Temperate period of Inner Isfjorden. *Astarte borealis* and *A. montagui,* which do not occur in the Temperate deposits of Isfjorden, are present in the horizon E of West Greenland.

<table>
<tr><th>INNER ISFJORDEN, VESTSPITSBERGEN</th><th>WEST GREENLAND</th><th>EAST GREENLAND</th></tr>
<tr><td>SUB-RECENT PERIOD</td><td rowspan="2">HORIZON F</td><td rowspan="2">DEPOSITS WITH MYTILUS and ASTARTE</td></tr>
<tr><td>POST-GLACIAL WARM PERIOD</td></tr>
<tr><td>POST-GLACIAL TEMPERATE PERIOD</td><td>HORIZON E</td><td>DEPOSITS WITH CHLAMYS, MYTILUS SAXICAVA, MYA</td></tr>
<tr><td>LATE-GLACIAL COLD PERIOD</td><td>HORIZON D
--- ? ---</td><td>DEPOSITS WITH SAXICAVA and MYA</td></tr>
<tr><td>—</td><td>HORIZON C</td><td>—</td></tr>
<tr><td>—</td><td>HORIZON B</td><td>—</td></tr>
<tr><td>—</td><td>HORIZON A</td><td>—</td></tr>
</table>

Fig. 15. Correlation with the stratigraphy of West Greenland and the deposits of East Greenland.

In East Greenland the composition of the corresponding fossil fauna is even more uniform with that of Inner Isfjorden (NOE-NYGAARD 1932), *Mytilus edulis* occuring there up to 57 m a.s.l. together with *Saxicava arctica* and *Mya truncata.*

The Late-Glacial Cold period of Inner Isfjorden is not so easily correlated with the West Greenland stratigraphy. Its scarceness of fossils suggests rather severe climatical conditions, the hardy byt eurytherme *Saxicava arctica* and *Mya truncata* being the only species found. The *horizon D* of West Greenland comprises high-arctic deposits, very poor in fossils. The following species were found there: *Portlandia arctica, P. intermedia, Nucula tenuis expansa, Leda minuta, Macoma calcarea, Clinocardium ciliatum* and *Mya truncata.* This makes it reasonable to correlate the Cold period of Isfjorden with the horizon D of West Greenland, even though *Portlandia arctica* has not been found in the high deposits of Isfjorden.

It is not ascertained, however, that the Late-Glacial Cold period of Inner Isfjorden corresponds with the horizon D alone. It may prove to comprise also parts of the horizon C. This horizon, too, is poor in shells and passes into the overlaying horizon D without any sharp distinction (LAURSEN 1950, p. 103). Among the fossils are *Macoma calcarea, Saxicava arctica,* and

Mya truncata (with varieties *uddevallensis* and *ovata*). A subdivision of the Late-Glacial Cold period of Isfjorden may prove to be accomplishable when greater areas of Svalbard have been investigated.

Marine deposits comparable with the horizons B and A were not found in the Inner Isfjorden Area, the inner fjord regions probably not being accessible to the sea at that time.

In the King Oscar Fjord area of East Greenland the only fossils found above the *Mytilus* bearing deposits were *Saxicava arctica* and *Mya truncata.*

We have thus arrived at the correlation between the Late-Pleistocene deposits of Inner Isfjorden and of Greenland which is illustrated in fig. 15.

The sea level at which the sediments of the horizon D were deposited was, in the Disko Bugt region of West Greenland, 60 m above the present. The layers of horizon E were deposited when the sea level was situated at 45 m above the present, and those of horizon F at a sea level of approx. 40 m above the present (LAURSEN 1950, pp. 127—128).

Correlation with Iceland and Scandinavia.

LAURSEN (1950, p. 133) correlated the West Greenland horizons with the Late-Pleistocene deposits of Iceland, Denmark, and Norway in the following way:

Greenland	Iceland	Denmark		Norway
Horizon F	7 6 5	*Dosinia* Sea *Tapes* Sea	Beech Oak	*Ostrea* layer I—II *Trivia* layer *Tapes* layer
Horizon E	4	—	Pine	*Mactra* layer *Pholas* layer *Littorina* layer
Horizon D	3	—	Younger *Dryas*	*Portlandia* layer
Horizon B—C Horizon A	2 1	*Zirphaea* Sea *Yoldia* Sea	Allerød Older *Dryas*	Glaciated ?

With reference to the correlation of Younger *Dryas* of Denmark with the *Portlandia* layer in southern Norway LAURSEN (l.c.) observes: „Southern Norway was probably glaciated during the first part of this time, but in the later period her coasts were washed by the sea in which *Portlandia arctica* lived". Otherwise, the Younger *Dryas* clay has been correlated with the Norwegian Ra period (i.a. HOLTEDAHL 1953; cf. also FÆGRI 1940, p. 165).

If we adopt LAURSEN's correlation of the West Greenland deposits with those of Iceland and Scandinavia we can, in accordance with our correlation of the stratigraphic divisions of Greenland with those of Inner Isfjorden,

TIME	INNER ISFJORDEN, VESTSPITSBERGEN	GREENLAND	ICELAND	DENMARK		BALTIC	NORWAY	YEARS
1000 0	RECENT SUB-RECENT PERIOD		7	DOSINIA SEA	BEECH	LIMNÆA SEA	*Mya arenaria* OSTREA LAYER	1000 0
1000 2000 3000 4000	POST-GLACIAL WARM PERIOD	HORIZON F	6 5	TAPES SEA	OAK	LITTORINA SEA	TRIVIA LAYER TAPES LAYER	1000 2000 3000 4000
5000 6000 7000	POST-GLACIAL TEMPERATE PERIOD	HORIZON E	4	—	PINE	ANCYLUS SEA	MACTRA PHOLAS LITTORINA LAYER	5000 6000 7000
?	LATE-GLACIAL COLD PERIOD	HORIZON D	3	—	YOUNGER DRYAS	YOLDIA SEA	PORTLANDIA LAYER	?

Fig. 16. Attempt at correlation with Scandinavian stratigraphy (partly from LAURSEN 1950).

incorporate the Late-Pleistocene periods of Inner Isfjorden into this table. Furthermore (e.g. in accordance with the Late-Pleistocene time table, pl. 22 in HOLTEDAHL 1953), Swedish and Baltic Late-Pleistocene developmental stages can be added to the table together with an approximate absolute time scale. The results are given in fig. 16.[1]

The investigations of the Late-Pleistocene of Greenland, although on a larger scale, have been carried out in approximately the same way as in Vestspitsbergen. The results from the two regions are therefore quite easily comparable with each other even though Inner Isfjorden is only a small and partial area, hardly representative of Vestspitsbergen as a whole. Direct correlation with the Late-Pleistocene of arctic and subarctic regions other than Greenland has not been attempted, partly because the fossil faunas there have not been associated with definite levels (e.g. Novaya Zemlya), and partly because the investigations there have been rather heterogeneous, involving mainly shoreline research and shoreline cronology (e.g. Finnmarken). The Late-Pleistocene of Spitsbergen cannot safely be correlated with such regions until larger areas of the country have been investigated.

[1] In fig. 16 it is the time divisions which are correlated with each other, not every single unit within each of them, e.g. the placings of the «*Ostrea* layer», «*Trivia* layer» and the «*Tapes* layer» have no special relation to the years in the time scale.

II. SPECIAL PART
Observations and Collections.

Anservika.

Anservika (78°27.7′ N.lat., 16°23′ E.long.) is a broad bay on the east side of the entrance to Billefjorden (pl. 2). In the bay there is a prominent wave-built terrace plain 200 m broad, which rises from 9.7 m a.s.l. at its front edge to 14.8 m a.s.l. at its rear edge (pl. 3, fig. 1). The deposits consist of sand and gravel resting on a sandy boulder clay which in turn rests on bedrock.

The following collection was made from the wave-cut cliff of the terrace (cf. a previous collection from the same locality recorded by FEYLING-HANSSEN and JØRSTAD 1950, p. 33):

9.7 m a.s.l. Anservika, terrace, sand and gravel (Sample No. 334).

Species	Frequency	Percentage
Astarte borealis (CHEMNITZ)	197.0	56.9
Mytilus edulis LINNÉ	92.5	26.7
Astarte montagui (DILLWYN)	22.5	6.5
Mya truncata LINNÉ	11.0	3.2
Saxicava arctica (LINNÉ)	8.5	2.5
Macoma calcarea (CHEMNITZ)	7.0	2.0
Astarte elliptica (BROWN)	2.5	0.7
Cyprina islandica (LINNÉ)	2.0	0.6
Buccinum glaciale LINNÉ	2.0	0.6
Balanus balanoides (LINNÉ)	1.0	0.3
Chlamys islandica (MÜLLER)	0.5	0.1
Lithothamnion		
	346.5	100.1

The complete valves of *Astarte borealis* and *A. montagui* were measured (figs. 19, 20). Many of them had their periostracum preserved, and some specimens had united valves (pls. 20 and 21).

Astarte borealis was represented mostly by large and quite high specimens, the majority of which had pronounced and nearly pointed beaks. Consequently the anterior dorsal margin was strongly concave whereas the posterior one was straight or slightly convex; a very few specimens had a more triangular marginal outline with both anterior and posterior dorsal margin straight (thus approaching the outline of *A. crenata*). Most specimens had a thin, light-coloured, mostly yellowish-brown periostracum, a dark-brown to black periostracum being found only in some specimens. The dark as well as the light-coloured periostracum occurred both with large and small specimens, but the darker periostracum was somewhat the thicker of the two. Some valves showed transitions in periostracum colours from yellowish-brown at the umbones over dark-brown to black towards the ventral margins. Many specimens had fine, dense folds at the umbo and more or less irregular lines of growth further down the shell; extraordinarily few shells had eroded beaks.

Astarte montagui had also some large representatives. Most specimens of this species were of the typical form, but some represented transitions to the var. *striata* LEACH.

The shells of *Mytilus edulis* were of a rather high form (fig. 21), and five of them showed traces of pearls. The *Mya* and *Saxicava* shells were thin and small. Of *Cyprina islandica* five hinge fragments and some other fragments were found (pl. 23, fig. 1, 2); and some clods of *Lithothamnion* were collected together with three carapaces of crab.

A section was made in the cliff of the 9.7 m terrace, and samples of the sediments taken at every 0.5 m from the top down to bedrock. These samples were later treated mechanically. (Cf. figs. 17 and 18). In addition the fossils were collected from the different zones from which minerogenic samples were taken. The profile showed the following succession:

I. 0.0 m below the surface. Material (sample no. 157M): gravel with sand; pebbles rounded, some of them frost-split. Median diameter, M=16.00 mm. Quartiles, Q_3=24.00 mm, Q_1=5.20 mm. Coefficient of sorting, So=$\sqrt{Q_3/Q_1}$=2.15, i.e. well sorted (TWENHOFEL and TYLER 1941). Coefficient of quartile skewness, Sk=Q_1Q_3/M^2=0.49, i.e. the maximum sorting lies on the coarse side of the median diameter.

The following fossils were collected from the surface layer (shell sample no. 335):

Mytilus edulis, some small shell fragments representing one valve.

Astarte borealis, 42 valves and umbonal fragments, most of them worn, a few carried remnants of periostracum; two specimens were found with their valves united. The largest valve of *A. borealis* measured: L=34 mm, H=28 mm.

Astarte montagui, 3 valves, of which one was of the var. *striata* LEACH (L=15.6 mm, H=13.0 mm), one was close to the var. *warhami* HANCOCK (L=12.0 mm, H=10.5 mm), and one was of the typical form (L=19 mm, H=17 mm).

Serripes groenlandicus, 1 umbonal and some marginal shell fragments probably belonging to a specimen brought on land by bird.

Buccinum glaciale, 1 spire.

Strongylocentrotus sp., some spines and plates.

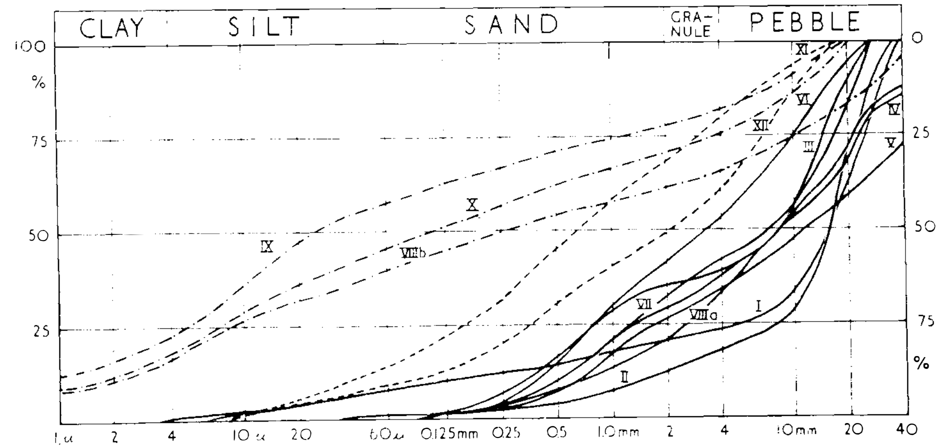


Fig. 17. Cumulative-frequency curves of 13 successive samples, 9.7 to 4.2 m a.s.l., from a section in the cliff of the *Astarte terrace* at Anservika.

II. 0.5 m below the surface. Material (sample no. 158M): gravel. Median diameter, M = 16.00 mm. Quartiles, $Q_3 = 21.00$ mm, $Q_1 = 8.00$ mm. Coefficient of sorting, So = 1.62, i.e. well sorted. Coefficient of quartile skewness, Sk = 0.66, i.e. the maximum sorting lies on the coarse side of the median diameter. Pebbles rounded, some of them frost-split.

The following fossils were found in this zone (shell sample no. 336):

Mytilus edulis, 1 valve, 1 umbonal fragment, and some other fragments.

Astarte borealis, 19 valves and umbonal fragments. The largest complete valve measured: L = 31 mm, H = 27 mm.

Astarte montagui, 1 broken valve.

Saxicava arctica, 2 hinge fragments of small specimens.

Mya truncata, 3 umbonal and some other fragments of small specimens.

Echinid spines and *Lithothamnion* fragments also occurred.

III. 1.0 m below the surface. Material (sample no. 159M): sandy gravel. Median diameter, M = 8.00 mm. Quartiles, $Q_3 = 14.00$ mm, $Q_1 = 0.80$ mm. Coefficient of sorting, So = 4.18, i.e. normal sorting. Coefficient of quartile skewness, Sk = 0.18, i.e. the maximum sorting lies on the coarse side of the median diameter. The pebbles were rounded, some of them split.

The following fossils were collected from this zone (shell sample no. 337):

Mytilus edulis, 10 broken valves and umbonal fragments; one valve was of a juvenile specimen, and one had a pearl.

Astarte borealis, 16 valves and umbonal fragments. The periostracum was more or less preserved in all of them, and one specimen had its valves united. The largest valve measured: L = 30.3 mm, H = 26.0 mm.

Astarte montagui, 1 broken valve.

Macoma calcarea, 1 complete valve measuring, L = 24 mm, H = 18 mm; it was of the typical form.

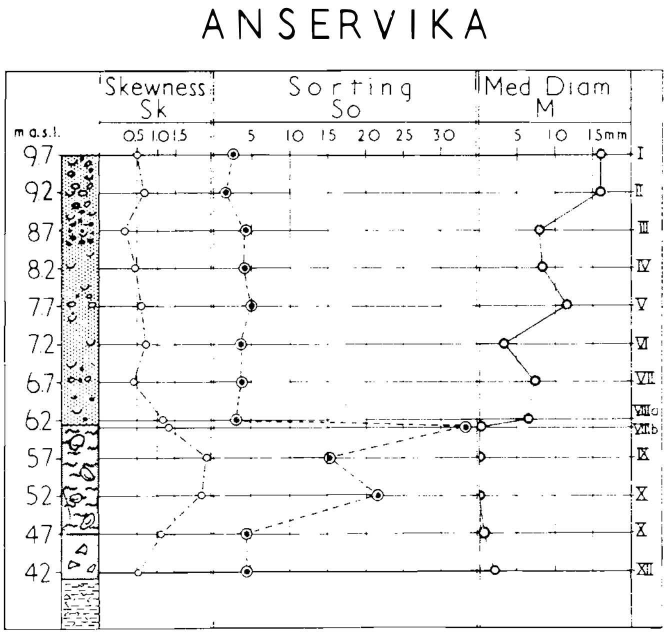


Fig. 18. Variations in median diamter, sorting and skewness of the samples from the section in the cliff of the *Astarte terrace* at Anservika.

Mya truncata, 2 hinge fragments.

Echinid spines and a few *Lithothamnion* fragments were also found.

IV. 1.5 m below the surface. Material (sample no. 160M): sandy gravel. Median diameter, M=8.30 mm. Quartiles, Q_3=22.00 mm, Q_1=1.35 mm. Coefficient of sorting, So=4.04, i.e. normal sorting. Coefficient of quartile skewness, Sk=0.43, i.e. the maximum sorting lies on the coarse side of the median diameter. The pebbles were rounded.

The following fossils were found in this zone (shell sample no. 338):

Mytilus edulis, 6 umbonal and some other fragments.

Astarte borealis, 12 valves and umbonal fragments; one specimen had united valves and completely preserved periostracum.

Astarte montagui, 2 valves, one of *striata* form.

Saxicava arctica, 1 small, broken valve.

Mya truncata, 1 umbonal and some other fragments.

Some echinid spines and numerous *Lithothamnion* clods were found.

V. 2.0 m below the surface. Material (sample no. 161M): sandy gravel. Median diameter, M=11.5 mm. Quartiles, Q_3=44.00 mm, Q_1=1.75 mm. Coefficient of sorting, So=5.01, i.e. poorly sorted. Coefficient of quartile skewness, Sk=0.85, i.e. the maximum sorting lies on the coarse side of the median diameter. The pebbles were rounded.

The following fossils were found in this zone (shell sample no. 339):

Mytilus edulis, 4 hinge fragments and some other fragments.

Astarte borealis, 12 valves and umbonal fragments. Three specimens had their valves united.

Echinid spines and numerous *Lithothamnion* clods were found.

VI. 2.5 m below the surface. Material (sample no. 162M): sandy gravel, finer than the previous. Median diameter, M=3.25 mm. Quartiles, Q_3= 9.60 mm, Q_1=0.78 mm. Coefficient of sorting, So=3.51, i.e. normal sorting. Coefficient of quartile skewness, Sk=0.71, i.e. the maximum sorting lies on the coarse side of the median diameter. The pebbles were partly well rounded.

The following fossils were found in this zone (shell sample no. 340):

Mytilus edulis, 1 umbonal and some other fragments.
Astarte borealis, 13 valves and umbonal fragments.
Mya truncata, 2 umbonal fragments and some others.
Lithothamnion, some fragments.

VII. 3.0 m below the surface. Material (sample no. 163M): sandy gravel. Median diameter, M=7.30 mm. Quartiles, Q_3=17.00 mm, Q_1=1.25 mm. Coefficient of sorting, So=3.70, i.e. normal sorting. Coefficient of quartile skewness, Sk=0.40, i.e. the maximum sorting lies on the coarse side of the median diameter. The pebbles were rounded.

The following fossils were found in this zone (shell sample no. 341):

Mytilus edulis, 2 umbonal and a few other fragments.

Astarte borealis, 2 valves, 2 umbonal fragments, and a few other fragments.

Macoma calcarea, 1 worn hinge fragment.

Mya truncata, 2 valves and 1 umbonal fragment. The valves, belonging to a young specimen, were united and their periostracum was preserved.

Some echinid spines and numerous *Lithothamnion* clods were found.

VIIIa. 3.5 m below the surface. Material (sample no. 164aM): sandy gravel. Median diameter, M=6.50 mm. Quartiles, Q_3=20.00 mm, Q_1= 2.40 mm. Coefficient of sorting, So=2.90, i.e. normal sorting. Coefficient of quartile skewness, Sk=1.17, i.a. the maximum sorting lies on the fine side of the median diameter. The majority of the pebbles were rounded but some were angular.

The following shells were found in this zone (shell sample no. 342):

Mytilus edulis, 1 small fragment.
Astarte borealis, 2 valves and 2 umbonal fragments.
Lithothamnion, some fragments.

VIIIb. 3.55 m below the surface. Material (sample no. 164bM): clayey silt with stones. Median diameter, M=0.25 mm. Quartiles, Q_3=9.50 mm, Q_1=0.0085 mm. Coefficient of sorting, So=33.40, i.e. poorly sorted.

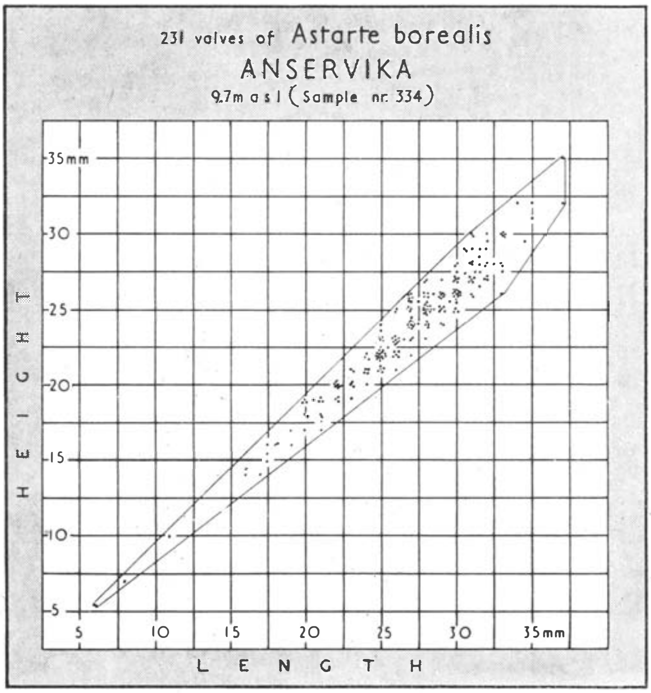


Fig. 19. Shell measurements of *Astarte borealis*.

Coefficient of quartile skewness, Sk=1,29, i.e. the maximum sorting lies on the fine side of the median diameter. Most of the pebbles were poorly rounded, and some were angular. Some of them carried striæ.

No megafossils were observed in this zone in the field, but the binocular microscope revealed 1 tiny fragment of *Mytilus edulis,* 1 worn specimen of the foraminifer *Elphidium incertum* (WILLIAMSON), and some small echinid spines. This biogenic material was probably derived from the overlaying beach deposit by contamination.

IX. 4.0 m below the surface. Material (sample no. 165M): clayey-silty sand with stones. Median diameter, M=0.025 mm. Quartiles, Q_3=1.15 mm, Q_1=0.005 mm. Coefficient of sorting, So=15.2, i.e. poorly sorted. Coefficient of quartile skewness, Sk=2.31, i.e. the maximum sorting lies on the fine side of the median diameter. Most of the pebbles were poorly rounded, and some of them distinctly striated.

No megafossils were found in this zone. Under the microscope were observed: three tiny fragments of *Mytilus edulis,* some broken echinid spines, and 1 worn specimen of *Quinqueloculina seminulum* (LINNÉ).

X. 4.5 m below the surface. Material (sample no. 166M): clayey-silty sand with stones. Median diameter, M=0.11 mm, Quartiles, Q_3=3.5 mm, Q_1=0.0075 mm. Coefficient of sorting, So=21.6, i.e. poorly sorted. Coefficient of quartile skewness, Sk=2.17, i.e. the maximim sorting lies on the

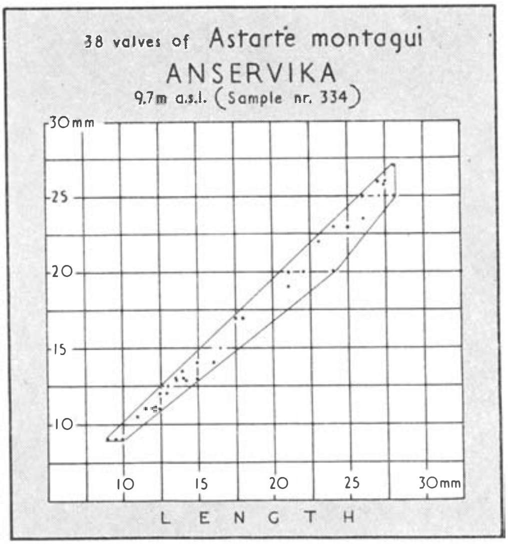


Fig. 20. Shell measurements of *Astarte montagui.*

fine side of the median diameter. Most of the pebbles were angular, some of them poorly rounded.

A very small fragment of *Mytilus edulis* was observed in the sample. A preliminary microscopic survey revealed some echinid spines, one *Quinqueloculina seminulum,* a worn specimen of a *Gyroidina,* and an ostracod valve. A mould of a *Textularia,* originating from much older deposits, was also observed in the sample.

XI. 5.0 m below the surface. Material (sample no. 167M): dusty material with sharp stones probably derived from the bedrock. Median diameter, M=0.63 mm. Quartiles, Q_3=2.80 mm, Q_1=0.16 mm. Coefficient of sorting, So=4.25, i.e. poorly sorted. Coefficient of quartile skewness, Sk=1.09, i.e. the maximum sorting lies on the fine side of the median diameter.

XII. 5.50 m below the surface. Material (sample no. 168M): the same as the previous, at the bedrock. Median diameter, M=2.10 mm. Quartiles, Q_3=6.60 mm, Q_1=0.35 mm. Coefficient of sorting, So=4.34, *i.e.* poorly sorted. Coefficient of quartile skewness, Sk=0.52, i.e. the maximum sorting lies on the coarse side of the median diameter.

Thus, at the front of the 9.7 m high terrace in Anservika, a 3.5 m thick deposit of beach material dating, according to its fossil content, from the Post-Glacial Warm period rests on a 1.5 m thick deposit of a clayey-silty sand with stones, probably representing morainic material, this in turn resting on 1 m of a dusty material with sharp stones, the latter in some way or another derived from the underlying bedrock.

The fossil-bearing beach gravel was deposited as a prograding beach during a period of emergence so that the shoreline was lowered from 14.8 to 9.7 m a.s.l. or probably even lower, because the terrace front has been driven back by wave erosion in Recent times. Geologically this beach gravel belongs

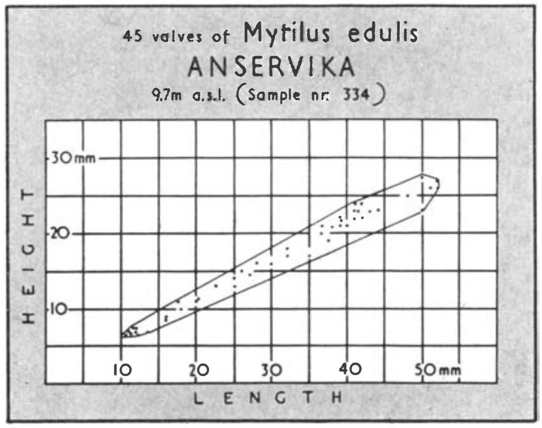


Fig. 21. Shell measurements of *Mytilus edulis*.

to one and the same unit, so that the fossils collected at different levels in the section can be treated, together with the previous collection from the cliff of the terrace (p. 58), as one assemblage which has the following composition:

9.7 m a.s.l. Anservika, terrace (Samples Nos. 334—342).

Species	Frequency	Percentage
Astarte borealis (CHEMNITZ)	258.0	59.2
Mytilus edulis LINNÉ	106.0	24.3
Astarte montagui (DILLWYN)	26.0	6.0
Mya truncata LINNÉ	17.5	4.0
Saxicava arctica (LINNÉ)	10.0	2.3
Macoma calcarea (CHEMNITZ)	8.5	2.0
Buccinum glaciale LINNÉ	3.0	0.7
Astarte elliptica (BROWN)	2.5	0.6
Cyprina islandica (LINNÉ)	2.0	0.5
Chlamys islandica (MÜLLER)	0.5	0.1
Serripes groenlandicus (CHEMNITZ)	0.5	0.1
Balanus balanoides (LINNÉ)	1.0	0.2
Strongylocentrotus sp. plates and spines		
Lithothamnion sp. clods and fragments		
	435.5	100.0

Mytilusbekken.

Mytilusbekken[1] is the rivulet 1.5 km NNE of the terrace in Anservika (pl. 2). On the south side of the rivulet a *Mytilus* terrace was measured, whose height was 5.8 m a.s.l. and from which the following shells were collected:

[1] The name refers to the occurrence of *Mytilus edulis* in the Post-Glacial deposits at the rivulet.

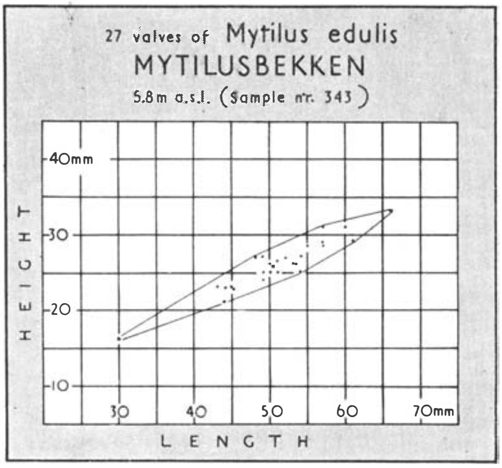


Fig. 22. Shell measurements of *Mytilus edulis*.

5.8 m a.s.l. Mytilusbekken, terrace, gravel (Sample No. 343).

Species	Frequency	Percentage
Mytilus edulis LINNÉ	44.0	85.4
Astarte borealis (CHEMNITZ)	5.5	10.7
Mya truncata LINNÉ	1.0	1.9
Clinocardium ciliatium (FABRICIUS)	0.5	1.0
Cyprina islandica (LINNÉ)	0.5	1.0
Lithothamnion sp.		
	51.5	100.0

88 valves and umbonal fragments of *Mytilus edulis* were found; many of the valves were complete (measurements fig. 22), the majority of them had well preserved periostracum, and two of them had incipient pearls. One broken valve of *Clinocardium ciliatum* and a marginal fragment of *Cyprina islandica* were found. *Lithothamnion* was rare.

Phantomodden.

Phantomodden (78°32.2′ N.lat., 16°29′ E.long.) is the southernmost of the major cuspate forelands on the east side of Billefjorden (fig. 23). It has a straight coastline to the west and a curved one to the north. It is prograded towards the north where close-set ridges with east-westerly direction are being added (fig. 24). The greater part of the beach plain between the point and the mountains to the ESE in occupied by a large alluvial fan formed by Tjosåselva, the river of Tjosåsdalen.

Towards the upper end of this fan there are remnants of two delta terraces (P and T on fig. 24) on the north side of the river, the higher delta remnant (T) having a counterpart on the south side of the river (S).

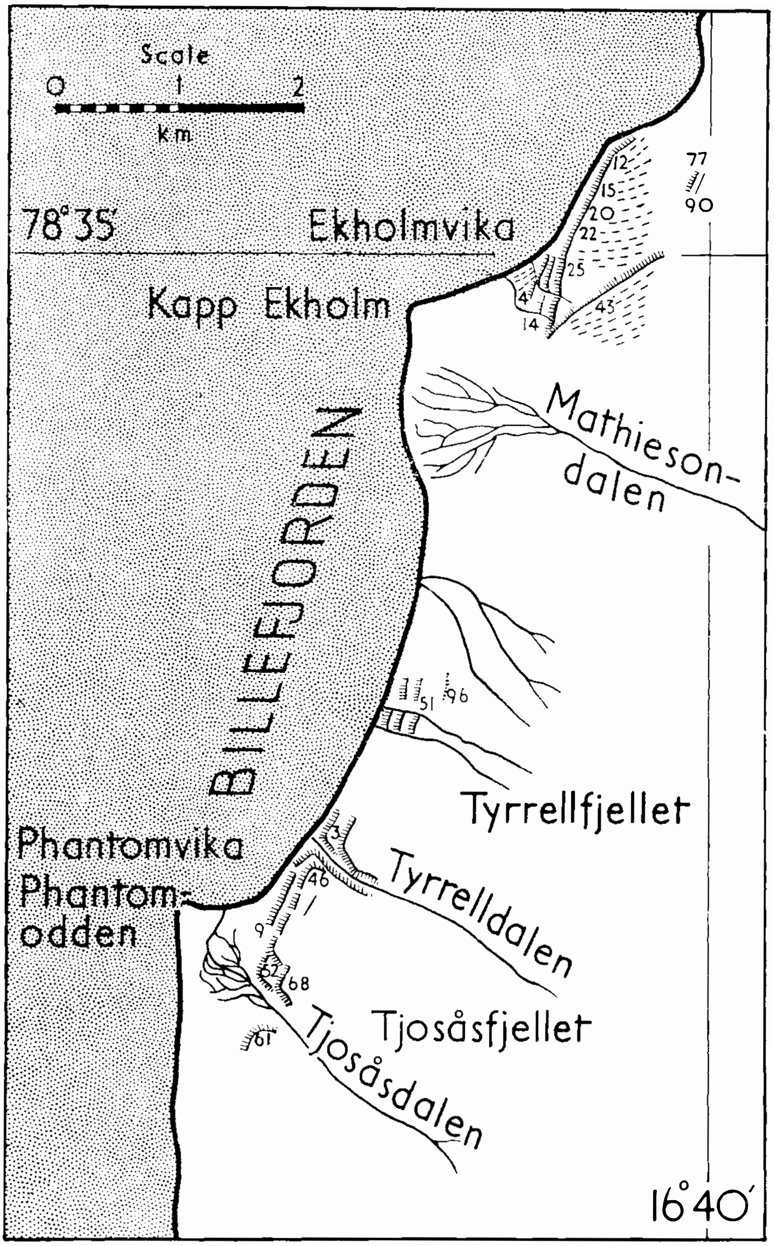


Fig. 23. The east coast of Billefjorden from Phantomodden to Ekholmvika, with the raised features which were investigated.

North of these features ,at Phantomvika, there are still more magnificent terraces and delta plains. At the mounth of Tyrrelldalen two delta generations have been preserved, their surfaces sloping towards the north on the north side of the river and towards the southwest on the south side — according to the slope of the surface of the original fans.

Between these features at the mouths of the two valleys, Tjosåsdalen and Tyrrelldalen, there is a succession of raised marine terraces (A, C, D, E of fig. 24; cf. pl. 3, fig. 2).

The tachymetrical height measurements of the raised features at Phantomodden and Phantomvika gave the following results (cf. fig. 24):

A,	8.2	m a.s.l.,	front edge of *Astarte* terrace.
B,	10.1	—»—	rear edge of *Astarte* terrace.
C,	13.4	—»—	front edge of small terrace.
D,	36.1	—»—	front edge of large *Mya* terrace.
E,	41.8	—»—	front edge of small terrace.
F,	43.4	—»—	on the higher delta plain on the south side of Tyrrelldalen; alluvial facies.
G,	46.2	—»—	further up on the same delta plain, alluvial facies.
H,	12.3	—»—	front of lower delta plain at the south side of Tyrrelelva (Tyrrell river).
J,	31.4	—»—	on the lower delta plain, towards its upper termination, on the south side of the river; alluvial facies.
K,	7.8	—»—	on the lower delta plain, at its erosional cliff on the south side of the river; marine facies.
L,	13.1	—»—	on the lower delta plain, on the north side of the river; alluvial facies.
M,	8.4	—»—	on the lower delta plain, at its erosional front at the north side of the river; marine facies.
N,	35.4	—»—	on the higher delta plain, on the north side of the river.
O_1,	43.7	—»—	front edge of small terrace cut into the cliff of the large delta terrace (P) on the north side of the mouth of Tjosåsdalen.
O_2,	44.6	—»—	rear edge of the same small terrace.
P,	51.9	—»—	front of large delta plain at the north side of Tjosåsdalen; alluvial facies.
R,	60.1	—»—	rear edge of the same large delta plain; alluvial facies.
S,	60.6	—»—	front edge of terrace remnant at the south side of Tjosåsdalen; marine facies.
T,	68.0	—»—	front of the highest delta plain at the north side of Tjosåsdalen; alluvial facies.
U,	48.7	—»—	on the large delta plain (P), north of erosion furrow; marine facies.

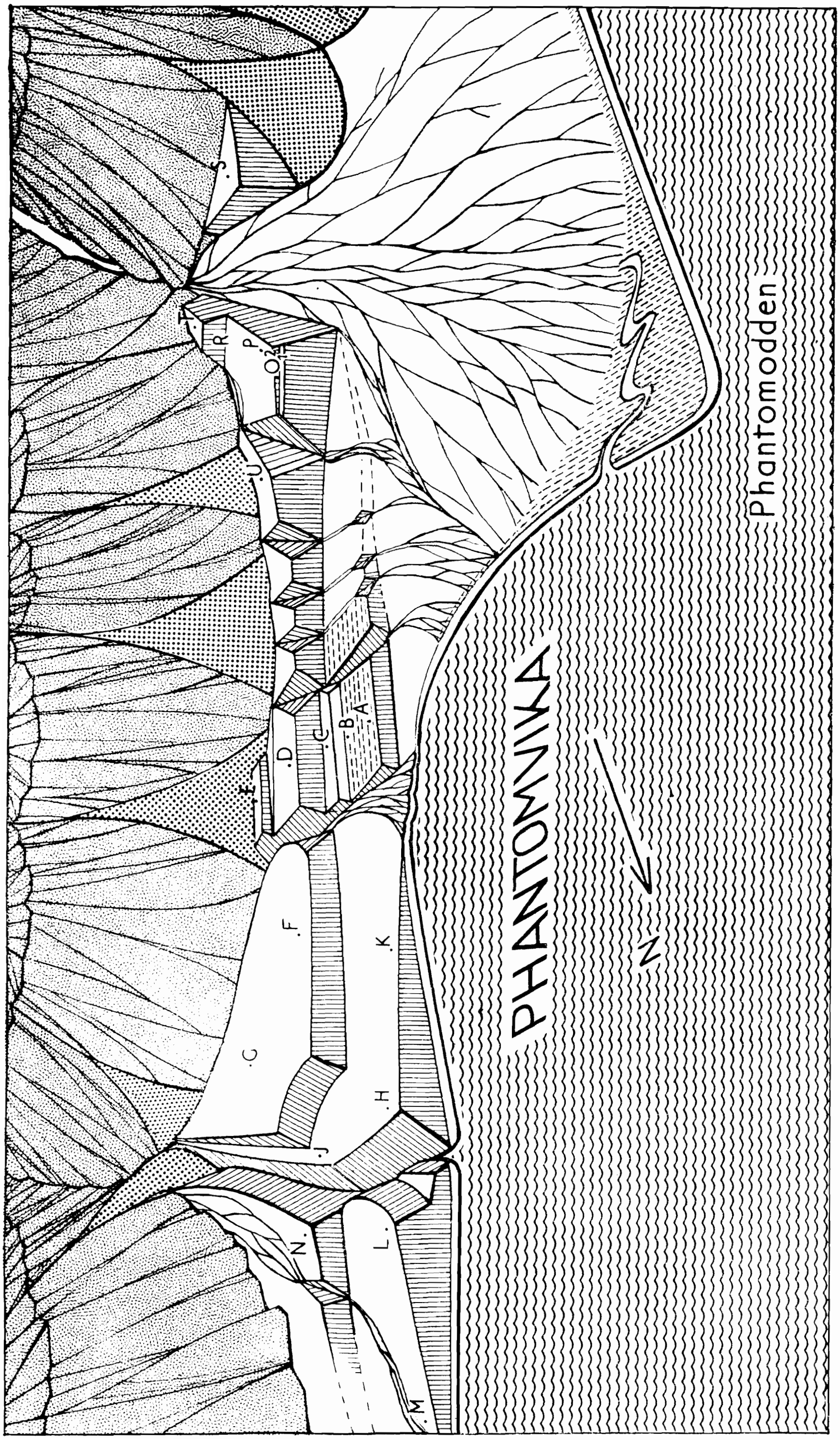


Fig. 24. Schematic illustration of the raised terraces at Phantomvika; the rivers of Tyrrelldalen, to the left, and of Tjosåsdalen, to the right, have croded the features. (Cf. fig. 23).

From the *Astarte* terrace, A, 8.2 m a.s.l., were collected (shell sample no. 344):

Mytilus edulis, six small fragments.
Astarte borealis, 16 valves and umbonal fragments.
Mya truncata, 1 umbonal fragment.

From the marine facies of the lower delta plain on the south side of Tyrrellelva, at K on fig. 24, the following shells were collected:

7.8—8.0 m a.s.l. Phantomvika, delta terrace, coarse sand (Sample No. 345).

Species	Frequency	Percentage
Astarte borealis (CHEMNITZ)	15.5	64.6
Mya truncata LINNÉ	2.5	10.4
Saxicava arctica (LINNÉ)	2.0	8.3
Astarte montagui (DILLWYN)	1.5	6.3
Mytilus edulis LINNÉ	1.0	4.2
Macoma calcarea (CHEMNITZ)	1.0	4.2
Cyprina islandica (LINNÉ)	0.5	2.1
	24.0	100.1

Of *Astarte borealis* 31 valves and umbonal fragments were collected. A few valves had their periostracum preserved. The largest complete valve measured, L=33 mm, H=28 mm, I=100·H/L=84.9, and the complete valve of *Astarte montagui* measured, L=15 mm, H=15 mm, I=100. Of *Cyprina islandica* one hinge fragment and two fragments from the ventral margin were found. One of the *Saxicava* valves was large, L=48.5 mm, H=22.5 mm, and of regular *pholadis* form, but the others were small and irregular.

From the *Mya* terrace (D) at Phantomvika, which represents the marine facies of the higher delta plain at Tyrrelldalen, more than 100 valves and umbonal fragments, in addition to other fragments, of *Mya truncata* were collected. The minerogenic material was largely composed of very coarse sand and the *Mya* shells were rather thin and small.

The population from the upper part of the deposit had the following composition:

36—37 m a.s.l. Phantomvika, terrace (D), very coarse sand (Sample No. 346).

Species	Frequency	Percentage
Mya truncata LINNÉ	50.3	90.2
Saxicava arctica (LINNÉ)	3.5	6.3
Chlamys islandica (MÜLLER)	0.5	0.9
Mytilus edulis LINNÉ	0.5	0.9
Balanus balanus (LINNÉ)	1.0	1.8
	56.0	100.1

Of *Mytilus edulis* 4 small shell fragments were found, and of *Chlamys islandica* a large umbonal fragment.

From the surface, 42.1 m a.s.l., of the small terrace (O), which has been cut into the cliff of the large delta terrace (P) on the north side of Tjosåsdalen, there were found (sample no. 347):

Mytilus edulis, 2 small shell fragments.

Mya truncata, 2 umbonal fragments and seven small shell fragments.

The surface of the delta plain (P) was irregular with incipient structural ground, the surface material being composed of gravel with frost-split and angular pebbles; this is the supramarine or alluvial facies of the delta plain. The marine facies of the same plain was found on the north side of the erosion furrow (at U on fig. 24), and the border between the supramarine and the marine surface was distinct and easily observable. The marine surface gravel was sandy with rounded bebbles, only a few of which were split by frost wedging. Of shells there were found only some very small fragments, viz. of (48.7 m a.s.l., sample no. 348):

Mya truncata
Saxicava arctica
Balanus balanus, a worn carinolateral compartment,
Strongylocentrotus cf. *droebachiensis,* a plate.

On the terrace remnant at the south side of Tjosåsdalen (S on fig. 24) were found (61—62 m a.s.l.):

Saxicava arctica, one valve,
Mya truncata, two shell fragments.

Further up in the valley remnants of four terminal moraines were observed situated high avobe each other.[1]

The Swedish expedition to Spitsbergen in the year of 1896 collected the following species from a shell bed southeast of Sfinxudden (=Phantomodden ?), Klas Billen Bay (Hägg 1951, p. 243, height not recorded):

Mytilus edulis Linné, 1 valve and one fragment,
Chlamys islandica (Müller), 5 valves,
Astarte borealis (Chemnitz), 5 valves,
Astarte montagui (Dillwyn) (=*A. banksi* Leach), 1 valve,
Macoma calcarea (Chemnitz), 2 valves,
Mya truncata Linné, 3 valves,
Saxicava arctica (Linné), 5 valves,
Littorina littorea (Linné), 1 specimen,
Littorina saxatilis (Olivi), 1 specimen,
Lacuna vincta (Montagu), frequency not indicated,
Lithothamnion, 1 clod.

---

[1] From the Recent shore of Phantomvika 17 valves and umbonal fragments of *Astarte borealis* and some *Lithothamnion* clods were picked up.

From „the valley at Sfinxudden" they collected (height not recorded):

Margarites groenlandicus (CHEMNITZ) var. *umbilicalis* BRODERIP and SOWERBY, 1 specimen,

Littorina littorea (LINNÉ), 5 specimens,

Buccinum glaciale LINNÉ, 1 small specimen,

Buccinum groenlandicum CHEMNITZ, 4 small specimens.

From „Udden innanför Gåskap", which is probably identical with Phantomodden, the same Swedish expedition collected (HÄGG 1951, p. 240, height not recorded):

Natica clausa BRODERIP and SOWERBY, 1 specimen,

Buccinum ciliatum FABRICIUS, 1 specimen,

Buccinum finmarchianum VERKRÜZEN var. *scalaris* G. O. SARS, 1 specimen,

Buccinum glaciale LINNÉ, 3 specimens,

Sipho islandicus (CHEMNITZ), 1 specimen,

Sipho togatus (MÖRCH), frequency not indicated,

Mya truncata LINNÉ, 2 valves.

Three periods of Late-Pleistocene history are represented at Phantomodden and Phantomvika, marked both by marine terraces and delta plains:

I. The lower raised delta (M, L, H, K) at Tyrrelldalen and the *Astarte* terrace (A). The supramarine facies of the delta rises to 31.4 m a.s.l. (at J on fig. 24), whereas the marine facies of the plain was found at approx. 8 m a.s.l. (at K), thus corresponding with the *Astarte* terrace (A) which rises from 8.2 to 10.1 m a.s.l. The delta and terrace date from the Post-Glacial Warm period.

II. The higher raised delta (G, F, N) at Tyrrelldalen, the large delta plain (P, R, U) at Tjosåsdalen, and the *Mya* terrace (D). The surface of the delta at Tyrrelldalen rises from 35.4—43.4—46.2 m to its undetermined apex. The delta at Tjosåsdalen has been eroded back closer to its apex thus rising from a higher level, viz. 48.7—51.9, to 60.1 m a.s.l. These delta deposits are contemperaneous with the *Mya* terrace, the front edge of which is situated at 36.1 m a.s.l., and date from the Post-Glacial Temperate period.

III. The highest delta terrace (T, S) at Tjosåsdalen, 60.6 and 68.0 m a.s.l., from the Late-Glacial Cold period.

North of Phantomvika.

This locality (78°32.8′ N.lat., 16°32.8′ E.long.) is found approx. 1 km NNE of the mouth of Tyrrellelva, i.e. between Phantomodden and Kapp Ekholm on the east side of Billefjorden (fig. 23). A prominent terrace level, at an altitude of approx. 50 m, which can be followed from Phantomvika (Tyrrelldalen) to Kapp Ekholm, is represented by a large remnant in the locality (pl. 3, fig. 3). To the north and south the feature has been eroded by streams, thus offering good cross-sections; fig. 25 illustrates the section as

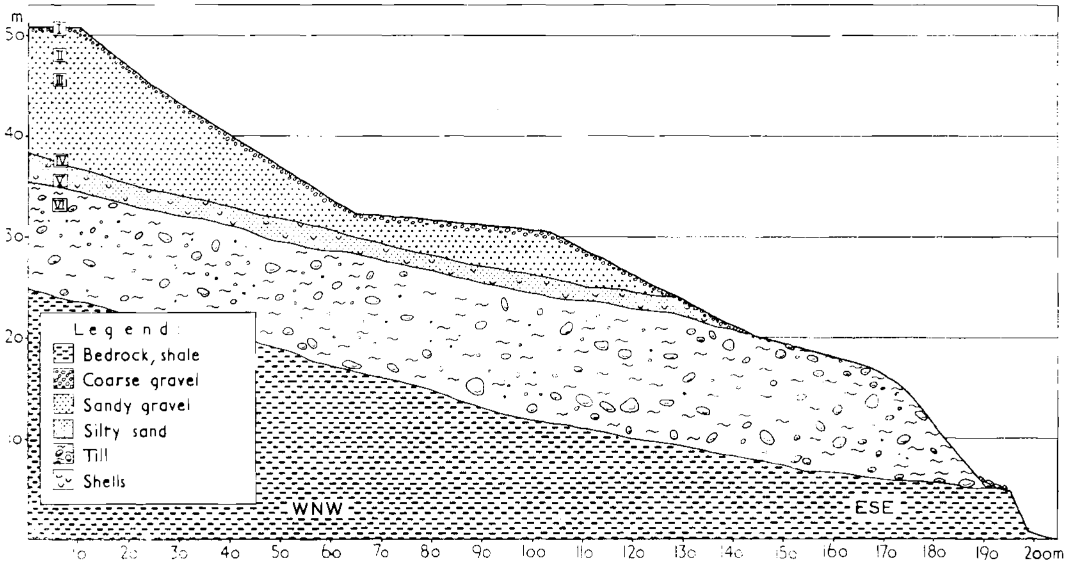


Fig. 25. Section through a *Mya terrace* north of Phantomvika (height twice exaggerated); the numbers in the squares refer to samples. (Cf. figs. 26, 27).

revealed in the northern erosion furrow[1]. Wave erosion had cut two benches in the deposits beneath the prominent terrace level. The following heights were measured:

15.3 m a.s.l., front edge of 30 m broad bench.
20.3 —»— rear » » » » » »
30.5 —»— front » » 40 » » »
32.3 —»— rear » » » » » »
50.7 —»— front edge of large terrace.

The rear edge of the prominent terrace could not be determined in the locality because it had been destroyed by subsequent erosion.

The feature was built up of three Pleistocene strata; measured in vertical section from near the front edge of the prominent terrace and down to bedrock these were:

Sandy gravel, thickness .... 13 m
Silty sand with fossils, thickness .... 2 »
Till, thickness .... c. 10 »

The till rests on bedrock of Culm shale (Orvin 1940). Six samples were taken from the section (cf. fig. 25), the results of the mechanical analyses of which are illustrated in the cumulative-frequency curves (fig. 26)

[1] The gravel wash which partly obliterated the strata in the field has been eliminated in the figure. The stream had eroded down to, and partly into, the bedrock. The stream bed was full of boulders of various dimensions washed out of the till.

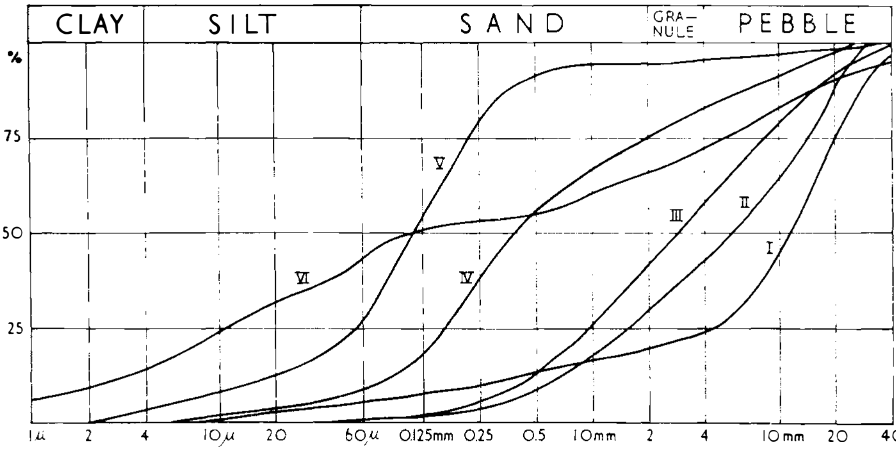


Fig. 26. Cumulative-frequency curves of six samples from a section through a *Mya terrace* north of Phantomvika. (Cf. figs. 25 and 27).

and in the graphs of the median diameters and coefficients of sorting (fig. 27). A brief description of the samples is given below:

I. 0.0 m below the surface (sample no. 174M). Coarse gravel. Median diameter, M=11.00 mm. Quartiles, Q_3=19.2 mm, Q_1=4.40 mm. Coefficient of sorting, So=2.1, i.e. the sediment is well sorted. It is an outwash gravel with several pebbles frost-split.

II. 2.5 m below the surface (sample no. 175M). Sandy gravel. Median diameter, M=5.40 mm. Quartiles, Q_3=14.00 mm, Q_1=1.50 mm. Coefficient of sorting, So=3.1, i.e. normal sorting. The pebbles were well rounded.

III. 5.0 m below the surface (sample no. 176M). Sandy gravel, finer than the previous. Median diameter, M=2.80 mm. Quartiles, Q_3=7.20 mm, Q_1=0.97 mm. Coefficient of sorting, So=2.7, i.e. the sediment is normally sorted.

IV. 12.5 m below the surface (sample no. 177M). Sand. Median diameter, M=0.37 mm. Quartiles, Q_3=2.00 mm, Q_1=0.16 mm. Coefficient of sorting, So=3.5, i.e. normal sorting. This sample represents the transition to the stratum of silty sand. Some quite large pebbles occurred.

V. 14.5 m below the surface (sample no. 178M). Fine, silty sand. Median diameter, M=0.11 mm. Quartiles, Q_3=0.22 mm, Q_1=0.052 mm. Coefficient of sorting, So=2.0, i.e. the sediment is well sorted. It was distributed in a 2 m thick stratum which was very rich in fossils, mainly *Mya truncata.*

VI. 17.0 m below the surface (sample no. 179M). Till. Median diameter, M=0.11 mm. Quartiles, Q_3=4.76 mm, Q_1=0.011 mm. Coefficient of sorting, So=20.8, i.e. the sediment is poorly sorted. It contains numerous pebbles, cobbles and boulders with striations. Two specimens of the foraminifer ***Elphidium clavatum*** Cushman were observed in this sample.

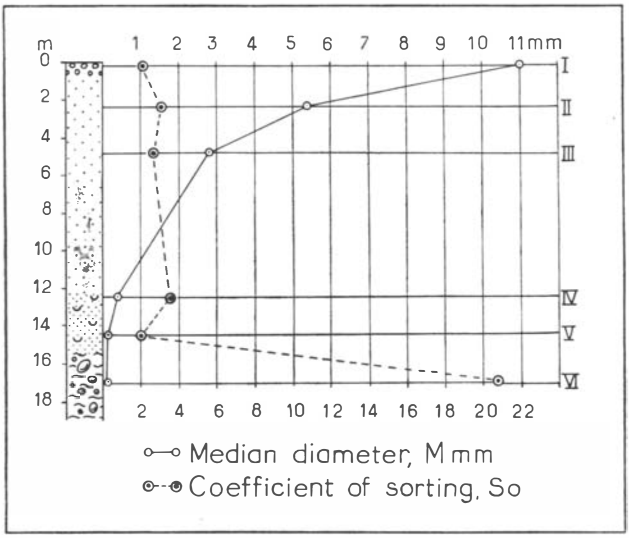


Fig. 27. Variationes in median diameter and sorting of six samples from a section through a *Mya terrace* north of Phantomvika. (Cf. figs. 25 and 26).

The till outcrops in the surface of the lowest bench, the marine silt and gravel having been washed away by wave erosion.

The fossil-bearing, fine, silty sand could be followed in a rising stratum further up in the erosion furrow. Numerous shells which originated from this stratum had been washed down into the stream bed. The following collection was made from the stratum with silty sand (some of the shells were picked up from the stream bed):

50.7 m a.s.l. North of Phantomvika, Mya terrace (Sample No. 349).

Species	Frequency	Percentage
Mya truncata LINNÉ	105	69.1
Macoma calcarea (CEMNITZ)	38	25.0
Saxicava arctica (LINNÉ)...............	7	4.6
Chlamys islandica (MÜLLER)	1	0.7
Balanus balanus (LINNÉ)	1	0.7
	152	100.1

210 valves and umbonal fragments of *Mya truncata* were collected. They were thick-shelled and, on the whole, similar to the forms from the *Mya* terrace at Myadalen (figs. 28 and 57). The shells of *Macoma calcarea* were quite small and had an ovate-triangular outline with somewhat pointed and truncated posterior part which was in all specimens bent somewhat to the right (pl. 23, figs. 8—11). The pallial sinus of the left valve was very deep, but less deep in the right. (Cf. SOOT-RYEN 1932). The largest shell

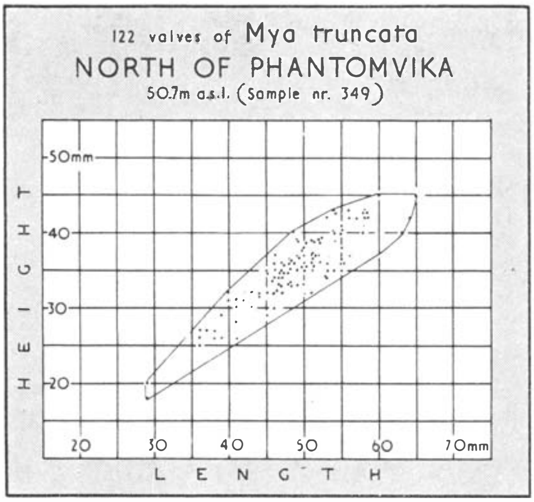


Fig. 28. Shell measurements of *Mya truncata*.

measured, length, L=31.5 mm, height, H=24.0 mm, index, 100•H/L= 76.19. The *Saxicava* shells were thick and of regular *pholadis* form (fig. 29).

The prominent terrace level, 50.7 m a.s.l., dips gently to the north. ENE of the locality just discussed was observed a distinct accumulation of unconsolidated material at the mountain side (pl. 3, fig. 3). Its horizontal surface was situated 96 m a.s.l.; it was uneven and composed mainly of coarse material (sample nr. 181M) with angular particles. The median diameter of the deposit, M=0.33 mm. Quartiles, Q_3=8.10 mm, Q_1=0.02 mm. Coefficient of sorting, So=20.12, i.e. poorly sorted. Neither megafossils nor microfossils were observed in the sample. This deposit is probably the remnant of a lateral moraine, though it could perhaps represent a marine terrace, the surface of which has been deformed by snow patch erosion.

Ekholmvika.

Ekholmvika (78°35′ N.lat., 16°37′ E.long.) is the broad bay north of Kapp Ekholm on the east side of Billefjorden (pl. 4). At the bay, approx. 1.3 km ENE of the cape, there is a conspicuous terrace complex which is schematically illustrated in the block diagram, fig. 30. (Cf. also sketch map, fig. 23).

The main feature is the raised ridged beach plain with *Astarte,* the surface of which slopes N28°E, almost the exact trend of the eastern shores of Billefjorden. The height of the plain was measured at some points along its direction of slope. It rises from 12.7 m a.s.l., at the obtuse point which terminates Ekholmvika to the north, to 37.0 m a.s.l. at its upper termination. Southwards along the Recent sea cliff the following heights were measured: 12.7 m at the above mentioned obtuse point, 15.2 m, 18.8 m, 20.4 m, and

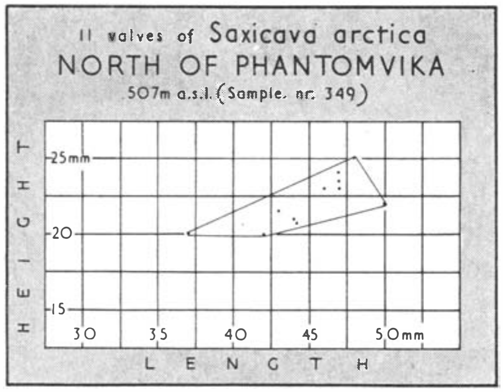


Fig. 29. Shell measurements of *Saxicava arctica.*

22.6 m, at the southern end of the sea cliff where a deep erosion furrow has been cut through the plain (pl. 5, fig. 1); the horizontal distance between the first and last points was 516 m. In fig. 31 it is demonstrated that the slope of the terrace surface is not uniform along this distance, but is largest between 15 and 20 m a.s.l. and smallest at 22 m a.s.l. The average gradient of the slope within this distance is 20 m per km, or 1.14 degrees (360 graduation). — The terrace surface rises southwards to 26 m, and to 37 m a.s.l. at the foot of the cliff of a *Mya* terrace above.

The surface of the large *Astarte* terrace is occupied by close-set beach ridges. These are slightly curved with a northward concavity. Their direction, at the sea cliff of the terrace, is N 64°W at an elevation of 15 m and N 62°W at a height of 19 m, i.e. perpendicular to the slope of the terrace surface.

The sea cliff, 500 m long, which has been cut in the terrace deposits by wave erosion in Recent times at the east shore of Ekholmvika reveals continuous incline bedding with alternating coarser and finer strata, the bulk of the material consisting of gravel. The strata have a true northerly dip of 20—25°, i.e. they dip in the same direction as the slope of the terrace surface (pl. 5, figs. 1, 2).

Six samples were taken in vertical succession at intervals of 15 cm from a clean section of the lower part of the cliff (figs. 32, 33, and pl. 6, fig. 23), and are briefly described in the following:

I. (Sample no. 186M). Sandy gravel. Median diameter, M=1.70 mm. Quartiles, Q_3=10.10 mm, Q_1=0.47 mm. Coefficient of sorting, So=4.6, i.e. poorly sorted. Coefficient of quartile skewness, Sk=1.64, i.e. maximum sorting on the fine side of the median diameter.

II. (Sample no. 187M), 15 cm below I. Sandy gravel. Median diameter, M=1.70 mm. Quartiles, Q_3=7.50 mm, Q_1=0.31 mm. Coefficient of sorting, So=4.9, i.e. poorly sorted. Coefficient of quartile skewness, Sk=0.80, i.e. maximum sorting on the coarse side of the median diameter.

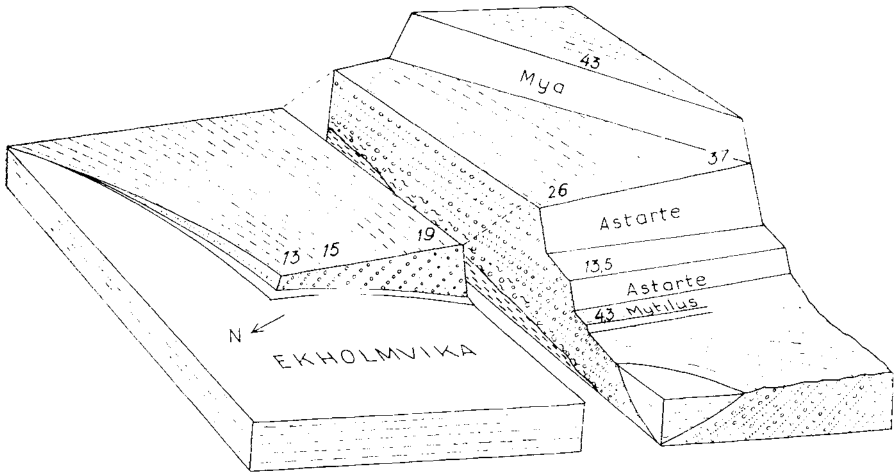


Fig. 30. Schematic illustration of the raised features at Ekholmvika. (Cf. pl. 4).

III. (Sample no. 188M), 30 cm below I. Sandy gravel of the same texture as the two previous. Median diameter, M=1.90 mm. Quartiles, Q_3=4.80 mm, Q_1=0.36 mm. Coefficient of sorting, So=3.70, i.e. normal sorting. Coefficient of quartile skewness, Sk=0.50, i.e. maximum sorting on the coarse side of the median diameter.

IV. (Sample no. 189M), 45 cm below I. Silty gravel. Median diameter, M=1.25 mm. Quartiles, Q_3=8.10 mm, Q_1=0.08 mm. Coefficient of sorting, So=10.00, i.e. poorly sorted. Coefficient of quartile skewness, Sk=0.40, i.e. maximum sorting on the coarse side of the median diameter.

V. (Sample no. 190M), 60 cm below I. Sandy gravel. Median diameter, M=3.30 mm. Quartiles, Q_3=8.80 mm, Q_1=1.40 mm. Coefficient of sorting, So=2.51, i.e. normally to well sorted. Coefficient of quartile skewness, Sk=1.13, i.e. maximum sorting on the fine side of the median diameter.

VI. (Sample no. 191M), 75 cm below I. Silty gravel. Median diameter, M=2.50 mm. Quartiles, Q_3=12.00 mm, Q_1=0.15 mm. Coefficient of sorting, So=8.90, i.e. poorly sorted. Coefficient of quartile skewness, Sk=0.30, i.e. maximum sorting on the coarse side of the median diameter.

The pebbles were well rounded in all samples.

Thus, two strata with sandy gravel and two with silty gravel are represented in this section.

On the whole the strata vary in thickness, and hence the distance between them is also variable. In general those with sandy gravel are thicker than the silty ones. The order of magnitude of the thickness of the sandy

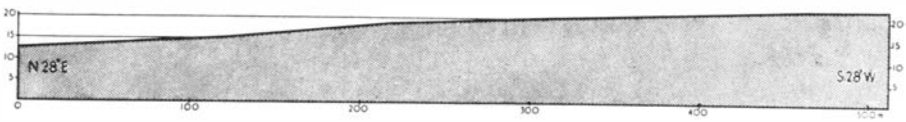


Fig. 31. Profile along the large ridged beach plain with *Astarte* at Ekholmvika, showing its slope (vertical scale 10 times horizontal).

strata is 30 cm, and for the thickness of the silty beds 10 cm, with great and frequent variations in both[1].

Due to their lower porosity the silt-bearing strata retain the moisture, thus to some extent becoming consolidated so that they stand out conspicuously from the cliff, beautifully emphasizing the stratification (pl. 5, fig. 2); an especially good impression of the stratification is attained when the sun is in the north. One stratum was exclusively composed of pebbles, all with their surfaces strongly stained red by iron oxide.

In the cliff where the erosion furrow cuts through the *Astarte* terrace the following collection was made:

17 m a.s.l. Ekholmvika. Terrace cliff and surface. Gravel. (Sample No. 350).

Species	Frequency	Percentage
Astarte borealis (CHEMNITZ)	45.5	92.9
Mya truncata LINNÉ	1.5	3.1
Mytilus edulis LINNÉ	1.0	2.0
Astarte montagui (DILLWYN)	1.0	2.0
	49.0	100.0

South of the prominent sea cliff a smaller terrace has been cut in the *Astarte* deposits at an altitude of 13.5 m, the trend of its front edge being NNE—SSW. It is horizontal as seen from the fjord, and its surface carries beach ridges which are parallel to the front edge of the terrace so that it rises slightly eastwards.

Below this lower *Astarte* terrace there is a small and indistinct *Mytilus* terrace at an elevation of 4.3 m a.s.l.; the beach ridges of its surface are parallel to those on the lower *Astarte* terrace.

[1] Plotted in the M-So diagram (SELMER-OLSEN 1954) sample III falls within the area of glacifluvial material, whereas the rest of the samples fall within the area of morainic gravel. This is due to the fact that the samples are inhomogeneous, one sample containing more than one unit of the sediment. The silty gravel (pl .6, figs. 2, 3) contains at least two sediments in one stratum; the wave current at which the coarse fraction was deposited must have been of an order of magnitude other than that at which the fine fraction came to rest. The silt fraction was deposited later than, and in between the particles of the gravel fraction so that in this protected position it could remain in the stratum during later periods of stronger water turbulence, thus being covered by new strata of gravel (cf. footnote p. 17). These conditions are also demonstrated by the trend of the cumulative-frequency curves, fig. 32.

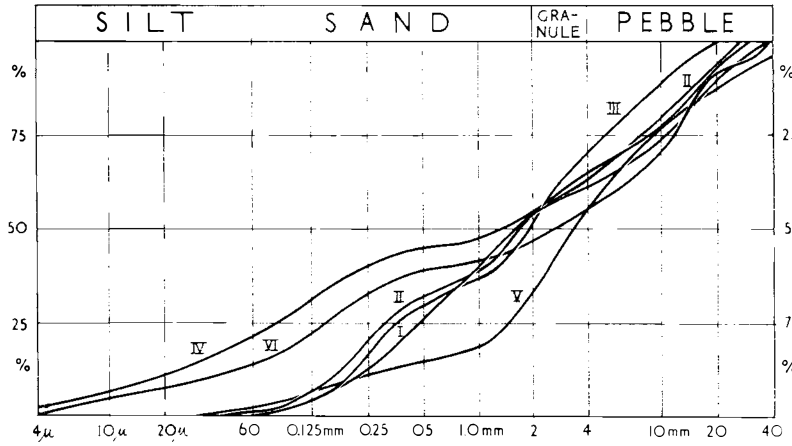


Fig. 32. Cumulative frequency curves of six samples from the cliff of the raised ridged beach plain with *Astarte* at Ekholmvika; IV and VI from strata with silty, the others from strata with sandy gravel. (Cf. fig. 33).

The large and prominent raised beach plain with *Astarte* has its upper termination, 37.2 m a.s.l., at the foot of the cliff of a *Mya* terrace. The front edge of the *Mya* terrace is situated 43 m a.s.l., its surface rising to the SSE, and BALCHIN (1941, p. 375) found its gradient to be 58 minutes towards N 38°W. This is another raised beach plain, and the direction of the beach ridges on its surface is perpendicular to the gradient of the slope of the surface. According to BALCHIN (1941, fig. 2, lines of levels no. 7 and 8) this plain rises to 50 m on the north side of Mathiesondalen and to 60 m further inland. The material consists of silty gravel (sample no. 185M) with many of the pebbles frost-split. The following shells were found at the terrace front, 43 m a.s.l. (sample no. 351):

Macoma calcarea, 2 valves and 3 umbonal fragments,
Saxicava arctica, 2 umbonal fragments,
Mya truncata, 18 umbonal fragments and many other fragments.

East of the obtuse point terminating Ekholmvika to the north remnants of two high marine terraces (pl. 5, fig. 3) were measured:

77.0 m a.s.l., front edge of terrace, its surface rises inland.
84.5 —»— rear edge of the same terrace.
90.0 —»— rear edge of the highest terrace.

These terraces are horizontal as seen from the fjord and *Mya truncata* and *Saxicava arctica* were observed at the rear edge of the lower of the two terraces, at 84.5 m a.s.l. This is the greatest elevation at which Pleistocene fossils have been recorded from marine deposits in Svalbard up to the present.

Summing up, the heights of the following marine features were determined around Ekholmvika:

4.3 m a.s.l., front edge of *Mytilus* terrace.
13.5 m a.s.l., front edge of lower *Astarte* terrace.

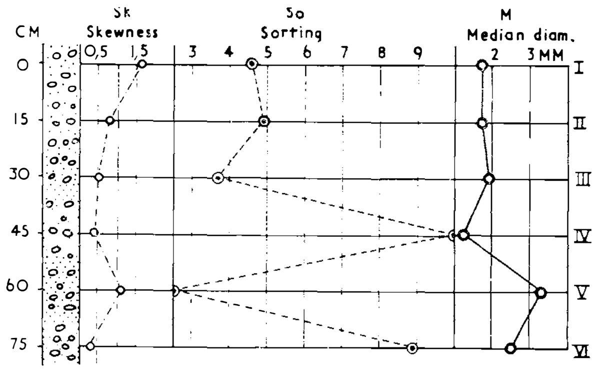


Fig. 33. Variations in median diameter, sorting and skewness of six samples from the cliff of the raised ridged beach plain with *Astarte* at Ekholmvika; the strata with silty gravel are the most poorly sorted.

12.7—37.2 m a.s.l., large ridged beach plain with *Astarte;* just north of Ekholmvika it reaches modern sea level.
43—60 m a.s.l., large ridged beach plain with *Mya.*
77.0—84.5 m a.s.l., terrace, *Mya* and *Saxicava* observed.
90 m a.s.l., rear edge of the highest marine terrace.

The heights of the marine features on the south side of Mathiesonelva (Mathieson river) were not measured.

The Scottish Spitsbergen Syndicate Expedition, 1920 (BADEN-POWELL 1939, p. 338) collected the following species from raised beaches at the mouth of Ekholm Valley (=Mathiesondalen), height not recorded:

Mytilus edulis LINNÉ,
Chlamys islandica (MÜLLER),
Astarte borealis (CHEMNITZ),
?Astarte montagui (DILLWYN),
Mya truncata LINNÉ var. *uddevallensis* HANCOCK,
Saxicava arctica LINNÉ var. *pholadis* LINNÉ,
Buccinum glaciale LINNÉ.

Kapp Scott.

At this locality (78°36.7′ N.lat., 16°41′ E.long.) the conditions described from Phantomodden and Kapp Ekholm are, on the whole, repeated. Just north of the cape there is a large raised beach plain, gently sloping to the N or NNE, with well developed beach ridges at right angles to the direction of the slope (pl. 7). This plain corresponds to the higher *Astarte* plains and continues northwards, interrupted by erosion furrows, to Kapp Napier where it reaches modern sea level. A 1 km long sea cliff at Scottvika, cut into these deposits by wave erosion in Recent times, beautifully reveals continuous incline bedding with the strata dipping northwards.

From the southern end of the sea cliff an older cliff continues towards the SSW with its base on the rear edge of a younger terrace which most probably corresponds to the lower *Astarte* terrace at Ekholmvika.

Above the large raised beach plain the pronounced cliff of a higher terrace is seen, the surface of which has a northward slope. This feature probably represents the *Mya* terrace in the locality.

No heights were determined at Kapp Scott, but according to BALCHIN (1941, fig. 2, map A) the scarp of the *Astarte* plain just ENE of the cape has an altitude of approx. 25 m, and on the higher terrace he determined a point at an elevation of 180 feet (approx. 60 m).

Teltfjellbekken.

Teltfjellbekken (78°37.7′ N.lat., 16°44′ E.long.) is a brook debouching into Billefjorden in the southern part of the Brucebyen area, at the northwestern foot of the mountain Teltfjellet (fig. 34 and pl. 7). Teltfjellbekken has eroded the gravel deposit of the *Astarte* plain and also cut a furrow through the underlying clayey silt with *Lithothamnion*. This *Lithothamnion* silt outcrops also in the sea cliff of the *Astarte* terrace (cf. sketch map fig. 34 and the profile fig. 35, section C—C).

A clean section was made in the silt bed at the brook (cf. map fig. 34) and six samples taken at 30 cm intervals. Mechanical analyses gave the following results (cf. figs. 36, 37):

I. (Sample no. 45M). Surface layer of the Lithothamnion silt, 7 m a.s.l., of yellowish colour, very rich in lime. Median diameter, M=0.011 mm. Quartiles, $Q_3=0.024$ mm, $Q_1=0.0045$ mm. Coefficient of sorting, So=2.4, i.e. well sorted. Coefficient of quartile skewness, Sk=0.87, i.e. the maximum sorting lies on the coarse side of the median diameter.

The sample was rich in ostracods and contained also Foranimifera. Some *Mytilus* fragments and plant remains were also present.

II. (Sample no. 46M) 30 cm below the surface. Silt of characteristic yellewish colour, very rich in lime. Median diameter, M=0.05 mm. $Q_3=0.12$ mm, $Q_1=0.018$ mm. So=2.58, i.e. normally sorted. Sk=0.86, i.e. maximum sorting on the coarse side of the median diameter.

The sample contained numerous ostracods, especially of the genus *Bythocypris; Lithothamnion,* a few shell fragments and some plant remains were also present.

III. (Sample no. 47M) 60 cm below the surface. Fine, grey sand with some silt and well rounded pebbles. Median diameter, M=0.23 mm. $Q_3=0.38$ mm, $Q_1=0.14$ mm. So=1.65, i.e. well sorted. Sk=1.01, i.e. maximum sorting slightly on the fine side of the median diameter.

The sample contained valves and fragments of *Mytilus edulis* and *Saxicava arctica*. One shell of *Omalogyra atomus* (PHILIPPI) was observed (recorded for the first time from the Pleistocene of Svalbard). Among the numerous Foraminifera were observed *Elphidium incertum* (WILLIAMSON), *Elphidium orbiculare* (BRADY), *Buccella frigida* (CUSHMAN), *Cibicides lobatulus* (WALKER and JACOB). Ostracods also occurred.

IV. (Sample no. 48M) 90 cm below the surface. Sandy silt. M=0.032 mm. $Q_3=1.00$ mm, $Q_1=0.011$ mm. So=9.54, i.e. poorly sorted. Sk=10.26, i.e. maximum sorting on the fine side of the median diameter.

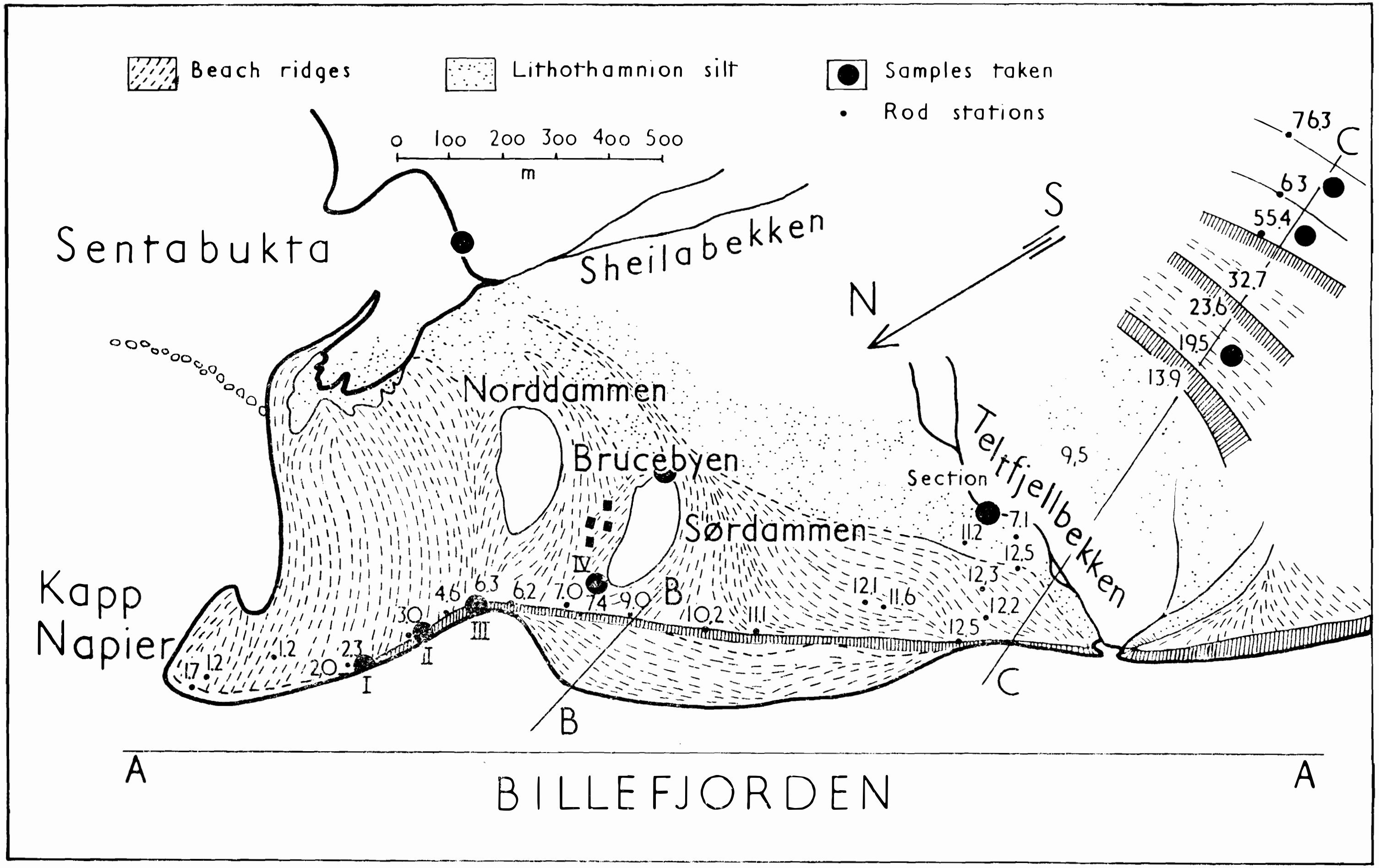


Fig. 34. The Brucebyen area (Cf. pl. 7) with the ridged beach plains and the raised features at Teltfjellbekken; the lines A—A, B—B and C—C refer to profiles. (Cf. figs. 35, 38, 39).

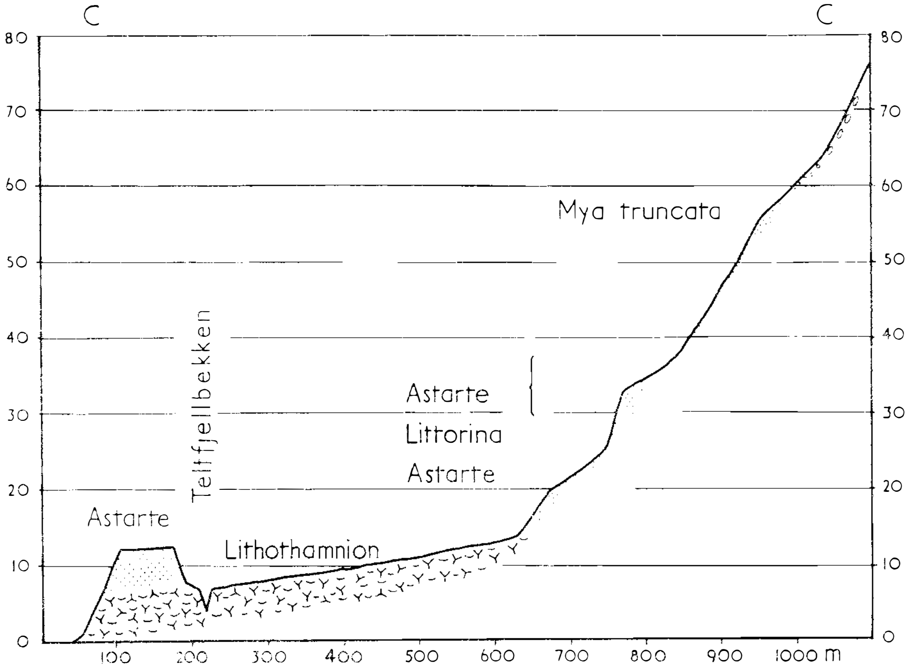


Fig. 35. Profile of the raised features at Teltfjellbekken (C—C on fig. 34).

This sample contained large quantities of *Lithothamnion,* some plates of *Tonicella marmorea,* valves and fragments of *Mytilus edulis, Macoma calcarea, Saxicava arctica* and *Mya truncata,* spines and plates of *Strongylocentrotus droebachiensis,* and two shells of *Omalogyra atomus.* Foraminifera were abundant also in this sample, the most frequent species being *Quinqueloculina arctica* CUSHMAN, *Quinqueloculina seminulum* (LINNÉ), *Elphidium clavatum* CUSHMAN, *Elphidium orbiculare* (BRADY), *Buccella frigida* (CUSHMAN) and *Cibicides lobatulus* (WALKER and JACOB). Some ostracods were also observed.

V. (Sample no. 49M) 120 cm below the surface. Sandy silt. M= 0.036 mm. Q_3=0.12 mm, Q_1=0.011 mm. So=3.30, i.e. normal sorting. Sk=1.02, i.e. maximum sorting slightly on the fine side of the median diameter.

The sample contained large quantities of *Lithothamnion. Tonicella marmorea* and fragments of *Mytilus edulis* occurred, together with numerous valves, especially juveniles, of *Saxicava arctica.* Further, two juvenile valves of different specimens of *Thyasira sarsii* (PHILIPPI) (not previously recorded from the Pleistocene of Svalbard), one shell of *Moelleria costulata,* and three of *Omalogyra atomus* were observed. Spines and plates of *Strongylocentrotus* were present, and numerous specimens of Foraminifera, *Quinqueloculina arctica, Quinqueloculina seminulum, Cibicides lobatulus* and *Buccella frigida* being the most frequent.

VI. (Sample no. 50M) 150 cm below the surface. Silt. M=0.03 mm. Q_3=0.09 mm, Q_1=0.01 mm. So=3.00, i.e. normal sorting. Sk=1.00, i.e. the maximum sorting coincides with the median diameter.

The sample contained quite large quantities of *Lithothamnion,* and shells and fragments, most of them of juveniles, were frequent. Fragments of *Mytilus edulis,* one valve of *Thyasira sarsii,* one of *Thyasira croulinensis* (JEFFREYS) (not previously recorded from the Pleistocene of Svalbard), one broken specimen of *Cyclostrema* sp., a few of *Omalogyra atomus,* and spines and plates of *Strongylocentrotus* occurred. Foraminifera were found abundantly, *Quinqueloculina* ssp. and *Cibicides lobatulus* being the most frequent. Ostracoda were quite common.

To the south of Teltfjellbekken the surface of the *Lithothamnion* silt rises gently to the foot of a gravel cliff, 14 m a.s.l. (Cf. sketch map fig. 34 and profile fig. 35). From the top of the cliff, at an elevation of 19 m a.s.l., a terrace surface, with some strongly developed beach ridges parallel to its front edge rises to approx. 25 m. *Astarte borealis* and *Littorina littorea* occurred, the latter quite commonly in a beach ridge at 23.6 m a.s.l. (pl. 26, figs. 4—8). At approx. 25 m a.s.l. there is another cliff ascending to the front of a second *Astarte* terrace at 32.7 m a.s.l. In the lowest part of the latter silty clay with *Mya truncata* outcropped, whereas the coarser material of the upper part of the cliff contained *Astarte borealis.* The quite strongly sloping surface of this second *Astarte* terrace was badly deformed by solifluction and snow patch erosion, so that the rear edge of the terrace was not easily discernible; it was probably situated at about 38 m a.s.l. Above this level a *Mya* terrace was recognized, the altitude of its front edge being 55.4 m, and of its somewhat uncertain rear edge 63.0 m a.s.l. Marine deposits were still present in the solifluction slope above 63 m, and fragments of *Mya truncata* were found almost up to the foot of the talus slopes at 76 m a.s.l. Large blocks were frequent in the upper part of the marine complex, some of them erratics, and the rest indigenous to the scree cones.

A collection of fossils was made around the most prominent beach ridge on the first *Astarte* terrace south of Teltfjellbekken:

23 m a.s.l. Teltfjellbekken. Terrace, beach ridge, silty gravel. (Sample No. 357).

Species	Frequency	Percentage
Astarte borealis (CHEMNITZ)	21.5	35.3
Littorina littorea (LINNÉ)	18.0	29.5
Mya truncata LINNÉ	9.0	14.8
Saxicava arctica (LINNÉ)	4.5	7.4
Macoma calcarea (CHEMNITZ)	3.0	4.9
Mytilus edulis LINNÉ	1.5	2.5
Astarte montagui (DILLWYN)	1.5	2.5
Cyprina islandica (LINNÉ)	1.0	1.6
Balanus balanoides (LINNÉ)	1.0	1.6
	61.0	100.1

The largest shell of *Littorina littorea* had a length of 29 mm

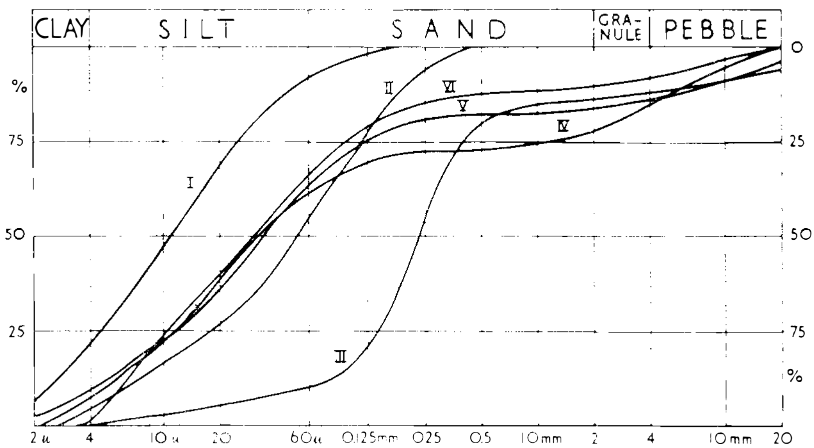


Fig. 36. Cumulative-frequency curves of six samples of *Lithothamnion silt* from a section at Teltfjellbekken (marked „Section" on fig. 34).

Some shell fragments were collected from the *Mya* terrace, 56 m a.s.l., among them being (sample no. 358):

Mya truncata, 7 umbonal fragments,
Macoma calcarea, 1 broken valve.

Further up, at approx. 70 m a.s.l., shell fragments of *Mya truncata* and a columella fragment of a gastropod were found.

Summing up the height measurements of the marine complex at Teltfjellbekken, we have:

12.2 m a.s.l., sea front of *Astarte* terrace.
7—14 m a.s.l., rising surface of *Lithothamnion* silt.
19.5 —»— front edge of *Astarte* terrace.
23.6 —»— beach ridge with *Astarte* and *Littorina.*
32.7 —»— front edge of *Astarte* terrace.
55.4 —»— front edge of *Mya* terrace.
63.0 —»— rear edge of *Mya* terrace.
76.0 —»— highest marine deposit in the locality.

According to BALCHIN (1941, p. 374, and fig. 2, first line of instrumental levels) there should be no Pleistocene marine terrace higher than 12—13 m a.s.l. in this locality.

Brucebyen.

The name of Brucebyen (Bruce City, 78°38.2′ N.lat., 16°45′ E.long.) includes the area between Teltfjellbekken and Adolfbukta, and between Billefjorden and Gerritelva (cf. sketch maps figs. 34 and 47, and also pl. 7).

As observed above, the prominent raised beach plain with *Astarte,* described from Kapp Scott, continues towards the NNE at a more or less uniform gradient until it reaches present-day sea level at Kapp Napier (fig. 38).

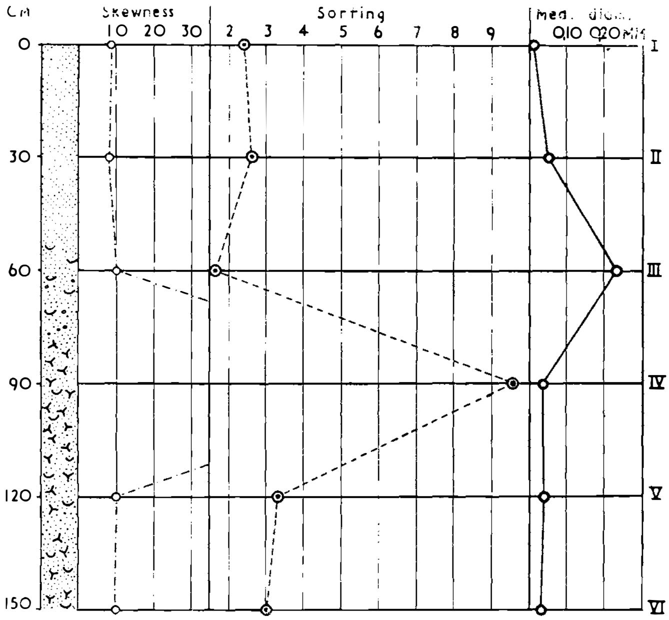


Fig. 37. Variations in median diameter, sorting and skewness of six samples of *Lithothamnion* silt from a section at Teltfjellbekken, 7.0 to 5.5 m a.s.l. (Cf. fig. 36).

All along this distance ridge patterns, representing the successive beach ridges during the process of recovery, occupy its surface; their main direction is E—W or ESE—WNW, with a pronounced tendency to curvature with a northward concavity. Other directions are also seen, and in fact, we can already from the air photographs read, more or less completely, the changing of the coastline during the period of recovery. At Kapp Napier, the pointed termination of this long succession of close-set ridges, a lagoon, the most westerly branch of Sentabukta, is being formed at present, as the later beach ridges have extended further to the east than their predecessors. This process will, in time, most probably lead to the formation of a lakelet as the later ridges enclose the basin so formed. At the huts of the Scottish Spitsbergen Syndicate (Brucebyen in sensu strictu), approx. 800 m south of Kapp Napier, two old lagoons of this kind have been preserved at 6 and 7 m above present sea level[1]. South of these lakelets the various configurations of the predecessors of Kapp Napier are beautifully demonstrated by the trends of the raised beach ridges.

This large raised beach plain slopes from 12.5 m a.s.l. at Teltfjellbekken to Recent sea level at Kapp Napier, its slope, in a profile parallel to the line A—A in the map (fig. 34) being illustrated in fig. 38. The gradient

[1] Several smaller ponds are marked on the sketch maps of SUMMERHAYES and ELTON (1923) and WALTON (1922). I did not observe them in 1950, and they are not marked on the Cambrigde expedition map (HARLAND 1952).

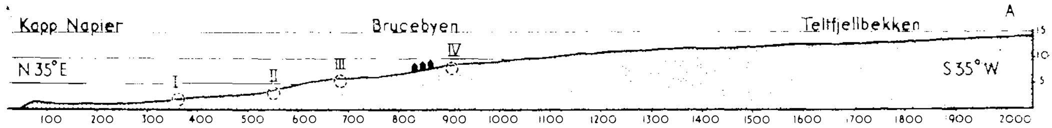


Fig. 38. Profile, parallel to the line A—A of fig. 34, of the sloping beach plain with *Astarte* at Brucebyen; I, II and III mark samples from the sea cliff, IV from the surface at Sørdammen. (Cf. fig. 31).

is small above 10 m, at 6.5 m and at 3 m. At Kapp Napier the later beach ridges are higher than their predecessors.

The large beach plain has been cliffed to the west by wave erosion, and during relatively Recent times a lower beach plain has been built out from the base of the cliff between Norddammen and Teltfjellbekken. The beach ridges on this lower plain are, moreover, parallel to the coast.

The heights of these beach ridges were measured along the line B—B on the map (fig. 34), and the result has been illustrated in the profile fig. 39. It appears that the later ridges are higher than the preceding ones. The height of the crest of the modern ridges was 1.8 m a.s.l. whereas the heights of the older ridges decreased towards the base of the cliff, to approx. 1.0 m a.s.l. (Cf. fig. 38). Similar conditions were found at Kapp Napier, as mentioned above, where the youngest ridges were higher than the inside adjacent ridges. The Recent ridge there had a height of 1.7 m a.s.l. and the older, neighbouring ridges one of 1.2 m a.s.l. (Cf. map fig. 34). Consequently the lower of the older ridges are truncated and overlain by the Recent storm-ridge to the west at the cape. The general slope of the large beach plain becomes less towards modern sea level, and from approx. 1 m a.s.l. the plain rises towards the Recent storm-ridge.

The ridged beach plain, the surface of which is composed of beach gravel, is bounded to the east by a clayey silt containing large quantities of *Lithothamnion* and *Astarte*. It is, moreover, covered by vegetation and appears dark in the field and on the air photographs, so that the border-line between *Lithothamnion* silt and light beach gravel is thus very sharp. (Cf. map fig. 34 and pl. 7).

Both Walton (1922, pp. 110, 114) and Summerhayes and Elton (1923, p. 258) distinguished between an unsilted and a silted region of the raised beaches, but they erroneously assumed that the raised shingle beaches were the primary features and that, on being raised, they came under the influence of silt-bearing streams from the mountains (Walton l.c. p. 114). In this way the greater part of the raised plain should have been silted over by streams.

In point of fact the *Lithothamnion* silt is the primary of the two deposits. It is marine throughout (cf. sample no. 356) and has been deposited partly in somewhat deeper water outside the corresponding beach, and

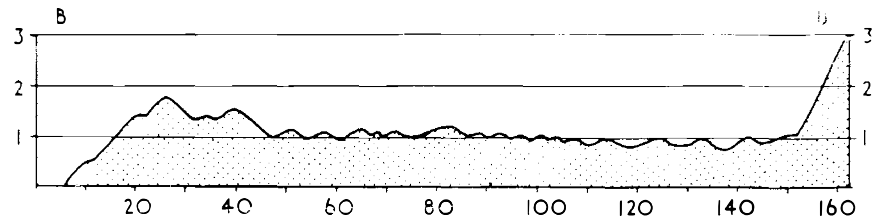


Fig. 39. Landward decrease in crest altitude of successive beach ridges along the line B—B of fig. 34; the numbers refer to meter.

partly in larger swales or lagoons. Similar depositional conditions can be studied to-day at Kapp Napier and at Sentabukta.

A row of large boulders traverses Sentabukta in a northeasterly direction, marking an old position of the front of Nordenskiöldbreen.

Four collections of fossils were made from the beach gravel of the large *Astarte* plain, three from its sea cliff (marked with black rings, I, II, III, on the map fig. 34, also fig. 38) and one from the northern end of Sørdammen at the huts (IV on the map), the height of the plain at the places of collections being 2.3 m, 4.0 m, 6.0 m, and 7—8 m a.s.l.

2.3 m a.s.l. I. Brucebyen. Terrace cliff. Sandy gravel (Sample No. 352).

Species	Frequency	Percentage
Astarte borealis (CHEMNITZ)	30.0	69.8
Astarte montagui (DILLWYN)	5.5	12.8
Mytilus edulis LINNÉ	2.5	5.8
Saxicava arctica (LINNÉ)	2.5	5.8
Astarte elliptica (BROWN)	1.0	2.3
Mya truncata LINNÉ	1.0	2.3
Serripes groenlandicus (CHEMNITZ)	0.5	1.2
	43.0	100.0

Further south in the same cliff were collected:

4.0 m a.s.l. II. Brucebyen. Terrace cliff. Sandy gravel (Sample No. 353).

Species	Frequency	Percentage
Astarte borealis (CHEMNITZ)	31.0	57.4
Mytilus edulis LINNÉ	17.0	31.5
Astarte montagui (DILLWYN)	3.5	6.5
Saxicava arctica (LINNÉ)	1.5	2.8
Astarte elliptica (BROWN)	0.5	0.9
Cyprina islandica (LINNÉ)	0.5	0.9
	54.0	100.0

Further south in the same cliff, at the bay formed by the prograding of the lower beach plain, were collected:

6.0 m a.s.l. III. Brucebyen. Terrace cliff. Sandy gravel (Sample No. 354).

Species	Frequency	Percentage
Astarte borealis (CHEMNITZ)	20.5	67.2
Mytilus edulis LINNÉ	5.5	18.0
Astarte elliptica (BROWN)	1.5	4.9
Astarte montagui (DILLWYN)	1.0	3.3
Saxicava arctica (LINNÉ)...............	1.0	3.3
Chlamys islandica (MÜLLER)	0.5	1.6
Mya truncata LINNÉ	0.5	1.6
	30.5	99.9

From the terrace surface, or rather from the low cliff, at the northern end of Sørdammen, 7—8 m a.s.l., the following shells were collected:

7—8 m a.s.l. IV. Brucebyen. Terrace. Gravel (Sample No. 355).

Species	Frequency	Percentage
Astarte borealis (CHEMNITZ)	48.0	66.7
Astarte montagui (DILLWYN)	14.0	19.5
Saxicava arctica (LINNÉ)...............	3.5	4.9
Mua truncata LINNÉ	2.0	2.8
Buccinum glaciale LINNÉ	2.0	2.8
Mytilus edulis LINNÉ	1.5	2.1
Cyprina islandica (LINNÉ)	0.5	0.7
Macoma calcarea (CHEMNITZ)...........	0.5	0.7
	72.0	100.2

Astarte borealis clearly dominated the fauna of all these gravel samples. The highest frequency of *Mytilus edulis* occurred in sample II from 4 m a.s.l. (fig. 40). Some valves of *Astarte borealis* and *A. montagui* have been measured (figs. 41 and 42).

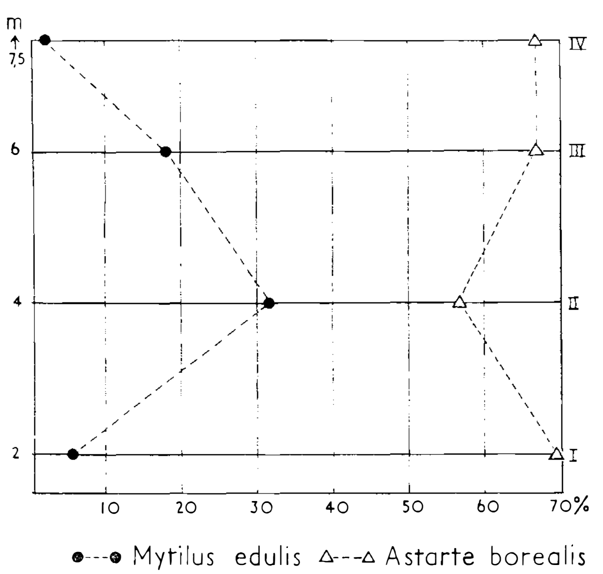


Fig. 40. The relative change in frequency of *Mytilus edulis* and *Astarte borealis* in the cliff and surface of the lower part of the sloping beach plain of Brucebyen (Samples I—IV, figs. 34 and 38).

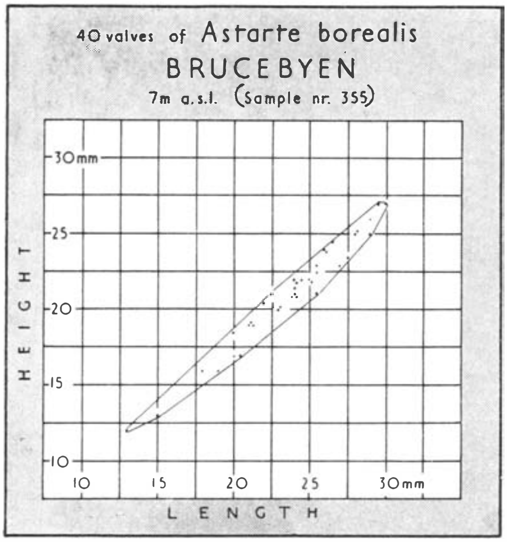


Fig. 41. Shell measurements of *Astarte borealis* from sample IV.

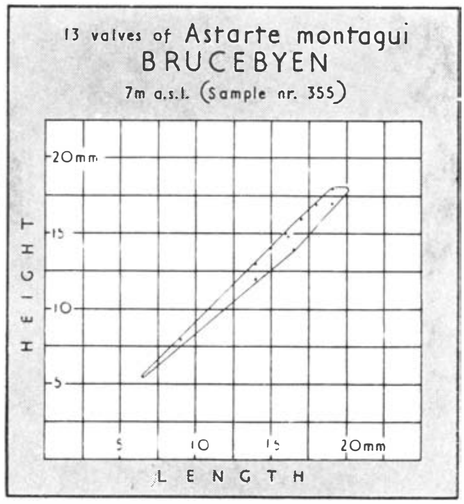


Fig. 42. Shell measurements of *Astarte montagui* from sample IV.

In *Lithothamnion* silt from the sea cliff at Sentabukta, 2 m a.s.l., the following collection was made:

2 m a.s.l. Sentabukta. Clayey Lithothamnion silt. (Sample No. 356).

Species	Frequency	Percentage
Astarte borealis (CHEMNITZ)	64.0	35.5
Mytilus edulis LINNÉ	33.5	18.6
Saxicava arctica (LINNÉ)	24.0	13.3
Astarte montagui (DILLWYN)	10.5	5.8
Astarte elliptica (BROWN)	8.5	4.7
Moelleria costulata (MÖLLER)	7.0	3.9
Margarites groenlandicus (CHEMNITZ)	5.0	2.8
Crenella decussata (MONTAGU)	4.5	2.5
Tonicella marmorea (FABRICIUS)	4.0	2.2
Cingula castanea (MÜLLER)	4.0	2.2
Mya truncata LINNÉ	3.0	1.7
Emarginula fissura incurva JEFFREYS	2.0	1.1
Trophon truncatus STRÖM	2.0	1.1
Macoma calcarea (CHEMNITZ)	1.5	0.8
Puncturella noachina (LINNÉ)	1.0	0.6
Acmaea rubella (FABRICIUS)	1.0	0.6
Margarites helicinus (PHIPPS)	1.0	0.6
Margarites cinereus (COUTHOUY)	1.0	0.6
Littorina saxatilis (OLIVI)	1.0	0.6
Omalogyra atomus (PHILIPPI)	1.0	0.6
Balanus balanoides (LINNÉ)	1.0	0.6
Lithothamnion, large quantities		
	180.5	100.4

Emarginula fissura incurva JEFFREYS has not previously been recorded from the Pleistocene of Svalbard; it is a boreal form now extinct in Spitsbergen waters (p. 152, pl. 24, fig. 12). Some valves of *Astarte* and *Saxicava* were measured (figs. 43—46).

A stoney, silty clay sample from the debouch (SE end) of Sørdammen at the huts of Brucebyen, 7 m a.s.l., yielded the following species (sample no. 269M):

Tonicella marmorea (FABRICIUS), 25 plates,
Trachydermon ruber (LINNÉ), 5 plates,
Trachydermon albus (LINNÉ), 1 plate,
Chlamys islandica (MÜLLER), 1 fragment,
Mytilus edulis LINNÉ, 1 fragment,
Astarte borealis (CHEMNITZ), 1 fragment,
Saxicava arctica (LINNÉ), 10 valves and umbonal fragments,
Mya truncata LINNÉ, 2 hinge fragments,
Acmaea rubella (FABRICIUS), 3 specimens,
Cingula castanea (MÖLLER), 3 specimens,
Lora bicarinata (COUTHOUY), 1 specimen,
Lora sp., 1 broken specimen,
Verruca stroemia (MÜLLER), 9 comparments, 2 scuta, 1 tergum,
Balanus crenatus BRUGUIÈRE, 1 scutum and 1 rostrum,
Strongylocentrotus cf. *droebachiensis,* plates and spines,
Lithothamnion sp., several fragments.

Additionally some Ostracoda and a few Foraminifera occurred. *Verruca stroemia* has not previously been recorded from the Pleistocene of Svalbard (p. 171, pl. 26, figs. 15, 16).

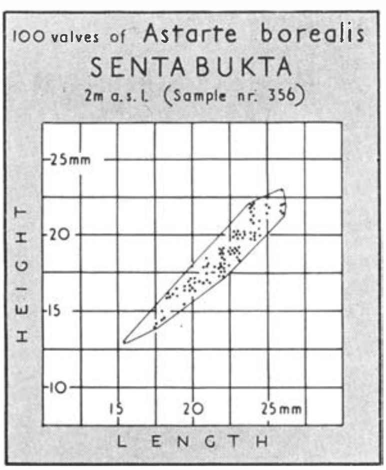


Fig. 43. Shell measurements of *Astarte borealis* from *Lithothamnion silt.*

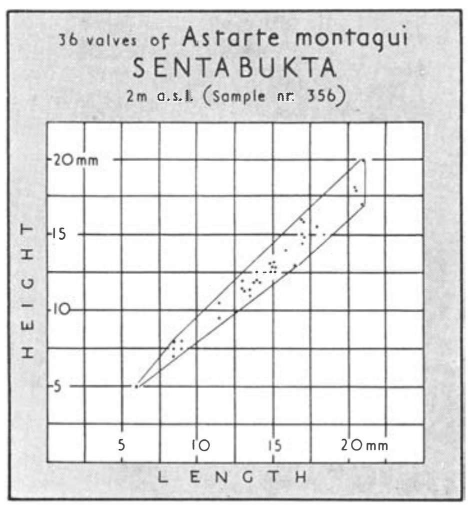


Fig. 44. Shell measurements of *Astarte montagui* from *Lithothamnion silt.*

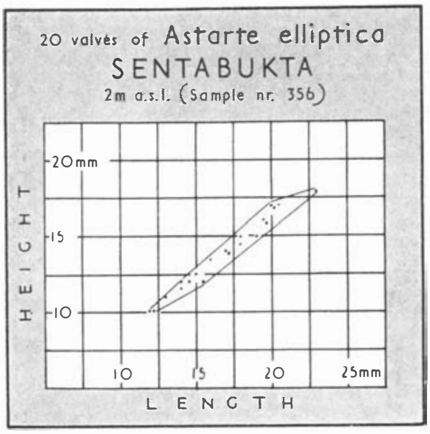


Fig. 45. Shell measurements of *Astarte elliptica* from *Lithothamnion silt.*

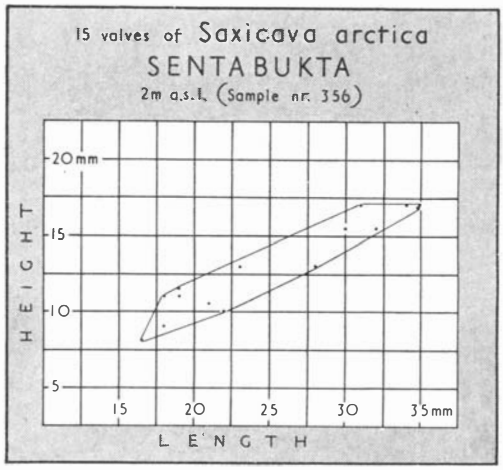


Fig. 46. Shell measurements of *Saxicava arctica* from *Lithothamnion silt.*

The Brucebyen area has been visited by several investigators. Sketch maps are found i.a. in SUMMERHAYES and ELTON (1923, p. 265), WALTON (1922, p. 110) and SLATER (1925, p. 430); the Cambridge Spitsbergen expedition, 1949, made a plane-table survey of the lowland at Brucebyen (HARLAND, 1952, p. 316). Some of the expeditions collected fossils from the raised marine Pleistocene deposits:

The Swedish expedition in the year of 1896 collected the following species from „The point SW of Nordenskiöldbreen" (HÄGG 1951, p. 242; height not recorded):

Chlamys islandica (MÜLLER), 1 valve,
Mytilus edulis LINNÉ, lost,
Astarte borealis (CHEMNITZ), 1 valve,
Serripes groenlandicus (CHEMNITZ) (=*Cardium groenlandicum*), 4 valves,
Saxicava arctica (LINNÉ), 2 valves,
Buccinum glaciale LINNÉ, 10 shells,
Sipho kroeyeri (MÖLLER), 9 shells,
Sipho togatus (MÖRCH), 2 shells.

Southwest of Nordenskiöldbreen they found:

Mya truncata LINNÉ, 3 valves and some fragments.

On a Russian expedition in the year 1900, A. WOLKOWITSCH collected the following Late-Pleistocene shells from terraces ½ km from the coast and some meters above sea level, on the east side of the head of Billefjorden (KNIPOWITSCH 1902, p. 425):

Astarte borealis (CHEMNITZ), 51 valves,
Mytilus edulis LINNÉ, 30 valves,
Mya truncata LINNÉ, 30 more or less broken valves and many fragments,
Saxicava arctica (LINNÉ), 7 valves and some in clods of *Lithothamnion,*
Macoma calcarea (CHEMNITZ), 8 valves,
Buccinum groenlandicum CHEMNITZ, 3 specimens,
Sipho kroeyeri (MÖLLER), 1 specimen,
Buccinum ciliatum FABRICIUS, 1 broken shell,
Chlamys islandica (MÜLLER), 2 fragments,
Astarte montagui (DILLWYN) (=*A. banksi* (LEACH)), 1 valve.

ELTON and BADEN-POWELL (1931, pp. 390, 395—404)[1] recorded the following mollusk species from a section through the upper part of a 10—12 m raised beach near one of the Scottish Spitsbergen Syndicate borings, known as „Bore No. 1" and situated one quarter of an Eglish mile southwest (probably a misprint of southeast) of Brucebyen:

Chlamys islandica
Crenella decussata
Mytilus edulis
Serripes groenlandicus
Astarte borealis
Thyasira flexuosa
Macoma calcarea
Mya truncata ovata (recorded as *Mya arenaria*)
Mya truncata
Saxicava arctica
Puncturella noachina
Margarites groenlandicus
Littorina saxatilis
Littorina littorea
Trophon truncatus (=*Boreotrophon truncatum)*[2]

Gerritelva.

Gerritelva (78°38.2′ N.lat., 16°51′ E.long.) is the river running along the southwest side of Ferriermorena, the southern lateral moraine of Nordenskiöldbreen (fig. 47). On its southwest side the river has eroded in raised marine deposits, the heights of which were measured as follows:

6.5 m a.s.l., front edge of silt terrace with *Astarte* and *Lithothamnion.*
11.3 —»— undistinct terrace.
14.0 —»— front edge of silt terrace with *Astarte* and *Lithothamnion.*
18.0 —»— front edge of gravel terrace with *Astarte.*

[1] These authors erroneously state (pp. 391, 403) that *Littorina saxatilis* (=*L. rudis*) is now extinct in Spitsbergen waters. (Cf. ODHNER 1915, p. 17; FEYLING-HANSSEN and JØRSTAD 1950, p. 77; FEYLING-HANSSEN 1953).

[2] Cf. footnote 1 on page 135.

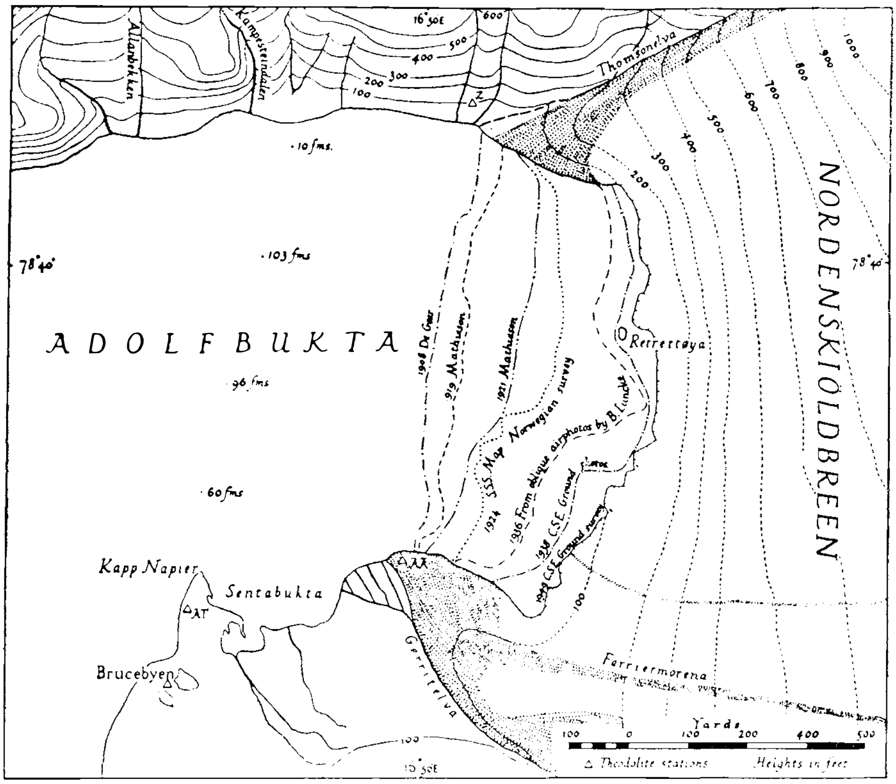


Fig. 47. (From HARLAND 1952, p. 318; the scale is incorrect.)

23.2 m a.s.l., front edge of gravel terrace with *Astarte.*
30.1 —»— small plain with *Astarte.*
36.5 —»— small terrace with *Mya truncata.*
40.0 —»— small terrace with *Mya truncate* and *Macoma calcarea.*
45.0 —»— terrace, surface destroyed by solifluction, *Mya truncata* occurred.
59.7 —»— disturbed terrace, partly coarse material, *Mya truncata* present.
68.0 —»— terrace remnant with *Mya,* otherwise difficult to recognize its marine origin.
77.8 —»— highest marine level.

The height of the front of the somewhat uneven silt plain with *Astarte* and *Lithothamnion,* 6.5 m a.s.l., was measured at the west side of the mouth of Gerritelva. The height of the cliff decreases towards the southwest. The silt was depsited in zuiet water under conditions similar to those in Sentabukta to-day.

At 14 m a.s.l., at the top of a low cliff in the same silty material, the following collection was made:

14 m a.s.l. Gerritelva. Small terrace, Lithothamnion silt. (Sample No. 360).

Species	Frequency	Percentage
Astarte borealis (CHEMNITZ)	63.5	56.0
Astarte montagui (DILLWYN)	18.0	15.9
Saxicava arctica (LINNÉ)...............	13.0	11.4
Mya truncata LINNÉ	10.0	8.8
Mytilus edulis LINNÉ	3.5	3.1
Littorina saxatilis (OLIVI)	2.0	1.8
Macoma calcarea (CHEMNITZ)...........	1.0	0.9
Trophon clathratus (LINNÉ)	1.0	0.9
Gastropoda	1.0	0.9
Cyprina islandica (LINNÉ)	0.5	0.4
Echinid spines		
Lithothamnion sp. masses.		
	113.5	100.1

Most of the *Saxicava* specimens were small and irregular.

From the gravel terrace at 18 m a.s.l. the following shells were collected:

18 m a.s.l. Gerritelva. Astarte terrace, gravel. (Sample No. 361).

Species	Frequency	Percentage
Astarte borealis (CHEMNITZ)	28.0	83.6
Mya truncata LINNÉ	2.5	7.5
Astarte montagui (DILLWYN)	1.5	4.5
Mytilus edulis LINNÉ	0.5	1.5
Macoma calcarea (CHEMNITZ)...........	0.5	1.5
Saxicava arctica (LINNÉ)...............	0.5	1.5
Lithothamnion sp., 1 small fragment.		
	33.5	100.1

From the *Astarte* terrace at 23.2 m a.s.l. were collected:

23.2 m a.s.l. Gerritelva. Astarte terrace, silty gravel. (Sample No. 362).

Species	Frequency	Percentage
Astarte borealis (CHEMNITZ)	66.0	33.9
Littorina littorea (LINNÉ)	33.0	16.9
Mytilus edulis LINNÉ	27.0	13.9
Mya truncata LINNÉ	21.0	10.8
Littorina saxatilis (OLIVI)	18.0	9.2
Saxicava arctica (LINNÉ)...............	5.5	2.8
Lacuna vincta (MONTAGU)	5.0	2.6
Astarte montagui (DILLWYN)	4.5	2.3
Macoma calcarea (CHEMNITZ)...........	4.5	2.3
Cyprina islandica (LINNÉ)	2.5	1.3
Astarte crenata GRAY..................	2.0	1.0
Balanus balanoides (LINNÉ)	2.0	1.0
Trophon sp.	1.0	0.5
Lora bicarinata (COUTHOUY)	1.0	0.5
Balanus crenatus BRUGUIÈRE	1.0	0.5
Serripes groenlandicus (CHEMNITZ)	0.5	0.3
Zirfaea crispata (LINNÉ)	0.5	0.3
	195.0	100.1

This fauna compares well with that from 23 m a.s.l. at Teltfjellbekken, both being indicative of optimal climatic conditions for the area.

The largest complete valve of *Littorina littorea* had a length of 28 mm. The *Mya* shells and fragments, moreover, belonged to small and thin-shelled specimens, and most of the *Saxicava* shells were small and irregular. Five hinge fragments and many other fragments of large specimens of *Cyprina islandica* were found (pl. 22, figs. 6—9; pl. 23, fig. 3). The *Trophon* specimen was too worn for safe specific identification. *Lora bicarinata* was of the form described as var. *lævior* by G. O. SARS (1878, p. 239, *Bela violacea* var. *lævior*). A hinge fragment of *Serripes groenlandicus* was found (pl. 22, fig. 4), and of *Zirfaea crispata* a fragment of the anterior end of a right valve. Two rostra and two lateral compartments of *Balanus balanoides* occurred.

In a little stream bed behind the 23 m terrace plain *Mya truncata* and *Saxicava arctica* occurred, having been washed out from the *Mya* sediments.

From the small gravel plain at 30.1 m a.s.l. the following shells were found (Sample no. 363):

Astarte borealis, 18 valves and some fragments,
Mya truncata, 7 umbonal and some other fragments,
Macoma calcarea, 3 broken valves,
Saxicava arctica, 2 broken valves,
Littorina saxatilis, 1 shell,
Littorina littorea, 1 broken shell,
Mytilus edulis, 1 small fragment,
Astarte montagui, 1 valve,
Cyprina islandica, 4 fragments.

From the small terrace at 36.5 m a.s.l. were collected:

Mya truncata, 5 umbonal and 30 other fragments,
Macoma calcarea, 2 broken valves,
Mytilus edulis, 5 small fragments,
Saxicava arctica, 1 fragment.

The small terrace at 40 m a.s.l. was partly destroyed; its material contained some head-sized boulders, and *Mya truncata* and *Macoma calcarea* occurred.

The marine features above were badly deformed. Quite large boulders and blocks occurred in the deposits, and scattered fragments of *Mya truncata* were found at all levels up to 77.8 m a.s.l.

In the stream bed of Gerritelva, which runs between the raised marine features just dealt with and the lateral moraine of Nordenskiöldbreen, there occurred some shells washed out from the eroded deposits. The following were collected (sample no. 365):

Mya truncata, 46 umbonal and many other fragments,
Astarte borealis, 3 valves,
Macoma calcarea, 3 broken valves,
Saxicava arctica, 3 broken valves.

These shells originate partly from the raised beaches, and partly from the lateral moraine of Nordenskiöldbreen, the glacier having slightly invaded the beaches and incorporated some of their material in its moraine. (Cf. LAMPLUGH 1911, p. 236).

Petuniabukta.

On the east side of Petuniabukta (78°42′ N.lat., 16°39′ E.long.) raised marine features were surveyed between Ebbaelva (Ebba river) and Rudmosepynten (pl. 8). At the coast south of the debouch of Ebbaelva there is an old hut, where the heights of two marine terraces were measured:

4.3 m a.s.l., front edge of the terrace with the hut.
8.0 —»— front edge of a terrace farther inland.

From the cliff of the 4.3 m terrace were collected:

4.3 m a.s.l. Petuniabukta. Terrace cliff, gravel. (Sample No. 366).

Species	Frequency	Percentage
Astarte borealis (CHEMNITZ)	56.0	76.2
Mytilus edulis LINNÉ	8.0	10.9
Saxicava arctica (LINNÉ)	4.5	6.1
Astarte montagui (DILLWYN)	2.0	2.7
Mya truncata LINNÉ	1.5	2.0
Littorina littorea (LINNÉ)	1.0	1.4
Astarte elliptica (BROWN)	0.5	0.7
Lithothamnion occurred		
	73.5	100.0

The fauna of the 8 m terrace was also dominated by *Astarte borealis*.

More marine levels were discernible farther in the valley, but these were not investigated.

To the south of the entrance to the valley the heights of the following marine levels were determined:

3.2 m a.s.l., front edge of lowest terrace,
29.7 —»— ridged beach plain with *Astarte*,
31.0 —»— farther south on the same beach plain,
34.5 —»— same plain at the talus, silt with *Astarte*,
41.3 —»— terrace with *Mya*.

The raised beach plain with *Astarte* slopes gently to the north with beach ridges in an approximately east-west direction. It has been deeply incised by streams, and is cliffed to the west by Recent wave erosion. To the north only a huge gravel hill with N—S edge remains.

Fossil shells were collected from the terrace surface and cliffs, the fauna being predominated by *Mya truncata* which is unusual for the level. A few *Mya* fragments belonged to large and thick-shelled specimens suggesting that they originated from older *Mya* deposits, but by far the major part of the *Mya* shells and fragments were of small and thin-shelled forms. The following species were found in the terrace:

31 m a.s.l. Petuniabukta. Beach plain, surface and cliff, sandy gravel. (Sample No. 368).

Species	Frequency	Percentage
Mya truncata LINNÉ	79.0	33.3
Mytilus edulis LINNÉ	43.5	18.4
Astarte borealis (CHEMNITZ)	24.5	10.3
Saxicava arctica (LINNÉ)	24.5	10.3
Heteranomia squamula (LINNÉ)	19.0	8.0
Littorina littorea (LINNÉ)	13.0	5.5
Macoma calcarea (CHEMNITZ)	9.5	4.0
Astarte montagui (DILLWYN)	5.5	2.3
Balanus balanoides (LINNÉ)	5.0	2.1
Zirfaea crispata (LINNÉ)	3.0	1.3
Volsella modiola (LINNÉ)	2.0	0.8
Balanus balanus (LINNÉ)	2.0	0.8
Chlamys islandica (MÜLLER)	1.5	0.6
Cyprina islandica (LINNÉ)	1.5	0.6
Acmaea rubella (FABRICIUS)	1.0	0.4
Littorina saxatilis (OLIVI)	1.0	0.4
Balanus sp.	1.0	0.4
Serripes groenlandicus (CHEMNITZ)	0.5	0.2
Strongylocentrotus cf. *droebachiensis* plates and spines		
	237.0	99.7

Six species indicative of a comparatively mild climate occur in this fauna, viz.: *Heteranomia squamula, Mytilus edulis, Volsella modiola, Cyprina islandica, Zirfaea crispata* and *Littorina littorea.* Of *Volsella modiola* 4 umbonal and many other fragments were found (pl. 19, figs. 1—3). Of *Cyprina islandica* 3 hinge fragments and a few others were present, and of *Zirfaea crispata* 6 hinge fragments. 4 carinae, 4 rostra, 4 lateral and 5 carinolateral compartments of *Balanus balanoides* were found.

Approximately 50 m south of this locality, on the same raised beach plain but on the other side of an erosion furrow, another collection was made, mainly from the surface:

31 m a.s.l. Petuniabukta. Beach plain, surface, sandy gravel. (Sample No. 369).

Species	Frequency	Percentage
Mytilus edulis LINNÉ	21.5	36.7
Mya truncata LINNÉ	16.5	28.2
Saxicava arctica (LINNÉ)	12.5	21.4
Lacuna vincta (MONTAGU)	3.0	5.1
Chlamys islandica (MÜLLER)	1.0	1.7
Astarte borealis (CHEMNITZ)	1.0	1.7
Zirfaea crispata (LINNÉ)	1.0	1.7
Balanus balanus (LINNÉ)	1.0	1.7
Astarte crenata GRAY	0.5	0.9
Macoma calcarea (CHEMNITZ)	0.5	0.9
Strongylocentrotus sp. spines and plates		
	58.5	100.0

Three of these species are now extinct in Spitsbergen waters, viz.: *Mytilus edulis, Zirfaea crispata* and *Lacuna vincta.*

Towards the mountain side there was a silty flow from the base of the talus out on to the plain. This silt contained *Astarte borealis* up to a height of 34.5 m a.s.l.

The following shells were collected from the silt, 34.5 m a.s.l. (sample no. 367):

Mya truncata, 1 valve, 9 umbonal and some other fragments,
Astarte borealis, 4 valves,
Saxicava arctica, 1 valve and 1 hinge fragment,
Littorina littorea, 1 broken shell,
Mytilus edulis, 3 small shell fragments,
Macoma calcarea, 1 hinge fragment,
Zirfaea crispata, 1 small shell fragment.

The *Littorina* shell was found somewhat lower on the terrace plain than the other shells.

Approximately 500 m farther south there is a *Mya* terrace 41.3 m a.s.l., and from its surface and cliff were collected the following species (sample no. 370):

Mya truncata, 21 umbonal fragments,
Saxicava arctica, 9 umbonal fragments,
Mytilus edulis, 2 hinge fragments and a few others,
Chlamys islandica, 2 small shell fragments,
Astarte montagui?, 1 umbonal fragment.

From *Mya* silt outcropping in the cliff of the same terrace at about 30 m a.s.l., the following species were collected:

c. 30 m a.s.l. Petuniabukta. Cliff of 41.3 m terrace. Silt. (Sample No. 371).

Species	Frequency	Percentage
Mya truncata LINNÉ	24.0	66.7
Saxicava arctica (LINNÉ)	11.5	32.0
Macoma calcarea (CHEMNITZ)	0.5	1.4
	36.0	100.1

From the storm-ridge and the present backshore at the above-mentioned hut the following shells, being of Recent origin, were collected:

1 m a.s.l. Petuniabukta. Recent storm-ridge, gravel. (Sample No. 372).

Species	Frequency	Percentage
Astarte borealis (CHEMNITZ)	141.5	92.2
Astarte montagui (DILLWYN)	4.5	2.9
Saxicava arctica (LINNÉ)	1.5	1.0
Mya truncata LINNÉ	1.5	1.0
Chlamys islandica (MÜLLER)	1.0	0.7
Trophon truncatus (STRÖM)	1.0	0.7
Buccinum groenlandicum (CHEMNITZ)	1.0	0.7
Astarte elliptica (BROWN)	0.5	0.3
Serripes groenlandicus (CHEMNITZ)	0.5	0.3
Thracia sp.	0.5	0.3
	153.5	100.1

The Swedish expedition to Spitsbergen in the year of 1896 found at „Klas Billen Bay. Innermost Bay" (HÄGG 1951, p. 241):

Cyprina islandica (LINNÉ), 1 shell fragment, but the height of the locality is not recorded.

At the „point west of Nordenskiöldbreen", which could probably be Rudmosepynten, they found:

Macoma calcarea (CHEMNITZ), 3 valves.

The Scottish Spitsbergen Syndicate Expedition, 1920, collected the following shells from a raised beach at Ebbadalen, 15 m a.s.l. (BADEN-POWELL 1939, p. 338):

Mytilus edulis LINNÉ,
Astarte borealis (CHEMNITZ),
Astarte montagui (DILLWYN),
Saxicava arctica (LINNÉ) var. *pholadis*.

The Oxford University Spitsbergen Expedition, 1933, collected the following shells from a raised beach at Petuniabukta, at 27 m a.s.l. (BADEN-POWELL 1939, p. 340):

Mytilus edulis LINNÉ,
Astarte borealis (CHEMNITZ),
Macoma calcarea (CHEMNITZ),
Mya truncata LINNÉ,
Saxicava arctica (LINNÉ),
Littorina littorea (LINNÉ).

From a raised beach at about 8 m a.s.l. at Petuniabukta they found (l.c. p. 341):

Astarte borealis (CHEMNITZ),
Cyprina islandica (LINNÉ),
Macoma calcarea (CHEMNITZ),
Mya truncata LINNÉ,
Saxicava arctica (LINNÉ) var. *pholadis*,
Buccinum glaciale LINNÉ.

BALCHIN (1941, p. 373) recorded the following species from the raised Pleistocene marine deposits on the east side of Billefjorden:

Mytilus edulis LINNÉ,
Chlamys islandica (MÜLLER),
Astarte borealis (CHEMNITZ),
Astarte sp.,
Cyprina islandica (LINNÉ),
Mya truncata LINNÉ,
Saxicava arctica (LINNÉ),
Margarites helicinus (PHIPPS),
Margarites groenlandicus (CHEMNITZ),
Lithothamnion glaciale KJELLMANN,
Whale bones.

Exact localities are not recorded and, due to his erroneous idea of an enormous local tilting of the Pleistocene beds on the east side of Billefjorden, nothing accurate can be said about the heights at which the fossils were found.

Mimerbukta.

Mimerbukta (78°39′ N.lat., 16°23′ E.long.) on the west side of Billefjorden near its head, was not visited by the author.

A Swedish expedition of 1911 (HÄGG 1951, p. 233) collected the following species from Mimerdalen at a height of 20 m above the sea:

Astarte borealis (CHEMNITZ), many valves,
Mya truncata LINNÉ, 11 valves,
Cyprina islandica (LINNÉ), 9 valves,
Macoma calcarea (CHEMNITZ), 7 valves,
Mytilus edulis LINNÉ, 4 valves,
Astarte montagui (DILLWYN) (=*A. banksi* (LEACH)), 3 valves,
Saxicava arctica (LINNÉ), 2 valves,
Serripes groenlandicus (CHEMNITZ) (=*Cardium groenlandicum*),
Lithothamnion, 2 clods.

From a cliff at the river, 20 m a.s.l., on the south side of Mimerdalen, the same expedition collected (l.c. p. 234):

Mya truncata LINNÉ var. *ovata* JENSEN, 10 valves,
Littorina littorea (LINNÉ), 4 specimens,
Mytilus edulis LINNÉ, 6 valves,
Macoma calcarea (CHEMNITZ), 4 valves,
Lepeta coeca (MÜLLER), 2 specimens,
Littorina saxatilis (OLIVI), 2 specimens,

Astarte borealis (CHEMNITZ), 3 valves,
Mya truncata LINNÉ, 1 specimen and 1 valve,
Saxicava arctica (LINNÉ), 3 valves,
Heteranomia squamula (LINNÉ) (=*Anomia squamula*), 2 valves,
Chlamys islandica (MÜLLER), 2 valves,
Cyprina islandica (LINNÉ), 1 small valve and 2 fragments.

At an elevation of 30 m above the sea in the same cliff they found:

Mya truncata LINNÉ, 4 valves.

From a shell bed south of Mimerdalen they collected:

Cyprina islandica (LINNÉ), 5 valves,
Mytilus edulis LINNÉ, 1 valve,
Chlamys islandica (MÜLLER), 1 shell fragment,
Mya truncata LINNÉ, 1 valve,
Lithothamnion, on a stone.

A Swedish expedition in the year 1908, found:
Cyprina islandica (LINNÉ), 2 specimens,
at Mimerbukta, „northern gat" (HÄGG 1951, p. 241).

Nidedalen.

Nidedalen (78°35′ N.lat., 16°21′ E.long) is a little valley debouching on the west side of Billefjorden between Mimerbukta and Skansbukta (fig. 48 and pl. 9). Along the northeast side of the river there is a succession of prominent beach ridges composed of coarse material, mainly boulders. The ridges are situated at the following heights:

1.3 m a.s.l., beach ridge with some old drift wood,
2.4 —»— , » » ,
3.3 —»— , » » ,
4.0 —»— , » » with small flat behind,
5.0 —»— , » » ,
7.7 —»— , » » ,
9.1 —»— , » » ,
10.8 —»— , » » ,
11.4 —»— , » » ,
13.1 —»— , » » ,
13.9 —»— , » » ,
16.2 —»— , » » ,
18.2 —»— , » » with small flat behind,
22.4 —»— , » » ,
27.2 —»— , » » , corresponding with a quite large beach plain on the southwest side of the river, slightly rising upstream. The horizontal distance between the lowest ridge (1.3 m) and the highest (27.2 m) is 158 m.

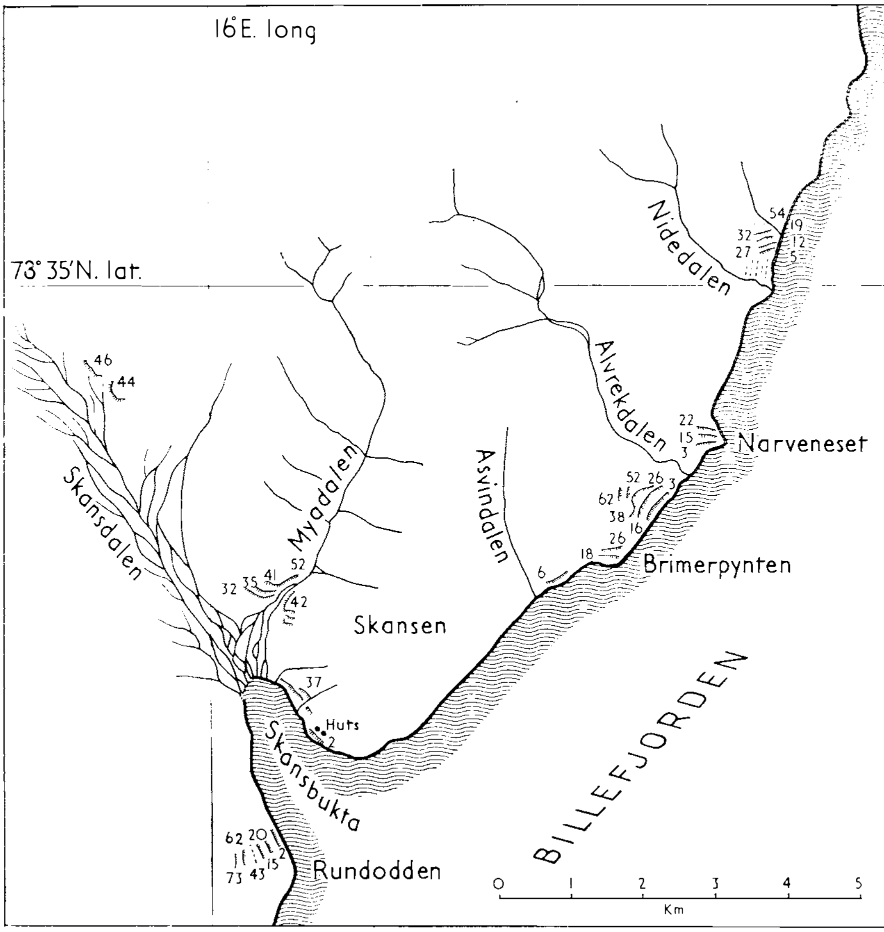


Fig. 48. The west side of Billefjorden, from Nidedalen to Skansbukta, with the raised marine features which were investigated.

The highest find of fossils was made at an elevation of 36.4 m a.s.l. The fossils occurred mostly as fragments in muddy material, and only two species were found (sample no. 331):

Mya truncata, 37 valves and umbonal fragments,
Macoma calcarea, 5 broken valves.

North of the mouth of Nidedalen remnants of a terrace complex occur, where the following heights were measured:

4.8 m a.s.l., *Mytilus* terrace,
12.2 —»— , small terrace,
18.6 —»— , terrace partly destroyed by soil flow,
31.8 —»— , on a large, uneven terrace,
54.0 —»— , shoreline with a small gravel flat.

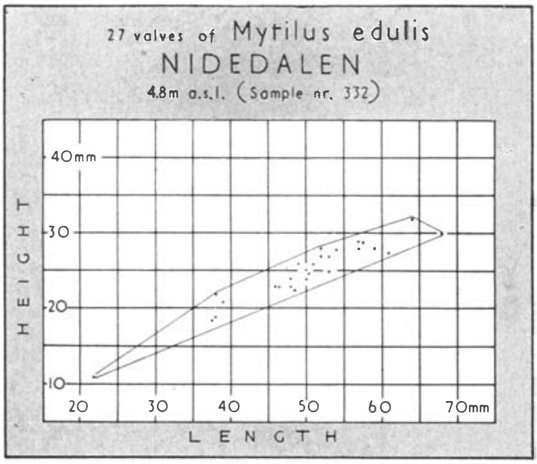


Fig. 49. Shell measurements of *Mytilus edulis*.

The large terrace rises towards the north, or rather towards the steep cliff at the rivulet which has eroded the complex on the north side. This plain represents the southern part of a delta terrace formerly built up by the rivulet. At the mountain side it attains an elevation of approx. 60 m a.s.l. *Mya truncata* occurred in it, and a fragment of *Chlamys islandica* and one of *Saxicava arctica* were found on its surface.

From the *Mytilus* terrace the following collection was made:

4.8 m a.s.l. Nidedalen N. Terrace, sandy gravel (Sample No. 332).

Species	Frequency	Percentage
Mytilus edulis LINNÉ	44.0	90.7
Astarte borealis (CHEMNITZ)	3.0	6.2
Buccinum sp.	1.0	2.1
Mya truncata LINNÉ	0.5	1.0
	48.5	100.0

The *Mytilus* shells were in the same good state of preservation as those from Asvindalen (6.2 m a.s.l., cf. p. 107). Two of them had initial pearls. The largest complete valve had a length, L=68 mm and a height, H=30 mm (cf. measurements fig. 49). Of *Astarte borealis* 5 valves and one fragment were found, the largest valve measuring, L=32 mm, H=27 mm. A small, broken, and worn specimen of a *Buccinum* rendered its specific determination unsafe. Of *Mya truncata* only a hinge fragment of a small specimen was found.

Narveneset.

Narveneset (78°33.8′ N.lat., 16°19′ E.long.) is a little cuspate foreland approx. 2.5 km SSW of the mouth of Nidedalen (fig. 48; pl. 9). A remnant of a raised ridged beach plain occurs there. It has a northeasterly slope with beach ridges approx. perpendicular to the direction of slope. It is eroded on all sides, but attains a height of 22 m a.s.l. The following species were picked up from the surface of this terrace (sample no. 330):

Mytilus edulis, numerous small fragments, no umbonal,
Astarte borealis, two broken valves and some fragments,
Astarte montagui, two broken valves and some fragments,
Cyprina islandica, one small fragment from the dorsal margin,
Saxicava arctica, one umbonal fragment,
Mya truncata, one valve, two umbonal fragments, and many other fragments.

At 14.7 m a.s.l. later wave action has cut a bench in the south side of the gravel deposits of the larger beach plain. *Mytilus edulis* occurred at this level. At 2.7 m a.s.l. there is a plain with ancient drift wood, unaffected by man.

The raised beach plain (22 m a.s.l.) dates back from the Post-Glacial Warm period, and has its continuation on the SW side of Alvrekelva (cf. below).

Alvrekdalen.

Alvrekdalen (78°33.6′ N.lat., 16°17.5′ E.long.) is the largest valley between Mimerbukta and Skansbukta on the west side of Billefjorden (fig. 48; pl. 10). The most prominent raised marine feature in this locality is a cliffed ridged beach plain with northeasterly sloping surface. The beach ridges, at approx. right angles to this slope, are slightly curved with a northeastward concavity. The following heights were measured on the surface of this plain: 26.5 m, 27.2 m and 37.8 m a.s.l., the last being the elevation of the rear edge of the terrace. It represents the upper marine limit for the Post-Glacial Warm period in this locality, which is in keeping with the height of the upper termination of the large beach plain with *Astarte* on the other side of Billefjorden, at Ekholmvika.

At an elevation of 16.5 m a.s.l. wave action has cut another terrace into the gravel deposits of the southeast side of the large beach plain. A lowest terrace plain is found at 3.7 m a.s.l.

Above the upper termination of the large beach plain two indistinct features were discernible, viz.: an uneven terrace surface at 52 m a.s.l., and a very uneven surface at 62 m a.s.l. A fragment of *Mya truncata* occurred in the 52 m terrace. The minerogenic material at 62 m a.s.l. was very coarse, boulders and cobbles occurring with the gravel.

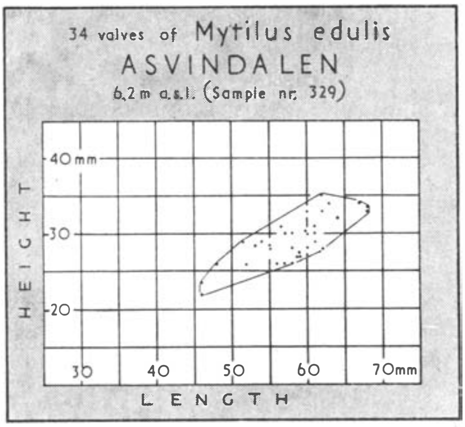


Fig. 50. Shell measurements of *Mytilus edulis.*

Brimerpynten.

Brimerpynten (78°32.8′ N.lat., 16°15′ E.long.) is the point between Alvrekdalen and Asvindalen (fig. 48; pl. 10).

The heights of two terraces were measured in this locality:

17.6 m a.s.l., front edge of first terrace,
24.2 —»— , rear edge of first terrace,
26.2 —»— , front edge of second terrace,
28.1 —»— , rear edge of second terrace.

No fossils were observed in this complex except some *Mya* shells in the highest terrace. *Astarte* and *Mytilus* would be expected in these terraces.

Asvindalen.

Asvindalen (78°32.6′ N.lat., 16°12.3′ E.long.) is the next valley SW of Alvrekdalen (fig. 48; pl. 10). A *Mytilus* terrace was observed in this locality at a height of 6.2 m a.s.l., and the following species were collected from it:

6.2 m a.s.l. Asvindalen. Mytilus terrace, sandy gravel (Sample No. 329).

Species	Frequency	Percentage
Mytilus edulis LINNÉ	54.0	93.9
Astarte borealis (CHEMNITZ)	2.5	4.3
Saxicava arctica (LINNÉ)................	0.5	0.9
Mya truncata LINNÉ	0.5	0.9
Echinid spine		
	57.5	100.0

Some of the *Mytilus* shells (pl. 18, figs. 4, 5) had remnants of periostracum. They were quite large, the largest complete valve measuring L=68 mm, H=33 mm (cf. measurements fig. 50). The largest shell of *A. borealis* measured, L=33 m, H=27.5 mm, the periostracum being partly preserved and the beak partly eroded. The valve of *Saxicava arctica* was a juvenile one with spines. One *Nonion* was observed in the sample.

Skansbukta.

Skansbukta (78°31.5′ N.lat., 16°3′ E.long.) is a sheltered bay on the west side of the entrance to Billefjorden (pl. 11, fig. 1). On the north side of the bay there are two huts (sketch map fig. 48) built on a low beach plain 2.2 m a.s.l. The beach plain is composed of sandy gravel, and its surface is very gently sloping inland. At its inner termination, at the foot of the scree cones from the mountain Skansen, it carries a swampy vegetation. The following shells were collected from the surface of this beach plain:

2.2 m a.s.l. Skansbukta N side. Beach plain, sandy gravel (Sample No. 301).

Species	Frequency	Percentage
Natica clausa BRODERIP and SOWERBY	8.0	24.3
Buccinum glaciale LINNÉ	8.0	24.3
Astarte borealis (CHEMNITZ)	6.0	18.2
Saxicava arctica (LINNÉ)	3.0	9.1
Serripes groenlandicus (CHEMNITZ)	2.5	7.6
Mytilus edulis LINNÉ	1.0	3.0
Mya truncata LINNÉ	1.0	3.0
Margarites groenlandicus (CHEMNITZ)	1.0	3.0
Buccinum groenlandicum (CHEMNITZ)	1.0	3.0
Pyrulofusus deformis (REEVE)	1.0	3.0
Astarte elliptica (BROWN)	0.5	1.5
Lithothamnion		
	33.0	100.0

Many of these shells may have been washed up unto the plain from the shore in Recent times; this certainly applies to most of the gastropod shells which are easily transported by waves and currents. Thus the shell of *Pyrulofusus deformis* (pl. 27, figs. 1, 2) can hardly be considered as a fossil in this sample (cf. p. 35). The largest valve of *Astarte borealis* measured, L=38 mm, H=31 mm; all valves showed traces of periostracum, and all had eroded beaks. The single shell of *A. elliptica* was small and broken. Of *Mytilus edulis* two umbonal fragments were found, both of them of left valves so that, in fact, two specimens of this species are represented in the sample. Of *Serripes groenlandicus* fragments belonging to five valves were collected. The two largest specimens of *Natica clausa* had lengths of 26 and 28 mm. The eight specimens of *Buccinum glaciale* were of the typical form, distinctly carinated with strongly developed spiral structure. They were all more or less broken. The specimen of *B. groenlandicum* was small and broken.

From the Recent beach, at the huts, the following shells were collected (sample no. 300):

Liocyma fluctuosa (GOULD), 6 valves, some of them united,
Mya truncata LINNÉ, 7 valves, some of them united,
Astarte borealis (CHEMNITZ), 1 specimen,
Serripes groenlandicus (CHEMNITZ), 1 specimen,
Buccinum undatum LINNÉ, 1 specimen,
Astarte montagui (DILLWYN), 1 valve,
Mytilus edulis LINNÉ, one small fragment.

The specimen of *A. borealis* measured, L=40 mm, H=34 mm. One specimen of *Liocyma fluctuosa* measured, L=10.1 mm, H=8.2 mm, but some of the fragments belonged to larger specimens. The shells of *Mya truncata* were thin, and one specimen belonged to the var. *ovata* JENSEN.

Northwest of the huts, on the northeast side of Skansbukta, there is a terrace complex consisting of coarse sand and gravel. The forms of the features are indistinct, but three levels are discernible (fig. 51), the heights of which were measured on the northwest side of a brook which had incised the terraces transversely:

13.8 m a.s.l., front of the first terrace,
18.3 —»— , rear edge of the first terrace,
24.5 —»— , front of the second terrace,
37.4 —»— , third terrace.

Between the highest terrace and the mountain side to the northeast there is a depression in the unconsolidated deposits caused by subsequent stream erosion.

A section, 4.5 m deep, was worked out in the strem cliff of the first terrace, from its surface at 17.7 m a.s.l. (figs. 52, 53; pl. 11, fig. 2). Samples were taken at intervals of 0.5 m:

I. (Sample no. 3M) surface layer, coarse gravel with frost-split pebbles (pl. 13). Median diameter, M=17.50 mm. Quartiles, Q_3=25.00 mm, Q_1= 12.0 mm. Coefficient of sorting, So=1.44, i.e. well sorted. No fossils were found.

II. (Sample no. 4M) 0.5 m below the surface, gravel. The greater part of the pebbles had kept their rounding, but some were split by frost wedging. M=9.80 mm, Q_3=27.00 mm, Q_1=3.45 mm. So=2.80, i.e. normal sorting. The following shells occurred in this zone (shell sample no. 306):

Chlamys islandica, 1 fragment,
Mytilus edulis, 4 umbonal fragments,
Macoma calcarea, 3 umbonal fragments,
Saxicava arctica, 2 umbonal fragments,
Mya truncata, 6 umbonal fragments,
Balanus balanus, 2 carinae.

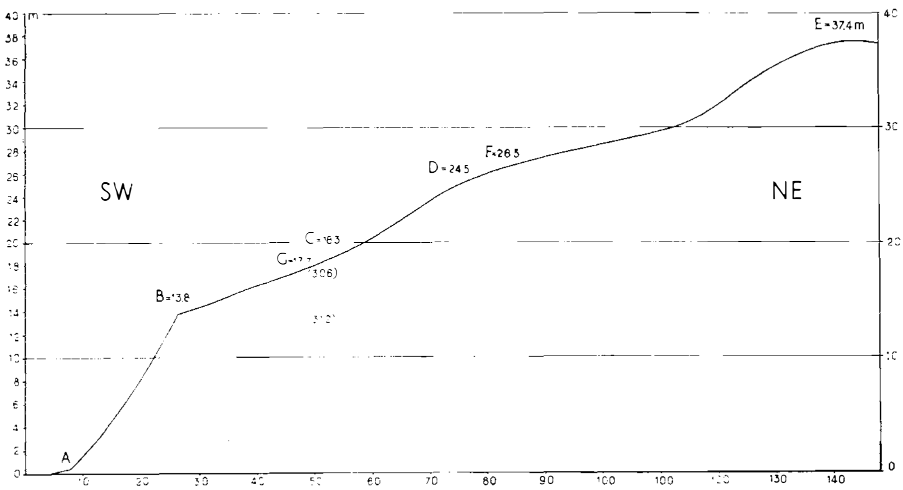


Fig. 51. Profile of the raised marine features at the northeast side of Skansbukta; a section was made from the surface at G. (Cf. fig. 52).

III. (Sample no. 5M) 1.0 m below the surface, sandy gravel, many pebbles frost-split (pl. 14). M=3.20 mm, Q_3=7.80 mm, Q_1=1.25 mm. So=2.50, i.e. well sorted. The following species were represented (shell sample no. 307):

Chlamys islandica, fragments of 1 valve,
Mytilus edulis, fragments of 1 valve,
Saxicava arctica, fragments of 1 valve,
Mya truncata, fragments of 3 valves.

IV. (Sample no. 6M) 1.5 m below the surface, coarse gravel with some sand. Many frost-split pebbles (pl. 15). M=16.50 mm, Q_3=27.00 mm, Q_1=7.50 mm. So=1.90, i.e. well sorted. A few, very small shell fragments of the same species as in sample III were found.

V. (Sample no. 7M) 2.0 m below the surface, coarse gravel with many angular and flat particles. M=16.00 mm, Q_3=21.00 mm, Q_1=11.00 mm. So=1.38, i.e. well sorted. The following species were found (shell sample no. 309):

Heteranomia squamula, 1 left valve,
Chlamys islandica, 1 hinge fragment,
Mytilus edulis, two fragments,
Astarte borealis, 2 broken valves of different specimens,
Astarte montagui, 1 complete valve and 2 broken,
Saxicava arctica, 1 shell fragment,
Mya truncata, 2 umbonal fragments,
Lepeta coeca, 1 specimen.

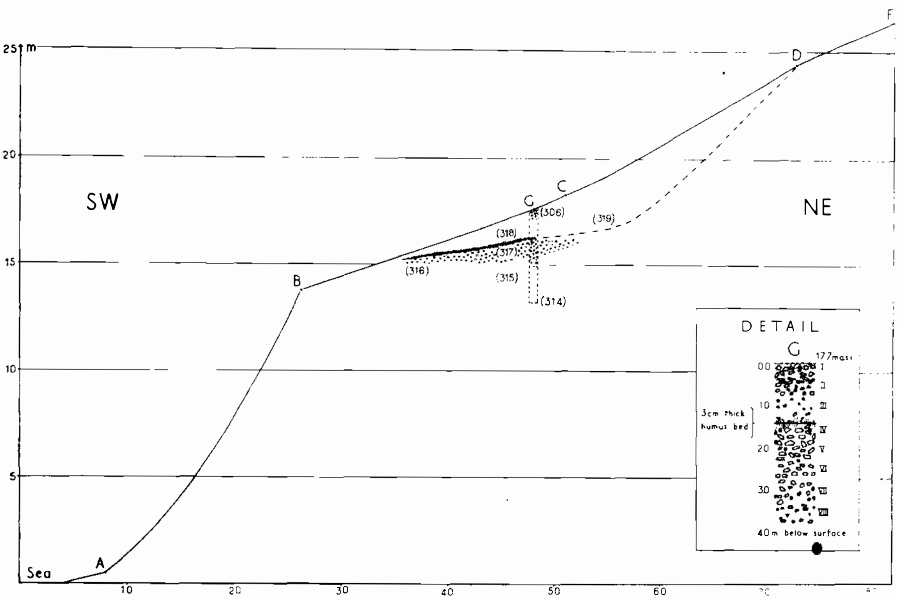


Fig. 52. Profile of the lower part of the raised features at the northeast side of Skansbukta, with a detail of the section at G.

VI. (Sample no. 8M) 2.5 m below the surface, gravel with rounded pebbles and sand. M=8.50 mm, Q_3=18.00 mm, Q_1=3.10 mm. So=2.41, i.e. well sorted. The following species occurred in this zone (shell sample no. 310):

Chlamys islandica, two small shell fragments,
Mytilus edulis, 3 umbonal fragments,
Astarte borealis, 8 valves (one specimen had united valves),
Astarte montagui, 20 valves (one with united valves),
Saxicava arctica, 3 hinge fragments and some others,
Mya truncata, 2 hinge fragments and some others,
Littorina saxatilis, 2 specimens, lengths 8 and 9 mm,
Lacuna vincta MONTAGU, 1 specimen, 7.2 mm long (pl. 26, fig. 1).

The largest shell of *A. borealis* measured, L=26.5 mm, H=22.2 mm, and the largest shell of *A. montagui,* L=21 mm, H=20 mm.

VII. (Sample no. 9M) 3.0 m below the surface, gravel with rounded and angular pebbles and granules. M=6.90 mm, Q_3=12.00 mm, Q_1= 2.90 mm. So=2.04, i.e. well sorted. The following species occurred in this zone (shell sample no. 311):

Chlamys islandica, two fragments of 1 specimen,
Mytilus edulis, 4 small umbonal fragments and some others,
Mya truncata, 7 valves, six of which were juveniles,
Margarites groenlandicus, 1 specimen,

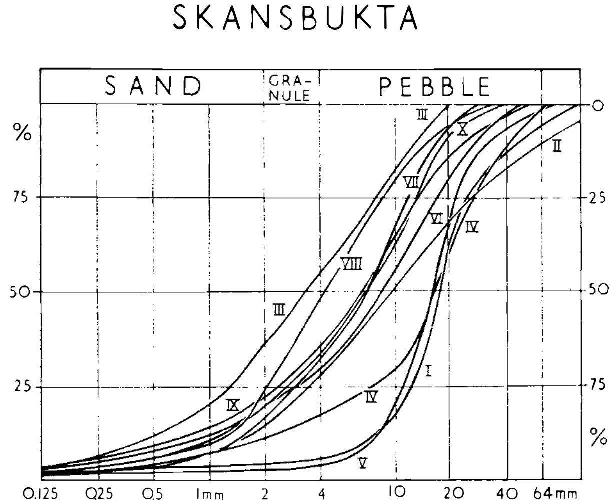


Fig. 53. Cumulative-frequency curves of 11 samples from the section in the terrace complex at the northeast side of Skansbukta.

Lacuna vincta, 1 specimen (pl. 26, fig. 2),
Littorina saxatilis, 1 columella with apex,
Balanus balanoides, 1 rostrum and 1 lateral compartment,
Balanua balanus, 1 carina and 1 lateral compartment.
Two Echinid spines were also observed.

VIII. (Sample no. 10M) 3.5 m below the surface, gravel with rounded and some angular pebbles and granules (pl. 16). M=4.20 mm, Q_3=8.80 mm, Q_1=2.05 mm. So=2.07, i.e. well sorted. The following species occurred (shell sample no. 312):

Chlamys islandica, 1 fragment,
Mytilus edulis, 1 umbonal fragment and another fragment,
Macoma calcarea, 2 umbonal fragments,
Saxicava arctica, 1 umbonal fragment,
Mya truncata, 2 small, broken valves and 1 umbonal fragment,
Zirfaea crispata, 1 umbonal fragment of a small right valve (pl. 24, fig. 7),
Lacuna vincta, 1 specimen 10.3 mm long (pl. 26, fig. 3),
Lepeta coeca, 1 broken specimen (pl. 24, fig. 13),
Balanus balanoides, 1 rostrum and 1 lateral compartment,
Balanus crenatus, 1 carinolateral compartment and 1 fragment.

IX. (Sample no. 11M) 4.0 m below the surface, gravel. M=6.60 mm, Q_3=13.50 mm, Q_1=2.45 mm. So=2.40, i.e. well sorted. The following species occurred in this zone (shell sample no. 313):

Mytilus edulis, 1 small fragment,
Astarte borealis, 1 broken shell,
Mya truncata, 2 small valves and some fragments,
Lepeta coeca, 1 small and broken specimen,
Lacuna vincta, 1 small and broken specimen,
Balanus balanoides, 2 lateral compartments.

X. (Sample no. 12M) 4.5 m below the surface, gravel. M=6.90 mm, Q_3=13.50 mm, Q_1=2.70 mm. So=2.24, i.e. well sorted. Only four species could be recognized among the very few shell fragments present, viz. (shell sample no. 314):

Mytilus edulis, 1 small hinge fragment and two others,
Saxicava arctica, 2 umbonal fragments,
Mya truncata, 1 umbonal and two other fragments,
Balanus balanoides, 1 carina and 2 lateral compartments.

In this section a 3 cm thick lamina of humus with roots occurred above the bed with coarse gravel, i.e. at approx. 1.5 m below the terrace surface (fig. 52). This humus lamina continued, gently sloping, for more than 3 m from the section towards the bay, approaching the terrace surface (cf. fig. 52), and in its whole extension carried roots and remnants of mosses and other vegetation. Humus samples of this layer taken from permanently frozen parts of the deposits also contained such remnants. Roots from the present vegetation on the terrace continued through the outer parts of the humus layer where it came close to the terrace surface. At the section (G, fig. 52), where 1.5 m sandy gravel separated the humus bed from the humus at the terrace surface, no difference could be observed between the present vegetation and that represented by roots and remnants in the buried humus bed. Between the humus bed and the underlying coarse gravel there was a sandy transition approx. 5 cm thick, and above the humus there was also some sand which became coarser upwards, forming coarse gravel towards the surface.

These conditions are explained by soil flow. At the present terrace surface a sparse vegetation, carried by a very thin humus layer with some sand in-between and below, kept by roots, rests on a coarse outwash consisting mainly of angular, frost-split pebbles which become smaller and more rounded downwards with increasing amount of sand. These conditions are repeated from the buried humus layer downwards, the humus layer representing a former terrace surface which, in part, has been buried by material that slid down from the former cliff at the rear edge of the terrace. The dotted line in fig. 52 suggests the former profile of the feature.

The deposits in this locality are situated close to the mountain side from which numerous brooks descend. Thus, being richly supplied with water, the deposits are subject to solifluction. By this means, in conjunction with frost and thaw, the morphology of the terrace complex has been greatly modified (cf. fig. 51).

Below the bed of coarse gravel, in the stream cliff, the following shells were collected (sample no. 315):

Mytilus edulis, 10 umbonal and some other fragments,
Astarte borealis, 1 umbonal fragment,
Astarte montagui, 2 valves and one umbonal fragment,
Saxicava arctica, 3 broken valves of small, thin-shelled specimens,
Mya truncata, 2 small valves of young specimens and 1 hinge fragment of an adult,
Lacuna vincta, 1 broken shell,
Balanus balanoides, 1 rostrum.

In the same cliff, about midway between front and rear edges of the first terrace, another collection was made up to, and partly into, the lower half of the coarse bed. The following species occurred (sample no. 316):

Mytilus edulis, some very small fragments,
Astarte borealis, 1 right valve,
Astarte montagui, 27 valves, complete and broken,
Saxicava arctica, 2 broken valves,
Mya truncata, 1 hinge fragment.

Within the bed of coarse gravel the following collection was made (sample no. 317; cf. fig. 52):

Chlamys islandica, 2 fragments with hinge,
Mytilus edulis, 3 umbonal and some other fragments,
Astarte borealis, 21 valves and umbonal fragments,
Astarte montagui, 18 valves and umbonal fragments,
Macoma calcarea, 2 broken valves,
Saxicava arctica, 4 broken valves,
Mya truncata, 5 umbonal fragments,
Littorina littorea, 2 specimens and one fragment.

Above the bed of coarse gravel very few shell fragments were found in the cliff (sample no. 318):

Chlamys islandica, 1 small hinge fragment,
Mytilus edulis, 1 hinge fragment,
Astarte montagui, 1 umbonal fragment,
Saxicava arctica, 3 hinge fragments,
Mya truncata, 2 hinge fragments,
Balanus balanoides, 1 rostrum,
Balanus balanus, 1 carina and 1 lateral compartment.

This stratification of the fauna, viz. the pronounced dominance of *Astarte borealis* within the bed of coarse gravel, has been caused by secondary sorting of the biogenic fraction together with the minerogenic one. The *Astarte* shells constitute the largest particles within the biogenic fraction of the material and, consequently, they occur with the coarser particles of the minerogenic fraction. (Cf. FEYLING-HANSSEN and JØRSTAD 1950, p. 19).

From the upper part of the stream cliff, just behind the rear edge (C) of the first terrace, the following collection was made:

18—17 m a.s.l. Skansbukta NE. Terrace cliff, gravel. (Sample No. 319).

Species	Frequency	Percentage
Mya truncata LINNÉ	12.0	27.9
Saxicava arctica (LINNÉ)	11.5	26.7
Mytilus edulis LINNÉ	4.0	9.3
Littorina saxatilis (OLIVI)	3.0	7.0
Zirfaea crispata (LINNÉ)	2.0	4.7
Margarites groenlandicus (CHEMNITZ)	2.0	4.7
Balanus balanus (LINNÉ)	2.0	4.7
Balanus balanoides (LINNÉ)	2.0	4.7
Chlamys islandica (MÜLLER)	1.5	3.5
Macoma calcarea (CHEMNITZ)	1.5	3.5
Astarte montagui (DILLWYN)	1.0	2.3
Astarte borealis (CHEMNITZ)	0.5	1.1
	43.0	100.1

Most of the species were represented by small fragments. The *Saxicava* shells were quite thick.

Above the front of the second terrace, at 26.5 m a.s.l., the following species were found (sample no. 320):

Chlamys islandica, 4 hinge fragments,
Mytilus edulis, two small fragments,
Astarte borealis, 1 umbonal and one marginal fragment,
Cyprina islandica, one marginal fragment,
Macoma calcarea, 4 hinge fragments,
Saxicava arctica, 7 hinge fragments and many others,
Mya truncata, 13 hinge fragments and numerous others,
Balanus balanus, 1 carina and 1 rostrum,
Balanus balanoides, 1 rostrum.

No fossils were found further up in the complex.

This terrace complex, at least up to approx. 30 m a.s.l., and most probably up to its top at 37.4 m a.s.l., should be regarded as one littoral formation deposited during the Post-Glacial Warm period. All shell collections from the feature contain one or more species now extinct in the area and some of them, viz. *Heteranomia squamula, Cyprina islandica, Zirfaea crispata* and *Littorina littorea,* leave no doubt as to the age of the formation. There is a remarkable scarcity of *Astarte* in most samples, as was also the case at Petuniabukta.

If all fossils collected from the complex are treated together, the faunal assemblage is as follows:

26.5—10 m a.s.l. Skansbukta NE. Terrace complex, gravel.

Species	Frequency	Percentage
Mya truncata LINNÉ	37.5	19.0
Astarte montagui (DILLWYN)	37.0	18.7
Saxicava arctica (LINNÉ)	26.5	13.4
Mytilus edulis LINNÉ	21.0	10.6
Astarte borealis (CHEMNITZ)	19.0	9.6
Chlamys islandica (MÜLLER)	9.0	4.6
Balanus balanoides (LINNÉ)	9.0	4.6
Macoma calcarea (CHEMNITZ	7.0	3.5
Balanus balanus (LINNÉ)	7.0	3.5
Littorina saxatilis (OLIVI)	6.0	3.0
Lacuna vincta (MONTAGU)	5.0	2.5
Margarites groenlandicus (CHEMNITZ)	3.0	1.5
Lepeta coeca (MÜLLER)	3.0	1.5
Littorina littorea (LINNÉ)	3.0	1.5
Zirfaea crispata (LINNÉ)	2.5	1.3
Balanus crenatus BRUGUIÈRE	1.0	0.5
Heteanomia squamula (LINNÉ)	0.5	0.3
Cyprina islandica (LINNÉ)	0.5	0.3
Echinid spines		
	197.5	99.9

The sea cliff of the first terrace of the complex just dealt with decreases in height towards the NW, so that, at the head of the bay, its height is only 2—3 m a.s.l. (pl. 12, fig. 1). The minerogenic material is composed partly of silty sand, partly of coarse gravel, and seems to be subject to solifluction. This accounts for the mixed composition of the sediment as well as of the fauna. The following collection was made from the cliff at the head of Skansbukta, at the debouch of the river from Myadalen:

2—3 m a.s.l. Skansbukta. Terrace cliff, silt and gravel. (Sample No. 304).

Species	Frequency	Percentage
Mya truncata LINNÉ	24.5	35.5
Saxicava arctica (LINNÉ)	12.0	17.4
Macoma calcarea (CHEMNITZ)	8.0	11.6
Littorina littorea (LINNÉ)	6.0	8.7
Mytilus edulis LINNÉ	5.5	8.0
Astarte borealis (CHEMNITZ)	5.0	7.3
Chlamys islandica (MÜLLER)	2.5	3.6
Astarte montagui (DILLWYN)	2.0	2.9
Buccinum totteni STIMPSON	1.0	1.5
Buccinum glaciale LINNÉ	1.0	1.5
Volsella modiola (LINNÉ)	0.5	0.7
Mya truncata ovata JENSEN	0.5	0.7
Zirfaea crispata (LINNÉ)	0.5	0.7
	69.0	100.1

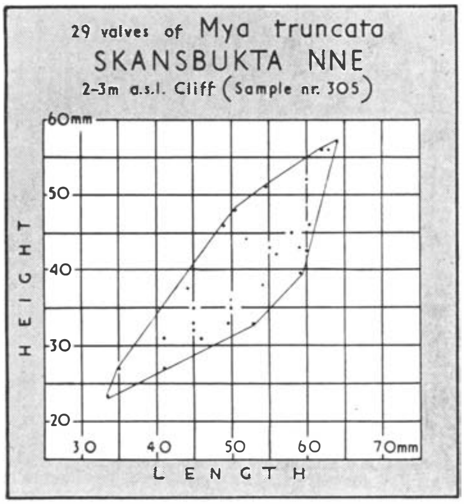


Fig. 54. Shell measurements of *Mya truncata*.

Foraminifera occurred in the sample. All shells of *Mytilus edulis* were broken, 11 umbonal and some other fragments being collected. Of *Volsella modiola* two shell fragments were found, none with umbo. *Astarte borealis* was represented only by small shells, the greatest valve measuring, L=27 mm, H=23.5 mm. Three complete valves of *A. montagui* measured, L=17.4 mm, H=15.3 mm; L=16.0 mm, H=14.5 mm; L=13.5 mm, H=11.4 mm, and the largest shell of *Macoma calcarea* had a length of 35 mm and a height of 26 mm. The *Saxicava* shells were also small, the largest one, which measured, L=54.0 mm, H=24.7 mm, being the only valve of typical *pholadis* form; the others were more or less irregular. The largest *Mya* valve measured, L=58.2 mm, H=42.0 mm. One small umbonal fragment of *Zirfaea crispata* was found. The shells of *Littorina littorea* were large, lengths varying from 25 to 35 mm. The specimen of *Buccinum totteni,* had a length of 42 mm and a breadth of 25 mm. This species has not previously been recorded from the Pleistocene of Svalbard.

A collection was made from another place in the same cliff at the innermost part of Skansbukta, and contained the following species:

2—3 m a.s.l. Skansbukta. Terrace cliff, silty gravel. (Sample No. 305).

Species	Frequency	Percentage
Mya truncata Linné	20.0	74.1
Mytilus edulis Linné	2.0	7.4
Saxicava arctica (Linné)	1.5	5.6
Chlamys islandica (Müller)	1.0	3.7
Thracia sp.	1.0	3.7
Littorina saxatilis (Olivi)	1.0	3.7
Macoma calcarea (Chemnitz)	0.5	1.8
	27.0	100.0

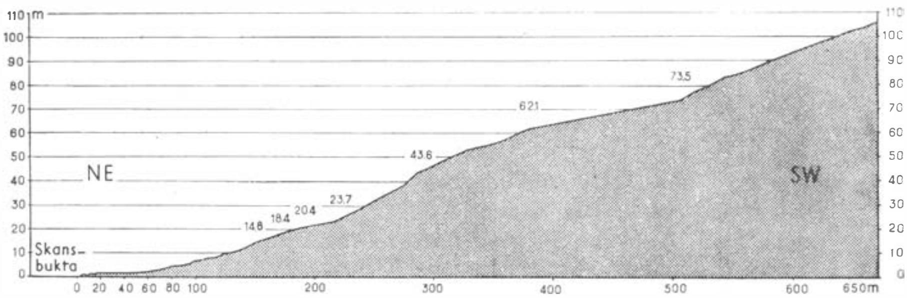


Fig. 55. Profile of the raised features at the southwest side of Skansbukta.

The largest, and only measurable, valve of *M. edulis* had a length of 57 mm and a height of 25 mm. The largest *Saxicava arctica* had a length of 53 mm and height 25 mm. The *Saxicava* shells were thick and regular, of a clear *pholadis* form. A fractured left valve and two fragments of a right valve of a young *Thracia* occurred, which is probably referable to *Thracia devexa* G. O. Sars. The length of the largest valve of *Mya truncata* was 64 mm, breadth 57 mm (cf. measurements fig. 54).

On the southwest side of Skansbukta a tachymetric line of levels was run approx. perpendicular to the coast line, i.e. in a southwesterly direction, and the heights of the following marine levels were determined (fig. 55):

2.0 m a.s.l., front edge of a 28 m broad beach plain,
1.9 —»— , rear edge of the beach plain,
4.6 —»— , beach ridge with pebbles,
6.7 —»— , beach ridge with pebbles,
8.1 —»— , beach ridge with pebbles,
9.6 —»— , foot of low cliff,
14.8 —»— , front edge of rising terrace surface,
18.4 —»— , rear edge of rising terrace,
20.4 —»— , front edge of small terrace,
23.7 —»— , rear edge of small terrace,
43.6 —»— , shoreline,
62.1 —»— , front edge of large terrace,
73.5 —»— , rear edge of large terrace.

Indistinct markings were observed at 83.0 and at 105.4 m a.s.l., but these were probably formed along snow patches and not by any marine action.

On the surface of the large terrace, at approx. 70 m a.s.l., some fragments of *Mya truncata* were found (sample no. 321).

From the surface of the lowest beach plain (2 m a.s.l.), which slopes very gently inland, the following species were collected:

2 m a.s.l. Skansbukta SW. Ridged beach plain, sandy gravel. (Sample No. 302).

Species	Frequency	Percentage
Astarte borealis (CHEMNITZ)	20.0	25.6
Buccinum glaciale LINNÉ	15.0	19.2
Mytilus edulis LINNÉ	14.0	18.0
Saxicava arctica (LINNÉ)	8.0	10.5
Serripes groenlandicus (CHEMNITZ)	7.0	9.0
Buccinum undatum LINNÉ	4.0	5.1
Buccinum groenlandicum (CHEMNITZ)	3.0	3.8
Musculus discors substriatus (GRAY)	2.0	2.6
Mya truncata LINNÉ	1.5	1.9
Cyprina islandica (LINNÉ)	1.0	1.3
Pandora glacialis LEACH	1.0	1.3
Natica clausa BRODERIP and SOWERBY	1.0	1.3
Macoma calcarea (CHEMNITZ)	0.5	0.6
Lithothamnion sp.		
	78.0	100.2

Many of these shells may have been washed up from the sea in Recent times and some may have been redeposited from higher levels, as this plain is the lowest level in the succession of raised beaches. Thus, the worn fragments of *Mytilus* and *Cyprina* were most probably redeposited.

Four right valves of *Mytilus edulis* were complete, the length of the largest being 61.0 mm, and the height 28.5 mm. The periostracum was completely abraded both on valves and fragments of the species. Most shells of *Astarte borealis* were complete, and some had a Recent appearance with periostracum and ligament preserved, but many of them had been strongly worned; only one specimen had united valves. The length of the largest shell of *A. borealis* was 39 mm, and its height 31 mm. All the shells of *Serripes groenlandicus* were thin and broken but had periostracum and ligament partly preserved. Of *Cyprina islandica* two hinge fragments and eight other fragments were found; the majority of the *Saxicava arctica* shells were small and irregular; the fragments of *Mya truncata* were thin and carried remnants of periostracum. Four small, complete valves of *Musculus discors substriatus* were collected. Their greenish periostracum was preserved, and the radiating striæ were more distinct on the anterior area than on the posterior. They measured: L=20.2 mm, H=13.2 mm; L=20.2 mm, H=13.1 mm; L=17.0 mm, H=10.5 mm; L=15.2 mm, H=10.3 mm, and appeared to represent three specimens. The specimen of *Pandora glacialis* had its almost complete valves united, length L=18.5 mm, H= 11.0 mm. Among the 15 shells of *Buccinum glaciale* there were several varieties, viz.: *bicarinata* FRIELE, *tricarinata* FRIELE and even *quadricarinata* DAUTZENBERG and FISCHER; three specimens were of the typical form described by LINNÉ (1761).[1] The length of the largest *B. glaciale* was 60 mm,

[1] According to DAUTZENBERG and FISCHER (1912, p. 120) the var. *unicarinata* FRIELE is synonymous with the *typica* (cf. p. 169).

its greatest breadth being 37 mm, and the largest *B. groenlandicum* had a length of 47 mm. Many of the *Buccinum* shells had been brought ashore by bird. Bryozoa were present in a shell of *B. undatum* and in the *Macoma* valve.

A small fragment of *Cyprina islandica* and one of *Mytilus edulis* were found in the Recent beach of this locality together with shells and fragments of *A. borealis* and some spines and fragments of *Strongylocentrotus*. On the whole, Recent shells were rare on the SW shores of Skansbukta, but living specimens of *Liocyma fluctuosa* occurred at the innermost part of Skansbukta where the rivers from Skansdalen and Myadalen debouch.

Myadalen.

Myadalen[1] (78°32.7′ N.lat., 16°4′ E.long.) is the valley which branches off towards the NNE 1 km north of the head of Skansbukta (fig. 48). On both sides of the river, Myadalselva, prominent raised marine terraces occur. On the east side there are two distinguished levels with a less pronounced between, the surface of the lower terrace, 33 m a.s.l., being uneven structural ground made up of clayey-silty sand with stones of varying size, in fact representing the underlying till. A soil sample (no. 16M) from this terrace, taken outside any distinguishable structural ground feature, was analysed to find the grain size distribution: Median diameter, M=0.055 mm. Quartiles, Q_3=2.4 mm, Q_1=0.008 mm. Coefficient of sorting, So=17.32, i.e. poorly sorted. Coefficient of quartile skewness, Sk=6.39, i.e. the maximum sorting lies on the fine side of the median diameter. (Cf. the till underlying the *Mya* terrace north of Phantomvika, p. 74, sample VI, figs. 25 and 26).

Of Pleistocene fossils this terrace held almost exclusively large shells of *Mya truncata,* though in addition some specimens of *Macoma calcarea* and *Saxicava arctica* occurred.

The highest terrace on the east side, approx. 43 m a.s.l., was, in its outer parts, made up of sandy gravel with littoral shells, viz. small and thin-shelled *Mya* with some *Mytilus* and *Littorina saxatilis.* The clayey-sandy silt of the lower terrace continued under this coarser deposit and appeared in the surface of the highest terrace behind its outer parts.

The following collection was made from the lower terrace:

33 m a.s.l. Myadalen E. Terrace, clayey-sandy silt with stones. (Sample No. 322).

Species	Frequency	Percentage
Mya truncata LINNÉ	60.0	95.2
Saxicava arctica (LINNÉ)...............	2.0	3.2
Macoma calcarea (CHEMNITZ)...........	1.0	1.6
	63.0	100.0

[1] This name is proposed because of the numerous valves of *Mya truncata* in the raised marine deposits of the valley. On the map of Central Vestspitsbergen by the Cambridge Spitsbergen Expedition 1949 (HARLAND 1952) this valley has erroneously been given the name Skansdalen. Skansdalen, however, is the wide valley in northwesterly direction from the head of Skansbukta (cf. The Place-Names of Svalbard 1942).

The shells of *Mya* and *Saxicava* were thick and quite large, most of them being broken.

From the coarse deposit of the highest terrace, at approx. 42 m a.s.l., the following species were collected:

42 m a.s.l. Myadalen. Terrace, sandy gravel. (Sample No. 323).

Species	Frequency	Percentage
Mya truncata LINNÉ	15.5	53.5
Saxicava arctica (LINNÉ)	5.0	17.3
Macoma calcarea (CHEMNITZ)	3.5	12.1
Littorina saxatilis (OLIVI)	3.0	10.3
Lepeta coeca (MÜLLER)	1.0	3.4
Mytilus edulis LINNÉ	0.5	1.7
Serripes groenlandicus (CHEMNITZ)	0.5	1.7
	29.0	100.0

Most specimens were fragmentary, the length of the largest complete valve of *Mya truncata* being 42 mm, with height not determinable.

On the west side of Myadalselva corresponding terraces occur even more conspicuously developed (fig. 56). The tachymetric survey gave the following result:

23.8 m a.s.l., base of the cliff of terrace I, 1035 m north of the head of Skansbukta (figs. 48 and 56),
31.8 —»— , front edge of terrace I,
35.5 —»— , front edge of terrace II,
41.2 —»— , front edge of terrace III,
43.0 —»— , on terrace III,
51.8 —»— , rear edge of terrace III.

The main part of the terrace surfaces consists of clayey-sandy silt with stones, and structural grounds are developed to various degrees. Numerous large shells of *Mya truncata* had been frozen to the surface. At the front edges of the terraces the finer fractions were absent in the surface and some meters down in the terrace. In terrace III frost-split pebbles occurred in the outer part of the surface, but further down they had kept their rounding. Towards the upper termination of the highest terrace sand and gravel again occur in the surface.

In the clayey silt of the lowest terrace, 32 m a.s.l., the following pelecypods were found (sample no. 324):

Chlamys islandica, 3 small fragments,
Macoma calcarea, 5 valves,
Saxicava arctica, 1 complete valve,
Mya truncata, 17 valves and umbonal fragments, thick-shelled.

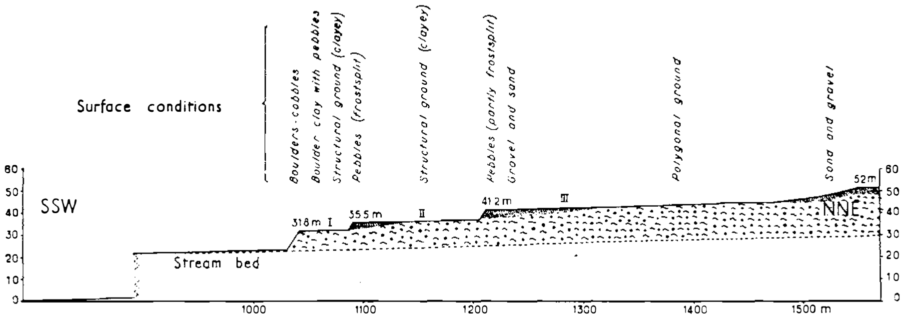


Fig. 56. Profile of the *Mya terraces* at the west side of Myadalselva; between the underlying till and the littoral deposits there is a transitional, fossil-bearing stratum composed of silt. (Cf. fig. 25).

From the river cliff of the highest terrace were collected:

42—35 m a.s.l. Myadalen W. Terrace cliff, sandy gravel. (Sample No. 325).

Species	Frequency	Percentage
Mya truncata LINNÉ	17.0	57.6
Macoma calcarea (CHEMNITZ)...........	7.0	23.7
Saxicava arctica (LINNÉ)...............	4.5	15.3
Buccinum groenlandicum (CHEMNITZ)	1.0	3.4
	29.5	100.0

The *Mya* shells were quite large and thick; the *Macoma* shells were small, the largest valve of *Macoma calcarea* having a length of 31 mm, and a height of 22 mm. One specimen of the latter showed affinities to var. *longisinuata* SOOT-RYEN (1932) in marginal outline, but the pallial sinus of the right valve was not particularly deep.

From the surface of the highest terrace were collected:

42 m a.s.l. Myadalen W. Terrace surface, clayey-sandy silt. (Sample No. 326).

Species	Frequency	Percentage
Mya truncata LINNÉ	116.5	95.1
Saxicava arctica (LINNÉ)...............	3.5	2.9
Macoma calcarea (CHEMNITZ)...........	2.5	2.0
	122.5	100.0

233 valves and umbonal fragments of *Mya truncata* were collected, the largest valve measuring, L=65.2 mm, H=45.5 mm (cf. measurements fig. 57). All the *Mya* shells were very thick and many of them short and obliquely truncated, thus being referable to the var. *uddevallensis* HANCOCK

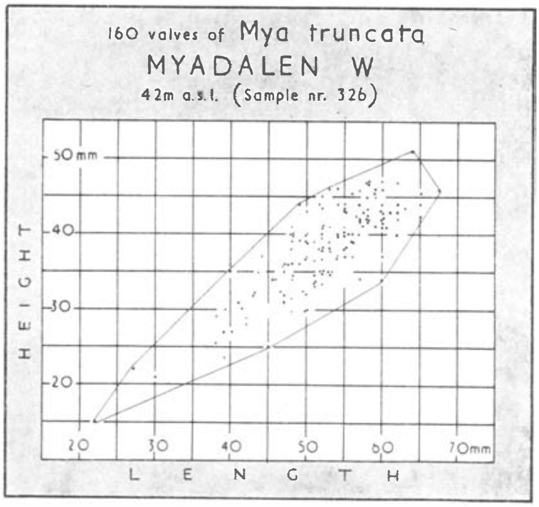


Fig. 57. Shell measurements of *Mya truncata* from the large terrace at the west side of Myadalselva.

(cf. pl. 25), but all transitions between *typica* and *uddevallensis* occurred in the sample. The *Saxicava* shells were of *pholadis* form, the length of the largest being 48.5 mm, height 23.6 mm. The largest shell of *Macoma calcarea* was 29 mm long and 22 mm high.

In the sandy gravel at the rear edge of the highest terrace, 51.8 m a.s.l., numerous small fragments of *Mya* and *Saxicava* were collected, among these being 9 umbonal fragments of *Mya truncata* and 2 of *Saxicava arctica*. Most of the fragments represented thin-shelled specimens. A windblown, dusty fraction occurred with the gravel in this locality.

Skansdalen.

In Skansdalen (78°33′ N.lat., 15°57′ E.long.), midway between Skansbukta and the glacier Skansdalsbreen at the end of the valley, marine terraces corresponding to the highest terrace level in Myadalen were found (fig. 48). Only three species of mollusks were found, collected partly from the terrace surface, and partly from an intersecting stream bed:

44—46 m a.s.l. Skansdalen. Terrace, very coarse sand. (Sample No. 328).

Species	Frequency	Percentage
Mya truncata LINNÉ	15.0	79.0
Saxicava arctica (LINNÉ)................	3.5	18.4
Macoma calcarea (CHEMNITZ)............	0.5	2.6
	19.0	100.0

Remnants of high lateral moraines occurred on both sides of the valley along its entire length extent (pl. 12, fig. 2), but terminal moraines were not observed until 500 m from the actual front of Skansdalsbreen at the inner termination of the valley. Another terminal moraine was located between the above mentioned and the glaciers front (pl. 12, fig. 3).

In Skansdalen no traces were found of a marine level corresponding to the highest large terrace at the SW side of Skansbukta, 62.1—73.5 m a.s.l.

Rundodden.

At Rundodden Light and Radio Circular (78°29′ N.lat., 15°58′ E.long.), on the west side of the entrance to Billefjorden, the surface of the lower raised marine deposits forms a terrace plain rising inland to approx. 7 m a.s.l. at the Radio circular. Bedrock with sandy gravel on top of it, appears in the base of the sea cliff, the particles of the unconsolidated material being quite sharply angular, probably due to frost wedging in conjunction with the humidity of the deposit. The height of the sea cliff was 3 to 5 m. From the terrace surface and cliff at the light, approx. 1 km east of Studentdalen, fossil shells were collected, most of them evidently in situ, the valves being articulated:

7—3 m a.s.l. Rundodden. Terrace surface and cliff, gravel. (Sample No. 373).

Species	Frequency	Percentage
Astarte borealis (CHEMNITZ)	62.5	63.8
Mytilus edulis LINNÉ	23.5	24.0
Saxicava arctica (LINNÉ)	6.0	6.2
Astarte montagui (DILLWYN)	1.5	1.5
Serripes groenlandicus (CHEMNITZ)	1.5	1.5
Mya truncata LINNÉ	1.0	1.0
Gastropod columella	1.0	1.0
Balanus balanus (LINNÉ)	1.0	1.0
Lithothamnion sp. rare		
	98.0	100.0

Samples collected in 1950 are kept in Paleontologisk Museum, Oslo.

III. SYSTEMATIC PART

Synopsis of the Species from the Late-Pleistocene of Billefjorden.

Amphineura.

Tonicella marmorea (FABRICIUS 1780).
Plate 17, figs. 1—3.

Chiton marmoreus FABRICIUS 1780, p. 420.
Boreochiton marmoreus, G. O. SARS 1878, p. 116, pl. 8, figs. 3a, b.

Late-Pleistocene records :

Billefjorden: Plates of this species were found in *Lithothamnion*-silt from 2 to 7 m above the sea in the Brucebyen area, viz. in the section at Teltfjellbekken (p. 84, sample IV and V), at Sørdammen (p. 92, 7 m a.s.l., plates belonging to 4 specimens) and at Sentabukta (p. 91, 2 m a.s.l., plates accounting for 4 specimens). Not previously recorded from the Pleistocene of Billefjorden.

Sassen area: Fragments of this species were found in terraces up to 28.8 m a.s.l. (Kapp Schoultz), and in the moraine of Von Postbreen at a height of 30 m (FEYLING-HANSSEN and JØRSTAD 1950, p. 79). A Swedish expedition of 1896 found it in Post-Glacial gravel together with *Littorina littorea* and *L. saxatilis* at Gipsvika (HÄGG 1951, p. 239).

Elsewhere in the Isfjorden area: Quite common in the morainic deposits on Coraholmen (Cora Island) in Ekmanfjorden, also recorded from Erdmannflya (Erdmann Tundra) 1—2 m a.s.l. (HÄGG 1951).

West coast region: Recherchefjorden (KNIPOWITSCH 1903 IV, HÄGG 1950) and Axeløya (Axel Island), 20 m a.s.l., (HÄGG 1951) in Bellsund, and in the moraine at Lilliehöökbreen (Lilliehöök Glacier) to the north of Krossfjorden (HOEL 1914).

East coast region: 10 plates from Kvalpynten (Whales Point), Edgeøya (KNIPOWITSCH 1902 III).

Adjacent arctic and subarctic regions: The Murman coast (KNIPOWITSCH 1900b), the region to the south of Varangerfjorden (Ishavsfinland, TANNER 1930, p. 192), East- and West Finnmarken (TANNER 1907b, who also considered previous records: HOLMBOE 1904, TANNER 1907a), Disko Bugt in West Greenland, at approx. 40 m a.s.l. (HARDER, JENSEN and LAURSEN 1949, p. 42).

Recent distribution :

Circumarctic-boreal-lusitanian, extending southwards to the Mediterranean (Cartagena), Cape Cod, Mexico, Japan (HÄGG 1905, ODHNER 1915). It is quite common in Isfjorden in shallow water down to a depth of 40 m (ODHNER, 1915).

Trachydermon albus (LINNÉ 1767).

Chiton albus LINNÉ 1767, p. 1107.
Trachydermon albus, VERRILL 1874, p. 412.
Lophyrus albus, G. O. SARS 1878, p. 114, pl. 8, figs. 2a, b.
Ischnochiton albus, HÄGG 1951, pp. 235, 236, 244.

Late-Pleistocene records :

Billefjorden: One plate of this species occurred in a sample from the debouch of Sørdammen, Brucebyen, 7 m a.s.l. (p. 92). Not previously recorded from the Pleistocene of Billefjorden.

Elsewhere in the Isfjorden area: Recorded from the morainic deposits of Coraholmen (HÄGG 1951).

Recent distribution :

Circumarctic-boreal-lusitanian, extending southwards to the British Isles, New England, California (HÄGG 1905, ODHNER 1915). It is quite common in Isfjorden in shallow water down to 150 m (ODHNER 1915, pp. 49—50).

Trachydermon ruber (LINNÉ 1767).

Plate 17, figs. 4, 5.

Chiton ruber LINNÉ 1767, p. 1107.
Trachydermon ruber, VERRILL and SMITH 1874, p. 368.
Boreochiton ruber, G. O. SARS 1878, p. 116, pl. 8, figs. 4a—l.
Tonicella rubra, HÄGG 1951, pp. 235, 236, 244.

Late-Pleistocene records :

Billefjorden: 5 plates of this species occurred in a sample from the debouch of Sørdammen, Brucebyen, 7 m above the sea (p. 92). It was not previously recorded from the Pleistocene of Billefjorden.

Elsewhere in the Isfjorden area: Present in the morainic deposits of Coraholmen in Ekmanfjorden (HÄGG 1951).

West coast region: Recorded from morainic deposits at Lilliehöökbreen, north of Krossfjorden (HOEL 1914, p. 33).

Adjacent arctic and subarctic regions: The Murman coast (KNIPOWITSCH 1900b), Finnmarken (TANNER 1907b), Northern West Greenland (LAURSEN 1944).

Recent distribution :

Arctic-boreal-lusitanian, occurring southwards to Portugal, New England, Japan. ODHNER (1915, p. 50) found 4 specimens at the entrance to Dicksonfjorden, Isfjorden, at a depth of 14—44 m.

Pelecypoda.

Heteranomia squamula (LINNÉ 1767).

Plate 17, figs. 6—9.

Anomia squamula LINNÉ 1767, p. 1151.
Anomia ephippium, FORBES and HANLEY 1853, p. 325 (part.).
Anomia aculeata, MÜLLER 1776, p. 249. LAMPLUGH 1911, p. 235.
Anomia squamula, JENSEN 1912, p. 5, pl. 1, figs. 2a—d.
Heteranomia squamula, WINCKWORTH 1932, p. 240.

Late-Pleistocene records :

Billefjorden: One left valve of this species was found 15 m a.s.l. (2 m below the surface) in a terrace on the north side of Skansbukta (p. 110), and 38 valves in the cliff of a 31 m terrace between Ebbadalen and Rudmose-pynten (p. 99). Two valves were found by a Swedish expedition in a cliff 20 m a.s.l. on the south side of Mimerbukta (HÄGG 1951, p. 234; cf. present paper p. 103).

Sassen area: 7 valves in stripes of soil flow 4.6 m a.s.l. at the Sassen Hut, and one valve 4 m a.s.l. at Ledalen (FEYLING-HANSSEN and JØRSTAD 1950, p. 70).

Elsewhere in the Isfjorden area: Recorded from the morainic deposits of Coraholmen in Ekmanfjorden (LAMPLUGH 1911, p. 235, NORDMANN 1912, p. 75, HÄGG 1951, p. 235).

Adjacent arctic and subarctic regions: White Sea and the Murman coast, where it has been recorded as *Anomia ephippium* and var. *aculeata* (KNIPOWITSCH 1900b, LINDHOLM 1921), the region to the south of Varangerfjorden (Ishavsfinland, TANNER 1930), East and West Finnmarken (TANNER 1907b, ØYEN 1929), Iceland (*Anomia* sp. THORODDSEN 1892, approx. 20 m above the sea; BÁRÐARSON 1921, 2—17 m a.s.l.), West Greenland (JENSEN 1905, JENSEN and HARDER 1910, JENSEN 1942, LAURSEN 1944, 1950).

Recent distribution :

Low-arctic—boreal—lusitanian, occurring northwards along the Norwegian coast, the Murman coast, the White Sea, the Barents Sea, and the southern parts of the Kara Sea (GAEVSKOIJ 1948, p. 427), Iceland (JENSEN 1912), Cape Hatteras to the southern part of Labrador (LAURSEN 1944, p. 48), Corea (FRIELE and GRIEG 1901).

It has never been taken alive in Spitsbergen waters, but SOOT-RYEN (1925, pp. 4—5) recorded it from fish stomachs up to 78°45′ N.lat. at Spitsbergen.

Remarks :

The left (upper) valves from Billefjorden had no ribs, but distinct concentric lines of growth; they were variable in form and marginal outline.

The laminae of the left valve are very liable to separate, this, if not considered, constituting a possibility of having the species over-represented in the faunas.

Heteranomia squamula is an important guide fossil to deposits from the Post-Glacial Warm period in Spitsbergen.

The largest valve from the east side of Petuniabukta had a diameter of 18 mm whereas the largest valve found by NORDMANN on Coraholmen measured 14 mm. The largest specimen collected by JENSEN (1912, p. 10) from the Faroes measured 23.5 mm.

Chlamys islandica (MÜLLER 1776).

Plate 18, fig. 1—3.

Ostrea islandica MÜLLER 1776, p. 248.
Pecten islandicus, O. FABRICIUS 1780, p. 415.
Chlamys islandica, BOLTEN 1798, p. 161. — DAUTZENBERG and FISCHER 1912, p. 319.

Late-Pleistocene records :

Billefjorden: This species was present in 23 of the samples from Billefjorden from present sea level up to 50.7 m above (north of Phantomvika, p. 75). It was usually rare, at the most accounting for 3.7 per cent of a fauna from a cliff at the north side of Skansbukta (2—3 m a.s.l.). In most samples a single valve or a few fragments were present.

Swedish expeditions found it at two places in Mimerbukta, up to 20 m a.s.l., at a point southwest of Nordenskiöldbreen, and southeast of Phantomodden (Sfinxudden, HÄGG 1951, p. 243). ELTON and BADEN-POWELL (1931, pp. 390, 395—404) recorded it from Brucebyen, 10—12 m above the sea, and BADEN-POWELL (1939) from raised beaches at the mouth of Mathiesondalen (Ekholm Valley). KNIPOWITSCH (1902 III) recorded it from the Brucebyen area, and BALCHIN (1941) from the west side of Billefjorden.

Sassen area: Recorded from numerous localities, though never in large quantities, from sea level up to 45 m above (FEYLING-HANSSEN and JØRSTAD 1950, 70). HÄGG (1950, 1951) recorded it from Pleistocene deposits at Sassenfjorden, Tempelfjorden and Gåsodden[1], 8 m a.s.l.

Elsewhere in the Isfjorden area: Large specimens were found at Kapp Thordsen (Saurie Hook) and on the east side of Adventfjorden, 6 m a.s.l. (HEER 1870, pp. 23, 25, 91). It was later recorded from numerous localities within the Isfjorden area (KNIPOWITSCH 1903 IV, LAMPLUGH 1911, NORDMANN 1912, GRIPP 1927, HÄGG 1950, 1951).

[1] HÄGG (1951, p. 233) writes Gåskap, and it is not quite certain if Gåsodden west of Anservika is meant by this. The shells were collected by Nordberg who, on the same day made a collection at „Goes Bay“ also 8 m a.s.l. „Goes Bay“ probably refers to Anservika and not to Gåshamna in Hornsund.

West coast region: Hornsund (HEINTZ 1953), Bellsund area (NATHORST 1900, HÖGBOM 1911, CÖSTER 1925), St. Jonsfjorden (DINELEY 1954), Blomsterstrandhamna, on the north side of Kongsfjorden, 19 m a.s.l. (HOEL 1914).

North coast region: Gyldénøyane (at the mouth of Wahlenbergfjorden), Lomfjorden, Tommelpynten (Duym Punt) on the west side of Hinlopenstretet (ELTON and BADEN-POWELL 1931, p. 396). KULLING (KULLING and AHLMANN 1936, p. 4) found it 14—21 m above the sea in Lomfjorden.

East coast region: Recorded from raised marine deposits at many localities in the Storfjorden area, including Barentsøya and Edgeøya, at up to 10 m a.s.l. and in morainic material at Ginevrabotnen up to 25 m (KNIPOWITSCH 1900a, 1902 III). It was also recorded from Isispynten on the east coast of Nordaustlandet „morainic deposit, south moraine, Isis Point" (BADEN-POWELL 1939, p. 342).

Adjacent arctic and subarctic regions: Cape Chelyuskin, 30 m a.s.l. (GRØNLIE 1928), Novaya Zemlya, up to 142 m (GRØNLIE 1924, KNIPOWITSCH 1900b), the northern coasts of the European part of the USSR (KNIPOWITSCH 1900b, 1904b, LINDHOLM 1921), Kolguev Island (KNIPOWITSCH 1904a), the region to the south of Varangerfjorden (TANNER 1930), Finnmarken (TANNER 1907b, ØYEN 1929, ROSENDAHL 1931), Iceland, up to 32 m (THORODDSEN 1892, BÁRÐARSON 1921), East Greenland, up to 9 m (NOE-NYGAARD 1932), North Greenland (JENSEN 1917) and West Greenland, up to 200 m (i.a. LAURSEN 1944, 1950).

Recent distribution :

Arctic—mid-boreal, occurring southwards to Trondheimsfjorden (DONS 1937, p. 29) and even to Lysefjorden at Stavanger on the southern part of the Norwegian west coast, Cape Cod, Korea, and North Japan (LECHE 1878' G. O. SARS 1878, NORDGAARD 1903, JENSEN 1912, GRIEG 1924b, THORSON 1933). It does not extend into the high-arctic areas of Greenland; in West Greenland it was found up to 76° N.lat., and in East Greenland it was taken alive in the Franz Joseph Fjord (LAURSEN 1944, THORSON 1933). In the Svalbard archipelago it is recorded from all around Spitsbergen (GRIEG 1924a, SOOT-RYEN 1925, west coast; TORELL 1859, FRIELE and GRIEG 1901, north coast; KNIPOWITSCH 1901 I, also reviewing older records from the east coast). It occurs in Isfjorden at depths from 11 to 150 m (ODHNER 1915) and even down to 253 m (SOOT-RYEN 1925, Grønfjorden), being most common in depths less than 30 m (ODHNER 1915), and at the most accounting for 16.6 per cent of the fauna.

Remarks :

Chlamys islandica is often met with in shelly moraines, e.g. at Hornsundbreen (HEINTZ 1953), Paulabreen (NATHORST 1900, HÖGBOM 1911, CÖSTER 1925), Damesmorena (HÄGG 1950) and the morainic deposits of

Coraholmen (LAMPLUGH 1911, NORDMANN 1912, HÄGG 1951). The specimens in the moraines are often large and numerous, such shells probably having been pushed up from the sea bottom and incorporated in the moraines by oscillations of the glacier fronts in Recent or Sub-Recent times.

Crenella decussata (MONTAGU 1808).

Plate 17, fig. 10.

Mytilus decussatus MONTAGU 1808, p. 69.
Crenella elliptica BROWN 1827, pl. 31, figs. 12—14.
Crenella decussata, MACGILLIVRAY 1844, p. 229. — DAUTZENBERG and FISCHER 1912, p. 371 (with extensive synonymy).

Late-Pleistocene records :

Billefjorden: 9 valves occurred in a sample of *Lithothamnion* silt from 2 m a.s.l. at Sentabukta, Brucebyen area (p. 91). Previously recorded from Brucebyen („Bore 1") 10—12 m a.s.l. (ELTON and BADEN-POWELL 1931, p. 396).

Sassen area: Found in three localities, Sveltihel, Von Postbreen (moraine), Gåsøyane, up to 7 m (FEYLING-HANSSEN and JØRSTAD 1950, p. 70).

Elsewhere in the Isfjorden area: Recorded from the morainic deposits of Coraholmen (LAMPLUGH 1911, NORDMANN 1912, HÄGG 1951).

Adjacent arctic and subarctic regions: Recorded from various localities along the northern coasts of the European part of the USSR (KNIPOWITSCH 1900b, 1904b), Boris-Gleb, Harefossen, Holmfossen (TANNER 1930, pp. 189, 190, 192), Finnmarken (TANNER 1907b, ØYEN 1929), and West Greenland up to 35 m a.s.l. (LAURSEN 1944, 1950).

Recent distribution :

Arctic-boreal-lusitanian, Kara Sea, Novaya Zemlya, Franz Josef Land, Svalbard, Greenland, Melville Bay, Bering Sea; southwards to the Mediterranean, the West-Indies, Korea (LECHE 1878, JENSEN 1912, ODHNER 1915, SOOT-RYEN 1932, GAEVSKOIJ 1948). It is rare in Isfjorden, preferring shallow water (ODHNER 1915, p. 79).

Mytilus edulis LINNÉ 1758.

Plate 18, figs. 4, 5.

Mytilus edulis LINNÉ 1758, p. 705. — DAUTZENBERG and FISCHER 1912, p. 353 (with extensive synonymy).

Late-Pleistocene records :

Billefjorden: This common species was present in 61 of our samples from the Pleistocene of Billefjorden, from 2 m to 42 m a.s.l., accounting for a maximum of 93.91 per cent of the fauna (Asvindalen, 6.2 m a.s.l., p. 107). It was previously found by Swedish expeditions up to 20 m — Mimerbukta, southwest of Nordenskiöldbreen, and Phantomodden — (HÄGG 1950, 1951).

British expeditions recorded it at Petuniabukta, 15 and 27 m a.s.l. (BADEN-POWELL 1939), in the Brucebyen area, up to an estimated height of 30—45 m (ELTON and BADEN-POWELL 1931), and at Kapp Ekholm (BADEN-POWELL 1939). A Russian expedition of 1900 recorded it from the Brucebyen area (KNIPOWITSCH 1902 III).

Sassen area: Common, especially in terraces, up to 45 m, and predominating at lower levels, 3—5 m (FEYLING-HANSSEN and JØRSTAD 1950). Found by Swedish expeditions at Sassenfjorden and Tempelfjorden (KNIPOWITSCH 1903 IV); found also at Gåsodden and Anservika, 8 m a.s.l., Gipsvika, Bjonahamna and Von Postbreen (NATHORST 1884, HÄGG 1950, 1951).

Elsewhere in the Isfjorden area: HOEL (1911, p. 252) recorded it at Lykta in Dicksonfjorden from a terrace, the surface of which rises from 40 to 60 m a.s.l.[1] Furthermore recorded from Kapp Wijk and both sides of Dicksonfjorden (KNIPOWITSCH 1903 IV, HÄGG 1950, 1951), Coraholmen in Ekmanfjorden (LAMPLUGH 1911, NORDMANN 1912, HÄGG 1951), Bohemanneset, Erdmannflya (KNIPOWITSCH 1903 IV, HÄGG 1950, 1951), Kapp Linné, 7—8 m a.s.l. (FEYLING-HANSSEN and JØRSTAD 1950, p. 48), Grønfjorden, up to 14 m (HÖGBOM 1911, p. 46, GRIPP 1927, p. 37, HÄGG 1951, p. 240), Colesbukta, 21 m (HÖGBOM 1911, GRIPP 1927, HÄGG 1951) and 30 m (HOLMSEN 1913, p. 7), Adventfjorden, 6 m (BLOMSTRAND 1864, p. 41, first record of *Mytilus edulis* from the Pleistocene of Spitsbergen, HEER 1870, pp. 23, 24, 92, NATHORST 1884, p. 53, KNIPOWITSCH 1903 IV, p. 139, JENSEN and HARDER 1910, p. 400, DAUTZENBERG and FISCHER 1912, pp. 540—41, HÄGG 1951, p. 231), and up to 10 m (HÄGG 1950, p. 331).

West coast region: Isøyane off Torellbreen (KNIPOWITSCH 1903 IV, p. 141,) Bellsund area (HÄGG 1950, 1951), St. Jonsfjorden (DINELEY 1954), the moraine of Eidembreen (GRIPP 1929), Kongsfjorden area, moraines (HOEL 1910, p. 15, 1914, pp. 32, 33).

North coast region: Breiddholmen (Eider Island) at the head of Woodfjorden, 2—3 m a.s.l. (HOEL 1910, 1914), Dirksbukta in Wijdefjorden (ELTON and BADEN-POWELL 1931, p. 395), Sorgfjorden, west side 4.5 m a.s.l. (CHYDENIUS 1865, pp. 141—42), Langgrunnodden (Shoal Point, HEER 1870, p. 80), Murchisonfjorden, 14.5 and 16—19 m (KULLING and AHLMANN 1936), Wahlenbergfjorden, in morainic boulder clay at approx. 55 m a.s.l. (SANDFORD 1929, p. 547, BADEN-POWELL 1939, p. 339)[2].

East coast region: Kraussbukta on Edgeøya (KNIPOWITSCH 1900a, 1902 III), Kapp Weissenfels on Kong Karls Land, 25 m above the sea

[1] FREBOLD (1935, p. 144) erroneously writes that HOEL found *Mytilus edulis* in Dicksonfjorden in terraces at a height of 70 m a.s.l. This erroneous height was later quoted by several authors.

[2] KNIPOWITSCH (1903 IV, p. 141) erroneously recorded it from Lomfjorden (Lommebay). Pleistocene shells were found there, but not *Mytilus edulis* (HEER 1870, p. 80).

(ANDERSSON 1900, p. 249; cf. NATHORST 1901, 1910, KNIPOWITSCH 1903 IV, p. 141, HÄGG 1950, p. 337).

Adjacent arctic and subarctic regions: Franz Josef Land, 3—6 m above the sea (NANSEN 1902, p. 420; cf. JENSEN and HARDER 1910, p. 401), Novaya Zemlya, up to 10 m a.s.l. (GRØNLIE 1924, p. 99), Kolguev Island, one fragment (KNIPOWITSCH 1904a, p. 177), the northern coasts of the European part of the USSR (KNIPOWITSCH 1900b, 1904b, LINDHOLM 1921), the region to the south of Varangerfjorden (Ishavsfinland, TANNER 1930), Finnmarken (HOLMBOE 1904, TANNER 1907a, b, ØYEN 1929, ROSENDAHL 1931), Iceland, up to 35 m (THORODDSEN 1892, BÁRDARSON 1921), East Greenland, up to 25 m (NATHORST 1901, FLINT 1948), up to 57 m (NOE-NYGAARD 1932), and West Greenland (JENSEN 1889, 1905, ENGELL 1904, JENSEN and HARDER 1910), up to 70 m (LAURSEN 1944, 1950).

Recent distribution :

Mid-arctic—boreal—lusitanian, lacking in high-arctic waters, otherwise nearly cosmopolitan (ANTEVS 1928, LAURSEN 1944). Living specimens of *Mytilus edulis* were never recorded from Spitsbergen waters[1]. Valves of this species were collected from the Recent shore at two places in Skansbukta; they had probably been washed out of older deposits (pp. 109, 120).

Remarks :

Mytilus edulis was previously regarded as an important index fossil for deposits from the Post-Glacial Warm period in Spitsbergen, being referable to the *Tapes* time in Scandinavia. It was later recognized that it appeared in the fauna of Spitsbergen before that time (FEYLING-HANSSEN and JØRSTAD 1950, cf. also HOEL 1914, p. 37).

[1] During the Swedish expedition of 1861 AGARDH found small specimens of *M. edulis* on sea-weed at Spitsbergen. HEER (1870, p. 82, cf. NORDENSKIÖLD 1866), therefore, considered this species to belong to the Recent fauna of Spitsbergen, but that it must have been far more common there in earlier periods, according to its frequency in raised beaches. KNIPOWITSCH (1903 IV, p. 4) wrote about this: „Aber da diese Art nie von irgend einem Forscher an den Küsten von Spitzbergen lebend gefunden ist, und wir ausserdem nicht wissen, woher diese Tange stammen und ob die Exemplare von *Mytilus* wirklich recent waren, so verliert diese Angabe fast jede Bedeutung." None of the later investigators of the Recent mollusk fauna of Svalbard have recorded *M. edulis* as living there. (Cf. i.a. HÄGG 1904, ODHNER 1915, DAUTZENBERG and FISCHER 1912, GRIEG 1925, BROTZKY 1930, IDELSON 1930). HEINTZ (1926) recorded fresh *Mytilus* specimens, attached to *Aschopyllum nodosum,* from the shore at Raudfjorden (Red Bay), and concluded that the specimens had drifted in from a remote southern locality (l.c. p. 76; also VOGT 1927, p. 376). The present author found numerous valves of *M. edulis,* of a remarkably fresh appearance, on the beach of Vesle Raudfjorden at the innermost part of Breibogen on the north coast.

Volsella modiola (LINNÉ 1758).

Plate 19, figs. 1—3.

Mytilus modiolus LINNÉ 1758, p. 706.
Musculus modulus BOLTEN 1798, p. 157.
Modiola papuana LEACH 1815, p. 33.
Modiolus vulgaris MACLAURIN 1838, p. 241.
Volsella modiolus, GRAY 1847, p. 198.
Perna umbilicata MÖRCH 1853, p. 53.
Volsella modiolus, DAUTZENBERG and FISCHER 1912, p. 363 (with extensive synonymy).
Modiolus modiolus, WINCKWORTH 1932, p. 240.

Late-Pleistocene records :

Billefjorden: Two shell fragments were found in a cliff of marine deposits, 2 m a.s.l., at Skansbukta (p. 116), and four umbonal fragments together with many other fragments of this species were present in a terrace, 31 m a.s.l., at Ebbadalen, Petuniabukta (p. 99). Not previously recorded from the Pleistocene of Billefjorden.

Sassen area: Four umbonal fragments were found 20 m a.s.l. in the 29 m high cliff of a terrace at Kapp Schoultz (FEYLING-HANSSEN and JORSTAD 1950, pp. 26, 70).

Elsewhere in the Isfjorden area: Adventfjorden (DAUTZENBERG and FISCHER 1912, pp. 540—41[1], cf. also ODHNER 1915, p. 267), and at Dicksonfjorden (HÄGG 1950, p. 334, 1951, p. 232).

Adjacent arctic and subarctic regions: The White Sea and the Murman coast (KNIPOWITSCH 1900b, LINDHOLM 1921), the region to the south of Varangerfjorden (TANNER 1930), Finnmarken (TANNER 1907b, ØYEN 1929), and Iceland (BÁRÐARSON 1921). It was not recorded from the Pleistocene of Greenland.

Recent distribution :

Low-arctic—boreal—lusitanian, (low-arctic—boreal, ANTEVS 1928), occurring in the southwestern part of the Barents Sea (GAEVSKOIJ 1948), in the White Sea, Norwegian coast, Iceland, the Faroes, the British Isles and France; on the west side of the Atlantic it is recorded from Labrador to North Carolina, and in the Pacific from the Bering Sea to California and Japan (JENSEN 1912). It also occurs in the Beaufort Sea (SOOT-RYEN 1932).

Remark : Volsella modiola is an important guide fossil to deposits from the Post-Glacial Warm period in Svalbard.

---

[1] DAUTZENBERG and FISCHER (1912, p. 368) recorded *V. modiola* as living in Adventfjorden. This is obviously incorrect as the collection was made on land (Stn. 2476 of 1906).

Musculus discors substriatus (GRAY 1824).

Plate 19, fig. 4—7.

Modiola laevigata var. *b. substriata* GRAY 1824, p. 245.
Modiolaria laevigata var. *substriata,* POSSELT 1895, p. 67.
Modiolaria substriata, HÄGG 1904, p. 25.
Modiolaria discors var. *substriata,* JENSEN 1912, p. 58, pl. 3, figs. 5a—b.
Musculus discors substriatus, SOOT-RYEN 1939, p. 10.

Late-Pleistocene records :

Billefjorden: Four small valves, representing three specimens, were found on the lowest terrace, 2 m a.s.l., at the southwest side of Skansbukta, the largest valve being 20.2 mm long. They had a Recent appearance and were probably washed ashore in Recent times (p. 119).

Sassen area: One specimen was found in Gipsvika, approx. 2 m a.s.l., and two specimens at the Gipshuken Hut, 2—3 m a.s.l. (FEYLING-HANSSEN and JØRSTAD 1950, pp. 57, 71); they too were probably of Recent origin.

Elsewhere in the Isfjorden area: Recorded from the northern end of Coraholmen in Ekmanfjorden, in morainic deposits (HÄGG 1951, p. 235).

East coast region: Edgeøya (KNIPOWITSCH 1902 III, p. 79).

Adjacent arctic and subarctic regions: West Greenland (LAURSEN 1950).

Recent distribution :

Circumarctic-highboreal, extending southwards to Lofoten, Massachusetts and Japan (JENSEN 1912, p. 60).

Astarte borealis (CHEMNITZ 1784).

Plate 20, figs. 1—8; plate 21, figs. 1, 2.

Venus borealis CHEMNITZ (part. non LINNÉ) 1784, p. 26, pl. 39, fig. 412.
Venus compressa MONTAGU (part. non LINNÉ) 1808, p. 43, pl. 26, fig. 1.
Tridonta borealis SCHUMACHER (non LINNÉ) 1817, p. 147, pl. 17, figs. 1a—b.
Crassina semisulcata LEACH 1819, p. 175.
Crassina borealis, NILSSON 1822, p. 188, pl. 2, figs. 3—5.
Crassina arctica GRAY 1824, p. 243.
Astarte lactea BRODERIP and SOWERBY 1829, p. 365.
Astarte borealis, PHILIPPI 1845, p. 58, pl. 1, fig. 11. — JENSEN 1912, p. 92, pl. 4, figs. 1a—f.
Astarte semisulcata, DAUTZENBERG and FISCHER 1912, p. 421, pl. 11, figs. 23—28 (with extensive synonymy).

Late-Pleistocene records :

Billefjorden: This species is the most common one in Post-Glacial Warm period deposits of Spitsbergen. It occurred in 47 samples from Billefjorden, from sea-level up to 34 m above (Petuniabukta, p. 100), accounting for 4.35 per cent (*Mytilus* terrace 6.2 m a.s.l. at Asvindalen, p. 107) to 69.77 per cent (cliff of *Astarte* plain 2 m a.s.l. at Brucebyen, p. 89) of the fauna.

It was previously recorded from the Pleistocene of Billefjorden by KNIPOWITSCH (1902 III), ELTON and BADEN-POWELL (1931), BADEN-POWELL

(1939), BALCHIN (1941), HÄGG (1950, 1951), from sea-level up to 27 m above (Petuniabukta, Oxford University Exp., 1933, BADEN-POWELL 1939, p. 340, present paper p. 101)[1].

Sassen area: *A. borealis* was found up to 21 m a.s.l. (solifluction slope at Kapp Belvedere), dominating the faunas of the Post-Glacial deposits at about 2 m above the sea and from 7 to 20.5 m a.s.l. (FEYLING-HANSSEN and JØRSTAD 1950, pp. 50, 53, 71). At Kapp Schoultz in Tempelfjorden it was found approx. 20 m a.s.l. in the cliff of a terrace, the surface of which was situated 28.8 m a.s.l. (l.c. p. 26). *A. borealis* should therefore be expected there at least up to that height. In morainic material at the south side of the front of Von Postbreen it occurred up to 30 m (l.c. p. 61).

HÄGG (1950, 1951) recorded it from Gåsodden (Gåskap) and Anservika (Goes Bay), 8 m a.s.l., Gipsvika, Von Postbreen (moraine), Sassenelva, and Diabasodden.

Elsewhere in the Isfjorden area: Adventfjorden, 6 m a.s.l. (HEER 1870, p. 92), Colesbukta (GRIPP 1927, p. 37), Grønfjorden (GRIPP 1927, HÄGG 1951), Coraholmen in Ekmanfjorden (LAMPLUGH 1911, NORDMANN 1912, HÄGG 1951), Kapp Thordsen, 23 m a.s.l., Saurieberget, Kapp Wijk, Dicksonfjorden, Erdmannflya, 1—2 m a.s.l., Longyeardalen (HÄGG 1950, 1951).

West coast region: Hornsund (HEINTZ 1953), at Torellbreen (HÄGG 1950), at different localities in the Bellsund area (CÖSTER 1925, HÄGG 1950, 1951). PEACH (1916, p. 299) found it in „Saxicava-Beach" deposits at Prins Karls Forland at heights of 50—70 feet (16—23 m); ELTON and BADEN-POWELL (1931) recorded it 12 m a.s.l. there (also HÄGG 1950, height not recorded), and DINELEY (1954) found it up to 18—22.5 m in marine deposits at St. Jonsfjorden (at 49.5 m in the Eidembreen moraine, cf. also GRIPP 1929). HOEL (1914, pp. 32—33) recorded it from Blomstrandhamna (Kongsfjorden), 14 m a.s.l., and from morainic deposits at Lilliehöökbreen, 8—10 m above the sea.

North coast region: Breiddholmen at the head of Woodfjorden, 2—3 m a.s.l. (HOEL 1914), Dirksodden in Wijdefjorden (ELTON and BADEN-POWELL 1931). From the area around Hinlopenstretet it was recorded from raised beaches up to an altitude of 22 m at Gyldénoyane, Wahlenbergfjorden, and Tommelpynten (ELTON and BADEN-POWELL 1931, p. 393). It was found in morainic material, boulder clay, at approx. 55 m a.s.l.[2] (SANDFORD 1929, p. 547, BADEN-POWELL 1939, p. 339) at the head of Wahlenbergfjorden.

---

[1] ELTON and BADEN-POWELL (1931, p. 391), recorded *A. borealis*, together with *Mytilus edulis, Astarte montagui, Cyprina islandica, Macoma calcarea, Mya truncata, Saxicava arctica* (var. *pholadis*), *Littorina saxatilis* and *Littorina littorea*, from „Upper raised beaches" in the vicinity of Brucebyen „at an estimated height of between 100 and 150 feet (30—45 m)". The present author found it up to 32.7 m at Teltfjellet, and up to 30.1 m at Gerritelva. The height of the finds recorded by ELTON and BADEN-POWELL (l.c.) does not necessarily excede these figures.

[2] FREBOLD (1935, p. 147) quoted this occurrence without mentioning the character of the deposit.

(For further details about the records of *A. borealis* from the Hinlopen region cf. KULLING in KULLING and AHLMANN 1936, and FEYLING-HANSSEN and JØRSTAD 1950, pp. 50—51).

East coast region: It was recorded from raised beaches in the Storfjorden area up to 10 m a.s.l. (KNIPOWITSCH 1902 III, pp. 434—35), and in moraine deposits up to 100 m (l.c.). WOODWARD (1860, p. 438) recorded it from a moraine at Tjuvfjorden (Deeve Bay).

Astarte, probably *borealis,* was recorded from Kong Karls Land at approx. 10 m above the sea (NATHORST 1901 a, p. 375, 1910, p. 414).

Adjacent arctic and subarctic regions: Franz Josef Land, 20—25 m a.s.l. (SOOT-RYEN 1939, p. 18), Novaya Zemlya (KNIPOWITSCH 1900b), up to 142 m a.s.l. (GRØNLIE 1924, p. 100), and up to 163 m on a glacier (l.c.), the Chelyuskin Peninsula, up to 40—50 m (GRØNLIE 1928), Kolguev Island and the northern coasts of Russia and Norway (KNIPOWITSCH 1900b, 1904a and b, LINDHOLM 1921, TANNER 1907b, 1930, ØYEN 1929), Iceland, 2—17 m a.s.l. (BÁRDARSON 1921), East Greenland, up to 25 m (NOE-NYGAARD 1932, FLINT 1948), North Greenland (JENSEN 1917, LAURSEN 1954), West Greenland, up to 28 m (LAURSEN 1950), and up to 39 m (LAURSEN 1944, Northern West Greenland).

Recent distribution :

Circumarctic—midboreal, extending southwards to Denmark, Nova Scotia, the Aleutian Islands, and North Japan (SOOT-RYEN 1932, p. 12; for details cf. HÄGG 1904 and JENSEN 1912). Vertical distribution: 0—463 m (ANTEVS 1928), usually found in shallow water, down to 45 m (THORSON 1933, 1934).

It is common in Isfjorden, accounting for 4.1—28.5 per cent of the local faunas (ODHNER 1915, p. 89).

Remarks :

The highest find of *Astarte borealis* from raised beaches in Spitsbergen is from Ebbadalen in Petuniabukta, 34 m above sea level (p. 100). Its first appearance in the mollusk fauna of Vestspitsbergen (and probably Svalbard as a whole) coincides with the beginning of the Post-Glacial Warm period there, and due to its high frequency it is the most useful guide fossil for deposits of that age, especially for their upper limits.

A. borealis did not disappear from Svalbard as the climate again became less favourable, but is one of the most common species there also to-day.

Astarte montagui (DILLWYN 1817).
Plate 21, figs. 3—12.

Venus compressa MONTAGU (part., non LINNÉ) 1808, p. 43, pl. 26, fig. 1.
Venus montagui DILLWYN (part.) 1817, p. 167.
Nicania banksii LEACH 1819, p. LXII.
Astarte compressa FLEMING 1828, p .440.
Astarte montagui, MÖRCH 1868, p. 223.
Astarte banksi, DAUTZENBERG and FISCHER 1912, p. 425, pl. 11, figs. 15—22.
Astarte montagui, JENSEN 1912, p. 97, pl. 4, figs. 2a—c.

Late-Pleistocene records :

Billefjorden: This species was present in 30 of the samples collected in 1950, from sea level up to 31 m above (Ebbadalen, Petuniabukta, p.99), accounting for 2.3—19.5 per cent of the fossil faunas and usually occurring together with *A. borealis*. A single umbonal fragment of *A. montagui* was present in a sample from a *Mya* terrace between Ebbadalen and Rudmosepynten, 41.3 m a.s.l., probably due to contamination.

It was previously recorded from the Pleistocene of Billefjorden by Swedish, Russian and English expeditions (HÄGG 1950, 1951, KNIPOWITSCH 1902 III, BADEN-POWELL 1939, ELTON and BADEN-POWELL 1931), from 8—15—17—20 m above sea level (as to the record of ELTON and BADEN-POWELL, p. 391, from an estimated height of 30—45 m a.s.l., cf. footnote p. 135 of the present paper).

Sassen area: Recorded from raised beaches in many localities, up to 20 m, and from the moraine of Von Postbreen up to 30 m (FEYLING-HANSSEN and JØRSTAD 1950). HÄGG (1950, p. 339, 1951, p. 242) recorded it from the same moraine, and, furthermore, from the mouth of Sassenelva, from Gipsvika (1951, pp. 239, 243, heights not recorded), and from Anservika (Coes Bay, cf. p. 128) at 8 m a.s.l. (l.c. p. 332).

Elsewhere in the Isfjorden area: Coraholmen in Ekmanfjorden (LAMPLUGH 1911, as *A. compressa* ; NORDMANN 1912, as *A. banksii* ; HÄGG 1951, as *A. banksi*) Erdmannflya, 1—2 m a.s.l., Bohemanneset (HÄGG 1951), Gronfjorden and Colesbukta (GRIPP 1927).

West coast region: Bellsund area, up to 18 m at Kapp Lyell (KNIPOWITSCH 1903 IV, CÖSTER 1925, HÄGG 1950), Prins Karls Forland, 12 m a.s.l. (ELTON and BADEN-POWELL 1931), Müllerneset and St. Jonsfjorden, up to 30—36 m (DINELEY 1954), Blomstrandhamna, in moraine 19 m above the sea (HOEL 1914).

North coast region: Breiddholmen at the head of Woodfjorden (HOEL 1914), Dirksodden in Wijdefjorden (ELTON and BADEN-POWELL 1931), Lomfjorden, 14—21 m a.s.l. (KULLING in KULLING and AHLMANN 1936, p. 4), one valve also found there by TORELL (HÄGG 1950).

East coast region: From the Storfjorden area it was recorded up to 4 m in raised beaches, and up to 100 m in moraines (KNIPOWITSCH 1902

III). WOODWARD (1860, p. 438) recorded it from a moraine at Tjuvfjorden (as *A. compressa* var. *striata*).

Adjacent arctic and subarctic regions: Cape Chelyuskin, 25—30 m a.s.l. (GRØNLIE 1928), Novaya Zemlya (KNIPOWITSCH 1900b), up to 170 m a.s.l. (GRØNLIE 1924), Kolguev Island (KNIPOWITSCH 1904a) and the arctic coasts of Russia and Norway (KNIPOWITSCH 1900b, 1904b, LINDHOLM 1921, TANNER 1907b, 1930, ØYEN 1929), Iceland (BÁRÐARSON 1921), East Greenland (JENSEN 1905, p. 313, FLINT 1948, p. 192), up to 20 m a.s.l. (NOE-NYGAARD 1932), North Greenland (JENSEN 1917), West Greenland, up to 36 m a.s.l. (LAURSEN 1950), and up to 42.5 m in northern West Greenland (LAURSEN 1944).

Recent distribution :

Circumarctic-boreal (ANTEVS 1928), extending southwards to France, Nova Scotia and British Columbia (SOOT-RYEN 1932). Vertical distribution: 0—534 m (HÄGG 1904), usually met with in shallow water (THORSON 1933). It occurs within the same main depth zone as *A. borealis,* but usually extends somewhat deeper than the latter (LAURSEN 1950, p. 113).

Astarte montagui is the most common species in Isfjorden, accounting for 28—64 per cent of the Recent faunas there. Only in Ymerbukta was a low frequency found, viz. 0.6—8.0 per cent (ODHNER 1915, p. 99).

Remarks :

A. montagui is common in most marine sediments in Spitsbergen deposited during the Post-Glacial Warm period there, and later. Different varieties are treated together in this account.

Astarte elliptica (BROWN 1827).

Plate 21, figs. 13, 14.

Crassina sulcata NILSSON (non DA COSTA) 1822, p. 187.
Crassina elliptica BROWN 1827, pl. 18, fig. 3.
Astarte semisulcata MÖLLER 1842, p. 19.
Venus compressa HANLEY 1855, p. 454.
Astarte elliptica, DAUTZENBERG and FISCHER 1912, p. 418, pl. 11, figs. 12—14 (with extensive synonymy). — JENSEN 1912, p. 108, pl. 4, figs. 4a—g.

Late-Pleistocene records :

Billefjorden: This species was present in 7 samples from the Post-Glacial Warm period in Billefjorden, at 2—9.7 m a.s.l., accounting for 0.7—4.9 per cent of the fossil faunas. It was previously recorded from Anservika, 8 m a.s.l. (HÄGG 1951).

Sassen area: It was found up to 10 m a.s.l. in raised marine deposits, and up to 30 m in the moraine of Von Postbreen (FEYLING-HANSSEN and JØRSTAD 1950). Swedish expeditions found it in the same moraine (HÄGG 1950), and KNIPOWITSCH (1903 IV, p. 138) recorded one valve from Tempelfjorden.

Elsewhere in the Isfjorden area: Recorded from the morainic deposits of Coraholmen (LAMPLUGH 1911, HÄGG 1951), from Erdmannflya, 1—2 m a.s.l. (HÄGG 1951), Grønfjorden (moraine), and Colesbukta (GRIPP 1927).

West coast region: Hornsund (HEINTZ 1953, moraine), Bellsund area (KNIPOWITSCH 1903 IV, HÄGG 1950, 1951, moraine), St. Jonsfjorden, at 28.5 m a.s.l. (DINELEY 1954) and Kongsfjorden area (HOEL 1914, moraines, 8—10 and 19 m a.s.l., recorded as *A. compressa*).

North coast region: Breiddholmen at the head of Woodfjorden, 2—3 m a.s.l. (HOEL 1914), Gyldénøyane in Wahlenbergfjorden, 5—22 m a.s.l. (ELTON and BADEN-POWELL 1931).

East coast region: From the Storfjorden area KNIPOWITSCH (1902 III) recorded it up to 4 m in raised beaches, and up to 100 m in moraine deposits. He also mentions a worn valve (specific identification uncertain) from Mistakodden (Förväxlingsudden), Barentsøya, at about 50 m a.s.l. N. L. FALCON, of the Cambridge exp. to Edge Island 1927, collected some shells from a raised beach at about 53 m above the sea, amongst them being *A. elliptica* (BADEN-POWELL 1939).

Adjacent arctic and subarctic regions: Novaya Zemlya (KNIPOWITSCH 1900b), 50—142 m a.s.l. (GRØNLIE 1924), Kolguev Island (KNIPOWITSCH 1904a), the northern coast of Russia and Finnmarken (KNIPOWITSCH 1900b, 1904b, LINDHOLM 1921, TANNER 1907b, 1930, ØYEN 1929), Iceland (BÁRÐARSON 1921, 2—17 m), East Greenland, up to 9 m (JENSEN 1905), up to 20 m (NOE-NYGAARD 1932), and northern West Greenland, up to 42.5 m and even 190 m a.s.l. (LAURSEN 1944).

Recent distribution :

Arctic—boreal, extending southwards to France and New England (JENSEN 1912, ANTEVS 1928, GAEVSKOIJ 1948). It occurs in Isfjorden at depths down to 75 m and even 150 m, accounting for a maximum of 19 per cent of the fauna (Ekmanfjorden) (ODHNER 1915, p. 93).

Astarte crenata (GRAY 1824).

Nicania crenata GRAY 1824, p. 242.
Astarte crebricostata MÖRCH 1857a, p. 91.
Astarte crenata, POSSELT 1895, p. 71. — JENSEN 1912, p. 113, pl. 4, figs. 5a—m.

Late-Pleistocene records :

Billefjorden: This species was present in two samples, one valve from a terrace at Petuniabukta, 31 m a.s.l., and two valves from a terrace at Gerritelva, 23,2 m a.s.l.

Sassen area: One valve from a 7 m terrace at Gipsvika, and one from a solifluction slope, 33 m a.s.l., in the same locality (FEYLING-HANSSEN and

JØRSTAD 1950, p. 72). HÄGG (1950, p. 339) recorded it from the south side of Von Postbreen.

West coast region: Recorded from Van Mijenfjorden by CÖSTER (1925) and HÄGG (1950), the latter recording it also from Kapp Lyell.

Adjacent arctic and subarctic regions: Novaya Zemlya (KNIPOWITSCH 1900b), up to 115 m (GRØNLIE 1924), Kolguev Island (KNIPOWITSCH 1904a), the arctic coasts of the European part of Russia (KNIPOWITSCH 1900b, 1904a, LINDHOLM 1921[1]), Finnmarken (TANNER 1907b), and West Greenland, up to 42.5 m (LAURSEN 1944).

Recent distribution :

Circumarctic(?)—mid-boreal, occurring as far south as Bergen (?) on the east side of the Atlantic (SOOT-RYEN 1932). Vertical range: 5—650 m (JENSEN 1912), deep-water form, only exceptionally in shallow water (LAURSEN 1944, p. 55).

ODHNER (1915, p. 94) recorded it from Isfjorden at depths of 0—300 m. It is further recorded from all around Spitsbergen (KNIPOWITSCH 1901 I).

Thyasira flexuosa (MONTAGU 1803).

Tellina flexuosa MONTAGU 1803, p. 72.
Axinus flexuosus, G. O. SARS 1878, p. 59, pl. 19, figs. 4a, b.

Late-Pleistocene records :

Billefjorden: Recorded from Brucebyen, 10—12 m above the sea, by ELTON and BADEN-POWELL (1931, „Bore No. 1").

Elsewhere in the Isfjorden area: Coraholmen (LAMPLUGH 1911, *Axinus gouldi ;* NORDMANN 1912; HÄGG 1951) and Erdmannflya (HÄGG 1951).

East coast region: KNIPOWITSCH (1902 III, p. 436) recorded *Thyasira flexuosa gouldi* (PHILIPPI) from Diabastangen in Ginevrabotnen, 4 m a.s.l., and from Kvalpynten (Whales Point), Edgeøya.

Adjacent arctic and subarctic regions: White Sea and the Murman coast (KNIPOWITSCH 1900b, 1904b, LINDHOLM 1921), Finnmarken (i.a. HOLMBOE 1904, TANNER 1907b), East Greenland (JENSEN 1905), North Greenland (JENSEN 1917), West Greenland (i.a. LAURSEN 1950).

Recent distribution :

Thyasira flexuosa incl. var. *gouldi* is widely distributed, in the Atlantic from the Arctic to the Canaries and south of Cape Cod, in the Pacific southwards to New South Wales and Corea (SOOT-RYEN 1932). It is common in Isfjorden at depths down to 100 m (ODHNER 1915).

[1] Recorded as *Astarte crebricostata* FORBES.

Thyasira croulinensis (JEFFREYS 1847).

Plate 22, fig. 1.

Clausina croulinensis JEFFREYS 1847, p. 19.
Axinus croulinensis, JEFFREYS 1863 II, p. 250; 1869 V, p. 180, pl. 33, fig. 2.
Thyasira croulinensis, DAUTZENBERG and FISCHER 1912, p. 487.

Late-Pleistocene records :

Billefjorden: One valve was found in the section at Teltfjellbekken, sample VI, 5.5 m a.s.l. Not previously recorded from the Pleistocene of Svalbard.

Recent distribution :

Mid-arctic—boreal—lusitanian, from the Murman coast to the Azores. It was dredged in Tempelfjorden, at a depth of 102 m, by the Prince of Monaco in 1898 (DAUTZENBERG and FISCHER 1912, ODHNER 1915).

Thyasira sarsii (PHILIPPI 1845).

Plate 22, fig. 2.

Axinus sarsii PHILIPPI 1845, p. 91.
G. O. SARS 1878, p. 60, pl. 19, figs. 5a, b.
Thyasira sarsii, DALL 1901, p. 786.

Late-Pleistocene records :

Billefjorden: 5 valves of this species were found in the section at Teltfjellbekken, 4 in sample V (5.8 m a.s.l.), and 1 in sample VI (5.3 m a.s.l.). Not recorded previously from Svalbard, either as a fossil or as a living animal.

Adjacent arctic and subarctic regions: Ura Bay on the Murman coast (KNIPOWITSCH 1900b, p. 37), Ishavsfinland (TANNER 1930).

Recent distribution :

Mid-arctic—boreal, Novaya Zemlya—Murman coast—Norway to the Oslofjord (JENSEN and SPÄRCK 1934, p. 91; GAEVSKOIJ 1948, p. 438).

Clinocardium ciliatum (FABRICIUS 1780).

Plate 22, fig. 3.

Cardium ciliatum FABRICIUS 1780, p. 410.
Cardium islandicum CHEMNITZ 1782 VI, p. 200, pl. 19, figs. 195, 196.
Cerastoderma ciliatum, MÖRCH 1853 II, p. 34.
Cardium (Cerastoderma) islandica DAUTZENBERG and FISCHER 1912, p. 448 (with extensive synonymy).

Late-Pleistocene records :

Billefjorden: This species was rare in the Pleistocene of Billefjorden, only one valve being found in a *Mytilus* terrace, 5.8 m a.s.l. at Mytilusbekken, 1.5 km north of Anservika. HÄGG (1951, p. 233) recorded one valve from Gåsodden (Gaskap), 8 m a.s.l.

Sassen area: One valve was found in a terrace at Svetlihel, 3.6 m a.s.l. In addition it was found in five other places in clayey material up to 7 m a.s.l., and at an elevation of 30 m in the moraine of Von Postbreen (FEYLING-HANSSEN and JØRSTAD 1950, p. 72).

Elsewhere in the Isfjorden area: 7 valves recorded from the east side of Dicksonfjorden (HÄGG 1950, p. 334). The species was also present in the morainic deposits of Coraholmen (LAMPLUGH 1911, p. 235).

West coast region: Swedish expeditions found it in four localities in the Bellsund area, viz.: Braganzavågen, Kapp Amsterdam, Barryneset, and Damesmorena (HÄGG 1950, 1951).

East coast region: KNIPOWITSCH (1902 III, p. 436) recorded it from Ginevrabotnen and Edgeøya.

Adjacent arctic and subarctic regions: GRØNLIE (1928, p. 4) recorded two valves and some fragments from the beach at Maudhavn to the south of Cape Chelyuskin, these being probably of Recent origin. It was recorded from Pleistocene deposits along the northern coasts of the European part of Russia (KNIPOWITSCH 1900b), Ishavsfinland (Boris-Gleb, TANNER 1930), Finnmarken (TANNER 1907b, ØYEN 1929, approx. 14 m a.s.l.), Iceland (LAURSEN 1944, p. 56), East Greenland, 25—50 m a.s.l. (NATHORST 1901b, cf. JENSEN 1905), up to 28 m (NOE-NYGAARD 1932, also FLINT 1948), North Greenland (JENSEN 1917, LAURSEN 1954) and West Greenland, up to 200 m (LAURSEN 1944, 1950).

Recent distribution :

Circumarctic (JENSEN 1912, p. 83). It is common in Isfjorden, occurring more frequently towards the open fjord than towards the heads of the fjord branches. It seemed to be more frequent at depths below, rather than above, 50 m (ODHNER 1915, p. 119). Its southern limit of distribution is East Finnmarken (in the Varanger district at depths of 22—125 m, cf. SOOT-RYEN 1951), Cape Cod, Puget Sound, and northern Japan (JENSEN 1912).

Remark :

Many specimens of *C. ciliatum* found on the terrace surfaces may have been brought there by birds.

Serripes groenlandicus (CHEMNITZ 1782).

Plate 22, figs. 4, 5.

Cardium groenlandicum CHEMNITZ 1782 VI, p. 202, pl. 19, fig. 198.
Aphrodite Groenlandica, STIMPSON 1851, p. 19.
Serripes groenlandicum, PACKARD 1866, pp. 227, 280.
Cardium (Serripes) groenlandicum, DAUTZENBERG and FISCHER 1912, p. 455 (with synonymy).

Late-Pleistocene records :

Billefjorden: This species was present in 10 samples, taken from sea level up to 42 m above (Myadalen p. 121), two of which were of Recent origin (Skansbukta and Petuniabukta). The maximum frequency was 7 valves, accounting for 9 per cent of the assemblage (Skansbukta). It was previously found by Swedish expeditions at Mimerbukta, 20 m a.s.l., and to the SW of Nordenskiöldbreen (HÄGG 1951). ELTON and BADEN-POWELL (1931) recorded it from Brucebyen, 10—12 m a.s.l.

Sassen area: Found from sea level up to 13,5 m above, rare (FEYLING-HANSSEN and JØRSTAD 1950, p. 73).

Elsewhere in the Isfjorden area: Saurieberget and the east side of Dicksonfjorden (HÄGG 1950), Coraholmen (LAMPLUGH 1911, NORDMANN 1912, HÄGG 1951), Nansenbreen (HÄGG 1950, 1951), Grønfjorden, moraine (GRIPP 1927), and Adventfjorden, 6 m a.s.l. (HEER 1870, p. 91).

West coast region: Recherchefjorden and Van Mijenfjorden (KNIPOWITSCH 1903 IV, CÖSTER 1925, HÄGG 1950, 1951), Prins Karls Forland (ELTON and BADEN-POWELL 1931), Blomsterstrandhamna and the moraine at Lilliehöökbreen (HOEL 1914).

East coast region: Ginevrabotnen, 4 m a.s.l. and in moraines at Negribreen, 25—100 m above the sea (KNIPOWITSCH 1902 III, p. 437), Edgeøya (KNIPOWITSCH 1902 III, BADEN-POWELL 1939, p. 338).

Adjacent arctic and subarctic regions: Franz Josef Land, 20—25 m a.s.l. (SOOT-RYEN 1939), southeast of Cape Chelyuskin, 40—50 m a.s.l. (GRØNLIE 1928), Novaya Zemlya, up to 120 m (GRØNLIE 1924, p. 100), Kolguev Island (KNIPOWITSCH 1904a), the northern coasts of the European part of Russia (KNIPOWITSCH 1900b), Ishavsfinland (Boris-Gleb, 0.85 m a.s.l. TANNER 1930, p. 188), East Greenland, 25—50 m a.s.l. (NATHORST 1901b, JENSEN 1905), 5 m a.s.l. (NOE-NYGAARD 1932), North Greenland (JENSEN 1917), West Greenland, up to 190 m (LAURSEN 1944, 1950), and also from the Disko Bugt (HARDER, JENSEN, and LAURSEN 1949).

Recent distribution :

Circumarctic; in the Atlantic south to eastern Finnmarken (SOOT-RYEN 1951), Iceland and Stonington; in the Pacific south to Puget Sound and Hakodadi (SOOT-RYEN 1932). It is one of the dominant species in Isfjorden at present, being most frequent in shallow water, at depths less than 30 m (ODHNER 1915).

Remark :

Many shells of *S. groenlandicus* have been brought on land by birds.

Cyprina islandica (LINNÉ 1767).

Plate 22, figs. 6—9; plate 23, figs. 1—3.

Venus islandica LINNÉ 1767, p. 1131.
Cyprina islandica, LAMARCK 1818 V, p. 557.
DAUTZENBERG and FISCHER 1912, p. 458 (with extensive synonymy).

Late-Pleistocene records :

Billefjorden: This large, conspicuous species occurred in 14 samples, from 2.0 to 31.0 m a.s.l. (Petuniabukta, p. 99). One fragment was found in the Recent shore of Skansbukta, certainly derived from older deposits. The frequency of *C. islandica* in the investigated Pleistocene deposits of Billefjorden was low.

Swedish expeditions found it at Mimerbukta, 20 m a.s.l., and at two other places in Billefjorden, heights not recorded (HÄGG 1951). British expeditions recorded it from Petuniabukta, 8 m a.s.l. (BADEN-POWELL 1939), Brucebyen, 30—45 m (?) (ELTON and BADEN-POWELL 1931), and from the east side of the fjord, height not recorded (BALCHIN 1941).

Sassen area: Half a kilometre west of the outlet of the rivulet in Ledalen, west of Vindodden, 20 valves and umbonal fragments of *C. islandica* were collected from a cliff of silty material, 0—6 m a.s.l. It was also found in four terraces, up to 19 m, and from a solifluction slope, 29 m a.s.l., a fragment probably belonging to this species, was collected (FEYLING-HANSSEN and JØRSTAD 1950, pp. 64, 65, 73). DE GEER found it up to 20 m at Diabasodden (Hyperitudden) in Sassenfjorden (NATHORST 1882, p. 60, HÄGG 1950, 1951).

Elsewhere in the Isfjorden area: The Swedish expedition of 1868 found it at Saurieberget (Saurie Hook) close to Sauriedalen (Rendalen) on the Kapp Thordsen peninsula (HEER 1870, p. 24, JENSEN and HARDER 1910, HÄGG 1950). B. HÖGBOM found it 23 m a.s.l. at Kapp Thordsen, WIMAN found it NW of Kapp Wijk, and ÖBERG collected 50 valves at Dicksonfjorden (HÄGG 1951). It was further recorded from clayey deposits on both sides of Dicksonfjorden (NATHORST 1882, p. 64, KNIPOWITSCH 1903 IV, p. 138, HÄGG 1950), from Coraholmen in Ekmanfjorden (LAMPLUGH 1911, HÄGG 1951), Bohemanneset (HÄGG 1951), from the east side of Adventfjorden (HEER 1870, JENSEN and HARDER 1910), and from Longyeardalen (HÄGG 1951).

West coast region: Recorded from Richardlaguna on Prins Karls Forland (HOEL 1914, p. 35), and from the moraine of Eidembreen (GRIPP 1929).

North coast region: KULLING (KULLING and AHLMANN 1936, p. 4—5) found it 14—21 m a.s.l. at the southern end of Lomfjorden in Hinlopenstretet.

Adjacent arctic and subarctic regions: Kolguev Island, the Russian coast to the south of Kolguev, the Murman coast, „Ishavsfinland", Finnmarken (KNIPOWITSCH 1900b, 1904a, TANNER 1907b, 1930, ØYEN 1929), Iceland, 2—35 m a.s.l. (BÁRÐARSON 1921), West Greenland (South Stromfjord, JENSEN 1942, p. 24, LAURSEN 1950, p 120).

Recent distribution :

Cyprina islandica is a low-arctic—boreal—lusitanian species (JENSEN 1942, p. 27), being distributed from southwestern France to the White Sea, and from Cape Hatteras to the southern part of the Gulf of St. Lawrence and Newfoundland.

Remark :

C. islandica is an excellent guide fossil for deposits dating from the Post-Glacial Warm period in Svalbard.

Macoma calcarea (CHEMNITZ 1782).

Plate 23, figs. 8—13.

Tellina calcarea CHEMNITZ 1782 VI, p. 140, pl. 13, fig. 136.
Macoma calcarea, DAUTZENBERG and FISCHER 1912, p. 514 (with extensive synonymy).

Late-Pleistocene records :

Billefjorden: This species occurred in 38 samples, from present sea level up to 56 m above (Teltfjellbekken, p. 86). It was most common in Late-Pleistocene deposits older than the Post-Glacial Warm period, where it usually occurred together with *Saxicava arctica* and *Mya truncata.*

Swedish expeditions recorded it from Mimerbukta, 20 m a.s.l., W of Nordenskiöldbreen and from „Sfinxudden" (HÄGG 1951), a Russian expedition collected it from Brucebyen (KNIPOWITSCH 1902 III), and British expeditions from Brucebyen, 30—45 m (?), (ELTON and BADEN-POWELL 1931), and Petuniabukta, up to 27 m, (BADEN-POWELL 1939).

Sassen area: It occurred in most of the investigated deposits, up to 45 m, and was far more common in clayey and silty than in coarser sediments (FEYLING-HANSSEN and JØRSTAD 1950). It was previously found at Diabasodden, at Sassenelva and in the moraine at Von Postbreen (HÄGG 1950, 1951).

Elsewhere in the Isfjorden area: Kapp Thordsen, Dicksonfjorden, Coraholmen, Bohemanneset, Erdmannflya, Kapp Starostin, Grønfjorden, Colesbukta, Adventfjorden, Longyeardalen (HEER 1870, KNIPOWITSCH 1902 III and 1903 IV, NATHORST 1910, LAMPLUGH 1911, DAUTZENBERG and FISCHER 1912, NORDMANN 1912, HOLMSEN 1913, HOEL 1914, GRIPP 1927, FREBOLD 1935, HÄGG 1950 and 1951).

West coast region: Recherchefjorden and Kapp Lyell (HÄGG 1950), Blomstrandhamna and Lilliehöökfjorden (HOEL 1914).

North coast region: North side of Liefdefjorden, up to 12 m a.s.l., Wijdefjorden, and Sorgfjorden, up to 21 m a.s.l. (ELTON and BADEN-POWELL 1931, BADEN-POWELL 1939), Murchisonfjorden, 14.5 m and 16—19 m, Lomfjorden, 14—21 m a.s.l. (KULLING in KULLING and AHLMANN 1936), and Wahlenbergfjorden, 14—16 m (SANDFORD 1929).

East coast region: Diabastangen in Ginevrabotnen, and Edgeøya, up to 53 m a.s.l. (KNIPOWITSCH 1902 III, BADEN-POWELL 1939).

Adjacent arctic and subarctic regions: Only a few of the numerous occurrences are mentioned below: Novaya Zemlya, up to 115 m (KNIPOWITSCH 1900b, GRØNLIE 1924), Kolguev Island, the northern coasts of the European part of Russia, Finnmarken (KNIPOWITSCH 1900b, 1904a and b, TANNER 1907b and 1930, LINDHOLM 1921, ØYEN 1929), Iceland, up to 40 m (BÁRÐARSON 1921), East Greenland, up to 48 m (JENSEN 1905, NOE-NYGAARD 1932, FLINT 1948), North Greenland (JENSEN 1917) and West Greenland, up to 70 m (LAURSEN 1944, 1950).

Recent distribution :

Circumarctic—midboreal, in the Atlantic south to Denmark and Long Island Sound, in the Pacific south to Oregon and North Japan (SOOT-RYEN 1932). In deeper water it extends southwards to the Bay of Biscay (JENSEN and SPÄRCK 1934, LAURSEN 1944, p. 58).

It is one of the dominant species in Isfjorden, occurring there at depths between 0 and 100 m on mud bottom (ODHNER 1915).

Liocyma fluctuosa (GOULD 1841).

Plate 24, figs. 8—11.

Venus fluctuosa GOULD 1841, p. 87, fig. 50.
Tapes fluctuosa, SOWERBY 1851 II, p. 786, pl. 168, fig. 167.
Chione astartoides, DESHAYES 1853, p. 147.
Liocyma fluctuosa, DALL 1870, p. 256. — SOOT-RYEN 1939, p. 16, pl. 1, fig. 8.

Late-Pleistocene records :

Billefjorden: This species was found in the Recent shore of Skansbukta, where living specimens were also observed. It is not recorded from the Pleistocene of Billefjorden.

Sassen area: 47 valves were found in a silty deposit 4 m a.s.l. west of the river outlet in Ledalen, and one valve in the moraine of Von Postbreen, 30 m a.s.l. (FEYLING-HANSSEN and JØRSTAD 1950, p. 73); there, too, it was quite common in the littoral of the Recent shore.

Elsewhere in the Isfjorden area: On the west side of Colesbukta, and from the moraine of Grønfjordbreen (GRIPP 1927).

West coast region: Blomstrandhamna in Kongsfjorden, 19 m a.s.l., in moraine (HOEL 1914).

East coast region: Diabastangen in Ginevrabotnen, 4 m a.s.l., and Kvalpynten on Edgeøya (KNIPOWITSCH 1900a and 1902 III, p. 436).

Recent distribution :

Circumarctic (though only dead specimens in the East Siberian Sea), occurring south to the Barents Sea, Massachusetts and Japan (SOOT-RYEN 1932, p. 20).

It is quite common in Isfjorden on mud bottoms, generally at depths between 0 and 20 m, and is recorded from the west, north and east coasts of Vestspitsbergen (FRIELE and GRIEG 1901, HÄGG 1904, ODHNER 1915).

Saxicava arctica (LINNÉ 1767).

Plate 23, figs. 4—7; plate 24, figs. 1—5.

Mya arctica LINNÉ 1767, p. 1113.
Mytilus pholadis LINNÉ 1771, p. 548.
Hiatella biaperta BOSC 1802, p. 120, pl. 21, fig. 2.
Mytilus rugosus DILLWYN 1817 I, p. 304.
Saxicava pholadis, LAMARCK 1818 V, p. 502.
Hiatella arctica, LAMARCK 1819 VI, p. 30.

Saxicava arctica, DAUTZENBERG and FISCHER 1912, p. 504.
Saxicava pholadis, DAUTZENBERG and FISCHER 1912, p. 510, pl. 11, figs. 34—40.
Hiatella arctica, WINCKWORTH 1932, p. 247. — SOOT-RYEN 1939, p. 17.

Late-Pleistocene records :

Billefjorden: This species is second only to *Mya truncata* in its abundance in the Pleistocene of Vestspitsbergen, and the two usually occur together. *Saxicava arctica* was found in 62 samples from Billefjorden, from modern sea level up to 84,5 m a.s.l. (north of Ekholmvika, p. 80), and was especially frequent at heights of about 40—50 m, and also at about 2 m.

This species was previously recorded from Billefjorden by KNIPOWITSCH (1902 III), ELTON and BADEN-POWELL (1931), BADEN-POWELL (1939), BALCHIN (1941) and HÄGG (1951), up to 30—45 m (Brucebyen, cf. p. 135).

Sassen area: It was very common in the terraces up to 60 m a.s.l. (FEYLING-HANSSEN and JØRSTAD 1950). Other expeditions found it in many places within the area (cf. i.a. HÄGG 1950, 1951), the highest record being from Diabasodden, 65 m a.s.l. (HÄGG 1951).

Elsewhere in the Isfjorden area: It was recorded from many localities (HEER 1870, KNIPOWITSCH 1902 III, NATHORST 1910, LAMPLUGH 1911, DAUTZENBERG and FISCHER 1912, NORDMANN 1912, HOLMSEN 1913, HOEL 1914, ODHNER 1915, PEACH 1916, GRIPP 1927, FREBOLD 1935, FEYLING-HANSSEN and JØRSTAD 1950, p. 48, HÄGG 1950, 1951). KNIPOWITSCH (1903 IV, p. 139) recorded it from approx. 50 m above the sea in Trygghamna. (Cf. HÄGG 1950, p. 340).

West coast region: Hornsund (HEINTZ 1953), Bellsund (CÖSTER 1925, HÄGG 1950, 1951), Prins Karls Forland and Forlandsundet (PEACH 1916), Eidembreen (GRIPP 1929), St. Jonsfjorden and Müllerneset, 30—36 m a.s.l. (DINELEY 1954) and the Kongsfjorden region (HOEL 1914, BADEN-POWELL 1939).

North coast region: Liefdefjorden, north side, up to 12 m (BADEN-POWELL 1939), Woodfjorden (HOEL 1914), Wijdefjorden (ELTON and BADEN-POWELL 1931), Sorgfjorden (BADEN-POWELL 1939), Hinlopen area (SANDFORD 1929, ELTON and BADEN-POWELL 1931, KULLING in KULLING and AHLMANN 1936, BADEN-POWELL 1939, HÄGG 1950). The highest record of *Saxicava arctica* from the north coast region is from Murchisonfjorden, 65 m a.s.l. (KULLING in KULLING and AHLMANN 1936). The Oxford University Arctic Expedition to North East Land 1935—36 found it at the eastern end of Nordaustlandet, up to 100 m above the sea in „morainic beach deposits south of South Land" (BADEN-POWELL 1939, p. 342).

East coast region: Edgeøya, up to 53 m a.s.l. (KNIPOWITSCH 1900a, 1902 III and 1903 IV, BADEN-POWELL 1939). KNIPOWITSCH (l.c.) recorded it also from many other localities in the Storfjorden area, and NATHORST (1901, p. 375) recorded it from Kong Karls Land, 10 m a.s.l.

Adjacent arctic and subarctic regions: *Saxicava arctica* being one of the most common species among Late-Pleistocene fossils in northern regions, has been recorded from numerous localities, only a few of which are mentioned below: Cape Chelyuskin, 40—50 m a.s.l. (GRØNLIE 1928), Franz Josef Land, 20—25 m a.s.l. (NEWTON 1899, p. 529, SOOT-RYEN 1939, p. 18), Novaya Zemlya, up to 200 m a.s.l. (KNIPOWITSCH 1900b, GRØNLIE 1924), Kolguev Island, Northern coasts of Russia, Finnland, Finnmarken (KNIPOWITSCH 1900b, 1904a and b, LINDHOLM 1921, TANNER 1930, 1907b, ØYEN 1929, ROSENDAHL 1931), Iceland, up to 55 m (THORODDSEN 1892, BÁRÐARSON 1921), East Greenland, up to 67 m (JENSEN 1905, NOE-NYGAARD 1932, FLINT 1948), North Greenland (JENSEN 1917, LAURSEN 1954), West Greenland, up to 70 m, and even up to 475 m (LAURSEN 1944, 1950), the find at 475 m being ascribed to transportation by bird.

Recent distribution :

Nearly cosmopolitan, mainly in shallow water, but also found at greater depths down to 1400 m (JENSEN and SPÄRCK 1934). It is one of the dominant species in Isfjorden, accounting for a maximum of 26.6 per cent of the local faunas, usually at depths of 0—75 m (ODHNER 1915).

Remarks :

The valves of *S. arctica* varied in shape from small, high and irregular forms to large, elongate valves of *pholadis* form (cf. measurements, figs. 29, 46). Shells with rows of spines on the posterior part of the exterior were found only among juveniles. The *pholadis* form was more frequent in Pleistocene deposits older than the Post-Glacial Warm period than in younger sediments; it occurred, for the most part, in finer sediments (silt—clay), whereas the small, irregular form was found in coarser deposits (gravel—sand). Small, irregular *S. arctica* usually occurred together with *Lithothamnion.* (Cf. KNIPOWITSCH 1902 III, p. 438; HOEL 1914, p. 33; FEYLING-HANSSEN and JØRSTAD 1950, p. 19).

Mya truncata LINNÉ 1758.

Plate 25.

LINNÉ 1758, p. 670.
JENSEN 1900, p. 137, text.-figs. 2 and 8.

Late-Pleistocene records :

Billefjorden: This is the most common species in the Pleistocene deposits of Vestspitsbergen, and predominates in Late-Pleistocene faunas of Inner Isfjorden older than the Post-Glacial Warm period.

It occurred in 79 samples from Billefjorden, from present sea level up to 84.5 m above (North of Ekholmvika, p. 80). At Teltfjellet, Brucebyen area, it was observed at 70 and 76 m a.s.l., at Gerritelva it occurred 77.8 m a.s.l., and at Skansbukta 70 m a.s.l. (p. 118).

It was previously recorded by KNIPOWITSCH (1902 III), ELTON and BADEN-POWELL (1931), BADEN-POWELL (1939), BALCHIN (1941), and HÄGG (1951).

Sassen area: Very common in terraces and clayey silt deposits up to 60 m a.s.l. (FEYLING-HANSSEN and JØRSTAD 1950). Previously found at many localities within the area (HÄGG 1950 and 1951).

Elsewhere in the Isfjorden area: Many expeditions found it in numerous localities (HEER 1870, KNIPOWITSCH 1902 III, NATHORST 1910, LAMPLUGH 1911, NORDMANN 1912, DAUTZENBERG and FISCHER 1912, HOLMSEN 1913, HOEL 1914, ODHNER 1915, PEACH 1916, GRIPP 1927, FREBOLD 1935, FEYLING-HANSSEN and JØRSTAD 1950, p. 48, HÄGG 1950, 1951). KNIPOWITSCH (1903 IV, p. 139) recorded it from approx. 50 m a.s.l. at Trygghamna (Safe Haven, collected by NATHORST). HÄGG (1950, p. 340) recorded another find from the same locality and at the same height, and HÖGBOM (1911, p. 45) found fragments of the species 65 m a.s.l. at Diabasodden (cf. HÄGG 1951, p. 232).

West coast region: Hornsund (HEINTZ 1953), at Torellbreen (HÄGG 1950), Bellsund (CÖSTER 1925, HÄGG 1950, 1951), Prins Karls Forland and Forlandsundet (PEACH 1916, ELTON and BADEN-POWELL 1931), St. Jonsfjorden and Müllerneset (DINELEY 1954), and the Kongsfjorden region (HOEL 1914, BADEN-POWELL 1939).

North coast region: Liefdefjorden, north side (KULLING in KULLING and AHLMANN 1936, BADEN-POWELL 1939), Wijdefjorden (ELTON and BADEN-POWELL 1931), Sorgfjorden (CHYDENIUS 1865, pp. 141—142), the Hinlopen area (SANDFORD 1929, ELTON and BADEN-POWELL 1931, KULLING in KULLING and AHLMANN 1936, BADEN-POWELL 1939, HÄGG 1950). The highest record of *Mya truncata* in situ from the north coast region is from Murchisonfjorden, 65 m a.s.l. (KULLING l.c.). The Oxford University expedition to North East Land, 1935—36, found it at Isispynten up to 80 m in moraine material (BADEN-POWELL 1939).

East coast region: Edgeoya (WOODWARD 1860, p. 438, KNIPOWITSCH 1900a, 1902 III, 1903 IV, BADEN-POWELL 1939, 53 m above the sea). KNIPOWITSCH (l.c.) recorded it from many other places in the Storfjorden area, and it was also found at Kong Karls Land, 10 m a.s.l. (NATHORST 1901a, p. 375).

Adjacent arctic and subarctic regions: This species, being the most common among Late-Pleistocene fossils in northern regions, has been recorded from numerous localities, a few of which are mentioned below: Franz Josef Land (recorded as *Mya arenaria* by NEWTON 1899, p. 529) 20—25 m a.s.l. (SOOT-RYEN 1939), Cape Chelyuskin, 40—50 m a.s.l. (GRONLIE 1928), Novaya Zemlya (KNIPOWITSCH 1900b) up to 200 m (?) (GRONLIE 1924), Kolguev Island and the northern coasts of Russia and Finnmarken (KNIPOWITSCH 1900b, 1904 a, b, LINDHOLM 1921, HOLMBOE 1904, TANNER 1907b, 1930, ØYEN 1929, ROSENDAHL 1931), Iceland (THORODDSEN 1892) 2—55 m a.s.l. (BÁRÐARSON 1921) East Greenland (JENSEN 1905, with older records) up to 130 m (NOE-NYGAARD 1932), North Greenland (JENSEN 1917, LAURSEN 1954) and West Greenland, up to 200 m (LAURSEN 1944, 1950).

Recent distribution :

As demonstrated by its fossil occurrence *Mya truncata* is a eurytherm species with a very wide Recent distribution. Its main distribution is arctic—boreal, occurring southwards to the Bay of Biscay, Massachusetts, Vancouver and Japan (DAUTZENBERG and FISCHER 1912, SOOT-RYEN 1932, JENSEN and SPÄRCK 1934, LAURSEN 1944). It is one of the dominant species in Isfjorden to-day, thriving at depths from 0 to 100 m there. Its maximum frequency was 5.1—13.8 per cent, being greatest towards the mouth of the fjord (ODHNER 1915, p. 122).

Remarks :

Some of the numerous valves of *Mya truncata* from the Late-Pleistocene of Billefjorden were of forma *ovata* JENSEN, and some of forma *uddevallensis* HANCOCK, though transitions occurred between the typical and the extreme forms (cf. shell measurements of *M. truncata,* figs. 28, 54, 57). Thick-shelled specimens were common in deposits older than the Post-Glacial Warm period, whereas thin-shelled specimens were most frequent in younger and coarser deposits. The *uddevallensis* form was usually associated with thick-shelled specimens, whereas the *ovata* form was found among thin-shelled ones[1].

Zirfaea crispata (LINNÉ 1758).

Plate 24, figs. 6, 7.

Pholas crispata LINNÉ 1758, p. 1111.

Late-Pleistocene records :

Billefjorden: This species was rare, but broken valves and umbonal fragments occurred in 7 samples from Billefjorden, from 2 to 34.5 m a.s.l. (Petuniabukta, p. 99). In all, fragments representing 16 valves were found in the Pleistocene of Billefjorden, from which it had not previously been recorded.

Sassen area: One umbonal fragment was found at Kapp Belvedere, 21 m a.s.l. (FEYLING-HANSSEN and JØRSTAD 1950, p. 75).

Elsewhere in the Isfjorden area: One shell fragment 23 m a.s.l. at Kapp Thordsen, and one from moraine material northwest of Bohemanneset (HÄGG 1951, pp. 233, 241).

Adjacent arctic and subarctic regions: Petchora region, White Sea, and the Murman coast (KNIPOWITSCH 1900b), „Ishavsfinland", up to 14.5 m (TANNER 1930), Finnmarken (HOLMBOE 1904, TANNER 1907b), Iceland, 3—35 m a.s.l. (BÁRÐARSON 1921, also THORODDSEN 1892), West Greenland, *Zirphaea*-layers (JENSEN 1905, ENGELL 1905, JENSEN and HARDER 1910, JENSEN 1942, HARDER, JENSEN, and LAURSEN 1949, up to 40 m a.s.l., LAURSEN 1944, 1950).

---

[1] SCHLESCH (1931, p. 136) raised *Mya truncata ovata* JENSEN to specific rank under the new name *Mya pseudoarenaria.* Cf. also SOOT-RYEN 1951, p. 3.

Recent distribution :

Its distribution is low-arctic—boreal—lusitanian, occurring from Jarfjord, Sør-Varanger in Finnmarken (SOOT-RYEN 1951) along the European west coast to western France, at the North American east coast and in the northern Pacific (JENSEN and SPÄRCK 1934).

Remarks :

Zirfaea crispata is an excellent index fossil for Svalbard deposits from the Post-Glacial Warm period. Its discontinuous boreal distribution, viz. its occurrence in the northern Atlantic and the northern Pacific, and its absence along the Siberian and the North American arctic coasts, is explained by the appearance of a less favourable climate at the decline of the Post-Glacial Warm period.

Pandora glacialis LEACH 1819.

Plate 19, figs. 8, 9.

Pandora glacialis LEACH 1819, p. 174.
LECHE 1878, p. 11, pl. 1, figs. 1a—b.
Pandora (Kennerlia) glacialis, SOOT-RYEN 1932, p. 11.
Calopodium (Kennerlia) glacialis, SOOT-RYEN 1939, p. 18.

Late-Pleistocene records :

Billefjorden: One specimen with united valves was found at the lowest plain on the south side of Skansbukta, 2.0 m a.s.l., but may well have been washed ashore in Recent times. (Cf. p. 119). Recorded from the Recent shore of Anservika (FEYLING-HANSSEN and JØRSTAD 1950, p. 37).

Sassen area: Found on the present beach at Vindodden (FEYLING-HANSSEN and JØRSTAD 1950, p. 35).

Elsewhere in the Isfjorden area: Recorded from the moraine of Grønfjordbreen (GRIPP 1927).

West coast region: One valve from the moraine of the Lilliehöökbreen, 8—10 m above the sea (HOEL 1914); as pointed out by HÄGG (1950, p. 344) this is the first record of *Pandora glacialis* as a Pleistocene fossil from Svalbard.

Adjacent arctic and subarctic regions: At the river Dwina, White Sea (KNIPOWITSCH 1900b).

Recent distribution :

High-arctic—mid-arctic, in the Atlantic occurring south to the Murman coast, in the Pacific south to Fuca Straits. Not recorded from the western part of the North American arctic seas (SOOT-RYEN 1932, p. 11).

In Isfjorden it was usually found in the littoral and in shallow water down to 30 m. At one locality only within Isfjorden it was taken at the depth of 80—90 m (ODHNER 1915, p. 130). It is recorded from the west, north and east coast of Spitsbergen (KNIPOWITSCH 1902 II).

Remark :

The two finds of *P. glacialis* in the moraines of Lilliehöökbreen and Grønfjordbreen do not prove its occurrence in the Pleistocene of Svalbard; the shells may have been incorporated in the moraines and pushed up from the sea bottom during a Recent advance of the two glaciers.

Gastropoda.

Emarginula fissura (LINNÉ 1766).

Plate 24, fig. 12.

Patella fissura LINNÉ 1766.
Emarginula reticulata SOWERBY 1812 I, p. 74, pl. 33.
Emarginula fissura, S. V. WOOD 1842, p. 528.
JEFFREYS 1865 III, p. 259; 1869 V, p. 200, pl. 59, fig. 2.
HARMER 1920—25 II, p. 776, pl. 62, fig. 7.
ODHNER 1912, pp. 14, 40, pl. 2, figs. 42—45.

Late-Pleistocene records :

Billefjorden: Two specimens of this species were found in a sample of *Lithothamnion*-silt from Sentabukta, Brucebyen, 2 m a.s.l. (p. 91). Both of them belong to the variety *incurva* JEFFREYS 1865, being small, with the beak almost overhanging the posterior margin.

Emarginula fissura has not previously been recorded from the Pleistocene of Svalbard.

Adjacent arctic and subarctic regions: LAURSEN (1950, pp. 73, 120) found one specimen, which also belonged to the variety *incurva,* in a section, 24—26 m a.s.l., in Muslingdalen, Giesecke Sø, West Greenland.

Recent distribution :

E. fissura is a boreal—lusitanian species, occurring along the East Atlantic coast from Hammerfest (Norway) to the Mediterranean (G. O. SARS 1878, ODHNER 1912, ANTEVS 1928, LAURSEN 1950). ODHNER (1912, p. 41) included Bellsund, Spitsbergen (35—40 fms) in his list of records of this species, but added, however: „Locality probably mistaken."

Remark :

E. fissura is an excellent index fossil for deposits from the Post-Glacial Warm period in Svalbard.

Puncturella noachina (LINNÉ 1771).

Patella noachina LINNÉ 1771, p. 551.
Patella fissurella MÜLLER 1776, p. 237.
Fissurella noachina, SCHUMACHER 1817, p. 181.
Puncturella noachina, LOWE 1827, p. 77.
ODHNER 1912, p. 13, pl. 2, figs. 28—41.

Late-Pleistocene records :

Billefjorden: One specimen was found in *Lithothamnion*-silt at Sentabukta, Brucebyen, 2 m a.s.l. (p. 91).

It was previously recorded from Brucebyen, 10—12 m a.s.l., by ELTON and BADEN-POWELL (1931, p. 402).

Sassen area: It was found there in terraces up to 7 m a.s.l. (FEYLING-HANSSEN and JØRSTAD 1950, p. 75).

Elsewhere in the Isfjorden area: Recorded from Coraholmen (LAMPLUGH 1911, NORDMANN 1912, HÄGG 1951) and from Erdmannflya, 1—2 m a.s.l. (HÄGG 1951).

West coast region: Recorded from a moraine at Braganzavågen, Van Mijenfjorden (HÄGG 1951).

East coast region: Found at two places at Edgeøya, 1—2 m a.s.l. (KNIPOWITSCH 1902 III).

Adjacent arctic and subarctic regions: The Murman coast and Finnmarken (KNIPOWITSCH 1900b, LINDHOLM 1921, TANNER 1907b, 1930), Iceland, 2—3 m a.s.l. (BÁRÐARSON 1921), West Greenland, up to 35 m, and even 70 m at Holsteinsborg (LAURSEN 1944, 1950).

Recent distribution:

Arctic-boreal, bipolar (GAEVSKOIJ 1948, p. 368).

It was quite rare in Isfjorden (ODHNER 1915, p. 142).

Acmaea rubella (FABRICIUS 1780).

Plate 24, fig. 14.

Patella rubella FABRICIUS 1780, p. 386.
Tectura rubella, G. O. SARS 1878, p. 121, pl. 8, figs. 5a—b.
Acmaea rubella, ODHNER 1912, p. 26, pl. 1, figs. 16—23.

Late-Pleistocene records:

Billefjorden: Five specimens, in all, were found in three samples, at 2, 7, and 31 m a.s.l. (Petuniabukta highest record, p. 99), the maximum number of specimens in any one sample being 3 (Sørdammen, Brucebyen). Not previously recorded from the Pleistocene of Billefjorden.

Elsewhere in the Isfjorden area: Recorded from the morainic deposits of Coraholmen in Ekmanfjorden (LAMPLUGH 1911, NORDMANN 1912, HÄGG 1951) and from Erdmannflya, 1—2 m a.s.l. (HÄGG 1951).

East coast region: Diabastangen in Ginevrabotnen, 4 and 5—7 m a.s.l., and on Kvalpynten, Edgeoya (KNIPOWITSCH 1900a and 1902 III).

Adjacent arctic and subarctic regions: Novaya Zemlya, 130—142 m a.s.l. (GRØNLIE 1924), the Murman coast (KNIPOWITSCH 1900b, LINDHOLM 1921), „Ishavsfinland“ (TANNER 1930), Finnmarken (TANNER 1907b), West Greenland (LAURSEN 1944, 1950).

Recent distribution:

Arctic—high-boreal, south to Tromsø, Iceland, and Newfoundland. Not in the Pacific. Vertical range: 4—565 m (THORSON 1944).

In Isfjorden it was found living only in the northern bays, where it was restricted to shallow water, down to 28 m (ODHNER 1915).

Lepeta coeca (MÜLLER 1776).
Plate 24, fig. 13.

Patella coeca O. F. MÜLLER 1776, p. 237.
Lepeta caeca, GRAY 1847, p. 168.
Lepeta coeca, ODHNER 1912, p. 32, pl. 2, figs. 2- -17.

Late-Pleistocene records:

Billefjorden: This species was found in 4 of the samples, from 13,7 up to 42 m a.s.l. (Myadalen, p. 121), one specimen in each sample. Previously recorded from Mimerbukta at a height of 20 m (HÄGG 1951).

Sassen area: Rather common, found up to 45 m a.s.l. at Gipsvika (FEYLING-HANSSEN and JØRSTAD 1950, p. 76). HÄGG (1951) recorded it from Von Postbreen and at Sassenelva.

Elsewhere in the Isfjorden area: Coraholmen (LAMPLUGH 1911, NORDMANN 1912, HÄGG 1951), Erdmannflya, Adventfjorden (HÄGG 1950, 1951), and Colesbukta (GRIPP 1927).

West coast region: Damesmorena, Kapp Amsterdam, and Braganzavågen in the Bellsund area (CÖSTER 1925, HÄGG 1950, 1951).

North coast region: Dirksodden in Wijdefjorden (ELTON and BADEN-POWELL 1931).

East coast region: Kvalpynten, Edgeøya (KNIPOWITSCH 1902 III).

Adjacent arctic and subarctic regions: Tscheschskaya Guba, White Sea (KNIPOWITSCH 1900b), Murman coast (LINDHOLM 1921), Petsamo Valley (TANNER 1930, p. 186), Iceland, up to 17 m (BÁRÐARSON 1921), East Greenland, 3 and 11 m a.s.l. (NOE-NYGAARD 1932), West Greenland, 2—34 m a.s.l. (LAURSEN 1950).

Recent distribution:

Arctic-boreal, on the east side of the Atlantic distributed southwards to the Shetlands, also recorded from the Azores. In East Greenland living specimens have never been taken at depths less than 20 m, and the species is found attached to the red algae epifauna at depths from 20 to 80—85 m (THORSON 1944, p. 14).

It is quite common in Isfjorden, usually in depths between 100 and 400 m (ODHNER 1915, p. 141).

Margarites groenlandicus (CHEMNITZ 1781).
Plate 24, fig. 15.

Trochus groenlandicus — — CHEMNITZ 1781 V, p. 108, pl. 171, fig. 1671.
Margarita groenlandica, ODHNER 1912, p. 56, pl. 4, figs. 4—27; pl. 6, figs. 14—20.
Margarites groenlandicus, FILATOVA and SAZEPIN in GAEVSKOIJ 1948, p. 369, pl. 96, figs. 1, 1a.

Late-Pleistocene records:

Billefjorden: This species was found in 4 samples, from 2 to 17.5 m a.s.l. (Skansbukta, p. 115), the maximum number of specimens in one sample being 5.

It was previously recorded from the „Valley at Sfinxudden" (HÄGG 1951), where one specimen of the var. *umbilicalis* BRODERIP and SOWERBY was found, and from Brucebyen, 10—12 m a.s.l. (ELTON and BADEN-POWELL 1931).

Sassen area: Found at four places, up to 4.1 m a.s.l. (FEYLING-HANSSEN and JØRSTAD 1950, p. 76).

Elsewhere in the Isfjorden area: Coraholmen in Ekmanfjorden (LAMPLUGH 1911, NORDMANN 1912, HÄGG 1951), Erdmannflya, 1—2 m a.s.l. (HÄGG 1951), Grønfjorden, moraine (GRIPP 1927).

North coast region: Dirksodden in Wijdefjorden (ELTON and BADEN-POWELL 1931).

East coast region: Ginevrabotnen and Edgeøya (KNIPOWITSCH 1900a and 1902 III).

Adjacent arctic and subarctic regions: Cape Chelyuskin, 20 m a.s.l. (GRØNLIE 1928), the north coast of the White Sea and the Murman coast (KNIPOWITSCH 1900b), the area to the south of Varangerfjorden, up to 18 m (TANNER 1930), Finnmarken (HOLMBOE 1904, TANNER 1907b, ØYEN 1929, ROSENDAHL 1931), Iceland, 5—6 m a.s.l. (BÁRÐARSON 1921), West Greenland (LAURSEN 1944, 1950, HARDER, JENSEN, and LAURSEN 1949).

Recent distribution :

Artic—boreal, extending southwards to Shetland and the North Channel on the East Atlantic coasts. Vertical range: 0 to 300 m (THORSON 1944, p. 19).

It is quite common in Isfjorden at depths less than 30 m (ODHNER 1915).

Margarites helicinus (PHIPPS 1774).

Turbo helicina PHIPPS 1774, p. 198.
Eumargarita helicina, DAUTZENBERG and FISCHER 1912, p. 270.
Margarita helicina, ODHNER 1912, p. 50, pl. 3, figs. 26—34; pl. 6, figs. 3—5.
Margarites helicinus, FILATOVA and SAZEPIN in GAEVSKOIJ 1948, p. 369, pl. 95, fig. 8.

Late-Pleistocene records :

Billefjorden: One specimen of this species occurred in a sample of *Lithothamnion*-silt, 2 m a.s.l., from Sentabukta in the Brucebyen area (p. 91).

It was previously recorded from the east side of Billefjorden (BALCHIN 1941).

Sassen area: 16 specimens was found, 2 m a.s.l., in the cliff of a 7 m terrace at Gåsøyane, and 3 specimens, 4.6 m a.s.l., in a solifluction slope at the Sassen Hut (FEYLING-HANSSEN and JØRSTAD 1950, p. 76).

Elsewhere in the Isfjorden area: Coraholmen in Ekmanfjorden (LAMPLUGH 1911, NORDMANN 1912).

East coast region: Kvalpynten, 2—3 m a.s.l. (KNIPOWITSCH 1900a and 1902 III).

Adjacent arctic and subarctic regions: The Murman coast (KNIPOWITSCH 1900b), Finnmarken (TANNER 1907b), West Greenland (LAURSEN 1944, 1950), up to 39.1 m at Disco Bugt (HARDER, JENSEN, and LAURSEN 1949).

Recent distribution :

Arctic—boreal, extending southwards to South Norway, the British Isles, the Faroes, and Iceland. Vertical range: 0 to 407 m (THORSON 1944, pp. 20—23.)

It is quite common in Isfjorden at depths between 0 and 10 m, but is rare at greater depths, down to 130 m (ODHNER 1915, pp. 143—145). It has been taken at many localities in the Svalbard archipelago (ODHNER 1912, p. 52).

Margarites cinereus (COUTHOUY 1838).

Turbo cinereus COUTHOUY 1838, p. 99, pl. 3, fig. 9.
Eumargarita cinerea, DAUTZENBERG and FISCHER 1912, p. 273.
Margarita cinerea, ODHNER 1912, p. 62, pl. 4, figs. 28—37; pl. 5, figs. 1—5; pl. 7, figs. 1-4.
Margarites (Pupillaria) cinereus, FILATOVA and SAZEPIN in GAEVSKOIJ 1948, p. 369, pl. 96, figs. 2, 2a.

Late-Pleistocene records :

Billefjorden: One specimen was found in *Lithothamnion* silt at Sentabukta in the Brucebyen area (p. 91). The species was not previously recorded from the Pleistocene of Billefjorden.

Elsewhere in the Isfjorden area: HÄGG (1950, p. 334) recorded one specimen from the east side of Dicksonfjorden.

East coast region: KNIPOWITSCH (1900a and 1902 III) recorded it from Ginevrabotnen and Edgeøya, up to 4 m a.s.l.

Adjacent arctic and subarctic regions: Cape Chelyuskin, probably washed ashore in Recent times (GRØNLIE 1928), Murman coast (KNIPOWITSCH 1900b), „Ishavsfinland", 15 m a.s.l. (TANNER 1930), Finnmarken (TANNER 1907b), East Greenland (NOE-NYGAARD 1932), and West Greenland (LAURSEN 1950).

Recent distribution :

Arctic—mid-boreal, southwards to Bergen on the Norwegian west coast. Vertical range: 8 to 660 m (THORSEN 1944, p. 25).

It occurs in Isfjorden at depths between 10 and 150 m (ODHNER 1915, p. 150).

Moelleria costulata (MÖLLER 1842).

Plate 24, figs. 16, 17.

Margarita? costulata MÖLLER 1842, p. 8.
Mölleria costulata, JEFFREYS 1867, p. 255.
Moelleria costulata, ODHNER 1912, p. 75, pl. 5, figs. 43—47.

Late-Pleistocene records :

Billefjorden: One specimen in sample V of the section at Teltfjellbekken in the Brucebyen area, 5.8 m a.s.l. (p. 84), and 7 specimens in a sample of *Lithothamnion* silt, 2 m a.s.l., at Sentabukta in the same area (p. 91). It was not previously recorded from the Pleistocene of Billefjorden.

Sassen area: Two specimens were found 2 m a.s.l. in the cliff of a 7 m terrace at Gåsøyane (FEYLING-HANSSEN and JØRSTAD 1950, p. 75).

Elsewhere in the Isfjorden area: Found in the morainic deposits of Coraholmen (LAMPLUGH 1911, NORDMANN 1912, HÄGG 1951).

East coast region: Diabastangen in Ginevrabotnen, 0.5—1.0 m above the sea, and Kvalpynten on Edgeøya, 1—2 m a.s.l. (KNIPOWITSCH 1900a, 1902 III).

Adjacent arctic and subarctic regions: The Murman coast (KNIPOWITSCH 1900b, 1904b, LINDHOLM 1921), Saarikoski (Holmfossen) to the south of Varangerfjorden (LINDBERG 1911, p. 175, cf. TANNER 1930, p. 192), Finnmarken (TANNER 1907b), West Greenland, up to 29 m a.s.l. (LAURSEN 1944, 1950, HARDER, JENSEN, and LAURSEN 1949).

Recent distribution :

Arctic—boreal—lusitanian, throughout the North Atlantic, especially associated with great depths (THORSON 1944, pp. 29—30), from Franz Josef Land to east of Morocco.

It is very rare in Isfjorden where ODHNER (1915, p. 152) found one empty shell at the entrance to Dicksonfjorden, depth between 14 and 44 m. It is recorded from the west and north coasts of Spitsbergen (ODHNER 1912, p. 75).

Cyclostrema species.

One broken specimen was found in the section at Teltfjellbekken, 5.5 m a.s.l.

Lacuna vincta (MONTAGU 1803).

Plate 26, figs. 1—3.

Turbo vinctus MONTAGU 1803, p. 307, pl. 20, fig. 3.
Lacuna vincta, TURTON 1828, p. 192.
Lacuna divaricata, G. O. SARS 1878, p. 169, pl. 21, fig. 22.
Lacuna (Epheria) vincta, DAUTZENBERG and FISCHER 1912, p. 201.

Late-Pleistocene records :

Billefjorden: This species occurred in 6 of the samples, from 13.7 to 31.0 m a.s.l. (Petuniabukta, p. 99), the maximum number of specimens in one sample being 5 (Gerritelva, p. 96).

It was previously found by a Swedish expedition, 1896, at Phantomodden (Sfinxudden, HÄGG 1951).

Sassen area: Gipsvika, 45 m a.s.l., Sassen Hut, 4.1 m, and Ledalen (FEYLING-HANSSEN and JØRSTAD 1950, p. 76).

Elsewhere in the Isfjorden area: Coraholmen, Erdmannflya, 1—2 m a.s.l., and Bohemanneset, moraine (HÄGG 1951).

North coast region: Breiddholmen (Eiderholmen) at the head of Woodfjorden, 2—3 m a.s.l. (HOEL 1914).

Adjacent arctic and subarctic regions: The Murman coast, up to 75 m a.s.l. (KNIPOWITSCH 1900 b,p. 43), „Ishavsfinland", up to 15 m (TANNER 1930), Finnmarken (HOLMBOE 1904, TANNER 1907b), Iceland, 5—17 m a.s.l. (BÁRDARSON 1921), West Greenland (LAURSEN 1944, HARDER, JENSEN, and LAURSEN 1949).

Recent distribution :

Mid-arctic—boreal—lusitanian, occurring from Novaya Zemlya (GAEVSKOIJ 1948, p. 373) to the Bay of Biscay. Elsewhere it is recorded i.a. from Iceland and West Greenland as far north as Jakobshavn, approx. 69°10' N.lat. (LAURSEN 1944). Its depth range is 0—100 m (ANTEVS 1928), usually living in the littoral or sublittoral, and often associated with *Laminaria* (GAEVSKOIJ 1948, p. 373).

Remarks :

KNIPOWITSCH (1900a) recorded *Lacuna divaricata* (=*L. vincta*) from Pleistocene deposits at Ginevrabotnen (p. 379) and Kvalpynten (Whales point, p. 383), but later (1902 III, pp. 428, 446) referred these specimens to *L. glacialis* MÖLLER (=*L. pallida* (DONOVAN)). FRIELE (1879) listed *L. divaricata* in his catalogue on Spitsbergen mollusks, but KNIPOWITSCH (1901 I, p. 453) found the record to be incorrect as FRIELE's find was made in the Bjørnøya (Bear Island) region rather than at Spitsbergen (cf. also HOEL 1914, p. 34). KNIPOWITSCH (1901 I, p. 451) recorded *L. glacialis* from five Spitsbergen stations, the specimens from the fifth station, Storfjorden, however, not being typical but forming a transition to *L. divaricata* (l.c.). FEYLING-HANSSEN and JØRSTAD (1950, p. 36) found shells of *L. vincta* in the modern beach of three localities within the Sassen area (at Tempelfjorden and at Gipsvika). These may have been washed out of deposits from the Post-Glacial Warm period; this applies especially to the sample from the inner part of Gipsvika because it contained many shells of *Mytilus edulis*. The two other collections, however, contained no species which do not live in the area to-day.

HÄGG (1950, p. 345 and 1951, pp. 245, 247) pointed out that *L.vincta* is a boreal species, extinct in Spitsbergen since the decline of the Post-Glacial Warm period. As we have seen, however, this species is not a real boreal one; its habitat is quite similar to that of *Mytilus edulis*. Its presence indicates mid-arctic conditions (Gulf Stream influence in arctic waters), and it should be regarded as an index fossil for deposits from the Post-Glacial Temperate period, as demonstrated by its occurrence 45 m a.s.l. at Gipsvika (FEYLING-HANSSEN and JØRSTAD 1950, p. 32).

Littorina saxatilis (OLIVI 1792).

Turbo saxatilis OLIVI 1792, p. 172, pl. 5, figs. 3a—d.
Turbo rudis MATON 1797, p. 277.
Littorina groenlandica MENKE 1830, p. 45.
Littorina saxatilis, JOHNSTON 1841, p. 268.
DAUTZENBERG and FISCHER 1912, p. 187, pl. 9, figs. 1—32; pl. 10, figs. 1—30.

Late-Pleistocene records:

Billefjorden: This species occurred in 10 of the samples, from 2 m up to 42 m a.s.l. (Myadalen, p. 121). In general there were 1—3 specimens in each sample, but the maximum number was 18 (Gerritelva, 23 m a.s.l., p. 96).

It was found by Swedish expeditions at Mimerbukta, 20 m a.s.l., and at „Sfinxudden" (Phantomodden) (HÄGG 1951), and has also been recorded from the Brucebyen area, 10—12 m and 30—45 ? m a.s.l. (ELTON and BADEN-POWELL 1931).

Sassen area: Found in three samples from terraces, up to 45 m a.s.l., and in two samples from silt deposits, c. 4 m a.s.l. (FEYLING-HANSSEN and JØRSTAD 1950). Recorded also from the mouth of Sassenelva and from Gipsvika (HÄGG 1951).

Elsewhere in the Isfjorden area: The east side of Dicksonfjorden, Coraholmen, Erdmannflya, Bohemanneset (KNIPOWITSCH 1903 IV, FEYLING-HANSSEN and JØRSTAD 1950, p. 77, HÄGG 1950, 1951), Gronfjorden, Colesbukta, (GRIPP 1927).

Adjacent arctic and subarctic regions: The White Sea, the Murman coast (KNIPOWITSCH 1900b, LINDHOLM 1921), „Ishavsfinland" (TANNER 1930), Finnmarken (HOLMBOE 1904, TANNER 1907b, ØYEN 1929), Iceland (BÁRDARSON 1921), and West Greenland, up to 70 m (LAURSEN 1950).

Recent distribution:

Mid-arctic—boreal—lusitanian (ANTEVS 1928), occurring from the White Sea and Svalbard southwards to the Mediterranean. There are many records i.a. from Greenland (ODHNER 1915, MADSEN 1936).

It is quite common on rocks and stones in the littoral of Isfjorden (ODHNER 1915, p. 170, FEYLING-HANSSEN and JORSTAD 1950, p. 77). It is also recorded from the west and north coasts of Vestspitsbergen (KNIPOWITSCH 1902 III, FEYLING-HANSSEN 1953).

Remarks:

All specimens of *Littorina saxatilis* from Svalbard should be referred to the var. *groenlandica* MENKE. ELTON and BADEN-POWELL (1931, pp. 391, 403) erroneously recorded *L. saxatilis* as being extinct in Spitsbergen waters.

Littorina littorea (LINNÉ 1758).

Plate 26, figs. 4—8.

Turbo littoreus LINNÉ 1758, p. 761.
Littorina littorea, LYELL 1835, p. 37.

Late-Pleistocene records:

Billefjorden: This species occurred in 9 of the samples, from 2 m up to 31 m a.s.l. (Petuniabukta, p. 99), the maximum number of specimens in any one sample being 33 (Gerritelva, 23.2 m a.s.l.).

It was previously recorded from Mimerbukta, 20 m a.s.l., Phantomodden (Sfinxudden, HÄGG 1951), Brucebyen, 10—12 m and 30—45? m (cf. p. 135) (ELTON and BADEN-POWELL 1931), and Petuniabukta, 27 m a.s.l. (BADEN-POWELL 1939).

Sassen area: It was found in a shoreline, 16.3 m a.s.l., at the Sassen Hut, and in a terrace, 19 m a.s.l., to the south of Von Postbreen (FEYLING-HANSSEN and JØRSTAD 1950, p. 77). Swedish expeditions found it at Bjonahamna, Gipsvika (NATHORST 1884, p. 38, HÄGG 1950, p. 332), and Tempelfjorden (KNIPOWITSCH 1903 IV).

Elsewhere in the Isfjorden area: The first record is from the „Mytilusbeds" on the east side of Adventfjorden, 6 m a.s.l. (HEER 1870). Elsewhere it is recorded from the east side of Dicksonfjorden, from Kapp Thordsen and Bohemanneset (HÄGG 1950, 1951, KNIPOWITSCH 1903 IV).

North coast region: Found by GOËS, 1861, at Gråhuken (HEER 1870) and by HOEL (1914) on Breiddholmen (Eiderholmen) at the head of Woodfjorden.

Adjacent arctic and subarctic regions: The White Sea and the Murman coast (KNIPOWITSCH 1900b, LINDHOLM 1921), „Ishavsfinland" (TANNER 1930), Finnmarken (HOLMBOE 1904, TANNER 1907b, ØYEN 1929, ROSENDAHL 1931), and Iceland, 20 m and 49 m a.s.l. (THORODDSEN 1892).

Recent distribution:

Low-arctic—boreal—lusitanian, from the Murman coast southwards to Gibraltar (DAUTZENBERG and FISCHER 1912).

Remark:

Littorina littorea is an excellent index fossil for littoral deposits from the Post-Glacial Warm period in Svalbard.

Cingula castanea (MÖLLER 1842).

Plate 26, figs. 9, 10.

Rissoa castanea MÖLLER 1842, p. 9.
Cingula castanea, G. O. SARS 1878, p. 174, pl. 10, figs. 1a—b.

Late-Pleistocene records:

Billefjorden: 3 specimens occurred in a sample from Brucebyen, 7 m a.s.l. (p. 92), and 4 in a sample of *Lithothamnion* silt from Sentabukta, 2 m a.s.l. (p. 91). It had not previously been recorded from the Pleistocene of Billefjorden.

Sassen area: Two specimens from the cliff of a 7 m- terrace at Gåsøyane, 2 m a.s.l. (FEYLING-HANSSEN and JORSTAD 1950).

Elsewhere in the Isfjorden area: Found in the morainic deposits of Coraholmen in Ekmanfjorden (LAMPLUGH 1911, HÄGG 1951).

Adjacent arctic and subarctic regions: HOLMBOE (1904) recorded it from Sør-Varanger, Finnmarken, 16 m a.s.l., and LAURSEN (1944, 1950) recorded it from West Greenland, up to 29 m.

Recent distribution:

Arctic, southwards to Finnmarken, Iceland and the Gulf of St. Lawrence.

It is rare in Isfjorden, where it occurs in fairly shallow water (ODHNER 1915).

Omalogyra atomus (PHILIPPI 1841).

Plate 26, figs. 11, 12.

Truncatella atomus PHILIPPI 1841, p. 54, pl. 5, fig. 4.
Homalogyra atomus, JEFFREYS 1867 IV, p. 69, pl. 1, fig. 5; 1869 V, pl. 70, fig. 2.
G. O. SARS 1878, p. 215, pl. 22, figs. 21a—c.
BROGGER 1900—1901, pl. 18, figs. 9a—b.
Omalogyra atomus, WINCKWORTH 1932, p. 223.
WENZ 1939, p. 647, fig. 1839.

Late-Pleistocene records:

Billefjorden: One specimen was found in a sample of *Lithothamnion* silt, 2 m a.s.l., at Sentabukta (p. 91), and in the section at Teltfjellbekken (Brucebyen area, p. 82) there occurred 1 specimen in sample III (6.4 m a.s.l.), 2 in sample IV (6.1 m a.s.l.), 3 in sample V (5.8 m a.s.l.) and a few in sample VI (5.5 m a.s.l.).

Greatest diameter of the specimen of pl. 26, figs. 11, 12, is 0.82 mm (sample VI).

Omalogyra atomus has not previously been recorded from Svalbard, either as a Pleistocene fossil, or as a living animal.

Recent distribution:

Mid-arctic—boreal—lusitanian. On the east side of the Atlantic it is recorded from Vadsø in Finnmarken to the Mediterranean, also from the Faroes, Iceland, and from the southern parts of East and West Greenland, though not north of Angmagssalik (MADSEN 1936, p. 12, THORSON 1944, p. 39). Vertical range: 0 m (Iceland) to 38 m (West Greenland), a typical inhabitant of the tidal zone (THORSON l.c.).

Remarks:

Omalogyra atomus was regarded as lusitanian (BROGGER 1900—1901) or boreal—lusitanian (ANTEVS 1928). After having found it at Angmagssalik, Southeast Greenland, THORSON (1944, p. 39) stated its main distribution to be „the Mediterranean, and the lusitanian, boreal and arctic parts of the N.E. Atlantic."

Its occurrence at the southern parts of Greenland, however, does not prove its high-arctic habitat. Its distribution has probably much in common with that of *Mytilus edulis*.

Natica clausa BRODERIP and SOWERBY 1829.

Plate 26, fig. 13.

BRODERIP and SOWERBY 1829, p. 372.
Natica affinis MÖRCH 1857, p. 51.
Natica clausa, G. O. SARS 1878, p. 159, pl. 21, figs. 12—13.
Natica affinis, G. O. SARS 1878, p. 160, pl. 21, figs. 14a—b.

Late-Pleistocene records:

Billefjorden: This species was found in the two lowest terraces at Skansbukta, 2.2 and 2.0 m a.s.l., 9 specimens in all (pp. 108 and 119).

Previously one specimen was found at „Udden innanför Gåskap. Klas Billers Bay 1896" (HÄGG 1951), and one in the Brucebyen area (KNIPOWITSCH 1902 III).

Sassen area: Found at three different places, one specimen in each, up to 4.1 m a.s.l. (FEYLING-HANSSEN and JØRSTAD 1950).

Elsewhere in the Isfjorden area: Recorded from the morainic deposits of Coraholmen (LAMPLUGH 1911, NORDMANN 1912, as *N. affinis,* and HÄGG 1951) and Grønfjorden (GRIPP 1927).

West coast region: Kapp Lyell, 18 m a.s.l. (HÄGG 1950, p. 336), Axeløya, c. 20 m a.s.l. (HÄGG 1951, p. 231), Blomstrandhamna, 14 m a.s.l. (HOEL 1914).

East coast region: Diabastangen in Ginevrabotnen, 4 m a.s.l., Kvalpynten on Edgeøya, and Kapp Balfour on Barentsøya (Freemansundet), 2—3 m a.s.l. (KNIPOWITSCH 1902 III, p. 428).

Adjacent arctic and subarctic regions: Novaya Zemlya, several places at present sea level (GRØNLIE 1924, p. 101), Kolguev Island (KNIPOWITSCH 1904a), the northern coasts of the European part of Russia (KNIPOWITSCH 1900b, LINDHOLM 1921), „Ishavsfinland" (TANNER 1930), Sør-Varanger in Finnmarken (HOLMBOE 1904, TANNER 1907b), Iceland, 5—35 m a.s.l. (BÁRÐARSON 1921), North Greenland (JENSEN 1917) and West Greenland, up to 32 m (LAURSEN 1944, 1950).

Recent distribution:

Arctic—boreal—lusitanian parts of the Atlantic and the Pacific. Vertical range: 0 m (Norway) to 2660 m (Algeria) (THORSON 1944, p. 58).

It is quite common at all depths in Isfjorden (ODHNER 1915).

Remark:

N. clausa is often brought on land by birds.

Trophon truncatus (STRÖM 1768).

Plate 26, fig. 14.

Buccinum truncatus STRÖM 1768, p. 369, pl. 16, fig. 26.
Murex (Trophon) truncatus, MÖRCH 1868, p. 213.
Trophon truncatus, G. O. SARS 1878, p. 246, pl. 15, fig. 9.

Late-Pleistocene records :

Billefjorden: Two specimens from *Lithothamnion*-silt, 2 m a.s.l., at Sentabukta (p. 91), and one from the Recent storm-ridge at Ebbadalen, Petuniabukta, the latter most probably of Recent origin (p. 101).

This species was recorded from Brucebyen, 10—12 m a.s.l., by ELTON and BADEN-POWELL (1931) as *Boreotrophon truncatum* in the tabular list on p. 404, but in the text, p. 403, they have written *Trophon clathratus.*

Sassen area: One specimen from a terrace 45 m a.s.l. at Gipsvika (FEYLING-HANSSEN and JØRSTAD 1950, p. 79).

Adjacent arctic and subarctic regions: The Murman coast (KNIPOWITSCH 1900b), „Ishavsfinland" (TANNER 1930), Finnmarken (HOLMBOE 1904, TANNER 1907b, ØYEN 1929), Iceland (BÁRÐARSON 1921), West Greenland (LAURSEN 1944, 1950).

Recent distribution :

Arctic—boreal, the Siberian Arctic Sea, Spitsbergen, Greenland, and southwards to Kattegat and the British Isles (THORSON 1944, p. 67).

It is very rare in Isfjorden (FRIELE and GRIEG 1901, ODHNER 1915). GRIPP (1927, p. 37) found it on the beach of Grønfjorden.

Trophon clathratus (LINNÉ 1767).

Murex clathratus LINNÉ 1767, p. 1223.
Trophon clathratus, G. O. SARS 1878, p. 247, pl. 15, fig. 10.

Late-Pleistocene records :

Billefjorden: One specimen was found 14 m a.s.l. at Gerritelva (p. 96) in the Brucebyen area. The species was not previously recorded from the Pleistocene of Billefjorden.

Sassen area: 3 specimens from a terrace, 3.6 m a.s.l., at Sveltihel, 2 from a terrace, 19 m a.s.l., at Von Postbreen, and 2 from the moraine to the south of the same glacier, 30 m a.s.l. (var. *grandis*) (FEYLING-HANSSEN and JØRSTAD 1950). KNIPOWITSCH (1903 IV, p. 138) and HÄGG (1950, p. 332) recorded it from Tempelfjorden.

Elsewhere in the Isfjorden area: Coraholmen in Ekmanfjorden (LAMPLUGH 1911, NORDMANN 1912) and Erdmannflya, 1—2 m a.s.l. (HÄGG 1951).

West coast region: Recorded from a morainic deposit at Braganzavågen at the head of Van Mijenfjorden (HÄGG 1951).

North coast region: Breiddholmen at the head of Woodfjorden, 2—3 m a.s.l. (HOEL 1914, p. 34).

East coast region: Diabastangen in Ginevrabotnen, 4 m a.s.l., Kvalpynten on Edgeøya (height not recorded), and from morainic deposits at Negribreen, 25—100 m a.s.l. (KNIPOWITSCH 1902 III).

Adjacent arctic and subarctic regions: The White Sea and the Murman coast (KNIPOWITSCH 1900b, LINDHOLM 1921), the area to the south of Varangerfjorden (Ishavsfinland, TANNER 1930), Finnmarken (HOLMBOE 1904, TANNER 1907b), Iceland, 5—35 m a.s.l. (BÁRÐARSON 1921), North Greenland (JENSEN 1917) and West Greenland (LAURSEN 1944, 1950).

Recent distribution :

Circumarctic—boreal, extending southwards along the whole Norwegian coast to Bohuslän, to North England, Cape Cod, Puget Sound and Japan. Vertical range: 8 m (Svalbard) to 1033 m (the Hebrides) (THORSON 1944, p. 68).

It is quite rare in Isfjorden; living specimens (var. *grandis* MÖRCH) were taken at depths from 8 to 71 m (ODHNER 1915, p. 176).

Trophon species.

One worn specimen from a terrace at Gerritelva (p. 96).

Sipho islandicus (CHEMNITZ 1780).

Fusus islandicus CHEMNITZ 1780 IV, p. 159, pl. 141, figs. 1312—1313.
Sipho islandicus, DAUTZENBERG and FISCHER 1912, p. 87, pl. 3, figs. 8—9 (with extensive synonymy).

Late-Pleistocene records :

Billefjorden: One specimen of this species was found by C. A. HANSSON, 1896, at „Udden innanför Gåskap. Klas Billers Bay" (HÄGG 1951, p. 240), which probably refers to Phantomodden.

Sassen area: One specimen was found in the moraine of Von Postbreen, 30 m a.s.l. (FEYLING-HANSSEN and JØRSTAD 1950).

Adjacent arctic and subarctic regions: The White Sea (KNIPOWITSCH 1900b).

Recent distribution :

Arctic-boreal, in the northern Atlantic and the arctic part of the Pacific. Vertical range: 5—1203 m (THORSON 1944, p. 77).

A single specimen was taken alive in Billefjorden, at depth 133—142 m, by a Russian expedition (KNIPOWITSCH 1901), otherwise only empty shells have been found in Isfjorden (ODHNER 1915).

Sipho togatus (MÖRCH 1869).

Fusus ebur var. *togata* MÖRCH 1869, p. 275 in PETIT DE LA SAUSSAYE 1869.
Sipho togatus, KOBELT 1878, p. 278, pl. 9, fig. 4.
DAUTZENBERG and FISCHER 1912, p. 91, pl. 3, figs. 12—13.

Late-Pleistocene records :

Billefjorden: Two specimens were found at the point to the southwest of Nordenskiöldbreen by DE GEER in 1896, height not recorded (HÄGG 1951, p. 242), also recorded from „Udden innanför Gåskapp" (l.c. p. 240).

Sassen area: 4 specimens were found in the moraine of Von Postbreen, up to 30 m above the sea (FEYLING-HANSSEN and JORSTAD 1950, p. 78).

Adjacent arctic and subarctic regions: Cape Chelyuskin, probably washed ashore in Recent times (GRØNLIE 1928), Iceland, 8—25 m a.s.l. (BÁRDARSON 1921), and West Greenland (LAURSEN 1944, 1950).

Recent distribution :

Arctic (GAEVSKOIJ 1948, p. 387), high-arctic (ANTEVS 1928) Franz Josef Land, the Kara Sea and the Murman coast, East and West Greenland.

It is common in all parts of Isfjorden and at all depths there (ODHNER 1915).

Sipho kroeyeri (MÖLLER 1842).

Fusus Kröyeri MÖLLER 1842, p. 15.
Sipho (Parasipho) Kröyeri, DAUTZENBERG and FISCHER 1912, p. 100, pl. 4, figs. 6—7.

Late-Pleistocene records :

Billefjorden: Recorded by a Swedish expedition, 1896, from the point southwest of Nordenskiöldbreen (HÄGG 1951), and by a Russian expedition from the Brucebyen area (KNIPOWITSCH 1902 III).

Elsewhere in the Isfjorden area: Found in the morainic deposits of Coraholmen (NORDMANN 1912), and also in a moraine at Grønfjordbreen (GRIPP 1927).

West coast region: Damesmorena, Van Mijenfjorden (HÄGG 1951).

North coast region: Sorgfjorden, 9 m a.s.l. (BADEN-POWELL 1939, p. 340).

East coast region: Ginevrabotnen and Edgeoya (KNIPOWITSCH 1902 III).

Adjacent arctic and subarctic regions: Kolguev Island (KNIPOWITSCH 1904a) and North Greenland (JENSEN 1917).

Recent distribution :

Circumarctic. Vertical range: 0—122 m (THORSON 1944, p. 85). It is also recorded from Isfjorden (ODHNER 1915, GRIPP 1927).

Pyrulofusus deformis (REEVE 1847).

Plate 27, figs. 1, 2.

Fusus deformis REEVE 1847 IV, pl. 12, figs. 45a—b.
Neptunea (Pyrulofusus) deformis, FRIELE 1879 VI, p. 280.
Pyrulofusus deformis, FRIELE 1882, p. 8, pl. 1, fig. 8; pl. 4, figs. 11—13.
DAUTZENBERG and FISCHER 1912, p. 67, pl. 1, figs. 6—7.

Late-Pleistocene records:

Billefjorden: One specimen was found on the lowest terrace plain at Skansbukta, 2.2 m a.s.l., but may probably have been washed ashore in Recent times (cf. p. 108).

Not previously recorded from Billefjorden.

Sassen area: One broken shell from the moraine of Von Postbreen, 30 m a.s.l., and two fragments 1 m above high-water level at the inner part of Gipsvika, probably of Recent origin (FEYLING-HANSSEN and JØRSTAD 1950, p. 78). A Swedish expedition of 1896 found two specimens at „Diabasudden, Gipsbay" (HÄGG 1951, p. 238).

West coast region: Damesmorena, probably pushed up from the bottom of Van Mijenfjorden (CÖSTER 1925, HÄGG 1950, p. 333).

Recent distribution:

P. deformis is an eastern arctic species.

It is rare in Isfjorden, and has only been recorded as living in Adventfjorden and Grønfjorden (DAUTZENBERG and FISCHER 1912). Empty shells were found on the beaches of Sassenfjorden and Grønfjorden (ODHNER 1915, p. 200, GRIPP 1927, p. 37).

It is also recorded from Magdalenefjorden, 112 m, and Storfjorden, 77—139 m (ODHNER 1915, pp. 200, 267).

Buccinum undatum LINNÉ 1758.

LINNÉ 1758, p. 740.
DAUTZENBERG and FISCHER 1912, p. 101, pl. 4, figs. 10—14; pl. 5, figs. 1—13; pl. 6, figs. 1—6.

Late-Pleistocene records:

Billefjorden: 4 shells in a sample from Skansbukta, 2.2 m a.s.l. (1 shell was found also in the Recent shore). Previously not recorded from Billefjorden.

Sassen area: 1 specimen from Sveltihel, 2.3 m a.s.l., and 2 from a terrace at Gipsvika, 45 m a.s.l. (FEYLING-HANSSEN and JØRSTAD 1950, p. 78). Recorded from Gipsvika („Diabasudden, Gips Bay") also by HÄGG (1951, p. 238).

Elsewhere in the Isfjorden area: Recorded from Coraholmen in Ekmanfjorden, 6 specimens in all (HÄGG 1951, pp. 236, 238).

Adjacent arctic and subarctic regions: Novaya Zemlya (KNIPOWITSCH 1900b, p. 147; GRØNLIE 1924, p. 101, with a„?"), the northern coasts of the European part of Russia (KNIPOWITSCH 1900b, 1904b),

„Ishavsfinland" (TANNER 1930), Finnmarken (TANNER 1907b), Iceland, 2—35 m a.s.l. (BÁRÐARSON 1921), West Greenland, up to 15 m (LAURSEN 1944, 1950).

Recent distribution :

B. undatum (and varieties) is supposed to be a circumarctic—boreal, and partly lusitanian species, occurring southwards to the Bay of Biscay and Cape Cod (FRIELE and GRIEG 1901, ODHNER 1915). THORSON (1944, p. 87) excluded it from the Recent fauna of East Greenland.

It occurs in Isfjorden, usually in shallow water, and almost exclusively on mud bottom (ODHNER 1915, p. 181).

Buccinum groenlandicum CHEMNITZ 1788.

CHEMNITZ 1788, p. 16.
DAUTZENBERG and FISCHER 1912, p. 129, pl. 8, figs. 9—15.

Late-Pleistocene records :

Billefjorden: This species occurred in three samples, from sea level up to 42 m above (Myadalen and Skansbukta), 5 specimens in all being found (together with one specimen in the Recent shore).

Three specimens were found by a Russian expedition, 1900, in the Brucebyen area (KNIPOWITSCH 1902 III, p. 429), and four by a Swedish expedition, 1896, at Phantomodden (Sfinxudden, HÄGG 1951, p. 243).

Sassen area: One specimen from a terrace at the inner part of Gipsvika. At the same locality, at 1 m a.s.l., 26 specimens were collected which were most probably of Recent origin (FEYLING-HANSSEN and JØRSTAD 1950, p. 78). It was recorded also from the mouth of Sassenelva (Sassen river) and from Bjonahamna (HÄGG 1950, 1951).

Elsewhere in the Isfjorden area: Coraholmen (LAMPLUGH 1911), the east side of Dicksonfjorden, and Bohemanneset (HÄGG 1950, 1951).

West coast region: Kapp Lyell, 18 m a.s.l. (HÄGG 1950).

East coast region: Diabastangen in Ginevrabotnen, 4 m a.s.l., and Edgeøya (KNIPOWITSCH 1902 III, p. 429).

Adjacent arctic and subarctic regions: Novaya Zemlya (KNIPOWITSCH 1900b; up to 50 m, GRØNLIE 1924), the Murman coast (KNIPOWITSCH 1900b), „Ishavsfinland" and Finnmarken (TANNER 1907b, 1930), and West Greenland, up to 24.5 m (LAURSEN 1944, 1950).

Recent distribution :

Circumarctic, occurring southwards to Finnmarken, Labrador and Nova Scotia, British Colombia and the Aleutians. Vertical range: 0—392 m (THORSON 1944, p. 97).

It is quite common in Isfjorden, generally at depths less than 75 m, and preferring the outer parts of the fjord (ODHNER 1915, pp. 192—194).

Buccinum ciliatum (FABRICIUS 1780).

Tritonium ciliatum FABRICIUS 1780, p. 401.
Buccinum ciliatum, MÖLLER 1842, p. 12.
DAUTZENBERG and FISCHER 1912, p. 116, pl. 4, figs. 8—9.

Late-Pleistocene records:

Billefjorden: One broken specimen, probably referable to this species, was found at Brucebyen (KNIPOWITSCH 1902 III, p. 429), 9 specimens were found northwest of Nordenskiöldbreen, and 1 at „the point inside Gåsodden, Klas Billers Bay" (HÄGG 1951), probably Phantomodden.

East coast region: 6 specimens from Diabastangen, Ginevrabotnen, 4 m a.s.l. (KNIPOWITSCH 1902 III).

Recent distribution:

B. ciliatum (and var. *laevior* MÖRCH) is a circumarctic species, occurring south to the Murman coast, Bjørnøya, Gulf of St. Lawrence, Bering Sea and Alaska (ODHNER 1915, THORSON 1944).

It occurs in Isfjorden and along the coasts of Svalbard (ODHNER 1915).

Buccinum finmarchianum VERKRÜZEN 1875.

VERKRÜZEN 1875, p. 237, pl. 8, figs. 1—3.
G. O. SARS 1878, p. 262, pl. 13, fig. 10; pl. 10, fig. 12.

Late-Pleistocene records:

Billefjorden: One specimen of *Buccinum finmarchianum* var. *scalaris* G. O. SARS was found by C. A. HANSSON, 1896, at „Udden innanför Gåskap" (HÄGG 1951, p. 240). This is the only record of this species from the Pleistocene of Svalbard.

Adjacent arctic and subarctic regions: Salmijärvi („Ishavsfinland", TANNER 1930) and Finnmarken (TANNER 1907b).

Recent distribution:

Low-arctic. Vertical range: 5—245 m (THORSON 1944, p. 105).

Buccinum glaciale LINNÉ 1761.

Plate 27, figs. 3—8.

LINNÉ 1761, p. 523.
DAUTZENBERG and FISCHER 1912, p. 117, pl. 7, figs. 1—4.

Late-Pleistocene records:

Billefjorden: This species occurred in 6 of the samples, from 2 m to 9.7 m a.s.l., and 15 specimens were also collected from the 2.0 m plain at the SW side of Skansbukta, though many of these were, no doubt, of Recent origin (p. 119).

It was previously found in Billefjorden by Swedish and British expeditions, up to 8 m a.s.l. (HÄGG 1951, ELTON and BADEN-POWELL 1931, BADEN-POWELL 1939).

Sassen area: Tempelfjorden (KNIPOWITSCH 1903 IV). It was rather common in the terraces up to 5.3 m, and one specimen was found in the moraine of Von Postbreen, 30 m above the sea (FEYLING-HANSSEN and JORSTAD 1950). Swedish expeditions found it at Gåsodden, Bjonahamna, and at Sasseneiva (HÄGG 1950, 1951).

Elsewhere in the Isfjorden area: The east side of Dicksonfjorden (HÄGG 1950), Coraholmen (LAMPLUGH 1911, NORDMANN 1912), the moraine of Gronfjordbreen (GRIPP 1927), Festningen (HÄGG 1951), and Bohemanneset (KNIPOWITSCH 1903 IV).

West coast region: Bellsund „at about 1½ to 2 miles inland and 400 or 500 feet above the sea-level" (WOODWARD 1860, p. 438) — probably transported by bird, and in the moraine of Eidembreen, Forlandsundet (DINELEY 1954).

North coast region: Sorgfjorden, 3 m a.s.l. (SANDFORD 1927, BADEN-POWELL 1939), Langgrunnodden (Shoal Point), 10—15 m above the sea (HÄGG 1950).

East coast region: Diabastangen in Ginevrabotnen, 4 m a.s.l., and Kvalpynten on Edgeoya, 2—3 m a.s.l. (KNIPOWITSCH 1902 III). It was also recorded from Hopen (DAUTZENBERG and FISCHER 1912, pp. 534—35).

Adjacent arctic and subarctic regions: Cape Chelyuskin (GRØNLIE 1928, probably of Recent origin), Novaya Zemlya (KNIPOWITSCH 1900b, p. 147).

Recent distribution :

Circumarctic, distributed south to Jan Mayen, Gulf of St. Lawrence, the Aleutians and Japan. Vertical range: 0 to 318 m. (FRIELE and GRIEG 1901, ODHNER 1915, THORSON 1944).

It is at present the most common gastropod in Isfjorden, living there at depths between 0 and 150 m (ODHNER 1915, pp. 185—188).

Remarks :

This species varies much in shape and, more especially, in structure. (Cf. present paper p. 119, and also DAUTZENBERG and FISCHER 1912, p. 121, and ODHNER 1915, p. 187).

Many shells of *B. glaciale* have been brought on land by birds.

Buccinum totteni STIMPSON 1865.

STIMPSON 1865, p. 385.
DAUTZENBERG and FISCHER 1912, p. 125, pl. 7, figs. 13—16.

Late-Pleistocene records :

Billefjorden: One broken specimen was found in a cliff, 2—3 m a.s.l., to the north of the head of Skansbukta (p. 116).

This species has not previously been recorded from the Pleistocene of Svalbard.

Recent distribution :

Circumarctic. It occurs in Isfjorden down to 150 m, and is recorded from the west and east coast of Vestspitsbergen (DAUTZENBERG and FISCHER 1912, ODHNER 1915).

Remark :

LØYNING (1932, p. 11) and others, hold the opinion that *Buccinum totteni* and *B. terrae-novae* are varieties of a single species.

Buccinum species.

A small, broken and worn specimen from a terrace 4.8 m a.s.l. at Nidedalen.

Lora bicarinata (COUTHOUY 1838).

Pleurotoma bicarinata COUTHOUY 1838, p. 104, pl. 1, fig. 11.
Pleurotoma violacea MIGHELS and ADAMS 1843, p. 51, pl. 4, fig. 21.
Bela bicarinata, G. O. SARS 1878, p. 237, pl. 16, figs. 11—12.

Late-Pleistocene records :

Billefjorden: One specimen was found in a terrace, 23.2 m a.s.l., at Gerritelva (p. 96) and one at the outlet of Sørdammen (p. 92), both localities in the Brucebyen area. Previously not recorded from the Pleistocene of Billefjorden.

Elsewhere in the Isfjorden area: Recorded from the morainic deposits of Coraholmen in Ekmanfjorden (LAMPLUGH 1911; NORDMANN 1912, var. *violacea ;* HÄGG 1951) and from Erdmannflya (HÄGG 1951).

East coast region: *Lora bicarinata* var. *violacea* and var. *laevior* were recorded from Diabastangen in Ginevrabotnen, approx. 4 m a.s.l., and from Kvalpynten on Edgeøya (KNIPOWITSCH 1902 III).

Adjacent arctic and subarctic regions: Var. *violacea* recorded from the Murman coast by KNIPOWITSCH (1900b). LAURSEN (1944, 1950) recorded both the typical form and the var. *violacea* from West Greenland.

Recent distribution :

Circumarctic—boreal, occurring southwards to Bohuslän, Ireland, New England, British Columbia. Vertical range: 0—761 m (THORSON 1944, p. 112, several varieties included).

It is quite common everywhere in Isfjorden (ODHNER 1915).

Lora species.

One broken specimen was found at Sørdammen, Brucebyen (p. 92).

Thracia species.

One valve was found on the Recent storm-ridge at Ebbadalen, Petunia-bukta, and two in a cliff, 2—3 m a.s.l., at the innermost part of Skansbukta (p. 117). They were all worn, rendering specific identification uncertain, but should probably be referred to *devexa* G. O. SARS.

Cirripedia.

Verruca stroemia (MÜLLER 1776).

Plate 26, figs. 15, 16.

Lepas stroemia O. F. MÜLLER 1776.
Verruca stroemia, BROCH 1924, p. 63, text-fig. 22.

Late-Pleistocene records :

Billefjorden: Compartements and operculars of two specimens were found at Sørdammen, Brucebyen, 7 m a.s.l. (p. 92).

The species has not previously been recorded from the Pleistocene of Svalbard.

Adjacent arctic and subarctic regions: At the river Dwina (White Sea) and on the Murman coast (KNIPOWITSCH 1900b, pp. 40, 66), also recorded from the Petsamo valley and Boris Gleb, 2.4 m a.s.l., and Kervanto and Pumanki, up to 18 m at the Norwegian-Russian border (TANNER 1930).

Recent distribution :

Verruca stroemia is an East Atlantic, mid-arctic—boreal—lusitanian species extending northwards to the White Sea and Spitsbergen (BROCH 1924, pp. 108—109).

Balanus balanus (LINNÉ 1758).

Lepas balanus LINNÉ 1758; 1767, p. 1107.
Balanus porcatus DA COSTA 1778.
Balanus balanus, BROCH 1924, p. 73, pl. 1, figs. 1—2; pl. 2, figs. 1—2.

Late-Pleistocene records :

Billefjorden: This species is the most common barnacle in the Pleistocene of Svalbard, and occurred in 11 samples, from 7.0 m up to 50.7 m (north of Phantomvika, p. 75). Not previously recorded from the Pleistocene of Billefjorden.

Sassen area: It occurred in 18 samples from 10 different localities within the area, from present sea level up 45 m above (FEYLING-HANSSEN and JØRSTAD 1950). Previously found by a Swedish expedition at Diabas-odden, 20 m a.s.l. (HÄGG 1951).

Elsewhere in the Isfjorden area: Coraholmen (LAMPLUGH 1911), Erdmannflya (HÄGG 1951), Kapp Linné (FEYLING-HANSSEN and JØRSTAD 1950, p. 48).

West coast region: Torellbreen, Richardodden in Van Mijenfjorden, Kapp Lyell (HÄGG 1950, 1951), Müllerneset, Forlandsundet (DINELEY 1954), Blomstrandhamna, 14 m a.s.l., and in moraine 19 m a.s.l. (HOEL 1914).

North coast region: Wijdefjorden, 18—22 m a.s.l. (ELTON and BADEN-POWELL 1931, p. 392), Sorgfjorden, 15 and 21 m a.s.l. (BADEN-POWELL 1939), and Tommelpynten in Hinlopenstretet (ELTON and BADEN-POWELL 1931).

East coast region: Diabastangen in Ginevrabotnen and Kvalpynten on Edgeøya (KNIPOWITSCH 1900a).

Adjacent arctic and subarctic regions: Cape Chelyuskin, 20 m a.s.l. (GRØNLIE 1928), Kolguev Island, Lamposhnja, Murman coast (KNIPOWITSCH 1900b, 1904a, b), „Ishavsfinland" (TANNER 1930), at Kirkenes in Finnmarken (ØYEN 1929), Iceland (BÁRDARSON 1921), North Greenland (JENSEN 1917) and West Greenland, up to 70 m (LAURSEN 1950).

Recent distribution :

Circumarctic, extending its habitat through the boreal to the lusitanian region. It is a bipolar species occurring also in antarctic waters.

There are several records of *B. balanus* from Isfjorden (BROCH 1924, pp. 73—78, 110—111).

Remark :

Many records of „Balanus" and „Balanus sp." should probably be referred to this species.

Balanus crenatus BRUGUIÈRE 1789.

BROCH 1924, p. 78, pl. 1, figs. 3—6; pl. 2, fig. 14.

Late-Pleistocene records :

Billefjorden: The species occurred in three samples, viz: Skansbukta, Brucebyen, Gerritelva, at 7.0, 14.2 and 23.2 m a.s.l. respectively. It was not previously recorded from the Pleistocene of Billefjorden.

Sassen area: One specimen was found at the Gipshuken hut, 2—3 m a.s.l., probably of Recent origin (FEYLING-HANSSEN and JØRSTAD 1950, p. 57).

West coast region: Fragments of this species (or *B. balanoides)* was found in the moraine of Lilliehöökbreen (HOEL 1914, p. 35).

Adjacent arctic and subarctic regions: Kolguev Island, Mesenj at the Kanin Peninsula, Murman coast (KNIPOWITSCH 1900b, 1904a, b),

„Ishavsfinland" (TANNER 1930), Kirkenes and Vardø in Finnmarken (HOLMBOE 1904, ØYEN 1929), Iceland (BÁRDARSON 1921, p. 352), and West Greenland, up to 70 m (LAURSEN 1944, 1950, HARDER, JENSEN, and LAURSEN 1949).

Recent distribution :

Circumarctic—boreal—lusitanian, extending southwards to the Mediterranean, Long Island, California, Japan (BROCH 1924).

Balanus balanoides (LINNÉ 1767).

Lepas balanoides LINNÉ 1767, p. 1108.
Balanus balanoides, DARWIN 1854, p. 267, pl. 7, figs. 2a—d.
BROCH 1924, p. 84, pl. 1, fig. 17; pl. 3, fig. 8.
FEYLING-HANSSEN 1953, pp. 1—65, pl. 1—8.

Late-Pleistocene records :

Billefjorden: The species occurred in 13 of the samples, from 2 to 31 m a.s.l. (Petuniabukta, p. 99, being highest record). It was not previously recorded from Billefjorden.

Sassen area: Compartments of this species were found in a terrace, 16.3 m a.s.l., on the east side of Sassenelva (FEYLING-HANSSEN and JØRSTAD 1950, p. 25, FEYLING-HANSSEN 1953, p. 17).

Adjacent arctic and subarctic regions: Recorded from a terrace some 20 km from the town of Mesenj south of the Kanin Peninsula (KNIPOWITSCH 1904b, p. 191, with a „?") and from a terrace, 16.6—20 m a.s.l. at Claushavn in West Greenland (HARDER, JENSEN, and LAURSEN 1949, p. 78; cf. FEYLING-HANSSEN 1953, pp. 17—18).

Recent distribution :

B. balanoides is distributed in both Atlantic and Pacific boreal waters, and has a scattered occurrence in the southern parts of Greenland and along the west and north coast of Vestspitsbergen as far as Verlegenhuken (80°3.7' N.lat.). On both sides of the Atlantic it extends soutwards to approx. 39° N.lat. (FEYLING-HANSSEN 1953).

Balanus species.

A worn rostrum occurred in a sample from Ebbadalen in Petuniabukta, 31 m a.s.l.

Echinoidea.

Strongylocentrotus cf. *droebachiensis* (MÜLLER 1776).

Late-Pleistocene records :

Billefjorden: Spines and plates of this species occurred in 17 of the samples, from sea level up to 48.7 m above (Phantomodden, p. 71), one of the samples being of Recent origin. The species has not previously been recorded from the Pleistocene of Billefjorden.

Sassen area: It occurred in 14 samples, from 2 to 45 m above the sea (FEYLING-HANSSEN and JØRSTAD 1950).

Elsewhere in the Isfjorden area: Coraholmen in Ekmanfjorden (LAMPLUGH 1911, HÄGG 1951).

West coast region: Recherchefjorden (KNIPOWITSCH 1903 IV, HÄGG 1950).

East coast region: Kvalpynten on Edgeøya, „Stachel von Seeigeln" (KNIPOWITSCH 1900, p. 384).

Adjacent arctic and subarctic regions: Novaya Zemlya, „Echinus" (GRØNLIE 1924, p. 73), Lamposhnja at the Kanin Peninsula (KNIPOWITSCH 1904b), the Murman coast (KNIPOWITSCH 1900b, LINDHOLM 1921), „Ishavsfinland" (TANNER 1930), Finnmarken (HOLMBOE 1904, p. 29), North Greenland (JENSEN 1917) and West Greenland, up to 70 m (LAURSEN 1944, 1950).

Recent distribution :

Circumarctic—boreal (for details cf. HOFSTEN 1915, pp. 135—144). It is very common in Isfjorden at all depths below 5 m (HOFSTEN l.c.).

Remark :

This species is often brought on land by birds.

Lithothamnia.

Lithothamnion species.

Plate 17, figs. 11—15.

Late-Pleistocene records :

Billefjorden: Clods and fragments occurred in 21 of the samples, from present sea level up to 18 m above.

A Swedish expedition found two clods 20 m a.s.l. at Mimerbukta, and coralline algae were recorded also from Phantomodden and Anservika ? (Goes Bay), 8 m a.s.l. (HÄGG 1951). ELTON and BADEN-POWELL (1931, p. 391) recorded *Lithothamnion glaciale* from Brucebyen.

Sassen area: Occurred in 19 samples, from present sea level up to 10.5 m a.s.l. in terraces, and up to 30 m a.s.l. in moraine (FEYLING-HANSSEN and JØRSTAD 1950). Swedish expeditions collected *Lithothamnion* sp. at Tempelfjorden, Von Postbreen, and at Sassenelva (HÄGG 1951).

Elsewhere in the Isfjorden area: Coraholmen (LAMPLUGH 1911, HÄGG 1951), the east side of Dicksonfjorden, Bohemanneset, Erdmannflya (HÄGG 1950, 1951).

West coast region: Hornsund (HEINTZ 1953), Torellbreen (HÄGG 1950), Recherchefjorden (KNIPOWITSCH 1903 IV, HÄGG 1950), Müllerneset, Forlandsundet (DINELEY 1954), Blomstrandhamna and Lilliehöökfjorden, *L. glaciale* (HOEL 1914).

Remarks :

Specific determination of the numerous clods and fragments of coralline algae collected in Billefjorden (and in the Sassen area) was not undertaken. The majority of them, however, seem to be referable to *Lithothamnion glaciale* KJELLMAN 1883, of which *forma typica* FOSLIE is the most common. (Cf. FOSLIE 1929, KJELLMAN 1883).[1]

---

[1] *The Foraminifera will be considered in a later paper.*

Index of Species from the Late-Pleistocene of Billefjorden.[1]

[1] Synonyms in common use have been added in brackets.

REFERENCES

AHLMANN, H. W:SON, 1954. Glaciärer och klimat i Norden under de senaste tusentalen år. Norsk Geogr. Tidsskr. *13*. Oslo.

ANDERSSON, G. 1900. Om växtlifvet i de arktiske trakterna. — Nord. Tidskr. Årg. 1900. Stockholm.

— 1910. Die jetzige und fossile Quartärflora Spitzbergens als Zeugnis von Klimaänderungen. — Die Veränderungen des Klimas seit dem Maximum der letzten Eiszeit. — Exekutivkomité des 11. Internationalen Geologenkongresses. Stockholm.

ANTEVS, E. 1928. Shell beds on the Skagerack. — Geol. Fören. Stockh. Förh. *50*. Stockholm.

AURIVILLIUS, C. W. S. 1894. Studien über Cirripeden. — K. svenska Vetensk. Akad. Handl. *26*. Stockholm.

APPELLÖF, A. 1912. Invertebrate bottom fauna of the Norwegian Sea and North Atlantic. — [In] Sir John Murray and Johan Hjort: The depths of the ocean. London.

BADEN-POWELL, D. F. W. 1939. On further collections of Quaternary fossils from Spitsbergen. — Geol. Mag. Lond. *76*. London.

BALCHIN, W. G. V. 1941. The raised features of Billefjord and Sassenfjord West Spitsbergen. — Geogr. Journ. *97*. London.

BÁRÐARSON, G. G. 1921. Fossile Skalafleiringer ved Breiðifjörður i Vest-Island. — Geol. Fören. Stockh. Förh. *43*. Stockholm.

Beach Erosion Board. 1953. Shore protection planning and design. Special issue No. 2. Washington D. C.

BLOMSTRAND, C. W. 1864. Geognostiska iakttagelser under en resa ti l Spetsbergen år 1861. K. svenska Vetensk. Akad. Handl. N.F. *4*. Stockholm.

BOLTEN, J. F. 1798. Museum Boltenianum sive catalogus cimeliorum e tribus regnis naturae quae olim colligerat Joa. Fried. Bolten. Pars secunda. Hamburgi.

BOSC, L. A. G. 1802. Histoire naturelle des coquilles. 3. Paris an 10 (1802).

BOYD, LOUISE A. 1948. The coast of Northeast Greenland — Amer. Geogr. Soc. Spec. Publ. No. 30. New York.

BROCH, HJ. 1924. Cirripedia Thoracia von Norwegen und dem norwegischen Nordmeere. Kristiania [Oslo] 1924. — Skrifter utg. av Vidensk. Selsk. i Kristiania. I. No. 17.

— 1933. Einige Probleme der biogeographischen Abgrenzung der arktischen Region. — Mitt. zool. Mus. Berl. *19*. Berlin.

BRODERIP, W. J., and G. B. SOWERBY. 1829. Observations on new or interesting Mollusca contained for the most part in the Museum of the Zoological Society. — Journ. Zool. Res. *4*. London.

BROTZKY, V. A. 1930. Materials for the quantitative evaluation of the bottom fauna of the Storfjord (E. Spitsbergen). — Ber. Wiss. Meeresinst. *4*. Moscow.

BROWN, TH. 1827. Illustrations of the conchology of Great Britain and Ireland. London.

BRUGUIÈRE, M. 1789. Encyclopédie métodique. Histoire naturelle des vers. *1*. Paris.

BRØGGER, W. C. 1900—01. Om de senglaciale og postglaciale nivåforandringer i Kristianiafeltet (molluskfaunan). — Norges Geol. Unders. No. 31. Kristiania.

CHEMNITZ, J. H. 1781, 1782, 1784. Neues systematisches Conchylien-Cabinet fortgesetzt von Johann Hieronymus Chemnitz. *5, 6, 7*. Nürnberg.

— 1788. Neues syst. Conchylien-Cabinet. Namen-Register. Nürnberg.

CHYDENIUS, K. 1865. Svenska expeditionen till Spetsbergen år 1861 under ledning af Otto Torell. — Norstedt & Söner. Stockholm.

COUTHOUY, J. P. 1838. Descriptions of new species of Mollusca and shells and remarks on several Polypi found in Massachusetts Bay. — Boston Journ. Nat. Hist. *2*. Boston.

CÖSTER, F. 1925. Quaternary geology of the region around the Kjellström Valley. Results of the Swedish exp. to Spitzbergen in 1924. I. — Geogr. Ann. Stockh. Stockholm.

DA COSTA, E. M. 1778. Historia naturalis Testaceorum Britanniae, or the British Conchology. London.

DALL, W. H. 1870. Revision of the classification of the Mollusca of Massachusetts. — Proc. Boston Soc. Nat. Hist. *5*. Boston.

— 1901. Synopsis of the Lucinacea and of the American species. — Proc. U.S. Nat. Mus. *23*. Washington.

DARWIN, CH. 1854. A monograph on the sub-class Cirripedia. The Balanidæ. — Ray. Soc. London.

DAUTZENBERG, PH., et H. FISCHER. 1912. Mollusques provenant des campagnes de l'Hirondelle et de la Princesse-Alice dans les mers du nord. — Rés. Camp. Sci. Albert I de Monaco. *37*. Monaco.

DE GEER, G. 1896. Rapport om den svenska expeditionen till Isfjorden på Spetsbergen sommaren 1896. — Ymer. *16*. Stockholm.

— 1910a. Guide de l'excursion au Spitzberg. — XIe Congrés Géologique International. Stockholm.

— 1910b. Den svenska Spetsbergexkursionen 1910 för deltagare i den 11:te internationella geologkongressen i Stockholm. — Ymer. *30*. Stockholm.

DESHAYES, G. P. 1853. Catalogue of Conchifera or bivalve shells in the collection of the British Museum. I. London.

DILLWYN, L. W. 1817. A descriptive catalogue of recent shells according to the Linnean method. *1* and *2*. London.

DINELEY, D. L. 1954. Quaternary faunas in the St. Jonsfjord—Eidembukta region, Vestspitsbergen. — Norsk Geol. Tidsskr. *34*. Oslo.

DONS, C. 1937. Norges strandfauna. XV. Muslinger 3. — Det Kgl. Norske Vid. Selsk. Forhandl. *10*. Trondheim.

EKMAN, S. 1935. Tiergeographie des Meeres. Leipzig.

ELTON, C. S., and D. F. W. BADEN-POWELL. 1931. On a collection of raised beach fossils from Spitsbergen. — Geol. Mag. Lond. *68*. London.

ENGELL, M. C. 1904. Undersøgelser og Opmaalinger ved Jakobshavn Isfjord og i Orpigsuit Sommeren 1902. — Medd. Grønland. H. 26. København.

— 1905. Eine nachtertiäre Wärmeperiode im Grønland. — Petermanns Mitt. *4*. Gotha.

FABRICIUS, O. 1780. Fauna Groenlandica. — Hafniae et Lipsiae.

FEYLING-HANSSEN, R. W. 1950. Changes of sea-level in West Spitsbergen: a new interpretation. — Geogr. Journ. *115*. London.

— 1952. Conglomerates formed in situ on the Gipshuk coastal plain, Vestspitsbergen. — Norsk Polarinstitutt. Medd. nr. 71. Oslo.

— 1953. The Barnacle Balanus balanoides (Linné 1766) in Spitsbergen. — Norsk Polarinstitutt. Skrifter nr. 98. Oslo.

— 1954. De gamle trankokerier på Vestspitsbergens nordvesthjørne og den formodede senkning av landet i ny tid. — Norsk Geogr. Tidsskr. *12*. Oslo.

FEYLING-HANSSEN, R. W., F. A. JORSTAD. 1950. Quaternary fossils from the Sassen-Area in Isfjorden, West-Spitsbergen (The marine mollusc fauna). — Norsk Polarinstitutt. Skrifter nr. 94. Oslo.

FLEMING, J. 1828. A history of British animals. — Edinburgh.

FLINT, R. FOSTER. 1948. Studies in glacial geology and goemorphology (1937) p. 91 in Louise A. Boyd: The coast of Northeast Greenland. — Amer. Geogr. Soc. Spec. Publ. No. 30. New York.

FORBES, E., and S. HANLEY. 1848—1853. A history of British Mollusca, and their shells. *1—4*. London.

FOSLIE, M. 1929. Contributions to a monograph of the Lithothamnia. Ed. by H. Printz. — Publ. by Kgl. Norske Vidensk.-Selsk. Mus. Trondhjem.

FREBOLD, H. 1935. Geologie von Spitzbergen, der Bäreninsel, des König Karl- und Franz-Joseph-Landes. — Berlin.

FRIELE, H. 1879. Catalog der auf der norwegischen Nordmeer-Expedition bei Spitzbergen gefundenen Mollusken. — Jahrb. Deuts. Malakol. Ges. *6*. Frankfurt a. M.

— 1882. Mollusca. I. Buccinidæ. — Den Norske Nordhavs-Expedition. *8*. Zoologi. Christiania.

FRIELE, H., and J. A. GRIEG. 1901. Mollusca III. — Den Norske Nordhavs-Expedition 1876—78. *7*. Kristiania.

FÆGRI, K. 1940. Quartärgeologische Untersuchungen im westlichen Norwegen. II. Zur spätquartären Geschichte Jærens. — Bergens Mus. Årb. 1939—40. Naturvid. rekke. Nr. 7. Bergen.

GAEVSKOIJ, N. S. 1948. Fauna and flora of the northern seas of SSSR. Moscow. (Russian).

GOULD, A. A. 1841. A report of the Invertebrata of Massachusetts. Cambridge.

GRAY, J. E. 1824. Supplement to the appendix to Parry's first voyage: Shells. London.

— 1847. A list of the genera of recent Mollusca, their Synonyma and types. — Proc. Zool. Soc. Lond. London.

GRIEG, J. A. 1924a. Evertebrater fra bankerne ved Spitsbergen. — Bergens Mus. Årb. 1923—24. Naturv. r. Nr. 9. Bergen.

— 1924b. Molluscs, brachiopods and echinoderms from Novaya Zemlya. — Rep. Scient. Res. Norw. Exp. to Novaya Zemlya 1921. No. 26. Kristiania.

GRIPP, K. 1927. Beiträge zur Geologie von Spitzbergen. — Naturw. Ver. Hamburg. Abh. *21*. Hamburg.

— 1929. Glaciologische und geologische Ergebnisse der Hamburgischen Spitzbergen-Expedition 1927. — Naturw. Ver. Hamburg. Abh. *22*. Hamburg.

GRØNLIE, O. T. 1924. Contributions to the Quaternary geology of Novaya Zemlya. — Rep. Scient. Res. Norw. Exp. to Novaya Zemlya 1921. No. 21. Kristiania.

— 1928. Fossil and subfossil shells from „Maud-Havn" and environs. — The Norwegian North Polar Exp. with the „Maud" 1918—1925. — Scient. Res. *5*. Bergen.

GURJANOVA, E., J. SACHS, P. USCHAKOV. 1925. Comparative survey of the littoral of the northern seas. — Trav. de la Murman Biol. St. *1*. Moscow.

HANLEY, S. 1855. Ipsa Linnæi conchylia. London.

HARDER, P., AD. S. JENSEN, DAN LAURSEN. 1949. The marine Quaternary sediments in Disko Bugt. — Medd. Grønland. *149*. København.

HARLAND, W. B. 1952. The Cambridge Spitsbergen expedition, 1949. — Geogr. Journ. *118*. London.

HARMER, F. W. 1914—1925. The Pliocene Mollusca of Great Britain. *1—2*. London.

HEER, O. 1870. Die miocene Flora und Fauna Spitzbergens. Mit einem Anhang über die diluvialen Ablagerungen Spitzbergens. — K. svenska Vetensk. Akad. Handl. N.F. *8*. Stockholm.

HEINTZ, A. 1926. Blåskjell på Spitsbergen. — Norsk Geol. Tidsskr. *9*. Oslo.

— 1953. Noen iakttagelser over isbreenes tilbakegang i Hornsund, V. Spitsbergen. — Norsk Geol. Tidsskr. *31*. Bergen.

HESSLAND, I. 1943. Marine Schalenablagerungen Nord-Bohusläns. — Bull. Geol. Instit. Upsala. *31*. Uppsala.

HOEL, A. 1910. Geologiske iagttagelser paa Spitsbergen-ekspeditionerne 1906 og 1907. — Norsk Geol. Tidsskr. *1*. Kristiania.
— 1911. La nouvelle expédition norvégienne au Spitsberg. — La Géographie. *24*. Paris.
— 1914. Géologie (Exploration du Nord-Ouest du Spitsberg. Entreprise sous les auspices de S.A.S. le Prince de Monaco par la Mission Isachsen. 3éme Partie). — Rés. Camp. scient. Monaco. *42*. Monaco.
— 1953. Flateinnholdet av breer og snøfonner i Norge. — Norsk Geogr. Tidsskr. *14*. Oslo.
HOFSTEN, N. VON. 1915. Die Echinodermen des Eisfjords. Zoologische Ergebnisse der schwedischen Exp. nach Spitzbergen 1908. Pt. II. 2. — K. svenska Vetensk. Akad. Handl. *54*. Stockholm.
HOLMBOE, J. 1904. Om faunaen i nogle skjælbanker og lerlag ved Norges nordlige kyst. — Norges Geol. Unders. Nr. 37. Aarbog for 1904. Kristiania.
HOLMSEN, G. 1913. Spitsbergens jordbundsis. — Norsk Geogr. Selsk. Årbok 1912—13. Kristiania.
HOLTEDAHL, O. 1953. Norges geologi. *2*. — Norges Geol. Unders. Nr. 164. Oslo.
HORN, G., and A. K. ORVIN. 1928. Geology of Bear Island. — Skrifter om Svalbard og Ishavet. Nr. 15. Oslo.
HÄGG, R. 1904. Mollusca und Brachiopoda gesammelt von der Schwedischen Zoologischen Polarexpedition nach Spitzbergen, dem nordöstlichen Grönland und Jan Mayen im J. 1900. — Ark. Zool. K. svenska Vetensk. Akad. *2*. Stockholm.
— 1905. Scaphopoda, Gastropoda, Placophora und zwei vorher nicht erwähnte Lamellibranchiata. Mollusca und Brachiopoda gesammelt von der Schwedischen Zoologischen Polarexpedition nach Spitzbergen, dem nordöstlichen Grönland und Jan Mayen i. J. 1900. II. — Ark. Zool. K. svenska Vetensk. Akad. Handl. *2*. Stockholm.
— 1950. Kvartära marina fossil från Spetsbergen insamlade av svenska expeditioner. — Geol. Fören. Stockh. Förh. *72*. Stockholm.
— 1951. Kvartära fossil från Spetsbergen insamlade av svenska expeditioner. — Geol. Fören. Stockh. Förh. *73*. Stockholm.
HÖGBOM, B. 1911. Bidrag till Isfjordsområdets kvartärgeologi. — Geol. Fören. Stockh. Förh. *33*. Stockholm.
— 1913. Om Spetsbergens mytilustid. — Geol. Fören. Stockh. Förh. *35*. Stockholm.
IDELSON, M. S. 1930. A preliminary quantitative evaluation of the bottom fauna of the Spitzbergen bank. — Ber. wiss. Meeresinst. *4*. Moscow.
JEFFREYS, J. G. 1847. Additional notices of British shells. — Ann. Mag. Nat. Hist. 1st ser. *20*. London.
— 1867. Fourth report on dredging among the Shetland Isles. — Ann. Mag. Nat. Hist. 3rd ser. *20*. London.
— 1863—69. British conchology or an account of the Mollusca which now inhabit the British Isles and the surrounding seas. *2—5*. London.
JENSEN, AD. S. 1889. Undersøgelse af Grønlands vestkyst fra 64° til 67° N.B. — Medd. Grønland. *8*. København.
— 1900. Mya. Studier over nordiske Mollusker I. — Vidensk. Medd. naturh. Foren. Kjøb. København.
— 1905. Lamellibranchiata. On the Mollusca of East-Greenland. I. With an introduction on Greenland's fossil Mollusc-fauna from the Quaternary time. — Medd. Grønland. *29*. København.
— 1912. Lamellibranchiata (Part I). The Danish Ingolf-Expedition. *2*. København.
— 1917. Quaternary fossils collected by the Danmark Expedition. — Medd. Grønland. *43*. København.
— 1942. Two new West Greenland localities for deposits from the Ice Age and the Post Glacial warm period. — K. danske Vidensk. Selsk. Biol. Medd. *17*. København.

JENSEN, AD. S., and P. HARDER. 1910. Post-Glacial changes of climate in Arctic regions as revealed by investigations on marine deposits. — Die Veränderungen des Klimas seit dem Maximum der letzten Eiszeit. — Exekutivkomm. des 11. Inter. Geol. Kongresses. Stockholm.

JENSEN, AD. S., and R. SPÄRCK. 1934. Saltvandsmuslinger. (Bløddyr II). Danmarks Fauna. Ed. by Dansk Naturh. Foren. *40*. København.

JOHNSON, D. WILSON. 1919. Shore processes and shoreline development. Wiley & Sons, New York.

JOHNSTON, G. 1841. A descriptive catalogue of the Gastropoduos Mollusca of Berwickshire. — Hist. Berwicksh. Nat. Club, *2*. Edinburgh.

KEEN, A. M. 1936. A new Pelecypod genus of the family Cardiidae. — Trans. San Diego Soc. Nat. Hist. *8*. San Diego.

KJELLMAN, F. R. 1883. The algæ of the Arctic Sea. A survey of the species, together with an exposition of the general characters and the development of the flora. — K. svenska Vetensk. Akad. Handl. *20*. Stockholm.

KNIPOWITSCH, N. 1900a. Über die postpliocaenen Mollusken und Brachiopoden von Spitzbergen. (Zoologische Ergebnisse der russischen Expedition nach Spitsbergen im Jahre 1899.) — Bull. de l'Acad. Imp. d. Sciences de St. Pétersbourg. *12*. St. Petersburg.

— 1900b. Zur Kenntnis der geologischen Geschichte der Fauna des Weissen und des Murman-Meeres. — Verhandl. d. Russ. Kaiserl. mineralog. Ges. St. Petersburg. 2. ser. *38*. St. Petersburg.

— 1901. I. Mollusca und Brachiopoda. (Zoologische Ergebnisse der russischen Expeditionen nach Spitzbergen.) — Extrait de l'Annuaire du Musée Zoologique de l'Academie Impériale des Sciences de St. Pétersbourg. *6*. St. Petersburg.

— 1902. II & III. Mollusca und Brachiopoda. (Zoologische Ergebnisse der russischen Expeditionen nach Spitzbergen.) — Extrait de l'Annuaire du Musée Zoologique de l'Academie Impériale des Sciences de St. Pétersbourg. *7*. St. Petersburg.

— 1903. IV. Mollusca und Brachiopoda. (Zoologische Ergebnisse der russischen Expeditionen nach Spitzbergen. Nachtrag.) — Extrait de l'Annuaire du Musée Zoologique de l'Academie des Sciences de St. Pétersbourg. *8*. St. Petersburg.

— 1904a. Ueber die Postpliocaenen Meeres-Mollusken auf der Insel Kolgujew. — Verh. Russ.-Kaiserl. Mineralog. Ges. St. Petersburg. *41*. St. Petersburg.

— 1904b. Neue Fundorte von Meeres-Mollusken und Balaniden in den Ablagerungen der borealen Transgression. — Verh. Russ.-Kaiserl. Mineralog. Ges. St. Petersburg. *41*. St. Petersburg.

KOBELT, W. 1878. Zur Kenntnis der nordischen Mollusken. — Jahrb. deuts. Malak. Ges. *5*. Frankfurt a. M.

KULLING, O., and H. W:SON AHLMANN. 1936. Observations on raised beaches and their faunas. Surface markings. (Scient. results of the Swedish-Norwegian Arctic exp. in the summer 1931). — Geogr. Ann. Stockh. *18*. Stockholm.

LAMARCK, M. 1818. Histoire naturelle des animaux sans vertèbres. *5*. Paris.

— 1819. Histoire naturelle des animaux sans vertèbres. *6*. Paris.

LAMPLUGH, H. W. 1911. On the shelly moraine of the Sefström Glacier and other Spitsbergen phenomena illustrative of British glacial conditions. — Proc. Yorksh. Geol. Soc. New ser. *17*. 1909—11. Leeds.

LAURSEN, DAN. 1944. Contributions to the Quaternary geology of Northern West Greenland, especially the raised marine deposits. With a contribution on Foraminifera by K. Dreyer Jørgensen. — Medd. Grønland. *135*. Or: Mus. de min. et de géol. de l'Université de Copenhague. Communications Géologiques. No. 23. København.

— 1946. Quaternary shells collected by the Fifth Thule Expedition 1921—24. — Report of the Fifth Thule Expedition 1921—24. *1*. København.

— 1946b. Henning Lemche m. fl. Diskussion efter Dan Laursens foredrag om resultaterne af de kvartærgeologiske undersøgelser på 5. Thule-ekspedition. — Medd. dansk geol. Foren. *11*. København.

LAURSEN, DAN. 1950. The stratigraphy of the marine Quaternary deposits in West Greenland. — Medd. Grønland. *151*. København.

— 1954. Emerged Pleistocene marine deposits of Peary Land (North Greenland). — Medd. Grønland. *127*. København.

LEACH, W. E. 1815. The zoological miscellany. II. London.

— 1819. A voyage of discovery by John Ross. Appendix II. A list of invert. animals. London.

LECHE, W. 1878. Öfversigt öfver de af svenska expeditionerna till Novaja Semlja och Jenissei 1875 och 1876 insamlade Hafs-Mollusker. — K. svenska Vetensk. Akad. Handl. *16*. Stockholm.

LINDBERG, H. 1911. Ett fynd af pilspets från stenaldern i marint skalgrus vid Pasvik älf, cirka två mil från Ishavskusten. — Medd. Soc. pro fauna et flora fennica. H. 37. Helsingfors.

LINDHOLM, W. A. 1921. Zur Kenntnis der postpliocaenen Mollusken Fauna des westlichen Murman. — North. Scient. Hunt. Exp. H. 12. Gouvern. ed. St. Petersburg.

LINNÉ, C. VON. 1758. Systema naturae. Regnum animale. Editio X. Lipsiae.

— 1767. Systema naturae editio XII reformata tom. I. Pars II. Classis VI. Vermes. Holmiae.

— 1771. Mantissa plantarum altera generum editionis VI et specierum editionis II. Holmiae.

LOWE, R. T. 1827. On Balanus punctatus, Puncturella Flemingii etc. together with some corrections relative to Turbo carneus and some of the Chitones before described. — Zool. Journ. *3*. London.

LYELL, CH. 1835. On the proofs of a gradual rising of the land in certain parts of Sweden. Appendix, list of fossil shells from the country near Stockholm. — Philos. Trans. Roy. Soc. *1*. London.

LÖYNING, P. 1932. Loricata and Gastropoda from the Siberian Arctic Ocean. Norw. North Polar Exp. with the „Maud" 1918—1925, Scient. Res. *5*. Bergen.

MACGILLIVRAY, W. 1844. A history of the molluscous animals of Scotland as found in the north-eastern district, particularly in the shires of Aberdeen, Kincardine and Banff. London.

MACLAURIN, R. 1838. List of bivalved shells found in Coldingham Bay. — Hist. Berwicksh. Nat. Club. *1*. Edinburgh.

MADSEN, H. 1936. Investigations on the shore fauna of East Greenland with a survey of the shores of other Arctic regions. — Medd. Grønland. *100*. København.

— 1940. A study of the littoral fauna of North-West Greenland. — Medd. Grønland. *124*. København.

MATON, W. G. 1797. Observations relative chiefly to natural history, picturesque scenery and antiquities of the western counties of England made in the years 1794 and 1797. Salisbury.

MATTHES, F. E. 1900. Glacial sculpture of the Bighorn Mountains Wyoming. — U.S. Geol. Surv. Ann. Rep. 21. Pt. 2. Washington.

MENKE, C. TH. 1830. Synopsis methodica molluscorum generum omnium et specierum earum quae in Museo Menkeano adservantur. Editio altera, auctior et emendatior. Pyrmonti.

MIGHELS, J. W., and C. B. ADAMS. 1843. Descriptions of twenty four species of shells of New England. — Boston Journ. Nat. Hist. *4*. Boston.

MONTAGU, G. 1803. Testacea Britannica or Natural history of British shells, marine, land and fresh-water. London.

— 1808. Supplement to Testacea Britannica. London.

MÜLLER, O. F. 1776. Zoologiae danicae prodromus seu animalium Daniae et Norvegiae indigenarum characteres, nomina et synonyma imprimes popularium. Havniae.

MÖLLER, H. P. C. 1842. Index molluscorum Groenlandiae. Hafniae.

MÖRCH, O. A. L. 1853. Catalogus conchyliorum quae reliquit D. Alphonso d'Aguirra et Gadea, Comes de Yoldi. II. Hafniae.

— 1857. Catalogus conchyliorum quae reliquit. Ill. M. N. Suenson. Hafniae.

— 1857a. Fortegnelse over Grønlands Bløddyr: Prodromus molluscorum Groenlandiae. (Tillæg 4 in H. Rink: Grønland geografisk og statistisk beskrevet.). Kjøbenhavn.

— 1868. Faunula molluscorum Islandiae. Oversigt over Islands Bløddyr. — Vidensk. Medd. naturh. Foren. Kjøbenh. Kjøbenhavn.

NANSEN, F. 1902. The oceanography of the North Polar Basin. — The Norwegian North Polar Expedition, 1893—1896. Scient. res. *3*. Christiania.

NATHORST, A. G. 1883. Nya bidrag till kännedomen om Spetsbergens kärlväxter och dess växtgeografiska förhållanden. — K. svenska Vetensk. Akad. Handl. N. F. *20*. Stockholm.

— 1884. Redogörelse för den tillsammans med G. de Geer år 1882 företagna geologiska expeditionen till Spetsbergen. Bihang till K. svenska Vetensk. Akad. Handl. *9*. Stockholm.

— 1900. Två somrar i Norra Ishafvet. Del I. Stockholm.

— 1901a. Bidrag till Kung Karls Lands geologi. — Geol. Fören. Stockh. Förhandl. *23*. Stockholm.

— 1901b. Bidrag till nordöstra Grönlands geologi. — Geol. Fören. Stockh. Förhandl. *23*. Stockholm.

— 1910. Beiträge zur Geologie der Bären-Insel, Spitzbergens und des Köning-Karl-Landes. — Bull. Geol. Inst. Univ. Upsala. *10* (1910—1911). Uppsala.

NEWTON, E. T. 1899. Notes on a collection of rocks and fossils from Franz Josef Land, made by the Jackson-Harmsworth Polar Expedition during 1894—1896. Appendix in F. G. Jackson: A thousand days in the Arctic. *2*. London and New York.

NILSSON, S. 1822. Beskrifning öfver några skandinaviska arter af mussle-slägtet Crassina. — K. svenska Vetensk. Akad. Handl. *43*. Stockholm.

NOE-NYGAARD, A. 1932. Remarks on Mytilus edulis L. in raised beaches in East Greenland. — Medd. Grønland. *95*. København.

NORDENSKIÖLD, A. E. 1866. Utkast till Spetsbergens geologi. — K. svenska Vetensk. Akad. Handl. *6*. Stockholm. [Engl. translation: Sketch of the geology of Spitzbergen. Stockholm 1867.]

— 1874—1875. Utkast till Isfjordens och Belsounds geologi. — Geol. Fören. Stockh. Förh. *2*. Stockholm.

NORDGAARD, O. 1903. Studier over naturforholdene i vestlandske fjorde. I. Hydrografi. — Bergens Mus. Aarbog. Bergen.

NORDMANN, V. 1912. Anomia squamula L. som Kvartærfossil på Spitzbergen. — Medd. dansk geol. Foren. *4*. København.

ODHNER, N. H. 1912. Prosobranchia. I. Diotocardia. — Northern and Arctic invertebrates in the collection of the Swedish State Museum. V. — K. svenska Vetensk. Akad. Handl. *48*. Uppsala & Stockholm.

— 1915. Die Molluskenfauna des Eisfjordes. Zoologische Ergebnisse der Schwedischen Expedition nach Spitzbergen 1908. Teil II. I. — K. svenska Vetensk. Akad. Handl. *54*. Stockholm.

OLIVI, G. 1792. Zoologia Adriatica. Bassano.

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

— 1942. Om dannelsen av strukturmark. — Norsk Geogr. Tidsskr. *9*. Oslo. (Medd. Norges Svalbard- og Ishavs-undersøkelser. Nr. 55. Oslo.)

PACKARD, A. S. 1866. Observations on the glacial phenomena of Labrador and Maine, with a view of the Recent invertebrate fauna of Labrador. — Mem. Boston Soc. Nat. Hist. *1*. Boston.

PEACH, A. M'EWEN. 1916. The preglacial platform and raised beaches of Prince Charles Foreland. — Trans. Edinb. Geol. Soc. *10*. Edinburgh.

PETIT DE LA SAUSSAYE, S. 1869. Catalogue des mollusques testacés des mers d'Europe. Paris.

PETTIJOHN, F. J. 1949. Sedimentary rocks. — Harper & Brothers, Publishers. New York.

PHILIPPI, R. A. 1841. Zoologische Bemerkungen. — Arch. Naturgesch. *7*. Pt. 1.

— 1845. Abbildungen und Beschreibungen neuer oder venig gekannter Conchylien. — Kassel.

PHIPPS, C. J. 1774. A voyage towards the North Pole undertaken by His Majesty's command. 1773. London.

POSSELT, H. J. 1895. Østergrønlandske Mollusker. — Medd. Grønland. *19*. Kjøbenhavn.

REEVE, L. 1843—1870. Conchologia Iconica. I—XVII. London.

ROSENDAHL, H. 1931. Bidrag til Varangernesets geologi. — Norsk Geol. Tidsskrift. *12*. Oslo.

SANDFORD, K. S. 1929. The glacial conditions and Quaternary history of North-East Land. — Geogr. Journ. *74*. London. [Also in: Greenland and Spitsbergen Papers. Part 2. London 1934.]

SARS, G. O. 1878. Mollusca regionis arcticæ Norvegicæ. Bidrag til kundskaben om Norges arktiske fauna. I. — Universitetsprogram for første halvaar 1878. Christiania.

SCHLESCH, H. 1931. Beitrag zur Kenntnis des marinen Molluskenfauna Islands. Kleine Mitteilungen VII. I. — Arch. f. Molluskenkunde. *63*. Frankfurt a. M.

SCHUMACHER, CHR. F. 1817. Essai d'un nouveau système des habitations des vers testacés. Copenhague.

SELMER-OLSEN, E. 1954. Om norske jordarters variasjon i korngradering og plastisitet. (Grain size distribution and plasticity in Norwegian soils.) — Norges Geol. Undersøkelse. Nr. 186. Oslo.

SLATER, G. 1925. Observations on the Nordenskiöld and neighbouring glaciers of Spitsbergen, 1921. — Journ. Geol. *33*. London. [Also in: Spitsbergen Papers. *1*. Oxford Univ. Press 1925.]

SOOT-RYEN, T. 1925. Notes on some Mollusca and Brachiopoda from Spitsbergen. — Tromsø Mus. Aarsh. *47*. Tromsø.

— 1932. Pelecypoda, with a discussion of possible migrations of Arctic pelecypods in Tertiary times. — The Norw. North Polar Exp. with the „Maud" 1918—1925. Sci. Res. Editor: H. U. Sverdrup. *5*. Bergen.

— 1939. Some pelecypods from Franz Josef Land, Victoriaøya and Hopen, collected on the Norwegian Scient. Exp. 1930. — Medd. Norges Svalbard- og Ishavs-undersøkelser. Nr. 43. Oslo.

— 1951. New records on the distribution of marine Mollusca in Northern Norway. — „Astarte". No. 1. Tromsø Mus. Tromsø.

SOWERBY, J. 1812. The mineral conchology or coloured figures and descriptions of those remains of testaceous animals or shells which have been preserved at various times and depths in the earth. *1*. London.

SOWERBY, G. B. 1851 (1847—1887). Thesaurus conchyliorum or monographs of genera of shells. II. (I—V). London.

STIMPSON, W. 1851. Shells of New England, a revision of the synonymy of the testaceous mollusks of New England. Boston.

— 1865. Review of the northern Buccinums. — Canadian Naturalist. N.S. *2*. Montreal.

STRÖM, H. 1768. Beskrivelse over norske Insecter. Andet stykke. — K. norske Vidensk. Selsk. Skrifter. *4*. Kjøbenhavn.

SUMMERHAYES, V. S., and C. S. ELTON. 1923. Contributions to the ecology of Spitsbergen and Bear Island. — Res. of the Oxford Univ. Exp. to Spitsbergen, 1921. No. 29. London. [Also in: Spitsbergen Papers. *1*. Oxford Univ. Press. London 1925.]

TANNER, V. 1907a. Till frågan om Ost-Finmarkens glaciation och nivåförändringar. Studier öfver kvartärsystemet i Fennoskandias nordliga delar. I. — Bull. Comm. géol. Finl. No. 18. Helsingfors.

— 1907b. Nya bidrag 'till frågan om Finmarkens glaciation och nivåförändringar. Studier öfver kvartärsystemet i Fenoskandias nordliga delar. II. — Bull. géol. Comm. No. 21. Helsingfors.

TANNER, V. 1930. Om nivåförändringarna och grunddragen av den geografiska utvecklingen efter istiden i Ishavs-Finland samt om homotaxin af Fennoskandias kvartära marina avlagringar. — Bull. Comm. géol. Finl. No. 88, Helsingfors.

THORODDSEN, TH. 1892. Postglaciale marine Aflejringer. Kystterrasser og Strandlinjer i Island. — Geogr. Tidsskr. Kjøbenhavn.

THORSON, G. 1933. Investigations on shallow water animal communities in the Franz Joseph Fjord (East Greenland) and adjacent waters. — Medd. Grønland. *100.* København.

— 1934. Contributions to the animal ecology of the Scoresby Sound Fjord complex (East Greenland). — Medd. Grønland. *100.* København.

— 1944. Marine Gastropoda Prosobranchiata. The zoology of East Greenland. — Medd. Grønland. *121.* København.

TORELL, O. 1859. Bidrag till Spitzbergens molluskfauna. Stockholm.

TURTON, W. 1828. On the genus Lacuna. — Zool. Rec. *3.* London.

TWENHOFEL, W. H., and S. A. TYLER 1941. Methods of study of sediments. — McGraw-Hill. New York and London.

VERKRÜZEN, T. A. 1875. Bericht über einen Schabe-Ausflug im Sommer 1874 (Norwegen). — Jahrb. deuts. Mal. Ges. *2.* Frankfurt a. M.

VERRILL, A. E. 1874. Result of recent dredging expeditions on the coast of New England. (Brief contributions to zoology from the Museum of Yale College. No. 28.) — Amer. Journ. Sci. Arts. No. 6. 3rd ser. *7.* New Haven.

VERRILL, A. E., and S. J. SMITH. 1874. Report upon the invertebrate animals of Vineyard Sound and adjacent waters. — Rep. Fish and Fisheries. Washington.

VOGT, TH. 1927. Bretrykk-teori og jordskorpe-bevegelser i arktiske trakter i ny tid. — Norsk Geogr. Tidsskr. *1.* Oslo.

— 1932. Landets senkning i nutiden på Spitsbergen og Øst-Grønland. — Norsk Geol. Tidsskr. *12* Oslo.

WALTON, J. 1922. A Spitsbergen salt marsh. — With observations on the ecological phenomena attendant on the emergence of land from the sea. — Journ. Ecology. *10.* [Also in: Spitsbergen papers. *1.* Oxford Univ. Press. London 1925.]

WENZ, W. 1939. Gastropoda. Teil 3: Prosobranchia. Handb. d. Paläozoologie. Herausg. O. H. Schindewolf. *6.* Berlin.

WINCKWORTH, R. 1932. The British marine Mollusca. — Journ. Conch. *19.* London.

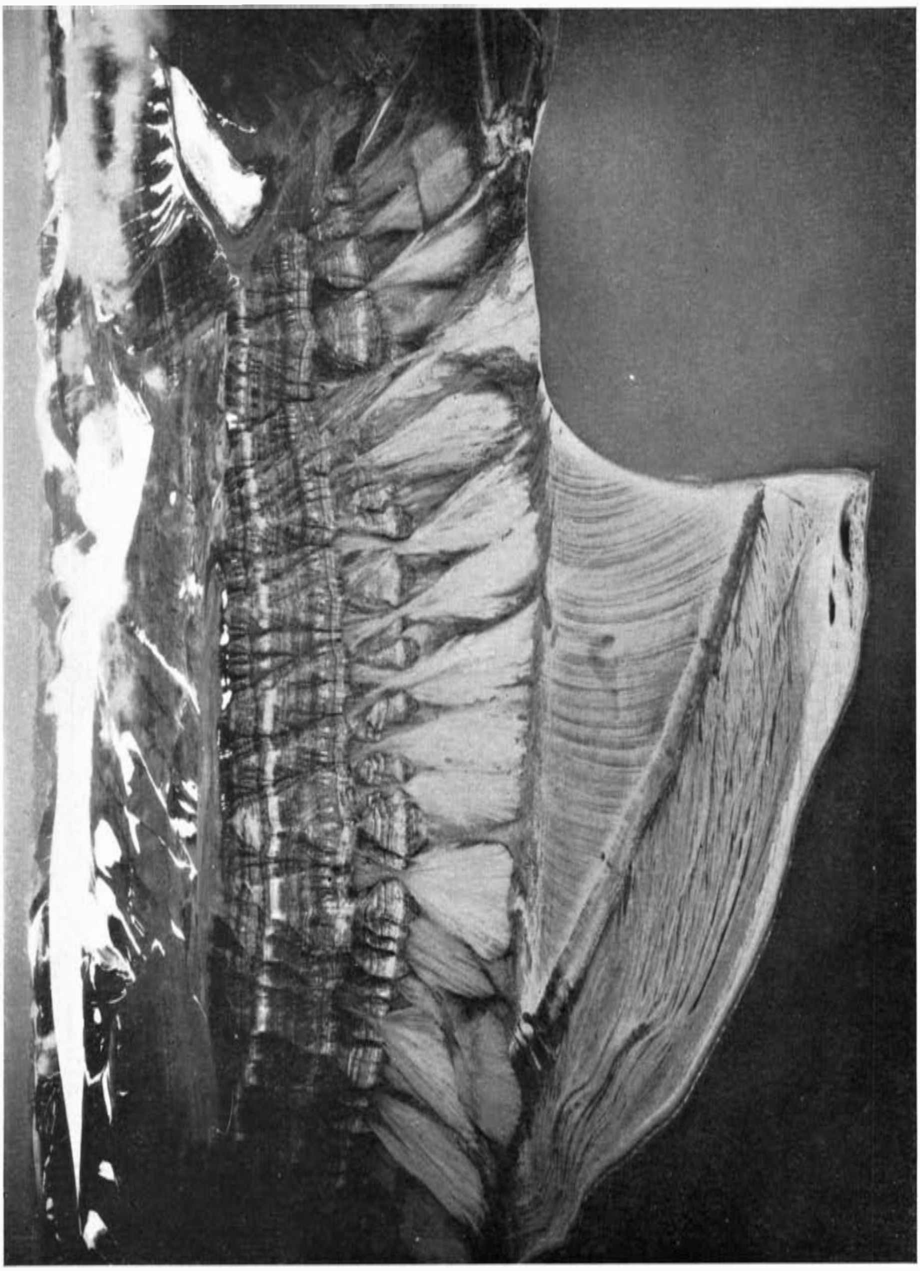
WOOD, S. V. 1842. A catalogue of shells from the Crag. — Ann. and Mag. Nat. Hist. 1. ser. *9.* London.

WOODWARD, S. P. 1860. Recent shells. Appendix to Lamont, J.: Notes about Spitzbergen in 1859. — Quart. Journ. Geol. Soc. Lond. *16.* London.

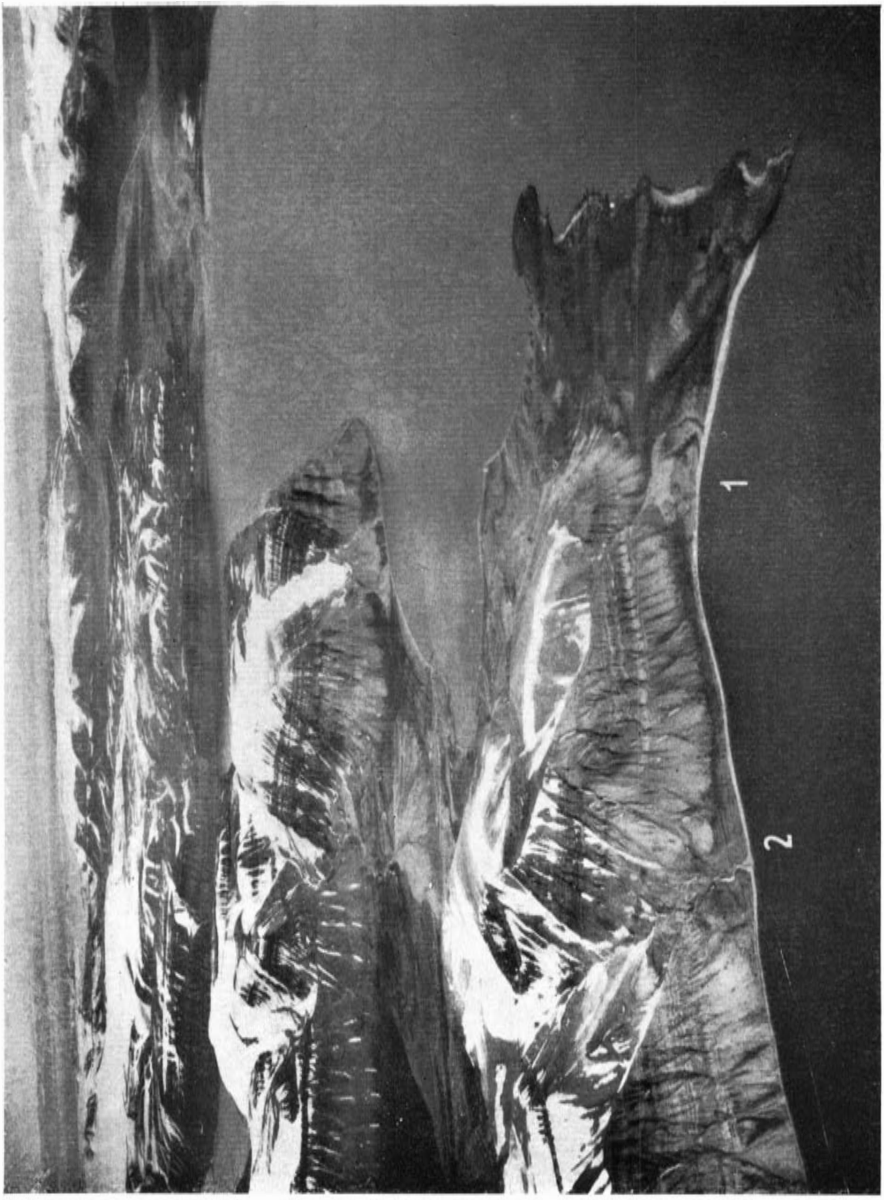
ØYEN, P. A. 1929. Quaternary deposits at Kirkenes. — Avhandl. Norske Vid. Akad. Oslo I. No. 1. Oslo.

PLATES

LOCALITIES AND RAISED MARINE FEATURES



The complex cuspate foreland of Bjonapynten, Tempelfjorden. Photo: B. LUNCKE, Aug. 1936.



Anservika (1) and Mytilusbekken (2). Sassenfjorden in the background. Photo: B. LUNCKE, Aug. 1936.

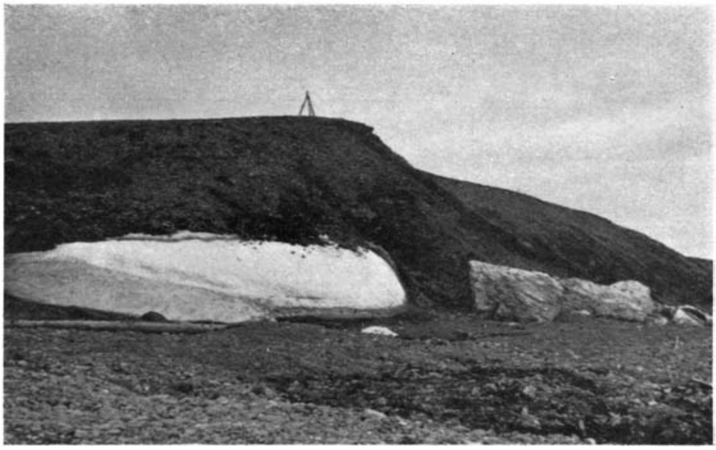


Fig. 1. The cliff and front edge of the *Astarte* terrace at Anservika, 9.7 m a.s.l. Photo: Author, July, 1950.

Fig. 2. The raised marine features at Phantomvika; Tjoåsfjellet (Tjosås mountain) with Tjosåsdalen to the right and Tyrrelldalen to the left. Photo: Author, July, 1950.

Fig. 3. Tyrrellfjellet (Tyrrell mountain) north of Phantomvika with raised marine terraces. The investigated part of the *Mya* terrace, 50.7 m a.s.l. (p. 73), lies a little to the right of the centre of the picture, the highest terrace found in Billefjorden, 96 m a.s.l., is seen to the left. Photo: Author, July, 1950.

Kapp Ekholm with Mathiesondalen. Photo: B. LUNCKE, July, 1936.

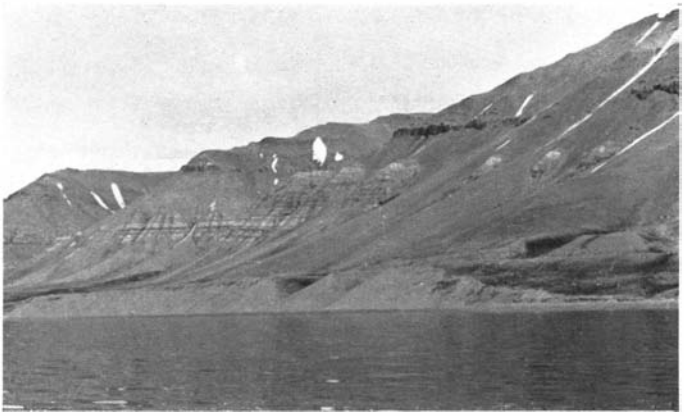


Fig. 1. The sea cliff of the sloping *Astarte* plain at Ekholmvika. Photo: L. PEDERSEN, July, 1950.

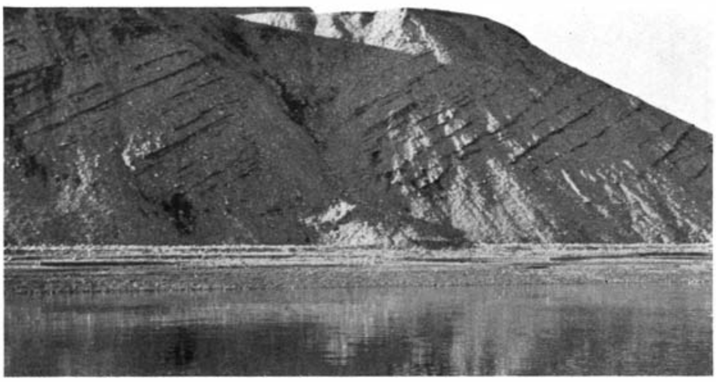


Fig. 2. The stratification of the sloping *Astarte* beach plain at Ekholmvika; height of cliff 22 m. Photo: Author, July, 1950.

Fig. 3. Part of the *Astarte* beach plain in the foreground (note the man on the other side of the erosion furrow), and the high terraces at 77 and 90 m a.s.l. in the background 1 km east of Ekholmvika. Photo: O. CHR. FEYLING-HANSSEN, July, 1950.

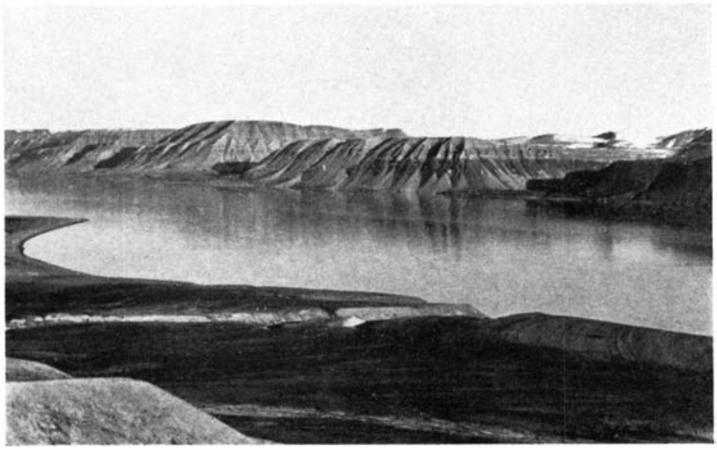
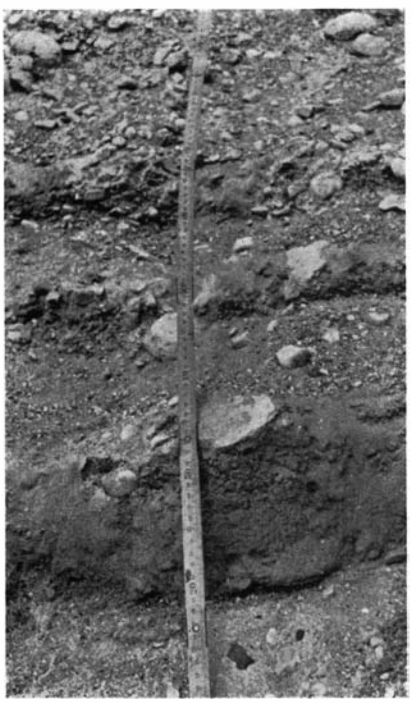
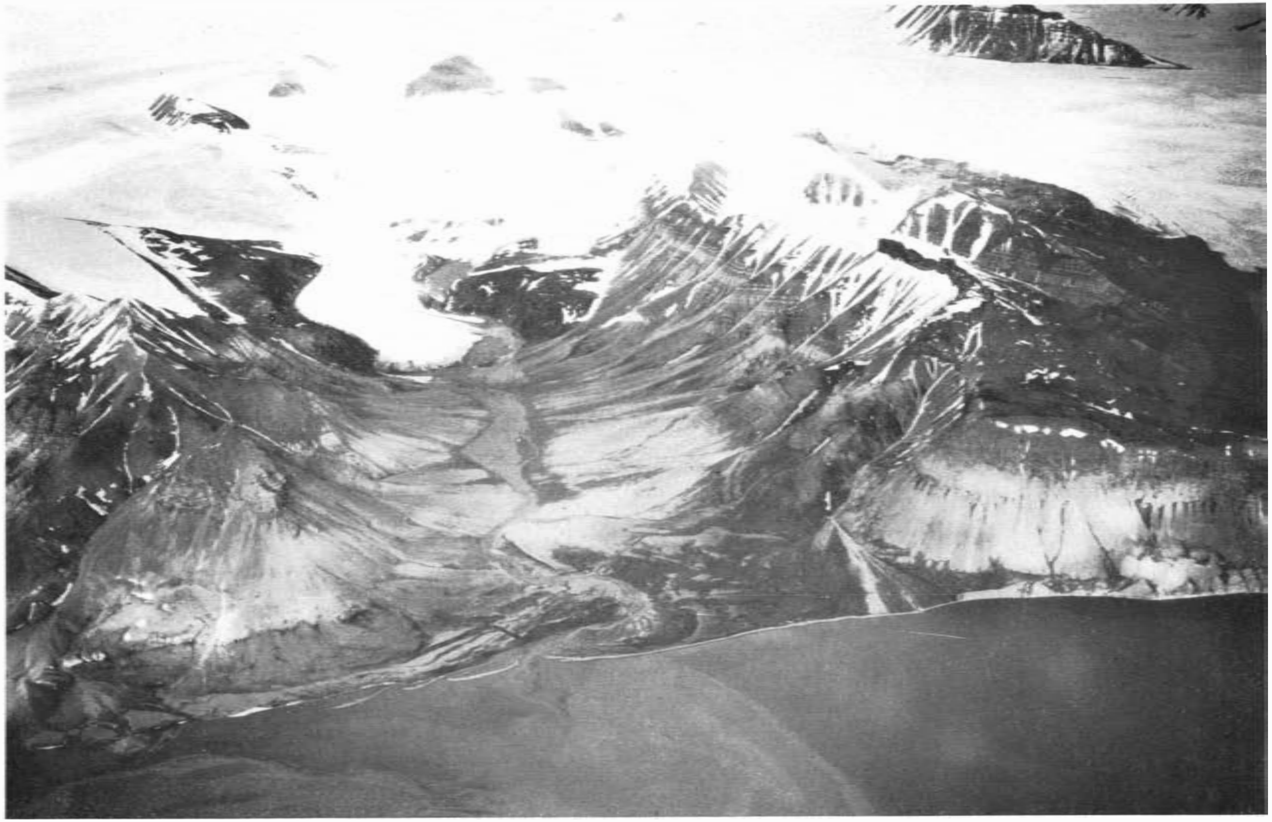


Fig. 1. Ekholmvika with the raised *Astarte* beach plain as seen from the high terrace, 77 m a.s.l., to the east of the bay.
Photo: O. CHR. FEYLING-HANSSEN, July, 1950.

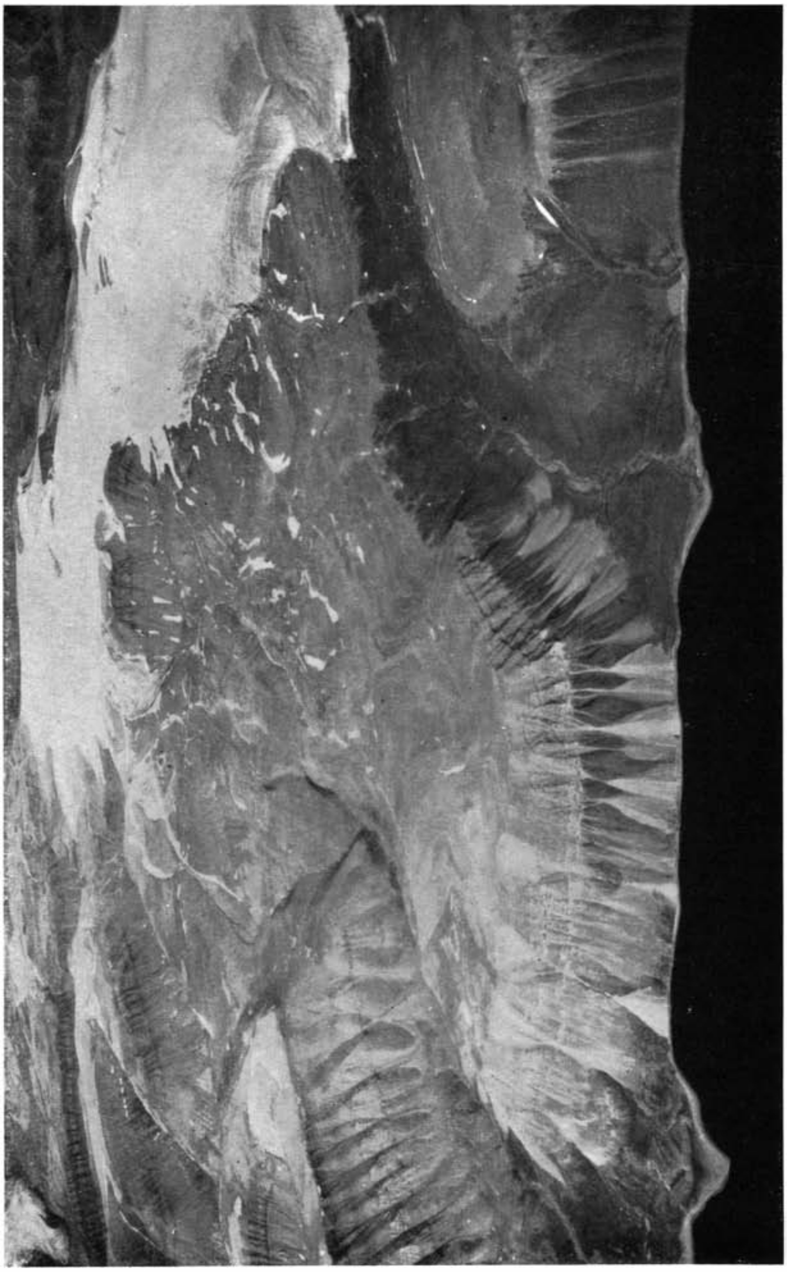


Figs. 2, 3. Details of the stratification within the beach plain deposits, alternating silty and sandy strata; from the *Astarte* beach plain at Ekholmvika.
Photo: L. PEDERSEN, July, 1950.

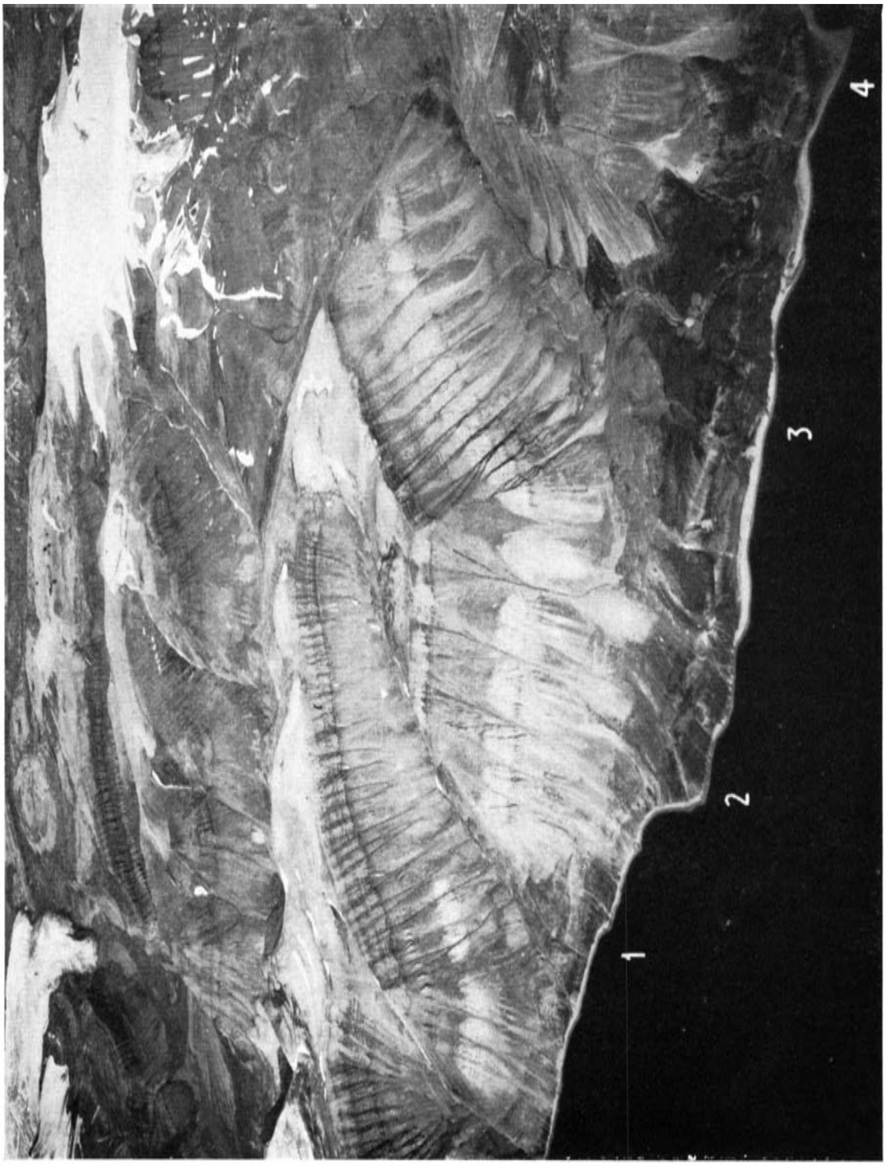
The Brucebyen area from Kapp Napier (1) to Kapp Scott (2). The southern, lateral part of Nordenskiöldbreen to the left bordered by Gerritelva. Photo: B. LUNCKE, July, 1936.



Petuniabukta with Ebbadalen and the raised marine features to the south of the valley. Photo: B. LUNCKE, July, 1936.



Narveneset and Nidedalen. Photo: B. Luncke, Aug. 1936.



Asvindalen (1), Brimerpynten (2), Alvrekdalen (3), and Narveneset (4). Photo: B. LUNCKE, Aug. 1936.

Fig. 1. Skansbukta and Skansdalen. Photo: B. LUNCKE, Aug. 1936.

Fig. 2. Working out a section in the cliff of a terrace on the northeast side of Skansbukta. (Cf. fig. 52 p. 111.) Photo: Author, July, 1950.

Fig. 1. Terrace cliffs at the head of Skansbukta.
Photo: Author, July, 1950.

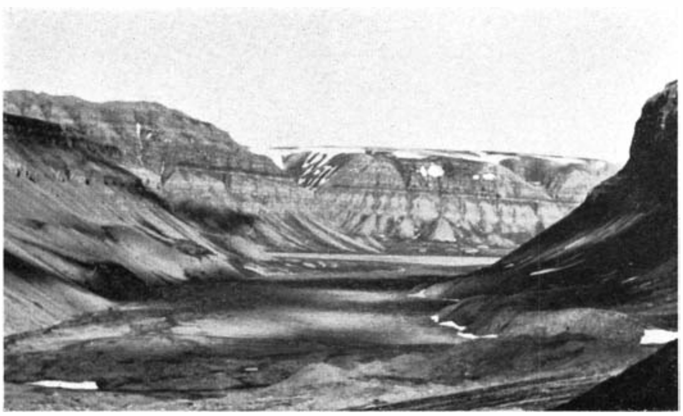
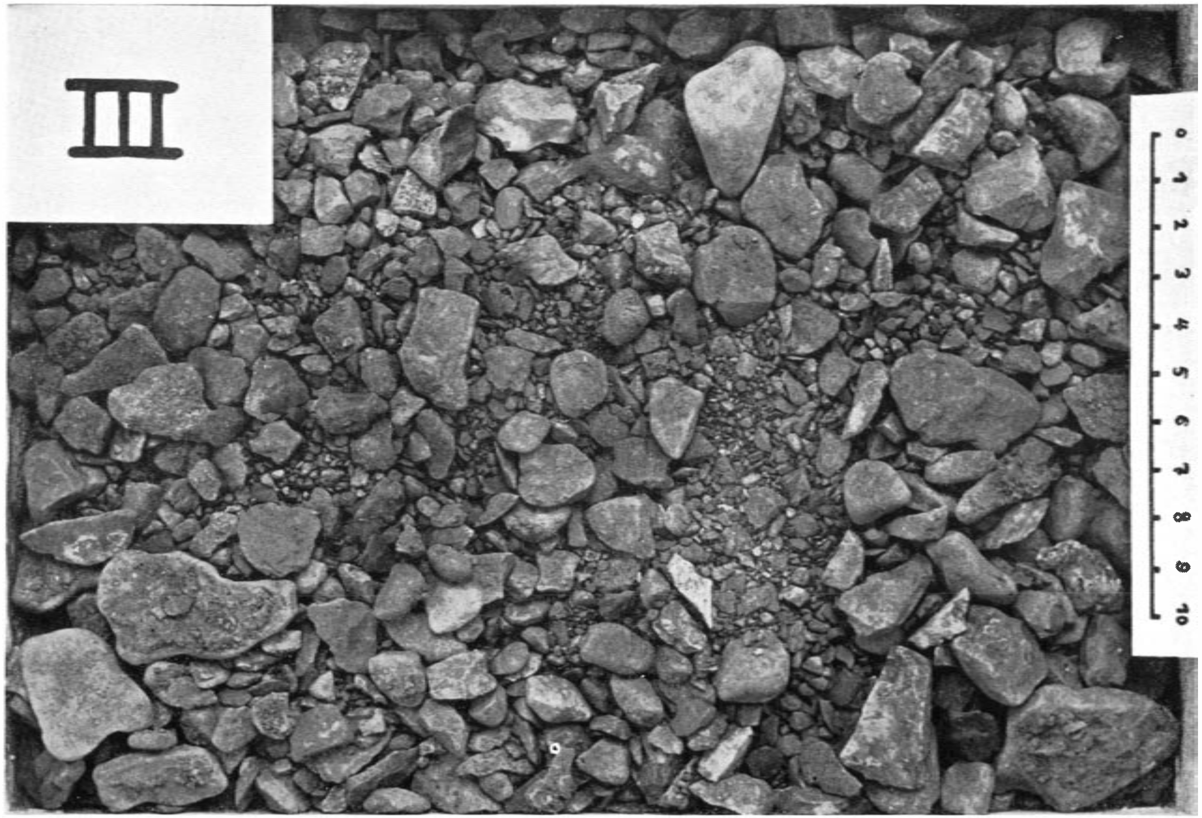


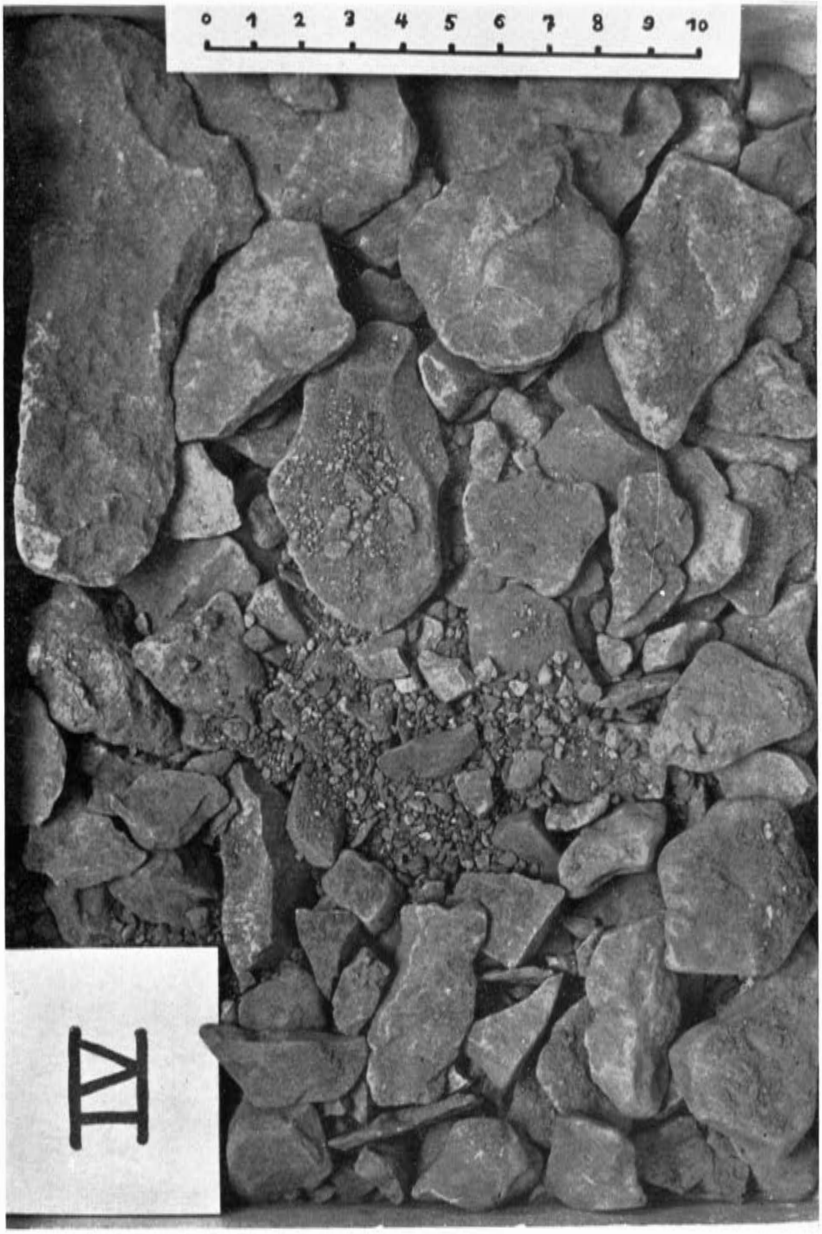
Fig. 2. Skansdalen from Skansdalsbreen.
Photo: Author, July, 1950.

Fig. 3. The terminal moraine of Skansdalsbreen, the front of the glacier to the right.
Photo: Author, July 19th, 1950.

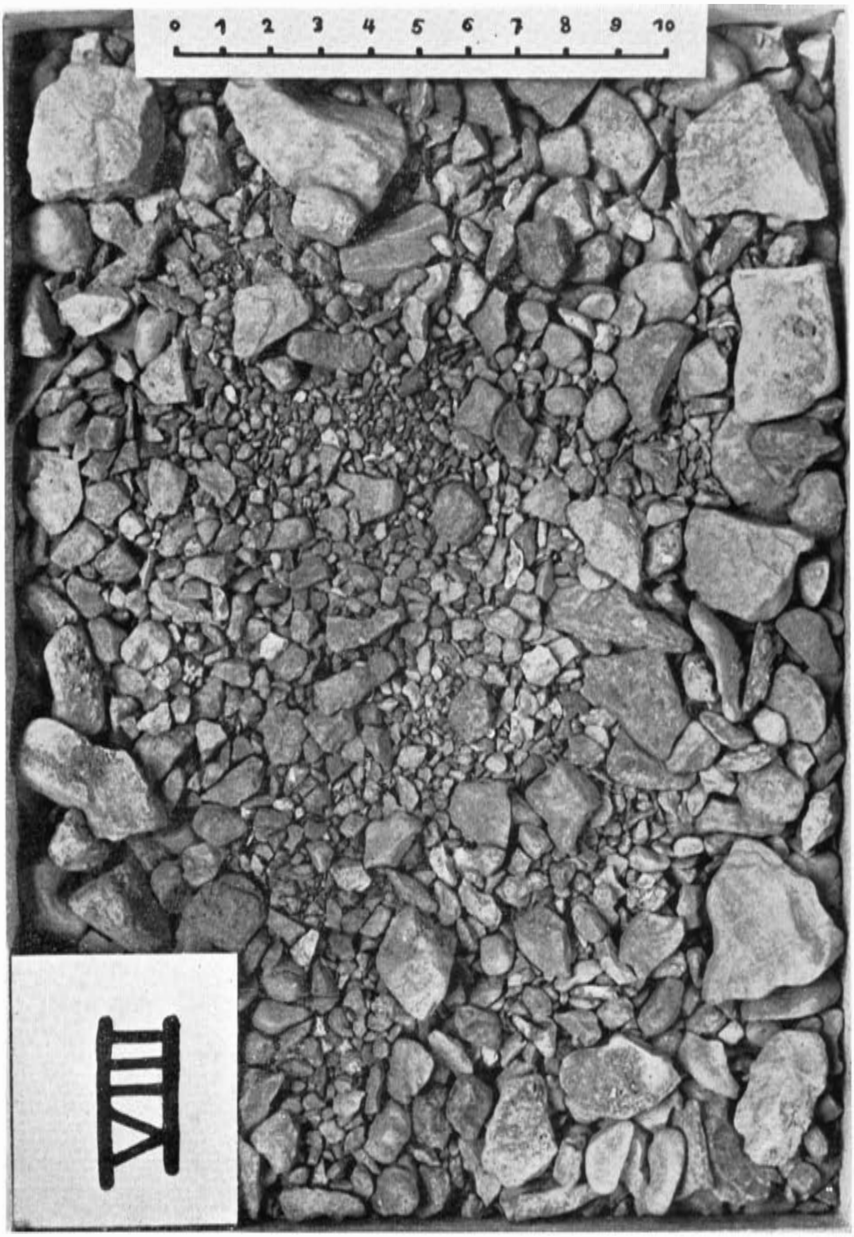
Coarse gravel with frost-split pebbles, sample from the surface layer, 17.7 m a.s.l., of the terrace at the northeast side of Skansbukta. (Cf. fig. 52, p. 111.) The scale refers to centimeter. Photo: B. Mauritz.



Sandy gravel with some frost-split pebbles, sample from 1 m below the surface of the terrace at the northeast side of Skansbukta. (Cf. fig. 52, pp. 111.) Photo: B. MAURITZ.



Coarse gravel with frost-split pebbles and some sand, sample from 1.5 m below the surface of the terrace at the north-east side of Skansbukta. (Cf. fig. 52, p. 111.) Photo: B. Mauritz.



Gravel with rounded and angular pebbles and granules, sample from 3.5 m below the surface of the terrace at the south-east side of Skansbukta. (Cf. fig. 52, p. 111.) Photo: B. MAURITZ.

FOSSIL SPECIES

Photo: B. MAURITZ

Plate 17.

Figs. 1—3. *Tonicella mormorea* (FABRICIUS) . . . . p. 125
Plates from Sørdammen, Brucebyen, 7 m a.s.l. (Sample no. 269 M), × 14.

Figs. 4, 5. *Trachydermon ruber* (LINNÉ) . . . . p. 126
Plates from Sørdammen, Brucebyen, 7 m a.s.l. (Sample no. 269 M), × 14.

Figs. 6—9. *Heteranomia squamula* (LINNÉ) . . . . p. 127
Four valves from a terrace at Petuniabukta, 31 m a.s.l. (Sample no. 368), × 1.4.

Fig. 10. *Crenella decussata* (MONTAGU) . . . . p. 130
A broken valve from *Lithothamnion* silt at Sentabukta, 2 m a.s.l. (Sample no. 356), × 17.

Figs. 11—15, *Lithothamnion* . . . . p. 174
Fragments from *Lithothamnion* silt at Sentabukta, 2 m a.s.l. (Sample no. 356), × 1.

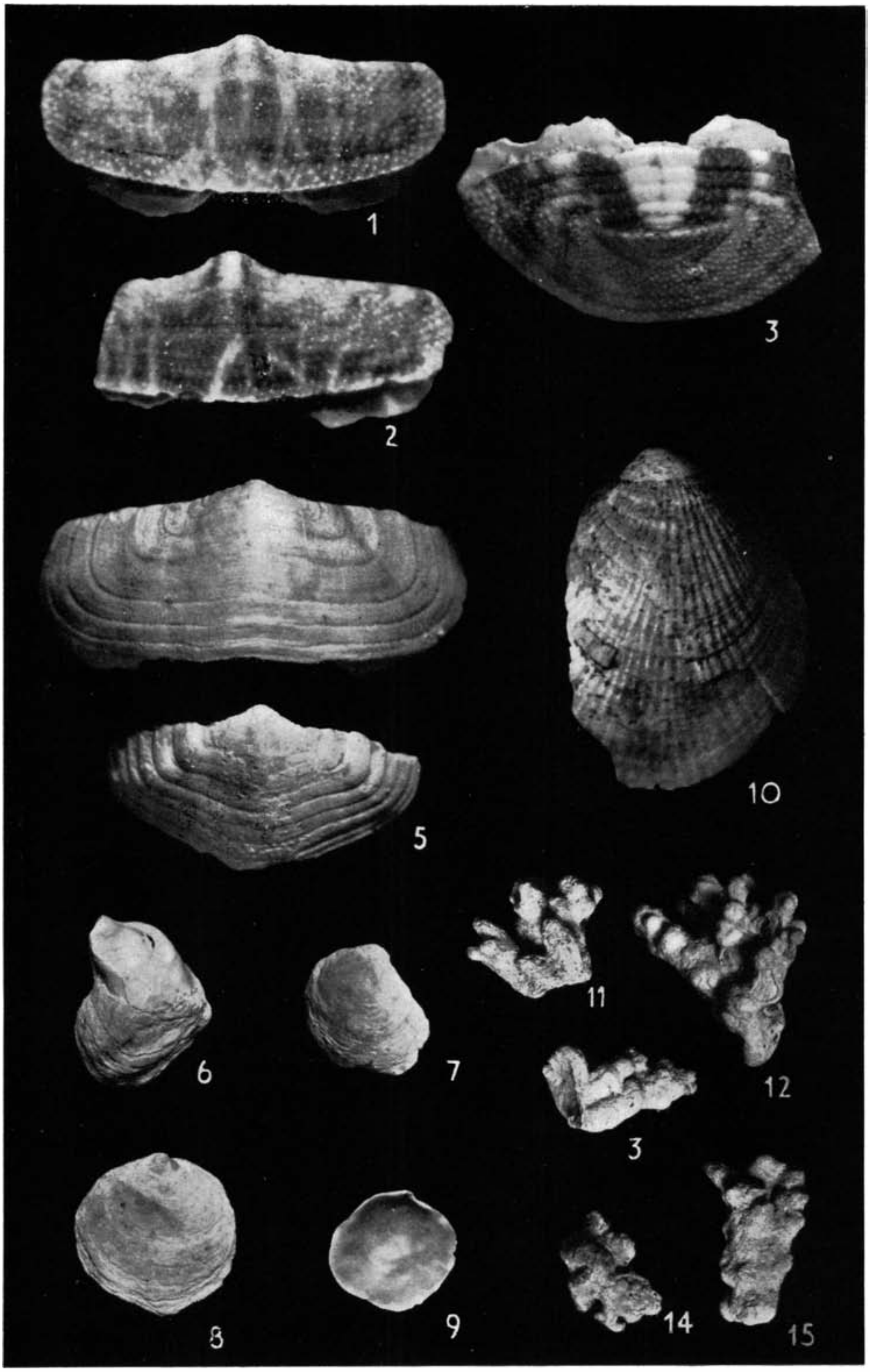

1
3
2
10
5
11
12
6
7
3
8
9
14
15

Plate 18.

Figs. 1—3. *Chlamys islandica* (MÜLLER) .... p. 128
1, A broken valve from a *Mya* terrace north of Phantomvika, 50,7 m a.s.l. (Sample no. 349), × 1; 2, valve from the Recent storm ridge at Petuniabukta, 1 m a.s.l. (Sample no. 372), × 1; 3, broken valve from a cliff at the head of Skansbukta, 2—3 m a.s.l. (Sample no. 305), × 1.

Figs. 4, 5. *Mytilus edulis* LINNÉ .... p. 130
4, internal, and 5, external view of two valves from a *Mytilus* terrace at Asvindalen, 6.2 m a.s.l. (Sample no. 329), × 1.

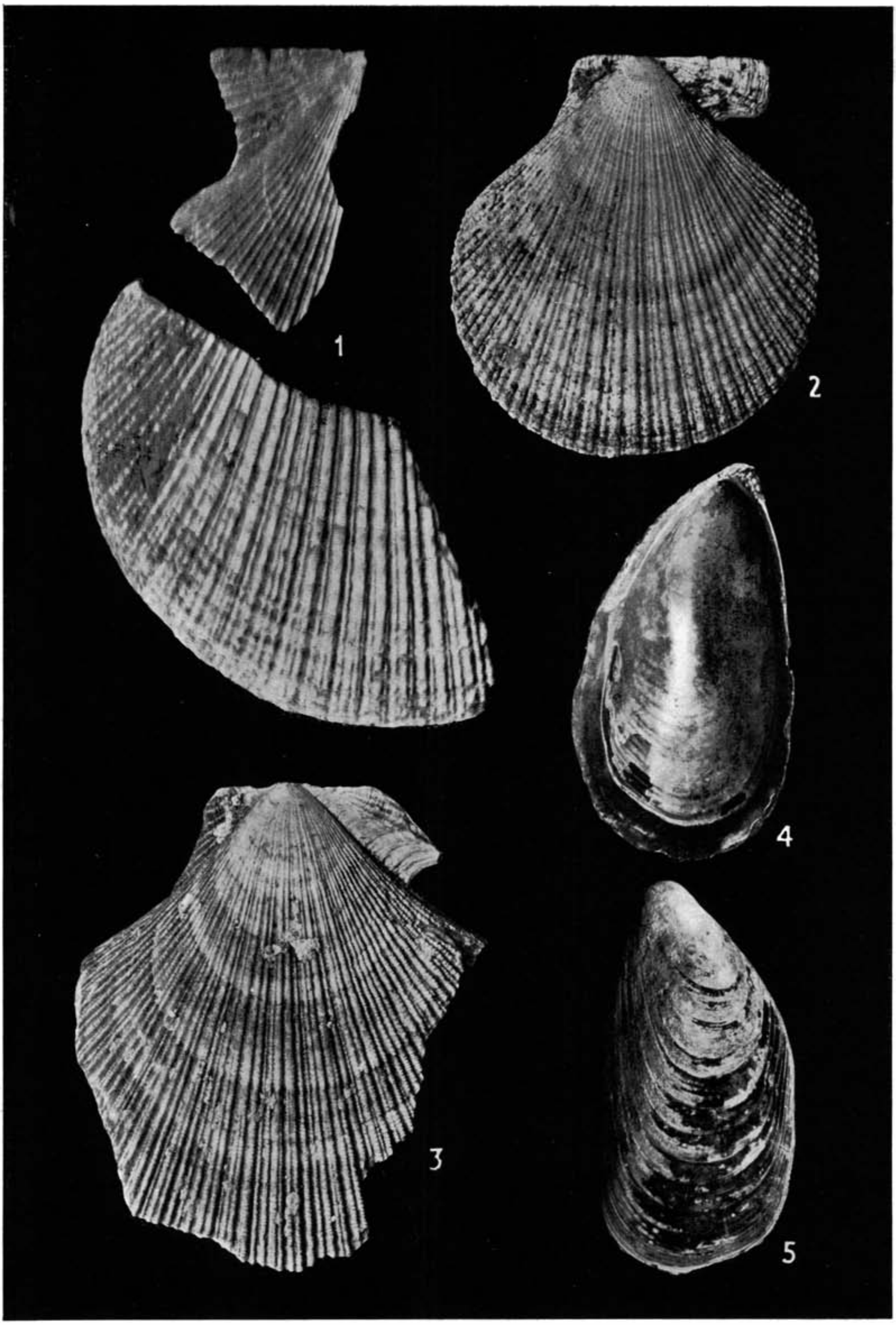

1
2
3
4
5

Plate 19.

Figs. 1—3. *Volsella modiola* (LINNÉ) . . . . p. 133
Three umbonal fragments from an *Astarte* terrace at Petuniabukta, 31 m a.s.l. (Sample no. 368), × 1.

Figs. 4—7. *Musculus discors substriatus* (GRAY) . . . . p. 134
4, external view of a left valve; 5 and 7, external view of right valves; 6, internal view of a right valve, all from the low beach plain at the southwest side of Skansbukta, 2 m a.s.l. (Sample no. 302), × 2.4.

Figs. 7, 8. *Pandora glacialis* LEACH . . . . p. 151
Internal view of the valves of a specimen from the low beach plain at the southwest side of Skansbukta, 2 m a.s.l. (Sample no. 302), × 2.7.


1
2
3
4
5
6
7
8
9

Plate 20.

Figs. 1—8. *Astarte borealis* (CHEMNITZ) .... p. 134

1—6, external view of valves from the sea cliff of the terrace at Anservika, 9.7 m a.s.l. (Sample no. 334), × 1.3; 7, 8, internal view of two valves from *Astarte* plain at Ekholmvika, collected 17 m a.s.l. (Sample no. 350), × 1.3.

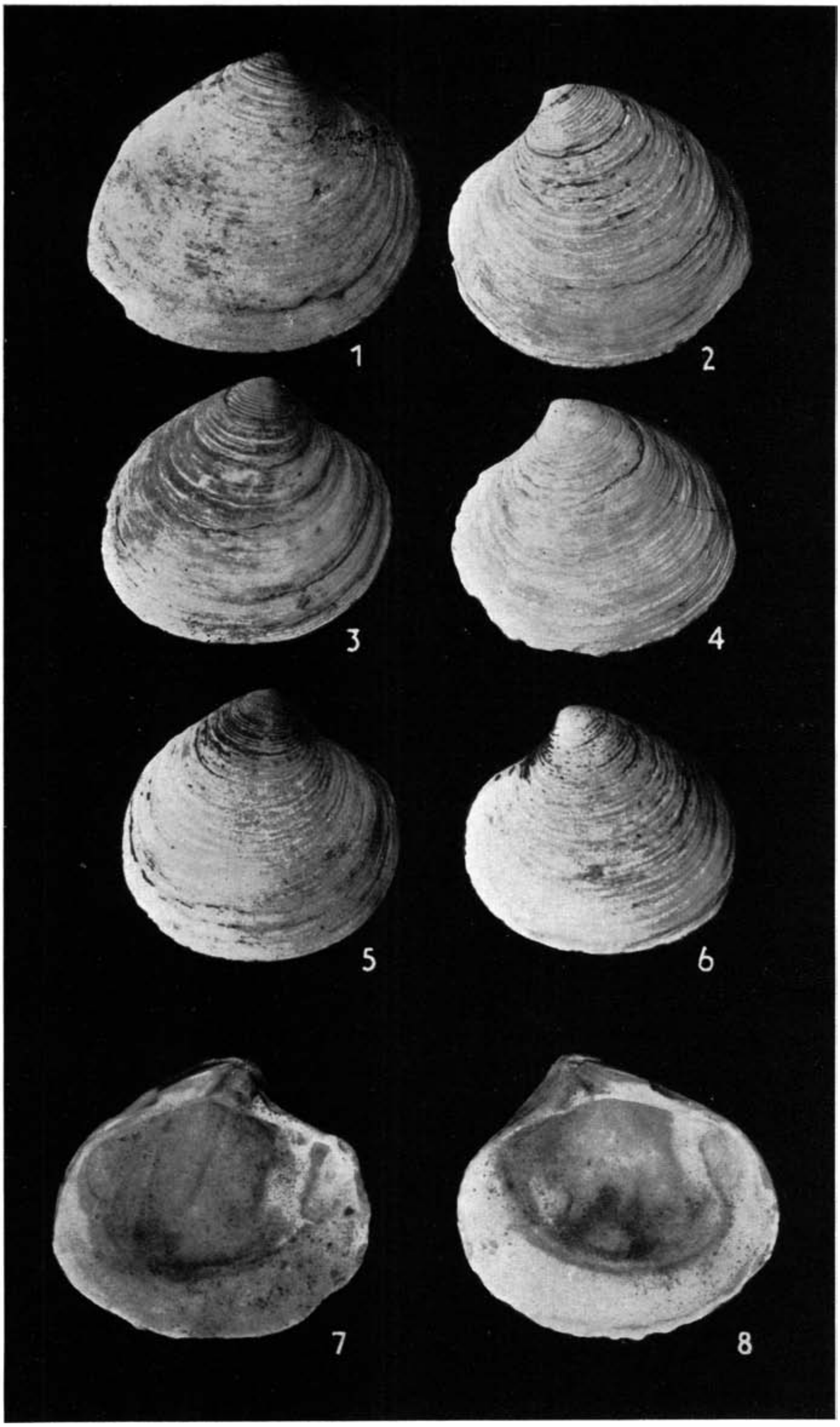

1
2
3
4
5
6
7
8

Plate 21.

Figs. 1, 2. *Astarte borealis* (CHEMNITZ) . . . . p. 134
Two valves with periostracum, from the sea cliff of the terrace at Anservika, 9.7 m a.s.l. (Sample no. 334), × 1.8.

Figs. 3—12. *Astarte montagui* (DILLWYN) . . . . p. 137
3—11, external view of valves with periostracum more or less preserved, from the sea cliff of the terrace at Anservika, 9.7 m a.s.l. (Sample no. 334), × 2.1; 12, internal view of one valve from a terrace at Gerritelva, 14 m a.s.l. (Sample no. 360), × 2.2.

Figs. 13, 14. *Astarte elliptica* (BROWN) . . . . p. 138
Two valves from the sea cliff of the terrace at Anservika, 9.7 m a.s.l. (Sample no. 334), × 1.

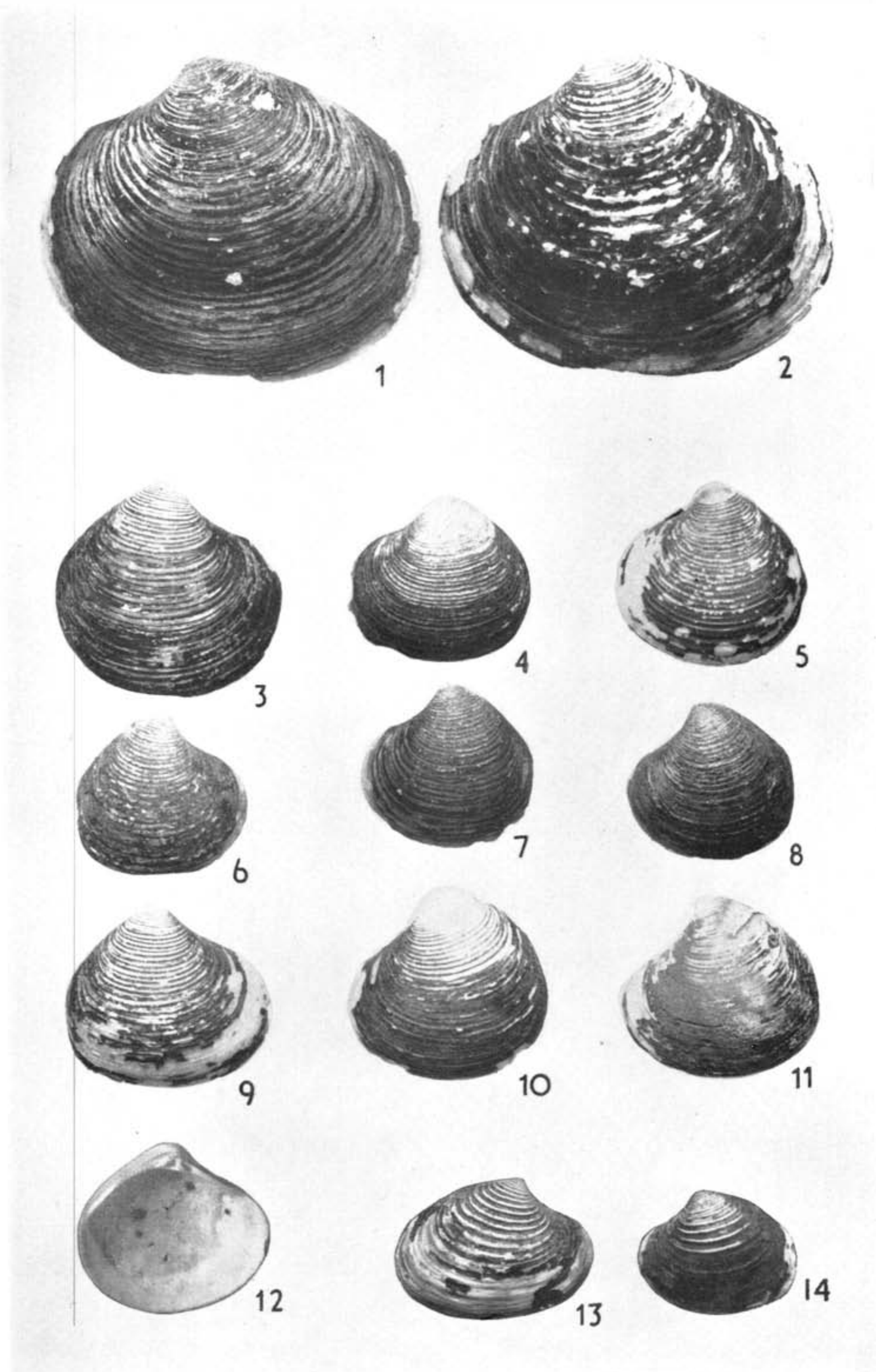

1
2
3
4
5
6
7
8
9
10
11
12
13
14

Plate 22.

Fig. 1. *Thyasira croulinensis* (JEFFREYS) .... p. 141
A valve from *Lithothamnion* silt at Teltfjellbekken, 5.5 m a.s.l. (Sample no. 50 M), × 10.

Fig. 2. *Thyasira sarsii* (PHILIPPI) .... p. 141
Juvenile valve from *Lithothamnion* silt at Teltfjellbekken, 5.8 m a.s.l. (Sample no. 49 M), × 10.

Fig. 3. *Clinocardium ciliatum* (FABRICIUS) .... p. 141
A broken valve from the *Mytilus* terrace at Mytilusbekken, 5.8 m a.s.l. (Sample no. 343), × 1.

Figs. 4, 5. *Serripes groenlandicus* (CHEMNITZ) .... p. 142
4, internal view of a hinge fragment from a terrace at Gerritelva, 23.2 m a.s.l. (Sample no. 362), × 1; 5, a broken valve from the low beach plain at the southwest side of Skansbukta, 2.0 m a.s.l. (Sample no. 302), × 1.

Figs. 6—9. *Cyprina islandica* (LINNÉ) .... p. 143
6, broken, small valve; 7—9, internal view of three hinge fragments, all from an *Astarte* terrace at Gerritelva, 23.2 m a.s.l. (Sample no. 362), × 1.

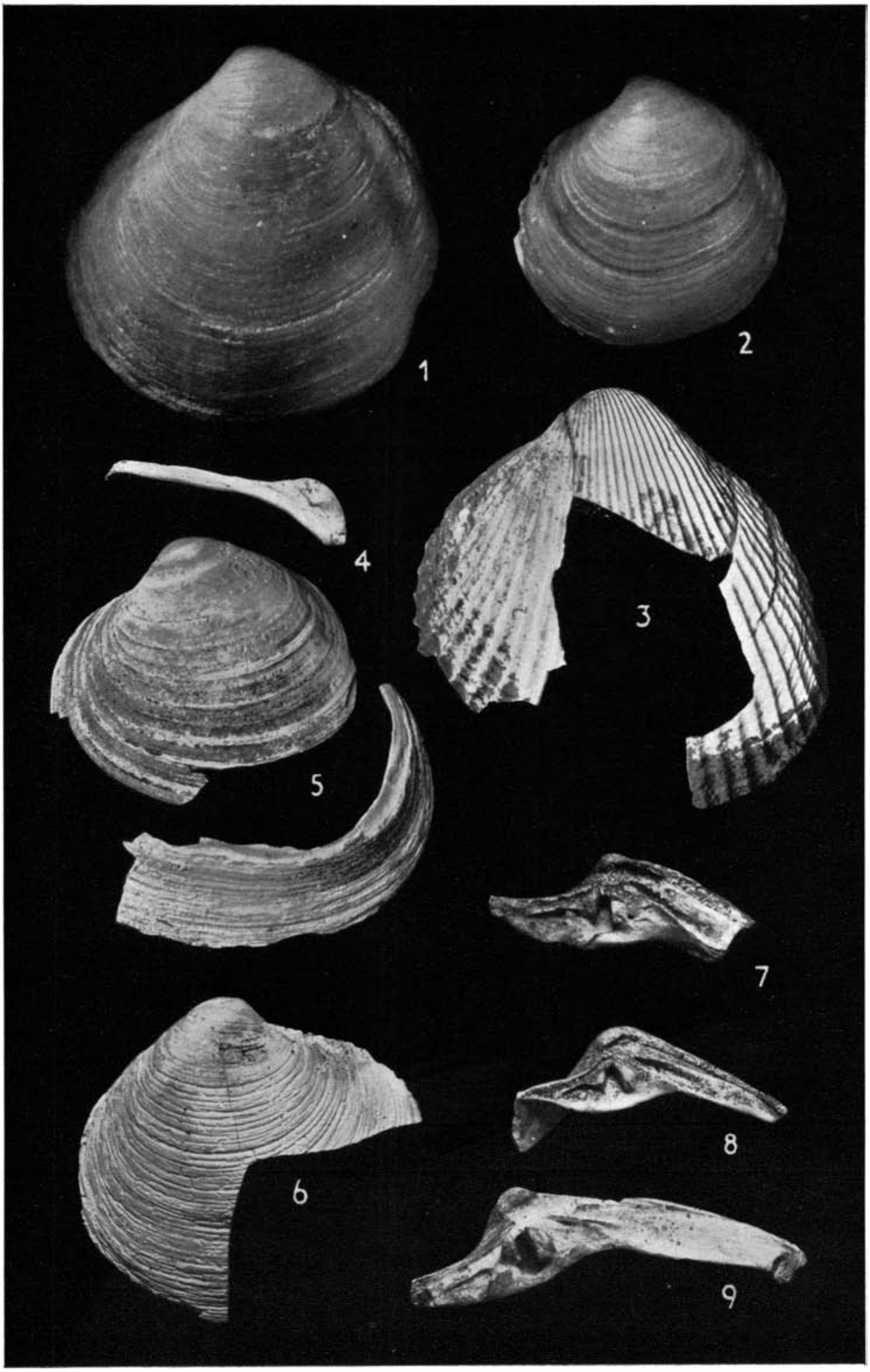

1
2
3
4
5
6
7
8
9

Plate 23.

Figs. 1—3. *Cyprina islandica* (LINNÉ) .... p. 143
1, 2, hinge fragments from the sea cliff of the terrace at Anservika, 9.7 m a.s.l. (Sample no. 334), × 1; 3, external view of a fragment from the ventral margin of a specimen from an *Astarte* terrace at Gerritelva, 23.2 m a.s.l. (Sample no. 362), × 1.

Figs. 4—7. *Saxicava arctica* (LINNÉ) .... p. 146
4, 7, external view, 5, 6, internal view of four valves from a *Mya* terrace north of Phantomvika, 50.7 m a.s.l. (Sample no. 349), × 1.

Figs. 8—13. *Macoma calcarea* (CHEMNITZ) .... p. 145
8, 9, internal view, 10, 11, external view of four valves from a *Mya* terrace north of Phantomvika, 50.7m a.s.l. (Sample no. 349), × 1; 12, 13, external view of two valves from a cliff at the head of Skansbukta, 2—3 m a.s.l. (Sample no. 304), × 1.5.

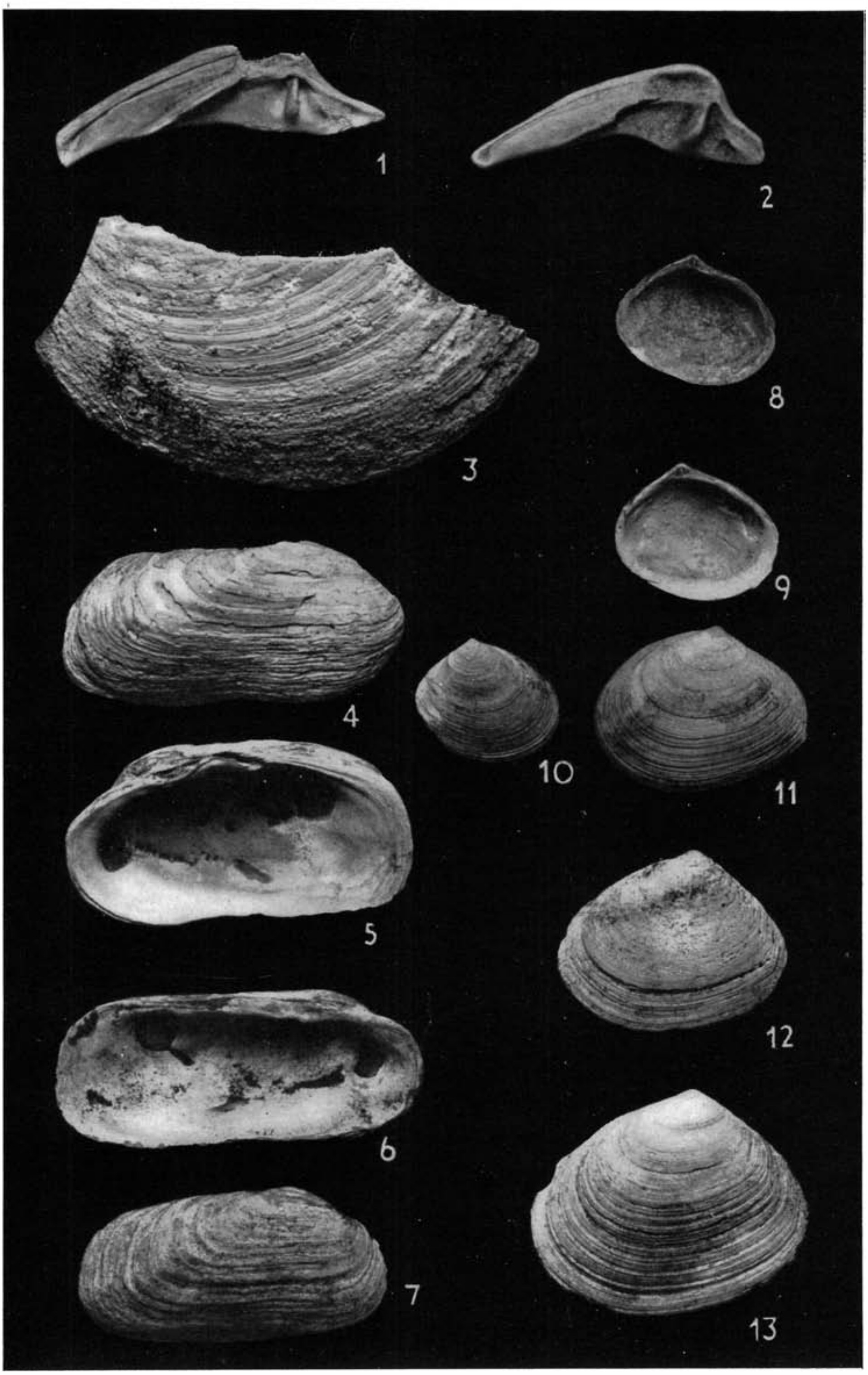


Plate 24.

Figs. 1—5. *Saxicava arctica* (LINNÉ) .... p. 146
Five valves from a cliff at the head of Skansbukta, approx. 2 m a.s.l. (Sample no. 304), × 1.5.

Figs. 6, 7. *Zirfaea crispata* (LINNÉ)... p. 150
6, umbonal fragment from the low beach plain at the southwest side of Skansbukta, 2.0 m a.s.l. (Sample no. 302), × 2.5; 7, umbonal fragment from a cliff at the northeast side of Skansbukta, 14.2 m a.s.l. (Sample no. 312), × 2.5.

Figs. 8—11. *Liocyma fluctuosa* (GOULD)....................................... p. 146
Four valves from the northeast beach of Skansbukta, 0—1 m a.s.l. (Sample no. 300), × 1.7.

Fig. 12. *Emarginula fissura incurva* JEFFREYS .... p. 152
A broken specimen from *Lithothamnion* silt at Sentabukta, 2 m a.s.l. (Sample no. 356), × 20.

Fig. 13. *Lepeta coeca* MÜLLER .... p. 154
A specimen from a cliff at the northeast side of Skansbukta, 14.2 m a.s.l. (Sample no. 312), × 2.5

Fig. 14. *Acmaea rubella* (FABRICIUS) .... p. 153
A specimen from an *Astarte* terrace at the east side of Petuniabukta, 31 m a.s.l. (Sample no. 368), × 1.4.

Fig. 15. *Margarites groenlandicus* (CHEMNITZ) .... p. 154
A specimen from a cliff at the northeast side of Skansbukta, 14.7 m a.s.l. (Sample no. 311), × 3.

Figs. 16, 17. *Moelleria costulata* (MÖLLER) .... p. 157
16, spiral view, 17, umbilical view of two specimens from *Lithothamnion* silt at Sentabukta, 2 m a.s.l. (Sample no. 356), × 16.

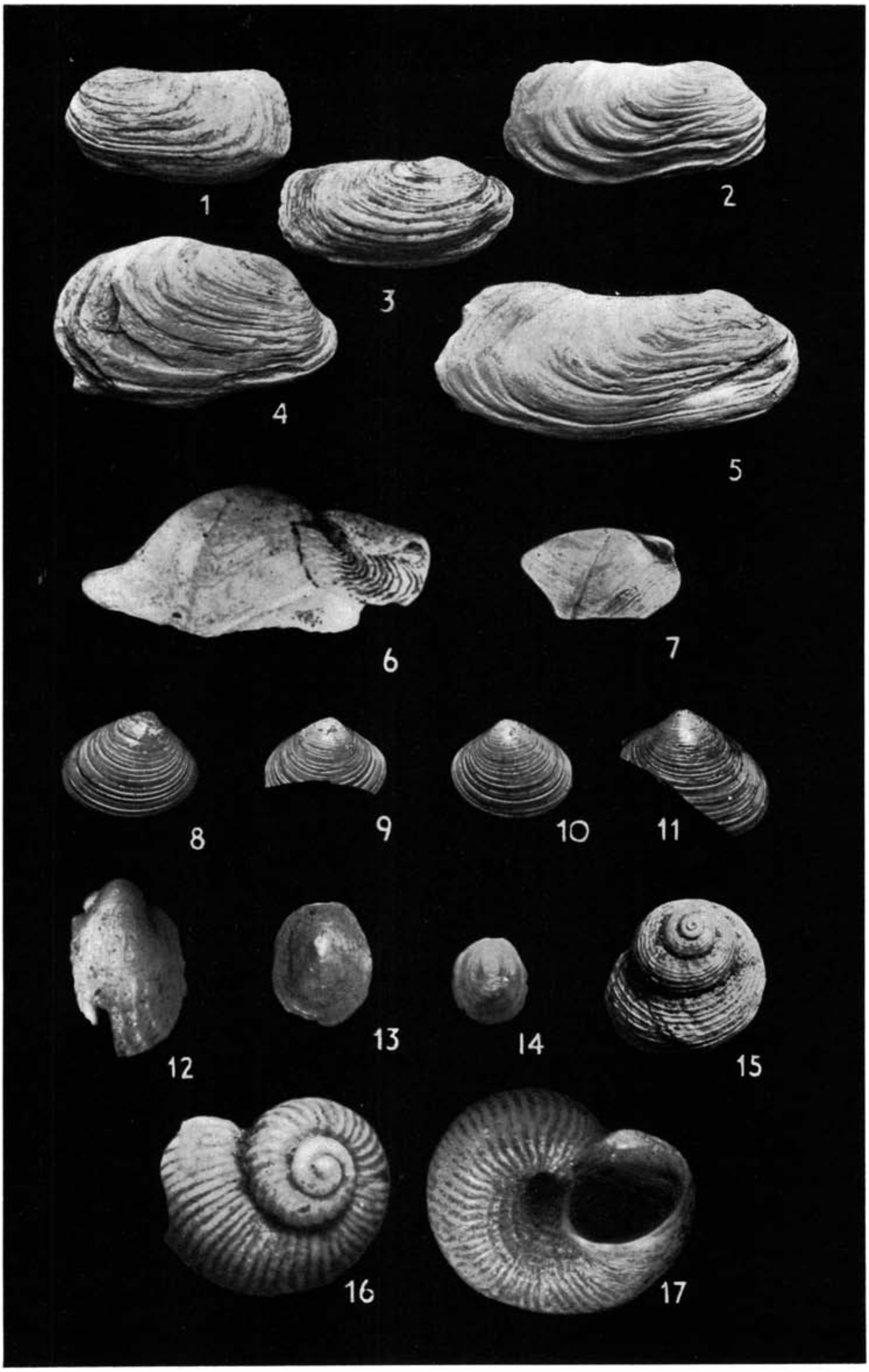

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

Plate 25.

Mya truncata LINNÉ . . . . p. 148
Different forms from the clayey-silty surface of the large *Mya* terrace of Myadalen, 42 m a.s.l. (Sample no. 326), × 0.9.

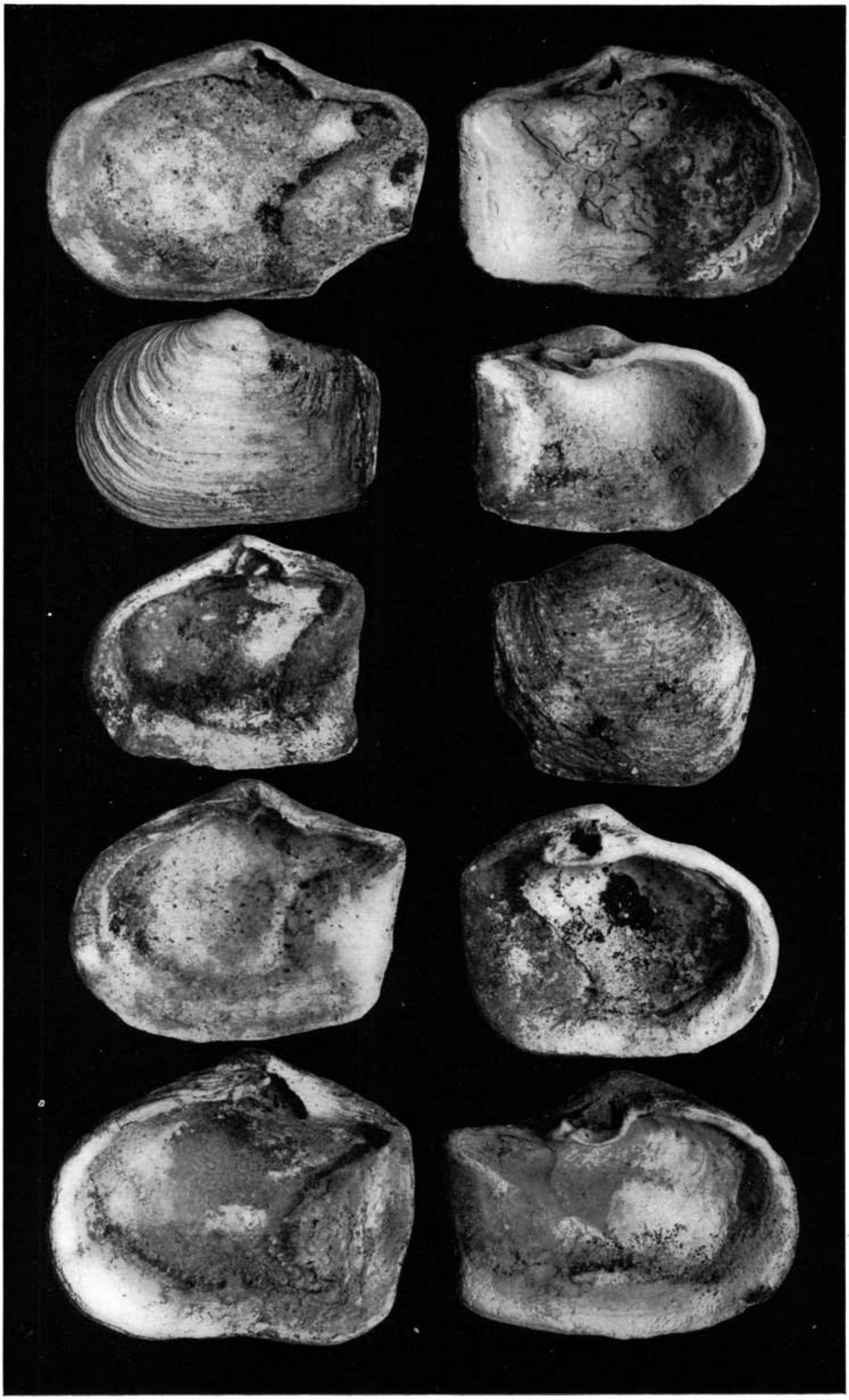


Plate 26.

Figs. 1—3. *Lacuna vincta* (MONTAGU) .... p. 157
1, A specimen from a terrace at the northeast side of Skansbukta, 15.2 m a.s.l. (Sample no. 310), × 2.8; 2, A specimen from the same terrace, 14.7 m a.s.l. (Sample no. 311), × 3; 3, A broken specimen from the same terrace 14.2 m a.s.l. (Sample no. 312), × 1.4.

Figs. 4—8. *Littorina littorea* (LINNÉ) .... p. 160
All specimens from a cliff at the head of Skansbukta, approx. 2 m a.s.l. (Sample no. 304), × 1.4.

Figs. 9, 10. *Cingula castanea* (MÖLLER) .... p. 160
9, A specimen from a silty sample from Sørdammen, Brucebyen, 7 m a.s.l. (Sample no. 269 M), × 17; 10, A specimen from *Lithothamnion* silt at Sentabukta, 2 m a.s.l. (Sample no. 356), × 17.

Figs. 11, 12. *Omalogyra atomus* (PHILIPPI) .... p. 161
11, Apertural view, 12, Side view of a specimen from *Lithothamnion* silt at Sentabukta, 2 m a.s.l. (Sample no. 356), × 22.

Fig. 13. *Natica clausa* BRODERIP and SOWERBY .... p. 162
A specimen from the low beach plain at the northeast side of Skansbukta, 2.2 m a.s.l. (Sample no. 301), × 1.

Fig. 14. *Trophon truncatus* (STRÖM) .... p. 163
A specimen from the Recent storm-ridge at the east side of Petuniabukta, 1 m a.s.l. (Sample no. 372), × 1.

Figs. 15, 16. *Verruca stroemia* (MÜLLER) .... p. 171
15, Tergum, 16, Carina (deformed) from a silty sample from Sordammen, Brucebyen, 7 m a.s.l. (Sample no. 269 M), × 17.

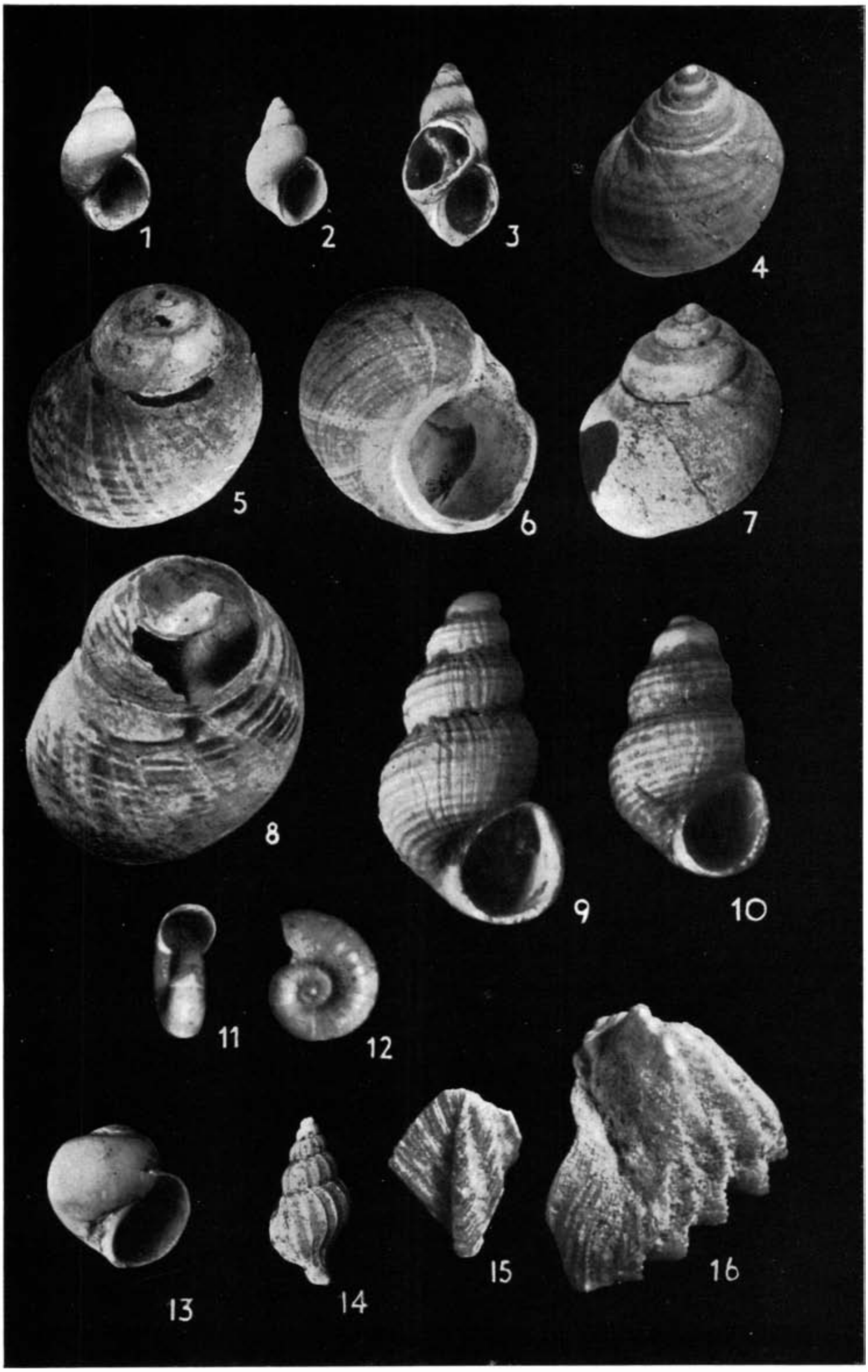
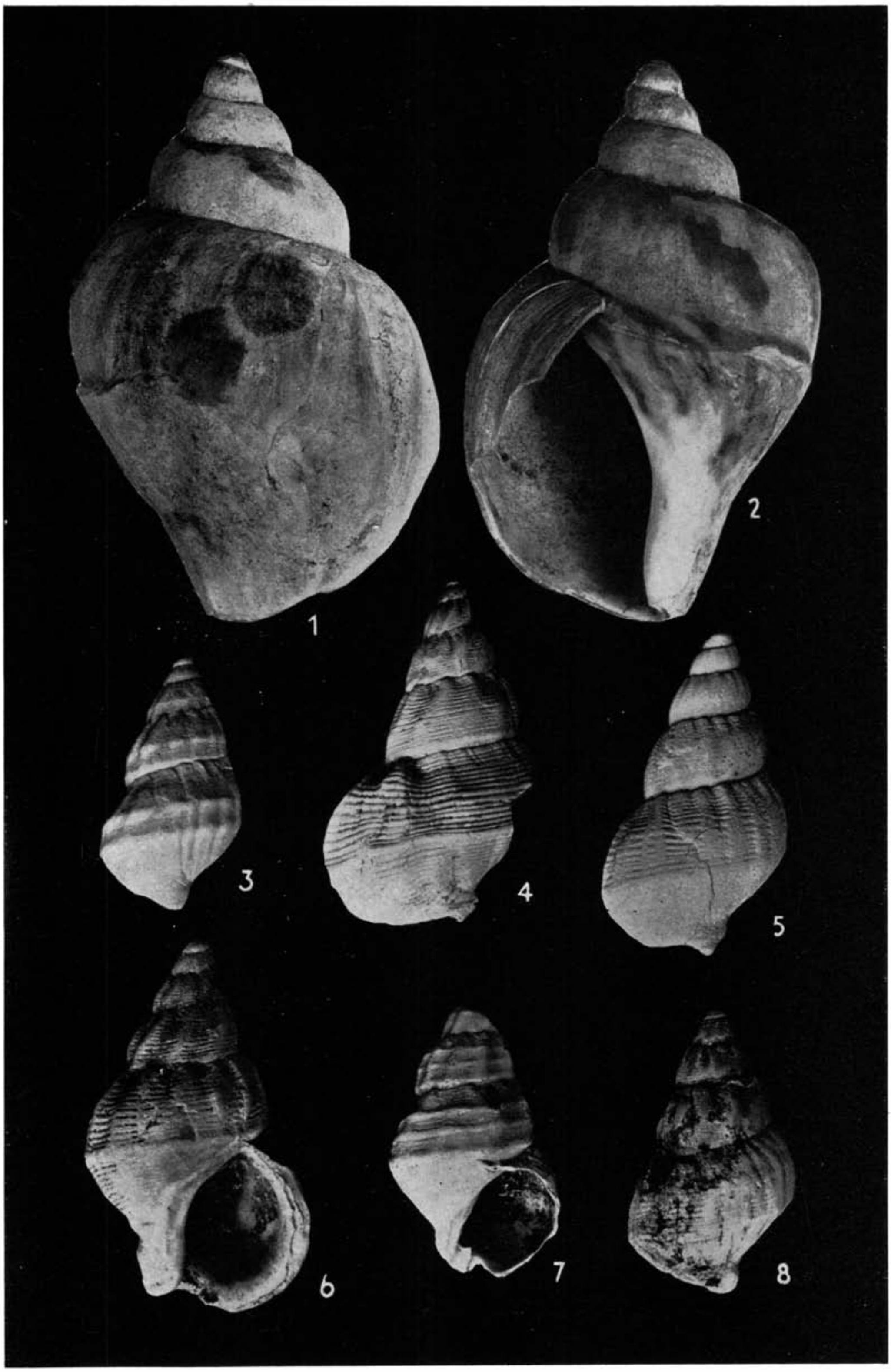

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

Plate 27.

Figs. 1, 2. *Pyrulofusus deformis* (REEVE) .... p. 166
1, side view, 2, apertural view of a specimen from the low beach plain at the northeast side of Skansbukta, 2.2 m a.s.l. (Sample no. 301), × 1.

Figs. 3—8. *Buccinum glaciale* LINNÉ... p. 168
Different forms from the low beach plain at the southwest side of Skansbukta, 2.0 m a.s.l. (Sample no. 302), × 1.


1
2
3
4
5
6
7
8

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.

MAPS AND CHARTS

The following topographical maps and charts have been published separately:

Maps:

Bjørnøya. 1:25000. 1925. New edition 1944. Kr. 3,00.
Bjørnøya. 1:10000. [In six sheets.] 1925. Kr. 30,00.
Adventfjorden—Braganzavågen. 1:100000. 1941. Kr. 2,00.
Svalbard. 1:2000000. 1937. New edition 1944. Kr. 1,00.
Topografisk kart over Svalbard. Blad C 13. Sørkapp. 1:100000. 1947. Kr. 3,00.
Topografisk kart over Svalbard. Blad B 10. Van Mijenfjorden. 1:100000. 1948. Kr. 3,00.
Topografisk kart over Svalbard. Blad C 9. Adventdalen. 1:100000. 1950. Kr. 3,00.
Topografisk kart over Svalbard. Blad B 11. Van Keulenfjorden. 1:100000. 1952. Kr. 3,00.
Topografisk kart over Svalbard. Blad B 12. Torellbreen. 1:100000. 1953. Kr. 3,00.
Austgrønland. Eirik Raudes Land frå Sofiasund til Youngsund. 1:200000. 1932. Kr. 2,00.

Preliminary topographical maps [1:50000] covering claims to land in Svalbard and a preliminary map of Hopen 1:100000 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. 1:40000. 1932. Kr. 4,00.
„ 502. Bjørnøyfarvatnet. 1:350000. 1937. Kr. 4,00.
„ 503. Frå Bellsund til Forlandsrevet med Isfjorden. 1:200000. 1932. Kr. 5,00.
„ 504. Frå Sørkapp til Bellsund. 1:200000. 1938. Kr. 5,00.
„ 505. Norge—Svalbard, nordre blad. 1:750000. 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. 1:100000. 1934. Kr. 4,00.
„ 509. Frå Storfjordrenna til Forlandsrevet med Isfjorden. 1:350000. 1946. Kr. 4,00.
„ 510. Frå Kapp Linné med Isfjorden til Sorgfjorden. 1:350000. 1946. Kr. 4,00.
„ 511. Austgrønland, frå Liverpoolkysten til Store Koldeweyøya. 1:600000. 1937. Kr. 4,00.

Prices above do not include purchase tax.