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THE MARINE QUATERNARY SEDIMENTS IN DISKO BUGT

BY

POUL HARDER†, AD. S. JENSEN,
AND DAN LAURSEN

WITH 18 FIGURES IN THE TEXT, 1 TABLE,
AND 8 PLATES

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Abstract.

On the basis of studies of the marine quaternary in four localities in Disko Bugt, viz.: Sydostbugten, Orpigsôq, Kangersuneq and Lerbugten south of Claushavn, made firstly by HARDER & JENSEN in 1906 (preliminary rapport 1910) and afterwards, in 1946, by LAURSEN (certain supplementary investigations), the authors have set up the sequence of these sediments in this part of the coast of West Greenland.

The marine quaternary is divided into six horizons as follows:

Horizon A: High-arctic sediments, characterized by *Portlandia arctica* (GRAY).
Horizon B: Arctic sediments, characterized by *Balanus hammeri* ASCAN.
Horizon C: Arctic sediments, characterized by *Mya truncata* (L.) forma *ovata* JENSEN.
Horizon D: High-arctic sediments, characterized by *Portlandia arctica* (GRAY).
Horizon E: Arctic sediments, characterized by *Pecten islandicus* MÜLL.
Horizon F: Boreal sediments, characterized by *Zirphaea crispata* (L.).

When describing the various localities the authors give an account of what species occur in the sediments, and it is pointed out prefatorily that *Pecten islandicus* MÜLL. in high-arctic regions must be regarded as a relict.

PREFACE

By Ad. S. Jensen.

In 1905 I published a paper: "On the Mollusca of East Greenland, I, Lamellibranchiata"[1]). It was introduced (pp. 289—305) with a section entitled: "On the fossil quaternary Mollusc-Fauna of Greenland", in which I advanced the opinion that the characteristic mollusc of the Arctic Ocean, *Portlandia arctica* (Gray) had disappeared from the south coast of West Greenland. Energetic private collectors and large official expeditions have all brought back a considerable material for the determination of the general character of the fauna, but without having found *Portlandia arctica*. It is true that in the earlier lists of Greenland's mollusc fauna, *Portlandia arctica* appeared as a recent form from certain localities of the west coast, but the specimens on which these records are based are either fossil or of a very old appearance, and therefore they cannot be taken as proof of the present occurrence of the species there. I was unsuccessful in tracing recent specimens found more to the south than in Murchison Sound, between lat. 77° and 78° N.; they were in the museum at Lund and had been found by the late Swedish zoologist A. Ohlin.

That *Portlandia arctica* was commonly distributed in southern West Greenland formerly in contrast to the present time is evident i. a. by the fact that it has frequently been taken in emerged layers on the east and south sides of Disko Bugt and the west side of Disko, regions particularly visited by travellers.

As available information regarding the hydrography of some West Greenland fiords made it seem not unlikely that *Portlandia arctica* might be living there nowadays, I presented the theory that it is extinct in southwestern Greenland for the reason that the temperature of the sea water during a period of the post-glacial time exceeded the limit at which this bivalve can live, and that it had no opportunity of migrating south and recovering the lost area afterwards when conditions had again become favourable. But, if there had been a warmer period in

[1]) Meddelelser om Grønland, Vol. XXIX, 1905.

post-glacial time, it would have left some traces and we might expect that some southern forms would have appeared and again have retired.

I considered I had found an example of this in *Cyprina islandica* L. This bivalve is a typical boreal form. The northern limit of its range may be drawn from the upper "warm" area of the White Sea and the Murman coast, round the north of Iceland to the Bank of Newfoundland and the southern part of the Gulf of St. Lawrence. However, dead shells of *Cyprina islandica* have frequently been found in southern West Greenland, where the species does not live at present. Accordingly, they originate from a warmer period in Greenland's history.

Another bivalve of a warmer period is *Anomia squamula* L. This too is a boreal form. In Europe it gets no farther than to the Murman coast and the "warm" area of the White Sea; it does not invade the eastern Murman Sea which forms part of the "cold" area of the Arctic Ocean. On the American side it ranges northwards to the southern part of Labrador, but it has never been found alive on the coast of Greenland. As a fossil, on the other hand, it has been recovered at two places on the west coast of Greenland: at Evighedsfjord (lat. 65°50′ N.) and Ikertôq (lat. 66°45′ N.) in beach ridges at heights of 15 to 25 feet.

Much interested as I was in these finds, which seemed to suggest that during a period of the quaternary West Greenland had a warmer marine climate than at present, I asked our naturalists visiting Greenland to collect shells from beach ridges and terraces. Among those who complied with my request, Dr. M. C. ENGELL succeeded in making an interesting and important find.

Among the shells he brought back from his explorations and surveys in the regions round Disko Bugt (1902—04) were two shells of *Zirphaea crispata* (L.) from marine sediments inside Orpigsôq fiord, south of Christianshaab. *Zirphaea crispata* no longer lives off the west coast of Greenland. In North America its proper home is at New England, and the northern limit is in southeastern Canada at the Gulf of St. Lawrence. On the European side of the Atlantic it ranges from western France to northern Norway, where it has been found in West Finmark, but not in East Finmark; it also lives off southwestern Iceland. *Zirphaea crispata* is thus a typically boreal form. The bed at Orpigsôq in which its shells occur must have been deposited during a climate at least as mild as that prevailing at present in the sea off southernmost Canada and West Finmark.

As a result of my reflections I pointed out that it would be a profitable task for Danish natural science to make a thorough examination of the quaternary sediments in West Greenland and their fossils for the purpose of obtaining a deeper insight into the history of Greenland in the quaternary period. In order to begin with a convenient field for an

investigation of this kind I proposed the territory in the southern and eastern parts of Disko Bugt, especially the region of Orpigsôq. My reason was that in this relatively limited area there were representatives of the changing fauna elements of the shifting periods: There HARTZ had collected the representative of the high-arctic fauna, *Portlandia arctica*, and ENGELL the representative of the boreal fauna, *Zirphaea crispata*.

As a result of that paper, the Commission for the Direction of Geological and Geographical Investigations in Greenland (Rear-Admiral C. F. WANDEL, Commodore GUSTAV HOLM and the geologist K. J. V. STEENSTRUP, Ph. D.) decided already in 1906 to send out an expedition to study the raised marine sediments of the quaternary at Sydostbugten. Those selected for the expedition were POUL HARDER, assistant at the Danish Geological Survey, and AD. S. JENSEN, assistant at the Zoological Museum, Copenhagen. The expedition sailed from Copenhagen on May 27th and arrived at Egedesminde on June 15th, whence it travelled by boat with a crew of Greenlanders to Orpigsôq, arriving there on June 21st, and camping on Qarajaq. On July 7th the camp was moved into the upper end of Orpigsôq fiord. On July 27th the expedition travelled to Sarfarssuit[1]) in Kangersuneq, and on August 4th to Naternaq. From there the journey proceeded on August 11th to Christianshaab and thence to Lerbugten at Claushavn, sojourning there from August 14th to 18th. The co-operation terminated at Jakobshavn, where AD. S. JENSEN with grab and plankton net studied the present-day fauna, while POUL HARDER proceeded along the southeast shore of Disko over to Godhavn, where he made geological investigations in Blæsedalen. The two members of the expedition met again at Egedesminde and left there on September 9th.

As a result of various circumstances, many years passed before the collective material of the expedition could be published[2]). In the autumn of 1945, however, I asked DAN LAURSEN, M. A., the quaternary specialist, who during the following summer intended to visit the areas where HARDER and I had worked in 1906, whether he would care to go through HARDER's diaries and put them into such shape that I could append my lists of shells. He very obligingly undertook that very arduous work and thereby helped me out of a difficulty which otherwise I should have been unable to surmount; for only a trained

[1]) Now officially called Sarfarssuaq.

[2]) A preliminary account was given in 1910 in a paper by AD. S. JENSEN and POUL HARDER: Post-Glacial changes of climate in Arctic regions as revealed by investigations on marine deposits. Postglaziale Klimaveränderungen. Stockholm 1910. The section on Greenland occupies pp. 402—406.

quaternary geologist, familiar with the regions in question from personal inspection, was qualified for the work now before him.

HARDER had left a diary of 63 close-written pages, with a description of the course of the investigation at the various localities; two journals, one concerning the photographs he took and one the surveys made; a sketch-book with numerous drawings of sections, and the beginnings of a manuscript with its disposition for the entire work.[1]) In addition, there were two lecture manuscripts, though these were of no assistance in the compilation of the report, being in general and rather popular terms. Moreover, in my own possession I had an album of photographs, but only those of the size 18×24 cm. By persistent energy DAN LAURSEN succeeded in finding the original plates of these pictures in the plate archives of the University Museum of Mineralogy and Geology, but not the many plates 9×12 cm which HARDER had also taken, according to his notes.

One difficulty about the work was that in his diary descriptions HARDER made almost exclusive use of locality names not directly recognizable on the available maps. Moreover, there were frequent references which made it practically impossible to find out the position of the clay or sand layers between which comparisons were made. As a consequence, it was necessary for DAN LAURSEN to draw maps of the areas concerned on a large scale (1:15,000) in order exactly to fix the position of these localities; the maps were drawn on the basis of the Geodetic Institute maps, scale 1:250,000. On the new maps we then reconstructed the routes travelled by HARDER and me and by HARDER alone. By means of inserting on the maps the rocks found at the various places, whether or not shells were found there, and finally the page number in the diary where the particular information was entered, it was possible gradually to obtain the necessary view over the areas to permit of the beginning of a manuscript.

HARDER having drawn up a disposition, it was natural that the report should be formed in accordance with it. DAN LAURSEN also considered it of importance to form the manuscript in a style as near to that of HARDER as possible, this being practicable because, as I have said, some manuscript had already been written by the latter. These things no doubt lightened the labour, but at the same time made the task more confined. When writing the manuscript it appeared that HARDER's diaries as regards one or two localities were not so exhaustive as to provide information enough for a description of the conditions there, but this was remedied partly by my giving DAN LAURSEN my diaries, which contained supplementary particulars, and partly by his

[1]) Pp. 15—24 and pp. 55—65 with some additions and verbal alterations.

filling the gaps when he visited the places himself. This applies to the localities: Lerbugten south of Claushavn in its entirety, and Marraq on the south shore of Sydostbugten in part.

In the spring of 1946 the descriptive part of the paper was finished; and as DAN LAURSEN as stated was to be sent out that summer by "GEOLOGICAL SURVEY OF GREENLAND (G. G. U.)" for the purpose of continuing certain already commenced quaternary-geological investigations in West Greenland, it was decided that he should visit the areas in question, partly to make supplementary surveys and partly in order to ascertain whether his account taken from the diaries agreed with the actual facts. Events proved that it did, and after his return from Greenland in the autumn of 1946 it was possible to draw up the summarizing chapters.

All the identifications in the lists of fossils were made by me with the exception of the Bryozoa and the Serpulides living in limestone tubes, kindly determined for me by the expert on such matters, G. M. R. LEVINSEN, keeper at the Zoological Museum.

Brackets () around a species mean that it is not native to the layer, but that its presence there is due to contamination, e. g. by being washed out from earlier sediments or by the frequent, violent storms.

To the observations made in the aforesaid paper of 1905 on the subject of changes in the fauna of West Greenland in the quaternary period, it may be proper to add some information concerning certain animal forms of particular importance to the question of climatic changes in the quaternary.

Regarding the present and past distribution of the arctic bivalve *Portlandia arctica* (GRAY) in Greenland, I gave a comprehensive account in a paper of 1942, together with a statement of its distribution all round the Arctic Ocean and of what may be said on its ecology[1]).

Cyprina islandica (L.) was found in raised layers in the southernmost part of Holsteinsborg District and brought home to the Zoological Museum. The then Royal Inspector of South Greenland, O. BENDIXEN, made the find in 1918 at Itivneq, between the head of Itivdleq fiord and Søndre Strømfjord, where there were deposits of clay and gravel with huge masses of shells. Mr. BENDIXEN took a sample of the shells, inter alia of *Cyprina islandica* a left valve of an adult specimen and a fragment of a shell, also of an adult specimen[2]). *C. islandica* no longer

[1]) AD. S. JENSEN in Det Kgl. Danske Vidensk. Selsk. Biolog. Meddel. Bd. XVII, No. 4, pp. 5—17 and pp. 18—22, chart 2 and chart 3. 1942. Also, cf. DAN LAURSEN, Medd. om Grønl. Bd. 135, No. 8, pp. 44—46 and fig. 15. 1944.

[2]) AD. S. JENSEN l. c. 1942 pp. 24—27 and fig. 4.

lives in Greenland; it is distinctly a boreal species and its presence in emerged layers proves that during a period of the postglacial time a mild climate prevailed similar to that which we have demonstrated for the region of Sydostbugten. The definite finding of *Cyprina islandica* in a post-glacial deposit in West Greenland is so much the more significant, as Swedish workers have exemplified its occurrence in post-glacial deposits on Svalbard[1]) as one of the proofs that a mild climate prevailed up there in a period near to the present time[2]).

I make use of this opportunity to recall that Dr. V. NORDMANN demonstrated that at Svalbard there lived another boreal mollusc that was common to that island and Greenland, but is now extinct at both places, viz. *Anomia squamula* L. Its occurrence in quaternary sediments in Svalbard is a further indication that during a section of post-glacial time a warmer climate prevailed up there than now[3]). As far as Greenland is concerned, it may be noted that in the course of time *Anomia squamula* has been found fossil along a considerable stretch of the coast, first, as stated above, in elevated sediments in Evighedsfjord (Sukkertoppen District) and in Ikertôq fiord (Holsteinsborg District); next it was found by Dr. V. NORDMANN in fine clay at Igíniarfik (Egedesminde District)[4]) and by HARDER & JENSEN in Sydostbugten in the middle of the *Zirphaea* layer at Orpigsôq (Christianshaab District). Thus this boreal bivalve has been found at a number of points at the very middle of West Greenland, from lat. 65°50′ to lat. 68°37′ N.[5]).

In some of the fossiliferous strata we found quantities of a *Mya* which by its ovate form resembles the long clam that is common round the Danish shores, *Mya arenaria* L., but which in other and more important characters comes very close to *Mya truncata* L. On account of its deviating form of shell AD. S. JENSEN called it *Mya truncata* forma *ovata*; the most reliable differential characters between it and *M. arenaria* are the string plate on the left valve and the corresponding pit on the right valve, as well as the umbo of the left valve, which JENSEN has described at length in a paper accompanied by numerous figures; this was so much the more necessary as all accounts of the occurrence of *M. arenaria* on high-arctic coasts from Greenland in the

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[1]) Svalbard is the official name of Spitsbergen.

[2]) JENSEN & HARDER, l. c. 1910, pp. 400—401.

[3]) V. NORDMANN: *Anomia squamula* L. som Kvartær-Fossil paa Spitsbergen. Meddel. fra Dansk geol. Forening, Bd. 4, 1912, p. 75.

[4]) This information came from DAN LAURSEN, cf. Medd. om Grønl. Bd. 135, No. 8 pp. 35 and 36, 1944.

[5]) In the 1905 paper I called the species *Anomia ephippium* L., but later (1912) I showed that the current opinion that *A. squamula* is a variety of *A. ephippium* is incorrect. Cf. The Danish Ingolf Expedition, II, 5, p. 3.

west to the Siberian Arctic in the east were the result of confusion with the ovate form of *Mya truncata*[1]).

As a recent animal, *M. truncata* f. *ovata* occurs on the Arctic coast of Siberia, in the Kara Sea, at Svalbard and Iceland. Moreover it is present in several localities in West Greenland, having for instance been taken at Godhavn and in Melville Bugt as well as Nordre Strømfjord (Holsteinsborg District); in the latter fiord it was collected in large numbers in 1911 by Dr. V. NORDMANN at several "stations", at depths of 6 to 18, 12 to 29, 75 and 80 m, on a clay bottom and at bottom temperatures of about 0° C., both small and large specimens (63 mm).

According to an opinion that is generally prevalent, *Macoma baltica* (L.) is a circumpolar species, with a northern range to Iceland, Svalbard, Kara Sea, Siberian Arctic, Bering Sea, Grinnel Land and Greenland. A critical revision of these reports, however, shows that this wide distribution in arctic regions is based on confusion with other species[2]). So far from being a circumpolar species, *Macoma baltica* in fact inhabits three well-defined regions, namely:

1) Europe from the Mediterranean and Madeira to Finmark and the "warm area" of the White Sea.[3])
2) The east coast of North America from Georgia to southern West Greenland.
3) The Pacific Ocean from California (Monterey) and northern Japan to Bering Strait.

Working upon the geographic distribution I drew the conclusion that instead of a high-arctic and circumpolar species, *Macoma baltica* must be regarded as a boreal species which had migrated into southern parts of the Arctic region. As far as Greenland was concerned, I considered that it had probably immigrated in comparatively recent times[4]), an opinion which was confirmed by HARDER's and my investigations; these show that at Orpigsôq it does not occur until we come to deposits which belong to or can be paralleled with the *Zirphaea* layer (Horizon F).

Macoma torelli was originally used by JAP. STEENSTRUP as the name on the labels of a small *Macoma* from ice-sea clay in northern

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[1]) AD. S. JENSEN: Studier over nordiske Mollusker. I. *Mya*. Vidensk. Medd. fra den naturhist. Foren. i København f. 1900, pp. 133—158, 1901. — The paper itself has no summary in another language, but a summary together with a reproduction of my figures was given in English by Sir HENRY HOYLE HOWORTH in Proc. Zool. Soc. of London 1909, pp. 754—756 and the figures 240, 241, 242 and 243.

[2]) AD. S. JENSEN: Studier over nordiske Mollusker, III, pp. 27—32, Tab. I, fig. 1a, b. Vidensk. Meddel. Naturhist. Foren. i Kbhvn. 1905.

[3]) Occurs neither at the Faroes nor at Iceland.

[4]) L. c. 1905, p. 31.

Jutland (Vendsyssel). It only became better known through a study made by the present author[1]).

Macoma torelli is a high-arctic animal form living in the Kara Sea, at Svalbard and northern East Greenland; two recent specimens have also come from West Greenland, but without particulars as to locality. It has also been found in the archipelago north of arctic America, viz. in Jones Sound[2]). Its bathymetric range is about 40—80 m. It grows to only 14—20 mm. in length.

As a fossil we have it from Marraq in Sydostbugten. In particular we collected it in a considerable number (18 specimens) in an erosion gully cutting through the plain behind Niaqornârusuaq; it occurred in a horizon characterized by *Portlandia arctica* (35 specimens) and other high-arctic bivalves.

Pecten islandicus MÜLLER. This handsome and, as to size, imposing bivalve—it attains to a size of 105 mm—lives in greatest quantity, forming whole banks of shells, at Finmarken, North Iceland and southern West Greenland as well as on the fishing banks of Nova Scotia and Newfoundland. But it does not seem to live in high-arctic waters[3]).

Therefore, no objection could presumably be raised when HARDER and I considered the layer rich in *Pecten islandicus* (Horizon E)—laid down during the transition period between the high-arctic and the warm period—as having been formed under conditions like those now prevailing in the sea off southern West Greenland.

However, since then information has been procured which seems to contradict the justification of our opinion. While in northeastern Greenland in 1931—32 Dr. GUNNAR THORSON made the remarkable and most interesting discovery that *Pecten islandicus* lives up there. A dredge haul from Kap Hedlund at the mouth of Rhedins Fjord, at 7—10 m, yielded about 125 *Pecten islandicus* juv. (5—7 mm width), and a dredge haul in the same locality, 30—25 m depth, yielded 29 young individuals of this species. It was also found in Solitærbugten, Ella Ø. The reason why this occurrence has not been observed earlier, says THORSON, is that the species is associated with a true red algae growth which is of relatively rare occurrence up there.

As I was unable to see from Dr. THORSON's publication whether he had also secured adult specimens of *Pecten islandicus* off northeast

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[1]) AD. S. JENSEN: Studier over nordiske Mollusker, III, *Tellina* (*Macoma*), pp. 34—38, Tab. I, fig. 3a, b, c, d, e and pp. 149—151. Vidensk. Meddel. Naturhist. Foren. i Kbhvn. 1905.

[2]) J. GRIEG: Brachiopods and Molluscs. Rep. Second Norw. Arct. Exped. in the "Fram" 1898—1902, No. 20, p. 14, 1909.

[3]) On the *Pecten islandicus* and its distribution cf. AD. S. JENSEN in The Danish Ingolf Expedition, II, 5, pp. 15—19. 1912.

Greenland, he has kindly informed me in response to my inquiry that he found adult individuals up there, but only few: 2 specimens in Solitærbugten, Ella Ø, and some few at Kap Hedlund. The size of these varied from 62 to 89 mm. Dr. THORSON also informed me that he considers *Pecten islandicus* to be a relict in the inner parts of Kejser Franz Josephs Fjord. Despite numerous dredgings he has never found it nearer the outer coast than Ella Ø. In the summer of 1933 round about Vinterøerne off the mouth of Duséns Fjord in Ymers Ø he made a number of dredgings, for the very purpose of searching for *P. islandicus*, but in vain. Nor was it found in the enormous material from the Scoresbysund fiord complex. All this agrees with the fact that the fiord water layer—i.e. the surface layer which attains to positive temperatures in summer—reaches a much greater thickness in the inner fiords than at the outer coast, and a much greater thickness inside Kejser Franz Josephs Fjord than in the inner part of Scoresbysund.

If now we compare Dr. THORSON's account of the occurrence of the species in northeast Greenland with the conditions under which it is found bedded in West Greenland, we shall observe the great difference. In the sediments at Orpigsôq, adult *P. islandicus* are found in large numbers; this shows that conditions there were similar to those under which the species thrives today, for example out at Egedesminde, where large *P. islandicus* can be dredged in quantities on "the banks"; the large adductor muscle has a very good taste and is considered a great delicacy.

On the other hand, Dr. THORSON's description of the conditions under which *Pecten islandicus* can exist in northeast Greenland seems to bear out HARDER's and my opinion of the value of the species as a guide fossil, its existence being conditioned by a rise of temperature from high-arctic to semi-arctic.

As regards the distribution of *Balanus hammeri* ASCAN.[1]) it is possible to say the following: This barnacle, remarkable for its size and as a fossil first known in Scandinavia under the name of *Balanus uddevallensis*, is given the following distribution by CHARLES DARWIN in his famous work on the *Cirripedia*: The British Isles, Finmarken, the Faroes, Iceland and Massachusetts[2]). Since then its northern limit has

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[1]) In the literature the name is written erroneously *hameri*, because ASCANIUS used this spelling by mistake; he says himself that he named the species after the county sheriff in Finmarken G. HAMMER, who was the first to find and give him this barnacle. The specific name should therefore be written *hammeri*, according to HJ. BROCH: *Cirripedia Thoracica* von Norwegen und dem Norwegischen Nordmeere, p. 90. Vidensk. Selsk. Skrifter, I, Mat.-Naturv. Klasse, 1924, No. 17. Kristiania 1924.

[2]) DARWIN: A monograph on the sub-class *Cirripedia*, Vol. II, p. 277. The Ray Society, 1854.

been extended to the White Sea[1]) and Nova Scotia[2]). BROCH also records *B. hammeri* from a series of localities along the Norwegian coast at depths from 40 to 120 metres[3]). In the Zoological Museum of Copenhagen are specimens from the North Sea and the Skagerrak (N.E. of the Scaw, 140 metres and 33 miles S.E. of Oksø, 259 metres).

To judge from this range, *Balanus hammeri* should be characterized as a purely boreal species. It has turned out, however, that it can also live off southern West Greenland, for in the summer of 1911 Dr. V. NORDMANN secured a specimen by dredging in the outer part of Nordre Strømfjord (Holsteinsborg District)[4]).

In Sydostbugten we frequently found *B. hammeri* in elevated sediments whose fauna resembled that living off southern West Greenland, but not in sediments that are characterized by the high-arctic circumpolar *Portlandia arctica.*

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[1]) WELTNER: Die Cirripedien der Arktis. Fauna Arctica, I, p. 298. 1900.
[2]) DAWSON: The Canadian Ice Age, 1894, p. 262.
[3]) HJ. BROCH: L. c. 1924, pp. 89—90.
[4]) Cf. K. STEPHENSEN, Medd. om Grønl. LI, No. 2, 1915, p. 71.

ORPIGSÔQ

The Terrace at Orpigsôq.

The Zirphaea Pynt and its environs.

From a point on the east coast of Disko Bugt, or, more precisely, on the east side of Sydostbugten and a little south of the colony of Christianshaab, two fiords cut into the land (fig. 1. Cf. plates I and II). In direction they form more or less a right-angle, for the one, Orpigsôq, runs almost southeast and the other, Kangersuneq, northeast. And extending from the northeast side of Orpigsôq is a small fiord arm, Qarajaq, running in between the mountains. Qarajaq has a length of about 5 km. The first 3 km run northeast, but from there the fiord bends almost at a right-angle towards the southeast and, in towards the head, divides into two rounded, bay-like sections. The westernmost and larger section goes the deeper into the land.

The head of Qarajaq is separated from the head of Orpigsôq by a peninsula, which juts out from Orpigsûp nunâ, the land between Orpigsôq and the ice cap on the east (plate I); but from Qarajaq a depression runs across the peninsula to the head of Orpigsôq. In this depression lies a small lake which has an outlet southwards to Orpigsôq. The height of the lake above sea level was measured at 23 m. Along the shores of the lake was grey-green clay at a number of places and also along the stream. No shells were found in the clay.

The ground from the lake to Orpigsôq is flat and the surface consists of the same kind of clay forming some caracteristic clay circles; there is a little rock outcrop here and there. At a height of about 4—5 m above the lake surface were sand, gravel and fairly large stones. It looks as if this was an old shoreline. Its height is 27—28 m above the sea.

A fairly large river debouches into the head of Orpigsôq. It has its source in the convergence of two meltwater streams, each through its low valley making its way from the ice cap out to the sea and uniting just before reaching the head of the fiord and emerging as one river. The northern tributary drains a large lake up against the ice cap on

the east. After forming several waterfalls it flows through the Orpigsûp tasia, which consists of two parts connected by a length of the river, which on this stretch also forms two waterfalls. Finally, this northern river arm drops over a waterfall just prior to converging with the southern

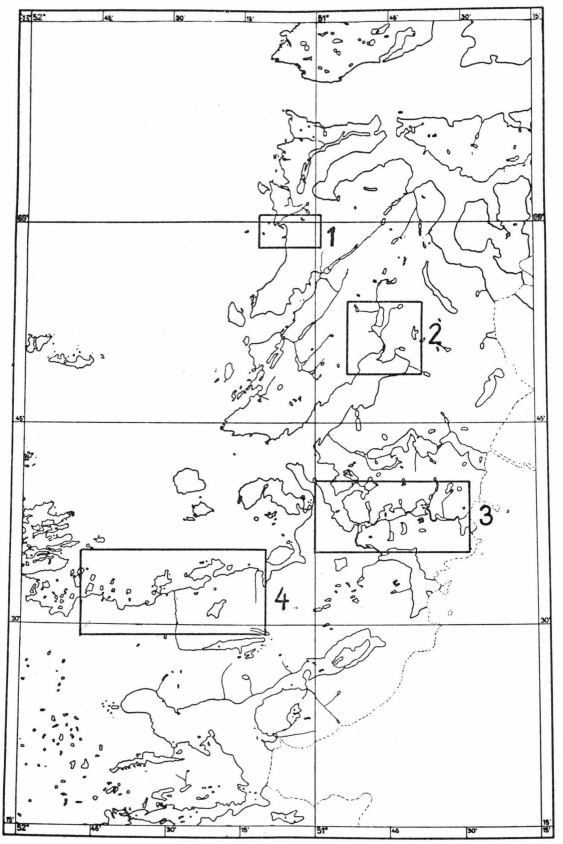
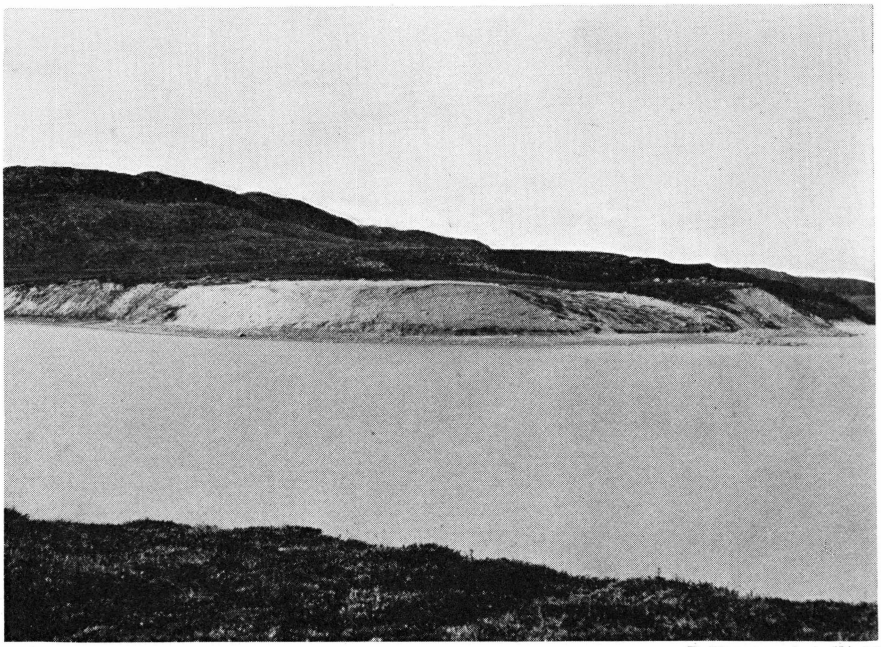


Fig. 1. General map of the areas surveyed (authorized reproduction). 1. Lerbugten south of Claushavn. 2. Head of Kangersuneq fiord. 3. Head of Orpigsôq fiord. 4. South coast of Sydostbugten.

branch. The latter drains lake Ilulialik, which is in direct contact with the margin of the ice cap.

Neither Kangersuneq nor Qarajaq receive any flow from the ice cap. As a consequence, these two fiords have clear water, in which respect they contrast sharply with the inner part of Orpigsôq, where the water is light grey from the large quantity of suspended clay which is carried out here and is gradually filling the fiord, so that a boat can only get right up to its head at high water.

Even as one comes sailing through Orpigsôq one's attention is caught by a large terrace which inwards terminates the fiord by cutting



P. HARDER phot. $^{17}/_{7}$ 06.

Fig. 2. The northeast corner of Zirphaea Halvøen, with Zirphaea Pynten in the centre. Ilulialik river coming from the left. The picture taken at low tide. At high tide the river level rises right up to the cliff foot and erodes in it.

obliquely across it, its shore running north-south. It closes the fiord and lies in front of the continuation—or rather the two continuations—of the fiord depressions farther inland. Only at its northern end is it interrupted, the above mentioned river having cut through it.

Seen from the fiord, this terrace has a very regular appearance, only a very few quite flat-topped and rounded boulders rising slightly above the terrace surface, which lies about 30 m above sea level. It seems almost covered with vegetation, and only at its southern end is there a very low cliff overlooking the fiord, while somewhat more to the north some small light-coloured clay walls in a small gully catch the eye. In advance it did not seem very promising. If its examination nevertheless yielded interesting results, the reason was the extensive fluvial erosion which has made handsome sections behind the shoreline. Actually there has been a considerable amount of breaking down here, and the conditions are curious, in so far as only a short stretch of the terrace—towards the south—extends right in and rests against the surrounding rocks, whereas towards the east it is bordered by an extensive, lower and younger fluvial plain and far to the north is cut through by the meltwater river. Thus it may be regarded almost as an erosion residue, stretching in the form of a low, plateau-like, fairly regular peninsula

northwards from the steep rock on the south. The fact that this residue of the originally much larger terrace is still holding out against the attacks of rivers and sea may be explained by the circumstance that its core consists of primitive rock.

The best sections, as already stated, are on the inner side of the terrace. This applies particularly to the area about its northeastern corner which, for reasons which will become clear from the following, may suitably be called the Zirphaea Pynt. Here, both along a short distance northwards out towards the river and on a longer stretch eastwards, we have a section through a comprehensive series of layers whose different horizons show much variation, both petrographically and faunistically. And not only here but also in the southeastern part of the terrace there are opportunities of gaining an insight into its structure. It is true that in the latter section only part of the series is present, but on the other hand the marine deposits here are combined with fluvial deposits in a manner which permits of further conclusions as to the post-glacial history of the region. An account of the conditions at these places will be given in what follows.

Beach gravel with *Zirphaea*.

The northeastern corner of the terrace itself consists of a somewhat prominent, smoothly rounded point, its plane surface lying 9—11 m above sea level; it is bounded by regular slopes with a fall of about 40°, due mostly to the fact that the point consists chiefly of gravel. An examination of this gravel reveals that this is a characteristic beach formation, built up of alternating beds of sand and gravel and containing sporadic stones of rather large size. The deposit is shell-bearing, and the large white shells of *Mya* and *Zirphaea* are especially conspicuous, lying scattered over the slopes and along the foot.

This deposit of beach gravel has a thickness of up to 7 m. Its horisontal extent, however, is small, because the base of the gravel, which is present only on this northeastern point, rises quickly towards the southwest and reaches the surface not far from the outer end of the point. Thus the whole occurrence is not large, and the limits of the gravel are easy to find, partly because the slopes, as long as they consist of gravel, are quite regular with a relatively small fall, and partly because as far as the gravel extends the surface is flat and forms a small "stony plain" where the sand has been blown from among the pebbles and has deposited itself in small hummocks of blown sand in the depression facing the river mouth just to the west of the point.

In order to determine the character of the gravel and its shell content, two ditches were excavated in the slope to its full height, one out

towards the river almost at the tip of the point (Excavation I) and one somewhat more to the south on the side facing the fluvial plain (Excavation II). The following may be recorded of the observations made:

Excavation I (fig. 3, plate III, fig. 1). From about 3 m above the foot of the section and to the top the slope consists of beach gravel, so that here it has a thickness of about 5 m. This relatively thick deposit

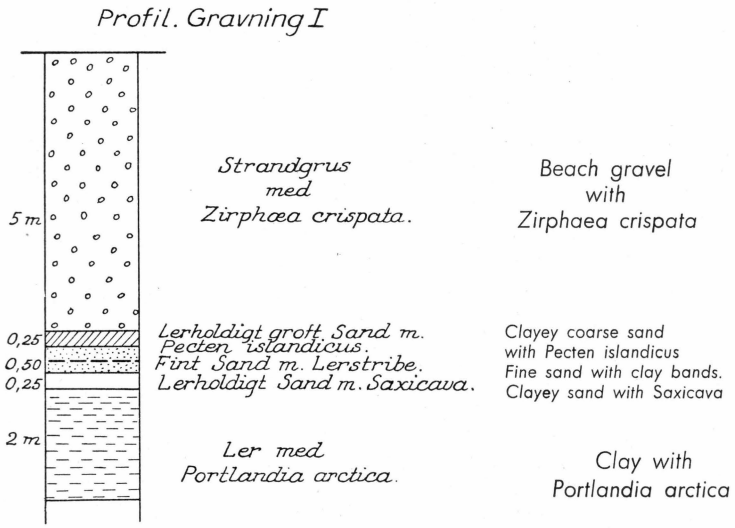


Fig. 3. Section, Excavation I. The position of the excavation is shown in pl. III fig. 1: Gravning I

consists of alternating layers of gravel and sand, while numerous small and a few large stones occur sporadically. All the same the deposit may be described as homogeneous, as no essential difference can be discerned between its upper and its lower layers. Shells, for instance, are abundant everywhere, though it should be said that the great majority are only fragments, mostly lying in small beds of slight extent, so that these beds are quite comparable with the small accumulations of shells and shell fragments always seen on beaches, washed together in small depressions. It is characteristic that such small beds of shells washed together are often encountered by the side of the large stones. This latter feature especially reveals the character of the deposit as a distinct beach formation. In addition to these shells which belong to the deposit, there are also a few more or less concretion-filled shells and concretions originating from earlier deposits.

Excavation II (plate 3, fig. 1). Here the thickness of the beach gravel is about 6.5 m and it extends down to .8 m above the foot of

the section. In all essentials the deposit is of the same character as in Excavation I, though on the whole the grain size is rather smaller, and in the upper half there are beds containing a little clay. Thus from above downwards we find: .8 m stratified gravel, .3 m coarse, slightly clayey sand, .2 m sand, .5 m clayey sand, .1 m sand and 1.0 m slightly clayey sand with a bed of stones almost at the middle. In all these layers except the top one there are shells and, as in the other excavation, mainly in the form of fragments assembled in short beds. Farther down the deposit continues for another 2.5 m in the form of sand with interbedded gravel layers and thin beds of shell fragments. It should be pointed out, however, that whole and often paired shells are more frequent here than at the other places, especially in the upper part of the deposit.

From these shell-bearing deposits came a large material of collected shells.

Excavation I.

Zirphaea deposit, uppermost, just below the surface:

Zirphaea crispata (L.). 20 shells, in fragments, from very small to full size.
Mya truncata (L.) about 100 shells, from quite small to lengths of about 50 mm. Mixed in character: rather short forms, obliquely truncated from above forwards; others more elongated, obliquely truncated from above rearwards; others of the *ovata* form.
Saxicava arctica (L.) about 70 shells, from quite small to length 33 mm, of the *pholadis* form.
Macoma baltica (L.) 30 shells, 7—17 mm.
Mytilus edulis L. Fragments of about ten shells, large and small.
Cardium ciliatum FABR. 15 shells, all small, 5—15 mm.
Macoma calcaria (CHEMN.) 5 shells, 11—20 mm.
Acmaea testudinalis (MÜLL.) 3 shells, 5—6 mm.
Puncturella noachina (L.) 3 specimens, 3—7 mm.
Littorina saxatilis (OLIVI) var. *rudis* MATON.

Zirphaea deposit, at about the middle:

Zirphaea crispata (L.). Fragments of 10 shells, both large and small.
Mya truncata (L.) about 100 shells, 3.25—45 mm. Thin-shelled, of a rather elongated, almost typical form.
Saxicava arctica (L.) about 100 shells, 2.5—30 mm. Elongated, of the *pholadis* form.
Macoma baltica (L.) 50 shells, 6.5—20 mm.
Mytilus edulis L. Fragments of 6 shells.
Anomia squamula L. One top shell, length 5 mm, height 5.5 mm.
Cardium ciliatum FABR. Fragments of 3 shells, small and medium.

Pecten islandicus MÜLL. 3 small shells (height 3.5—7 mm) and fragment of a slightly larger shell.
Acmaea testudinalis (MÜLL.) 10 specimens, 7—12 mm.
Littorina saxatilis (OLIVI) var. *rudis* MATON.
Strongylocentrotus dröbachiensis (MÜLL.) 6 shell fragments and about 10 spines.

Zirphaea deposit, lowest, immediately overlying the *Pecten* deposit.
Zirphaea crispata (L.). Fragments of 15 shells, from tiny (6 mm) to medium. Also 7 detached apophyses.
Mya truncata (L.). About 100 shells, all fragments except the very small. The smallest only 3.5 mm long, the largest presumably were 50 mm.
Saxicava arctica (L.). About 60 shells, 2.5—26 mm. Nearly all the larger shells are fragments, but they seem to have been of the *pholadis* form, or an elongated *arctica* form.
Macoma baltica (L.). 45 shells, many whole, length 6—16 mm.
Cardium ciliatum FABR. 8 shells, length 6.5—57 mm. All in fragments.
Macoma calcaria (CHEMN.). 3 fragments, of medium specimens.
Mytilus edulis L. Fragments of a number of shells.
Modiolaria discors (L.) var. *laevigata* GRAY. A fragment of a small shell.
Pecten islandicus MÜLL. Small fragments of a few medium shells.
Acmaea testudinalis (MÜLL.). 2 specimens, small (5—6 mm).
Littorina saxatilis (OLIVI) var. *rudis* MATON.
Strongylocentrotus dröbachiensis (MÜLL.). 20 shell fragments and 50 spines.
Balanus hammeri ASCAN. 3 shell fragments.

Excavation II.

Zirphaea deposit overlying *Pecten* deposit.
Zirphaea crispata (L.). 60 shells, from quite small to large; greatest length 83 mm.
Mya truncata (L.). Several hundred shells, from quite small (3 mm) to a length of 52 mm. Mostly of a rather elongated and thin-shelled form; some of the *ovata* form.
Saxicava arctica (L.). Several hundred shells, from tiny young (2.75 mm) to a length of 34 mm. Of the *pholadis* form.
Macoma baltica (L.). Several hundred shells, from quite small (4 mm) to 19 mm.
Macoma calcaria (CHEMN.). About 150 shells, 8—27 mm long.
Mytilus edulis L. Fragments of about 150 small and large shells.
Serripes groenlandicum (CHEMN.). 45 shells, length 5.5—45 mm.

Cardium ciliatum FABR. 25 shells, small (2.5 mm) to medium.
Pecten islandicus MÜLL. 15 shells, small, height 3.75—43 mm.
Modiolaria discors (L.) var. *laevigata* GRAY. 7 shells, length 6—13 mm.
Axinopsis orbiculata G. O. SARS. 5 shells, of adult specimens.
Acmaea testudinalis (MÜLL.). 65 shells, small (2.5—13.5 mm.).
Littorina saxatilis (OLIVI) var. *rudis* MATON. 4 shells, medium.
Lacuna divaricata (FABR.). 1 shell, 6.5 mm.
Polydora sp. bore-holes in *Mya* and *Pecten*.
Balanus crenatus BRUG. About 10 shell fragments.
Balanus hammeri ASCAN. 2 *opercula*.
Strongylocentrotus dröbachiensis (MÜLL.). 44 shell fragments and 56 spines.
Bryozoa and hydroids growing upon shells.

The relative composition of the fauna will appear from the following list, which gives the species found in a pure sample taken from Excavation I:

Macoma baltica (L.). About 80 shells, max. length 20.5 mm.
Saxicava arctica (L.). About 80 shells, maximum length 38 mm. Of the *pholadis* form. 2 shells "double" posteriorly.
Mya truncata (L.). 37 shells, thin, some of the short form, from above forwards truncated, others of the more elongated form, straight or from above rearwards truncated. From quite small to 48 mm in length. Also a few shells of the *ovata* form.
Zirphaea crispata (L.). 12 shells, all large to medium. The longest is 77 mm, the shortest 35 mm.
Cardium ciliatum FABR. 5 shells of small to medium specimens; one is a cast, another impression in the hard mass.
Macoma calcaria (CHEMN.). 3 shells, length 10—28 mm.
Mytilus edulis L. Fragments of 2 adult shells.
(*Portlandia arctica* (GRAY). A cast, length 15 mm.)
(*Nucula tenuis* (MONT.) var. *expansa* REEVE. 1 spec., length 8.25 mm.)
Buccinum sp.
Littorina saxatilis (OLIVI) var. *rudis* MATON.
Littorina obtusata L.
Acmaea testudinalis (MÜLL.). 5 specimens, length 6.25—11.25 mm.
Strongylocentrotus dröbachiensis (MÜLL.). 1 spine.

Earlier deposits in the foot of the Zirphaea Pynt.

The aforesaid beach gravel, which is characterized by the frequent occurrence of *Zirphaea crispata*, forms the greater part of the north-eastern point of the terrace. At no place, however, is it so thick that

it gets right down to the level of the river running past, and therefore, all the way round the point it can be seen in the section that underlying, earlier deposits project. These earlier layers differ petrographically and faunistically from the overlying beach gravel, and they show great variations mutually as well. Taking them as a whole, it is possible to distinguish between two different horizons: an upper, sandy horizon with a fauna almost corresponding to that of the present day in these regions, and a lower horizon, consisting of fat clay containing shells of *Portlandia arctica*. The sediments which together form the first of these zones have a total thickness of about 1 m. As to the lower clay deposit with *Portlandia arctica*, nothing can be said of its thickness because it continues down below the foot of the section; but at any rate it is more than 2 m. All beds lie conformably one above the other.

The details of the stratigraphy of the earlier deposits will appear best from an account of the observations made in the aforesaid Excavation I (fig. 3). In this excavation the beach gravel lies conformably over a clayey bed .25 m thick with many shells of *Pecten islandicus*. There is no really sharp boundary between the two deposits, as in the shelly gravel below, under a coarse bed, comes a finer one which downwards becomes clayey and passes into the upper sandy part of the underlying bed. The latter may almost be called coarse, rather heterogeneous sand, though it differs clearly from the beach gravel by containing so much clay that in the wet state the mass is coherent and somewhat plastic. Nevertheless, dried samples of it display a tendency to crumble. If the bed were not so rich in shells, at a cursory glance it would mostly recall clayey glacial sand. Its actual composition will be seen from a mechanical analysis, shown as No. 1 in the table on page 85.

As stated, this bed has a thickness of .25 m. As will be seen from the lists of fossils below, it is rich in shells, and of these the handsome red shells of *Pecten islandicus* are especially conspicuous. In one band at about the middle of the bed this mollusc is extremely common and its shells here always lie on the flat side.

In Excavation I, under the clayey bed with *Pecten islandicus*, is a bed of homogeneous white sand, .5 m thick, though a little above the middle it is interrupted by a band of clay .04 m thick. In this sand bed shells are very rare, though a few shells of *Mya truncata* were observed in the clayey band and in the sand underlying it.

Underlying this shell-poor sand is another clayey bed with many shells. In many respects it resembles the aforesaid deposit with *Pecten islandicus*, except that the sand is rather finer. The fauna is also similar. *Pecten* still occurs, but only in sporadic specimens, and the mollusc which particularly characterizes the layer by being present in large

numbers is *Saxicava arctica*. To a depth of .2 m under the upper edge of the bed it continues to be rich in shells. Under this it becomes more clayey and, without any real boundary, passes into the underlying clay, whose shells were observed up to .3 m below the upper edge of the bed just described. Therefore it will scarcely be far wrong to estimate its thickness at about .25 m.

As already stated, the lowest of the deposits revealed by the excavation consists of fat clay, in which it forms a sharp contrast to all the later sediments. Its mechanical composition will be seen from the analysis No. 2 given on page 85, which shows that this must be a sediment deposited in water of considerable depth. In this deposit there are only few but extremely well-preserved shells, lying singly here and there in the clay. The only species found were *Portlandia arctica* and *Nucula tenuis* var. *expansa*. In appearance they are so fresh that one might be misled into thinking that they came from recently dead animals.

These layers can be followed from the locality of Excavation I towards the southeast and south in the foot of the section around the point. There, however, they slope gradually down to a lower level, and southwards more and more of them disappear under the section foot. Still farther south, however, they rise again, but without being accessible for examination, as the cliff here is covered with very considerable quantities of screes. Along the stretch where the strata can be seen they remain more or less unchanged, but with the difference that the shell-poor sand bed thins off and finally disappears completely where the strata lie lowest. About 10 m southeast of Excavation I its thickness is only .4 m; 15 m more to the south .3 m and 15 m still farther south .15 m; finally, in Excavation II about 15 m south of the last-named place it has gone altogether. Whether or not it appears again in the next stretch where the strata reappear must be left unsaid for the reason already given. Gradually as the shell-poor sand thins off southwards, the overlying bed with *Pecten islandicus* increases a little in thickness and along one stretch is .3 m thick. The underlying layer with *Saxicava arctica* seems to remain very constant.

The shells collected from the various layers are:

The *Pecten* layer under the *Zirphaea* layer.

Pecten islandicus MÜLL. 70 shells and numerous fragments. Height 2.5—58 mm. Some bored by *Natica*.

Mya truncata (L.). About 200 shells and 9 specimens. Of mixed character, some of the *ovata* form, others elongated, square truncated, others again short forms, from above forwards truncated. Length 3.5—54 mm. Two bored by *Natica*.

Saxicava arctica (L.). 160 shells and 2 specimens, some of an elongated *arctica* form, others of the *pholadis* form. 3—36.5 mm.
Macoma calcaria (CHEMN.). 30 shells, 3—18 mm. 5 bored by *Natica.*
Astarte montagui (DILL.) var. *warhami* HANC. 19 shells, 3—19 mm.
Cardium ciliatum FABR. Fragments of 5 medium specimens.
Serripes groenlandicum (CHEMN.). 7 shells, 8.5—40 mm.
Modiolaria discors (L.) var. *laevigata* GRAY. 1 fragment.
Axinopsis orbiculata G. O. SARS. 1 specimen and 4 shells, 2.5—3.5 mm.
Leda minuta (MÜLL.). 7 shells, 13.5 mm and less.
Lepeta coeca (MÜLL.). 9 specimens, 4.5—9.5 mm.
Moelleria costulata (MØLL.). 2 specimens, 2.5 mm.
Bela violacea (MIGH.) var. *bicarinata* COUTH. 3 specimens, 3—4 mm.
Balanus hammeri ASCAN. 3 shell fragments.
Balanus balanus DA COSTA. 3 shell fragments.
Strongylocentrotus dröbachiensis (MÜLL.). 13 shell fragments and 40 spines.

Clayey layer underlying the *Pecten* layer.

Mya truncata (L.). 32 shells, 3—49 mm. All the larger shells are of the *ovata* form, some of the smaller belong to a longer or shorter truncate form.
Saxicava arctica (L.). 15 shells, 3.5—42 mm. Partly the *pholadis* form, partly an elongated *arctica* form.
Pecten islandicus MÜLL. 10 shells, 2 mm to medium (fragmentary only).
Cardium ciliatum FABR. 25 shells, 2—18 mm.
Leda minuta (MÜLL.) 10 shells, 3.5—11 mm.
Modiolaria discors (L.) var. *laevigata* GRAY. 2 fragments.
Macoma calcaria (CHEMN.) 1 shell, 20 mm.
Balanus hammeri ASCAN. 2 fragments.
Strongylocentrotus dröbachiensis (MÜLL.). 4 spines, 1 shell fragment and 1 tooth.

Portlandia layer.

Portlandia arctica (GRAY). 9 specimens, 4.5—9 mm.
Nucula tenuis (MONT.) var. *expansa* REEVE. 41 specimens, 3.5—12 mm. 8 shells.

Excavation II.

Pecten layer, underlying *Zirphaea* layer.

Mya truncata (L.). 82 shells, 2—38 mm. Most of a shorter or longer, truncate form, some of the *ovata* form.
Saxicava arctica (L.). 44 specimens, 4—28 mm. Some of an elongated *arctica* form, some of the *pholadis* form.

Pecten islandicus MÜLL. 19 shells, height 5—37 mm.
Macoma calcaria (CHEMN.). 45 shells, small form, 3—17.5 mm. 5 bored by *Natica*.
Cardium ciliatum FABR. 45 shells, 2—25 mm.
Serripes groenlandicum (CHEMN.). 19 shells, 9 mm. to medium.
Astarte montagui (DILL.) var. *warhami* HANC. Fragments of 2 shells, and four small shells (1.5—3 mm).
Leda minuta (MÜLL.). 4 fragments.
Axinopsis orbiculata G. O. SARS. 2 shells, 3.25 mm.
Thyasira flexuosa (MONT.). 2 shells.
Lepeta coeca (MÜLL.). 7 specimens, 3—8 mm.
Moelleria costulata (MØLL.). 1 specimen, diam. 2.5 mm.
Lunatia pallida (BROD. & SOW.). 1 specimen (fragment).
Bela violacea (MIGH.) var. *bicarinata* (COUTH.). 3 specimens, 3—6 mm.
Strongylocentrotus dröbachiensis (MÜLL.). 28 shell fragments, 12 spines and 2 teeth.
Arm "vertebrae" of an *Ophiur*.

Immediate surroundings of the Zirphaea Pynt.

From the mouth of the river at the northwest corner of the plateau to the Zirphaea Pynt there is a low cliff. It begins at the northwest corner with a rock knob of gneiss, followed by a bowl-shaped depression in the cliff at the place where the river widens out and spreads southwards. The slope is covered with vegetation, though on the southeast side of the depression there is fine sand here and there with distinct bands of clay. On the slope and at its foot lie many large moraine boulders. From there the cliff becomes lower, especially along the last stretch before the narrows and there is a part where there is coarse sand like that underlying the *Portlandia* clay south of the *Zirphaea* section (p. 28); at the same time the number of stones decreases rapidly. From here the cliff rises again towards the Zirphaea Pynt; there is still sand in its foot, whereas at the top there is an abundance of stones. The sand continues as far as a small gully. In this gully the slope on the west side is covered with blown sand with shell fragments. In the bottom of the gully thin layers of sand and clay are inclined to slip, and these layers continue up over the coarse sand at the mouth of the gully on the west side.

From the gully the cliff was surveyed as far as to the Zirphaea Pynt (Plate III, fig. 1.0—135 m proceeding northwest). The coarse sand soon disappears down under the foot of the cliff. In the overlying sand were the following shells:

Balanus hammeri Ascan. About 38 shell fragments.
Cardium ciliatum Fabr. 13 specimens and 12 shells, 4.75—35 mm.
Mya truncata (L.). 9 shells, about 18—32 mm.
Saxicava arctica (L.). 3 specimens and 4 shells, 16.5—28.5 mm; of an elongated *arctica* form.
Serripes groenlandicum (Chemn.). 1 specimen and 1 shell, 16—36 mm.
Some plate-formed concretions.

The mechanical composition of the sand will be seen from the analysis in the table page 85, No. 3.

Along the next part the cliff has slipped to some extent, but alternating thin beds of clay and sand can be seen. The lower part of the cliff is sandy, the upper mostly clayey. Here the cliff surface is hard and clayey with hillocks of blown sand. After a part that has slipped entirely comes a very flat slope covered with blown sand, evidently designating the place where the fat *Portlandia* clay in the foot of the *Zirphaea* section runs upwards and has caused the slide. Thus the fossiliferous fine sand with clay bands corresponds to the very thin bands of fine sand between the *Portlandia* clay and the coarse sand found in the east section at the "Balanstenene"[1]) (fig. 5).

Then follows the Zirphaea Pynt itself. From it was surveyed a section as far as 620 m southwards along the east side of the plateau.

Continuation of the Zirphaea section southwards.

Immediately after the point follows a stretch of relatively high cliff. It is fairly steep, but the slope is slipping and at the top fissured. The *Pecten* layer and its loose shells lie on the slope and are undoubtedly in situ in the top of the cliff.

The following species were collected in the sliding *Pecten* layer:

Mya truncata (L.). 29 shells, 35—69 mm. 22 are of the *ovata* form and are large; only 7 are truncate and otherwise of an elongated form.
Saxicava arctica (L.). 15 shells, 25—35 mm, some of the *pholadis* form, others of an elongated *arctica* form.
Pecten islandicus Müll. 11 shells, height 37—77 mm.
Cardium ciliatum Fabr. 6 shells, 21—49 mm.
Serripes groenlandicum (Chemn.). 6 shells, 15—69 mm.

[1]) The name of the locality is derived from the occurrence of boulders thickly covered with barnacles.

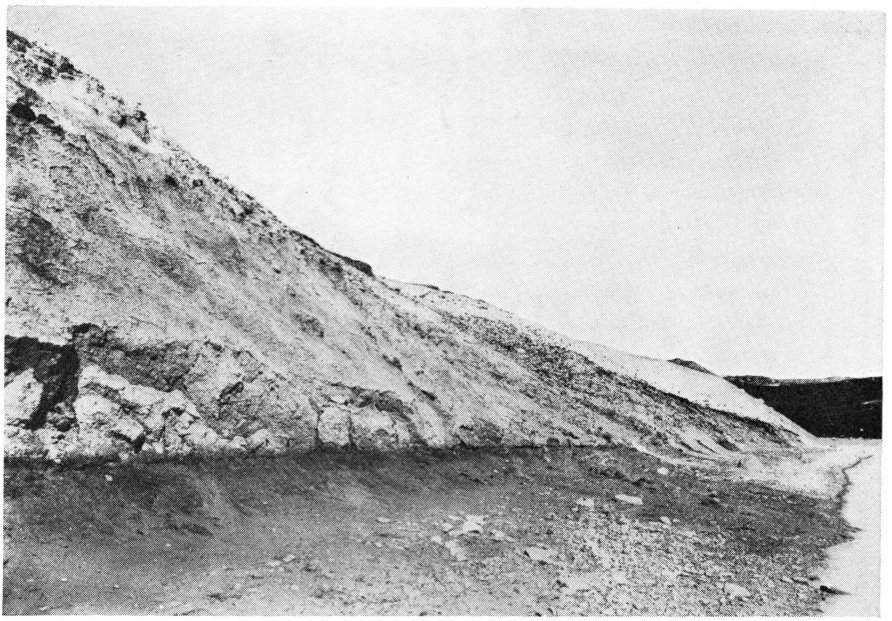


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Fig. 4. The *Zirphaea* section along Ilulialik river. In the foreground clay falling northwards, where it is overlain by the *Zirphaea* gravel.

Thereafter follows a funnel-shaped fall. In it the *Pecten* layer can be observed, and it is also found up in the cliff behind the next point. South of this the top of the cliff is split into noses along the next 50 metres. On this stretch the cliff section is as shown in the drawing (fig. 5). At the top of the section is *Portlandia* clay, which can stand vertically when it is dry; lowest is fluvioglacial sand. At the border between clay and sand are scattered stones both large and small. On the river bank here is quite a stony point (fig. 5). The stones must have come from the stony bed up in the cliff, as appears from the fact that this stony point occurs only on the stretch where there is fluvioglacial sand in the foot of the cliff. At the border between the *Portlandia* clay and the fluvioglacial sand is a thin band of fine, clayey sand. There were *Balanus* feet on several of the stones on the shore, and also on a large stone adhering at the boundary between the layers. Just at the foot of the cliff was a large stone with many of these feet (fig. 6). It had recently slipped down from the cliff, as on its top there was still some coherent, fine, clayey sand with distinct stratification. In it were the following species:

Balanus hammeri ASCAN. Several foot-, side- and operculum plates.
Saxicava arctica (L.). 1 specimen, 13 mm. Of the *arctica* form, has the two keels well developed and furnished with spines.

Membranipora monostachys Busk. Colonies on the underside of four foot-plates; it is the frontal wall of the bryozoa that is on the stone, the whole of the basal wall being missing.

Worm tubes.

More to the south the fluvioglacial sand in the cliff foot disappears.

The next part of the cliff has slipped a good deal and passes over into a stretch with two vertical noses of *Portlandia* clay separated by a very loose fall. A number of shells were collected from these noses.

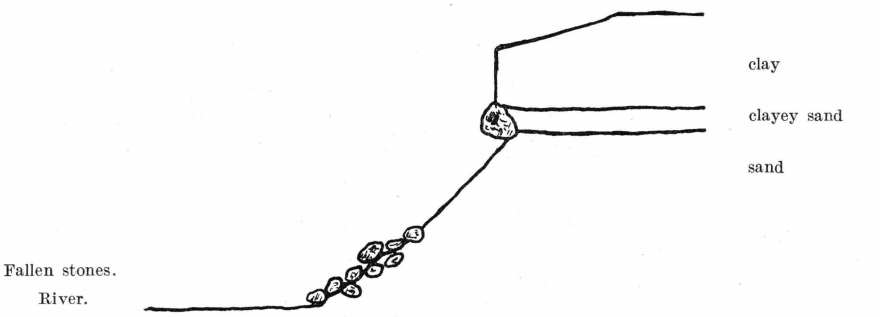


Fig. 5. Cross section of the cliff along the west bank of Ilulialik river at the „Balanstenene".

The fall between the two vertical *Portlandia* clay noses:

Nucula tenuis (Mont.) var. *expansa* Reeve. 78 shells, 6—9.5 mm. On several shells the periostracum was well preserved.

Mya truncata (L.). 13 specimens and 2 shells, 24—50 mm. All of the *ovata* form.

Portlandia arctica (Gray). 12 specimens, 5.5—17 mm.

Macoma calcaria (Chemn.). 10 specimens, 10—18 mm.

Leda pernula (Müll.). 8 specimens, 11—17.5 mm; some with well-preserved periostracum.

Thyasira flexuosa (Mont.). 6 specimens.

Cardium ciliatum Fabr. 3 specimens and 6 shells, 8—24 mm.

Serripes groenlandicum (Chemn.). 1 specimen, 15 mm.

Concretions of star-fishes and ? angmagssat.

Shells in situ $^1/_2$—1 m above the sandy bed in the steep wall on the north side of the fall between the two noses:

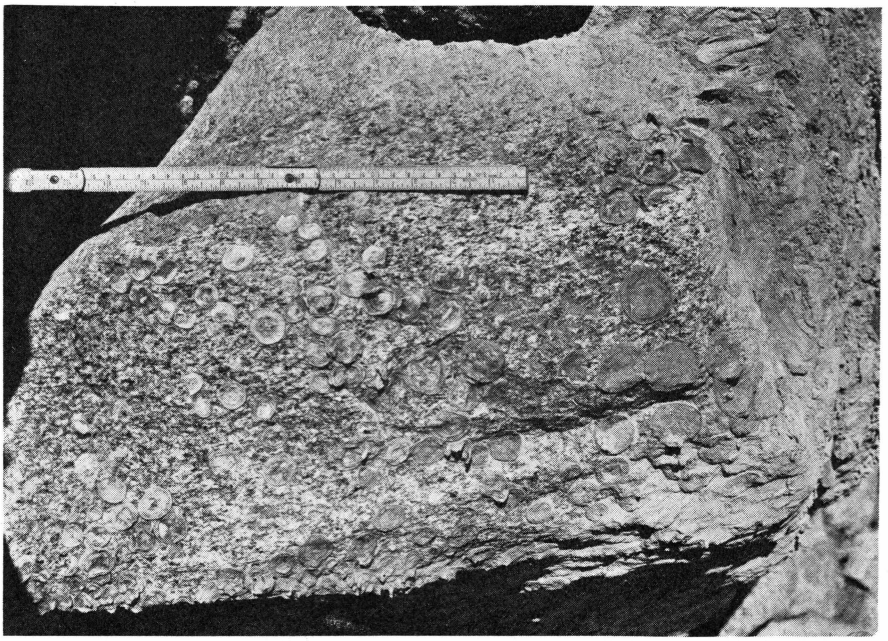
Mya truncata (L.). 1 specimen and 3 shells, 30—40 mm, of the *ovata* form.

Thyasira flexuosa (Mont.). 4 shells, 5.25—8.75 mm.

Cardium ciliatum Fabr. 2 specimens, 11—22.5 mm.

Some concretions.

Loose finds on the beach below the two noses, between 270 and 315 m from the beginning of the longitudinal section:



P. HARDER, phot. $^{21}/_{7}$ 06.

Fig. 6. Stone with feet of *Balanus hammeri*.

Ctenodiscus crispus (RETZ.). 12 more or less well preserved specimens. Concretions. A number, including one containing a fish vertebra.

The mechanical composition of the *Portlandia* clay will be seen from the table page 85, No. 4.

To the south of the above follows a very loose part with a number of small noses, succeeded by a length of tall cliff, of which the lower layer for some distance consists of glacial gravel the surface of which falls slightly towards the south. The greatest measured thickness of this gravel was 5.4 m. It is overlain by *Portlandia* clay, which here has a thickness of 15.4 m. The height of the cliff at this spot is 20.8 m and it is quite flat at the top. This height is also the upper limit of the *Portlandia* clay in the other points, where it is overlain by sand. At one of these points the height was read at 33.6 m.

The southeastern part of the terrace.

After this long section of loose earths the gneiss comes into view again in the river bank at one place, whereafter clay reappears in a length of cliff which is divided up into noses (fig. 8). Conditions being most clearly developed in the southern part of the section, its description will run from south to north. Lowest in the section is sandy *Portlandia*

clay, which is overlain by beds of more fat clay containing *Macoma baltica*. A number of small stones were found in this fat clay and it turned out to be built up entirely of fragmented clay of this kind. These fragments were distinctly rolled and the whole formed a sediment with an obvious but coarse stratification. The thickness of the clay in the first nose, called the Macoma Næse, was 2 m. It becomes thicker towards the southwest and thins off towards the northeast.

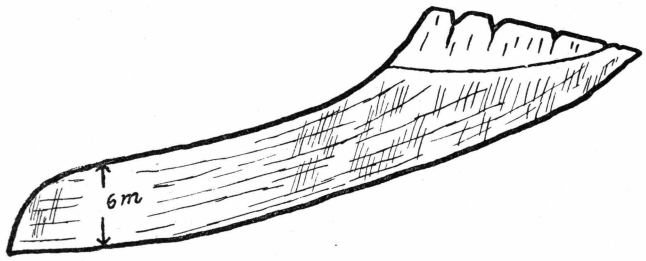


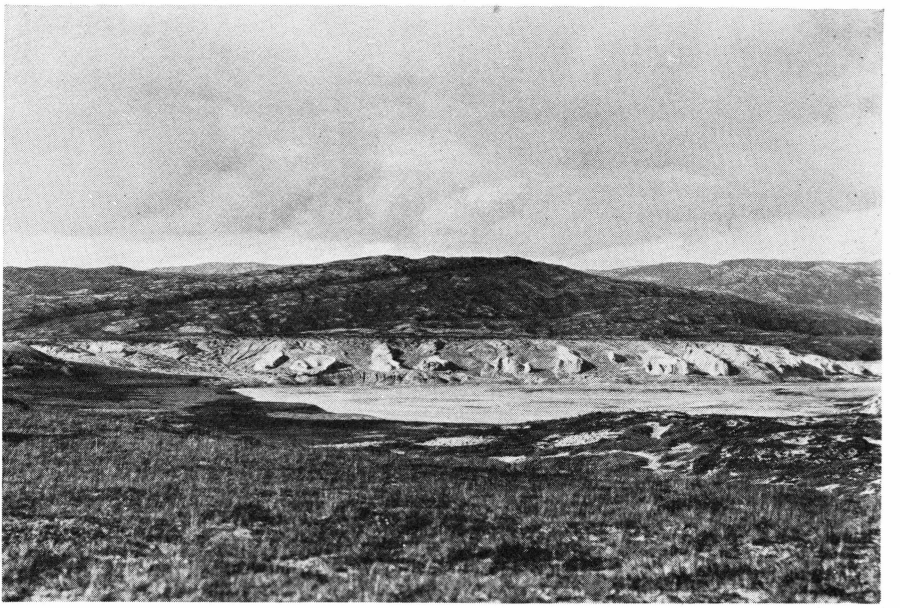
Fig. 7. Cross section of coastal cliff southernmost at Ilulialik river. A "nose" uppermost, of *Portlandia* clay, overlying a lower, more sandy clay.

The following shells were collected in the fatter clay:

Macoma baltica (L.). About 250 specimens, 9.5—24 mm.
Macoma calcaria (CHEMN.). 100 specimens, 9.5—35 mm.
Mya truncata (L.). 67 specimens and 4 shells, 8.5—55 mm, on the whole small and medium-sized. All of the *ovata* form, only 2 truncate.
Cardium ciliatum FABR. 6 specimens, 8.5—21.5 mm.
Serripes groenlandicum (CHEMN.). 5 specimens and 5 shells, 11—26.5 mm.
Thyasira flexuosa (MONT.). 2 specimens, 8—9.5 mm.
Saxicava arctica (L.). 1 specimen, 18 mm.
(*Portlandia arctica* (GRAY). 1 specimen, 10 mm).
Nucula tenuis (MONT.) var. *expansa* REEVE.
Chionoecetes opilio O. FABR. 1 claw.

In the following noses the fat clay still appears like a cap over the sandy *Portlandia* clay, though on a smaller scale. After the Macoma Næse follow two noses with marked stratification all the way up, whereafter there is a large fall with hillocks of blown sand. Then comes a larger nose capped by fat clay with more irregular and steeper contours. In it were found *Macoma calcaria* and *Mya truncata*. A little way out in the nose the thickness of the sandy *Portlandia* clay was estimated at 6 m (fig. 7). A sample of this clay was taken (see table page 85, No. 5).

Then follows a fall, in the southwestern part of which there is a



P. HARDER phot. $^{16}/_{7}$ 06.

Fig. 8. The south part of the cliff in the river Ilulialik, taken from a terrace on the opposite side of the river.

rock face, and higher up and farther in a small nose with a little fat clay above.

In the northeastern side of the fall lay many stones, and uppermost blown sand. The following nose had a somewhat smaller cap of fat clay at the top; it was followed by a small fall with stones and blown sand, whereafter came another nose with a small cap of fat clay. Then came a fall with a rock at the top towards the northeast. Above it was a little of the fat clay, which downwards and east of the rock continued into the next nose over the sandy *Portlandia* clay. The following fall was rather flat at the top with some lichen-covered stones above a steeper rock surface. The next nose also had a cap of fat clay, upon which lay small stones which continued down into the following fall, which is very wide and has a small isolated nose of clay at the top of the rock slope. The following nose is elevated inland and runs into the root of the next nose.

The following shells were collected from the highest level in the slopes:

Portlandia arctica (GRAY). 27 specimens and 2 shells, 9.5—18.5 mm.
Thyasira flexuosa (MONT.). 17 specimens, 7—9.5 mm.
Macoma calcaria (CHEMN.). 3 specimens, 9.5—16.5 mm.
Mya truncata (L.). 2 specimens, 14 mm.

Cardium ciliatum FABR. 1 specimen and 1 shell, 8.5—10 mm.
Leda pernula (MÜLL.). 1 specimen, 16 mm.
Nucula tenuis (MONT.) var. *expansa* REEVE. 1 specimen, 7 mm.
Concretions.

Then followed a broad-backed, stubby nose, called Koryggen. The following fall was not eroded right down, like so many of the earlier ones; it was succeeded by a high, large nose which branches out downwards and becomes very wide. In this nose there is much of the fat clay, which contains large *Mya truncata.* Then follows a number of smaller noses with small falls between, after which there is a nose,

Fig. 9.

cut in two at the end by a small stone stream. It is like a glacier coming down among "rocks" of clay. Its structure is illustrated by the drawing (fig. 9).

Then comes a flatter fall with two poorly developed noses, followed by a nose called Sandpynten. Some way down its slope a terrace-like shelf discloses that it too has clay in the bottom. In the part nearest Sandpynten the sandy *Portlandia* clay is less sandy and thus less distinctly stratified than farther south. Only the very lowest layer is markedly sandy. Upwards the deposit becomes more clayey, and some way up there begins a broad zone reaching to the top and containing *Mya truncata* and *Macoma calcaria.* No sharp boundary could be observed between lower sandy and upper, more clayey layers. More to the south the lower layer gradually becomes more sandy and distinctly stratified, whereby the difference between it and the upper, more fat clay forming caps on top of the noses becomes clearer and is especially noticeable in the shape of the noses (see fig. 8).

At Sandpynten the following shells were collected:

Lower layer:
Nucula tenuis (MONT.) var. *expansa* REEVE. 225 specimens, 6—13 mm.
Thyasira flexuosa (MONT.). 160 specimens, 5—9 mm.
Portlandia arctica (GRAY). 84 specimens, 9—18.5 mm.
Macoma calcaria (CHEMN.). 71 specimens, 9—25 mm.
Cardium ciliatum FABR. 28 specimens. 7—18 mm.
Leda pernula (MÜLL.). 8 specimens, 12—20 mm.
Serripes groenlandicum (CHEMN.). 1 specimen, 12 mm.

Saxicava arctica (L.). 1 specimen, 23 mm. Of an elongated *arctica* form.
(*Mytilus edulis* L. Fragment of an adult shell with adhering clay.)
Buccinum sp. 1 specimen.

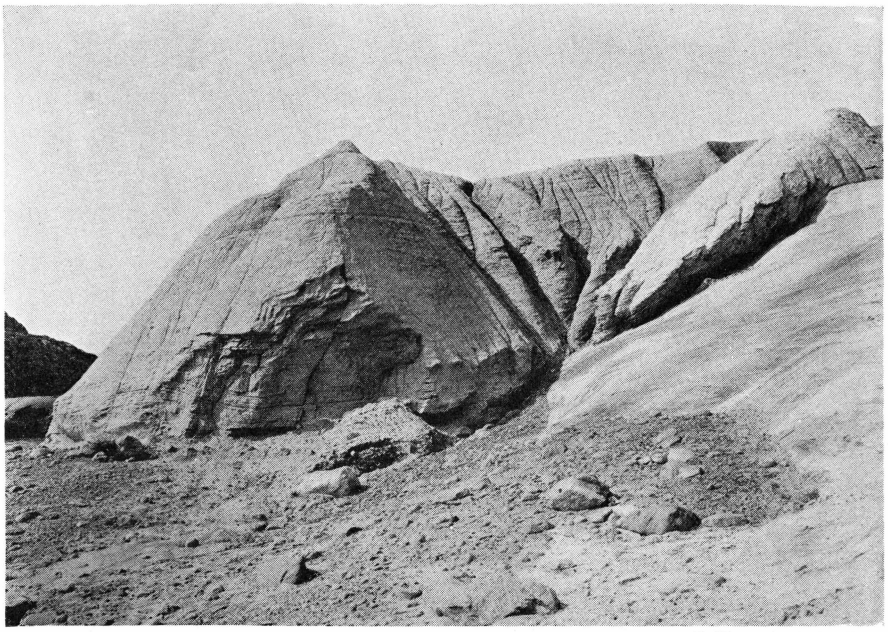
Upper layer:

Macoma calcaria (CHEMN.). 156 specimens and 3 shells, 16—35 mm.
Mya truncata (L.). 86 specimens and 30 shells. Length 12—80 mm. Of the *ovata* form; only one or two of the smaller specimens have the posterior end truncate.
Cardium ciliatum FABR. 40 specimens, 13.5—32 mm.
Nucula tenuis (MONT.) var. *expansa* REEVE. 3 specimens and 1 shell, 9—12 mm.
Serripes groenlandicum (CHEMN.). 1 specimen and 2 shells, 18—31 mm.
Leda minuta (MÜLL.). 1 specimen, 13.5 mm.
Pecten islandicus MÜLL. 1 fragment of a shell of an adult specimen.
Mytilus edulis L. 1 shell, 68 mm.
Cylichna alba (BROWN). 4 specimens, 6—9 mm.
Ctenodiscus sp. Several.
Atlas of a caribou.
Concretions with impressions of fishes.

Found loose along the cliff:

Macoma calcaria (CHEMN.). 103 specimens and 5 shells, 13—34 mm.
Mya truncata (L.). 85 specimens and 8 shells, 10—75 mm. Of the *ovata* form.
Cardium ciliatum FABR. 59 specimens and 26 shells, 11—46 mm.
Portlandia arctica (GRAY). 2 specimens, 14—15.5 mm.
Serripes groenlandicum (CHEMN.). 7 specimens and 3 shells, 10—55 mm.
Saxicava arctica (L.). 1 specimen, 39 mm. Of an elongated *arctica* form.
Thyasira flexuosa (MONT.). 1 specimen, 6.5 mm.
Ctenodiscus crispatus (RETZ.). 11 specimens.
Concretions.

Inside the bay northwest of Sandpynten there is first sand in continuation of that in the point; between this sand and the rock dividing the south end of the section from the Zirphaea Pynt and southwards is a clay deposit, where alternating bands of clay and fine sand appear below. It is very like the sandy *Portlandia* clay but not quite the same, for if anything it forms a transition between the latter and the sandy layer more to the north. Overlying it is clay in large fragments, well placed on the corner of a relatively long erosion gully in the clay. On following the layer up through the gully it was seen that the clay gradually became more fragmentary. Up at the top of the north wall of the gully



P. HARDER phot. $^{16}/_{7}$ 06.

Fig. 10. Sandy *Portlandia* clay seen from the side. In the foreground ice-striated gneiss.

was a gravel bed which thinned off in the clay inwards. The following shells came from the clay:

Mya truncata (L.). 3 specimens and 1 shell, 24—35 mm. Of the *ovata* form.

Serripes groenlandicum (CHEMN.). 2 specimens and 1 fragment, 20—42 mm.

Cardium ciliatum FABR. 2 specimens, 15—18 mm.

Leda pernula (MÜLL.). 1 specimen, 20 mm.

Portlandia arctica (GRAY). 3 specimens, 15—22 mm.

Nucula tenuis (MONT.) var. *expansa* REEVE. 2 specimens and 1 shell, 7.5—12 mm.

Saxicava arctica (L.). 1 shell, 22.5 mm. Of the *arctica* form.

Other sections.

Southernmost in the low plateau up at the very head of the fiord are some very low cliffs that are sliding to some extent. At the top the surface slopes evenly inwards and is no doubt slowly sliding far inland on the plateau. Here again are the usual clay circles; that they are connected with the sliding seems to appear from the fact that they are closer together out at the cliff, where the movement must be greatest on account of the slope of the cliff whereas they decrease in number inland.

On these clay circles, which lay at a height of 36 m above the sea, the following shells were collected:

Macoma calcaria (CHEMN.). 94 specimens, 10.5—27 mm.
Nucula tenuis (MONT.) var. *expansa* REEVE. 63 specimens, 5.5—12 mm.
Thyasira flexuosa (MONT.). 40 specimens, 4.5—8 mm.
Portlandia arctica (GRAY). 17 specimens, 11—17 mm.
Leda pernula (MÜLL.). 8 specimens, 12.5—20 mm.
Cardium ciliatum FABR. 7 specimens, 8—22 mm.
Mya truncata (L.). 6 specimens, 8—41 mm. Of the *ovata* form.
Serripes groenlandicum (CHEMN.). 3 specimens and 1 shell, 6.5—26 mm.
Cylichna alba (BROWN). 5 specimens, 10.5—13 mm.

Above and below in the cliff was highly fragmented clay; between was sand. The northernmost point consisted of sand exclusively.

From there these southern cliffs were interrupted northwards by an area of rock which seemed to stretch across the plateau. A little way in on the plateau this rock area is bounded on the north by gneiss which stretches right up to the northwest corner of the plateau at the mouth of the river. At the shore, on the other hand, about midway across the plateau it is interrupted, there being a small depression in the gneiss which out at the shore forms a small bay. In this bay, which once was larger, is sandy *Portlandia* clay exactly like that on the other side of the plateau. It is sandy and distinctly stratified and contains shells and concretions; the following were collected:

Macoma calcaria (CHEMN.). 25 specimens and 3 shells, 10—30 mm.
Thyasira flexuosa (MONT.). 18 specimens, 4.5—8 mm.
Mya truncata (L.). 14 specimens and 15 shells, 11—41.5 mm. All of the *ovata* form; two of the smaller ones are truncate.
Cardium ciliatum FABR. 9 specimens and 7 shells, 11—41.5 mm.
Nucula tenuis (MONT.) var. *expansa* REEVE. 2 specimens and 1 shell, 5—9 mm.
Saxicava arctica (L.). 2 specimens and 1 shell, 30 mm.
Leda pernula (MÜLL.). 1 specimen, 17.5 mm.
?*Axinopsis* sp.
Balanus foot, bored by *Polydora*.
Concretions.

On the eastern side of the peninsula were also shells on the surface of some of the numerous clay circles. The situation of these shell-bearing planes was inland, 200 m south of the Zirphaea Pynt. The following were collected:

Macoma calcaria (CHEMN.) 41 specimens and 7 shells, 10—24 mm.
Thyasira flexuosa (MONT.). 34 specimens, 5—8 mm.

Nucula tenuis (MONT.) var. *expansa* REEVE, 31 specimens, 6—11 mm.
Mya truncata (L.). 19 specimens and 14 shells, 10—51 mm, (fragment of a still larger shell). Of the *ovata* form.
Portlandia arctica (GRAY). 4 specimens, 11—15 mm.
Leda pernula (MÜLL.). 3 specimens, 13—14.5 mm.
Leda minuta (MÜLL.). 1 specimen, 8.5 mm.
Serripes groenlandicum (CHEMN.). 5 specimens and 2 shells, 9—24 mm.
Cardium ciliatum FABR. 6 specimens and 5 shells, 7—29 mm.
Concretions.

Here too the surface seems to be sliding, though to a lesser degree. It slopes more, and the clay circles are not so markedly developed or so cracked—all no doubt due to the less fat character of the clay at this place.

In the small inlet to the southwest of the small island in Orpigsôq fiord, *Portlandia* clay was found in at the head. From the low cliffs along the inlet the surface rises steadily in towards the surrounding rocks. A little brook runs through a cleft down to the sea, whereby sections are opened in the marine sediments. Sections were also found in the coastal cliffs. For instance, on the northern side of the bay there is fine sand in a low cliff. In the head of the inlet are three noses consisting of fat clay at the bottom with well-preserved shells. Overlying it is fine sand, and uppermost perhaps a little more clay, which, however, is very fragmented and perhaps slided. Moreover, in the nose farthest to the northwest a sand bed was observed projecting out from the foot. Measurements were taken from the highwater line at the three noses from southeast to northwest:

Nose 1: upper edge of clay 1.5 m; upper edge of nose 5 m; 2: upper edge of clay 3.5 m; upper edge of nose 6.5 m; nose 3: upper edge of clay 4 m, upper edge of nose 7 m. Besides these noses, on the west side a little sliding clay was exposed overlying ice-striated rock, and finally, up the bed of the brook where it branches was a nose exactly like the three in the inlet. It was 7 m high and its foot lay a good 2 m above the highwater line.

The following shells were collected:

Portlandia arctica (GRAY). 29 specimens and 2 shells, 3.5—18 mm.
Yoldia hyperborea LOVÉN. 2 specimens, 10—34 mm.
Nucula tenuis (MONT.) var. *expansa* REEVE. 3 specimens and 4 shells, 7.5—12.5 mm.
Mya truncata (L.). 2 specimens and 1 shell, 16—22.5 mm. The two small specimens still "indifferent"; the shell was of a very short form, *uddevallensis*.

Macoma calcaria (CHEMN.). 1 specimen, 21.5 mm.
Cylichna scalpta REEVE. 1 specimen, 8 mm.

A small valley runs from the head of the inlet eastwards to the precipice at the head of the fiord. A small lake was found at a height of about 33—34 m above sea level. In a low slope on the shore of the lake was a small section, built up of sand and clay. An excavation gave the following shells:

In the clay:

Mya truncata (L.). Fragments of at least 5 shells, all adult.

In the sand:

Macoma baltica (L.). Fragments of 3 shells.
Mytilus edulis L. Some fragments.

Summarizing remarks.

The earliest incoherent sediments in this area are the fluvioglacial sand, occurring some hundred metres up the river Ilulialik, in its western bank (Horizon A). It is overlain by *Portlandia* clay, but at the boundary between the two deposits there is a thin band of fine sand as well as a layer of stones (Horizon B). The sand is poor in shells, only a single specimen of *Saxicava arctica* having been found. On the stones, however, a re traces of *Balanus hammeri*, which shows that after the deposition of the fluvioglacial sediments a temperature prevailed that was higher than the present in this region. Horizon B must also be made to include the bed of sand, about 5 m thick, overlying the coarse sand in the cliff about 110—130 m northwest of the Zirphaea Pynt at the mouth of the river (page 27, Plate III, fig. 1), the fact being that there is a preponderance of shells of *Balanus hammeri* here, besides a few mollusc shells. In the cliff, Horizon B is overlain by a bed of clay at least 15 m thick. It is somewhat sandy in its lowest layers, but becomes more fat upwards. In the lowest, sandy part, *Mya truncata* forma *ovata* predominates, whereas *Portlandia arctica* is missing; the latter, however, makes its appearance upwards in the fatter clay. The sandy part (Horizon C) thus forms a climatic transition from Horizon B to the high-arctic layers with *Portlandia arctica* (Horizon D). There is no sharp demarcation between the two horizons, which pass smoothly into each other. Horizon D—the *Portlandia* clay—is the most widespread sediment at Orpigsôq. It also forms the lowest layer in the section along its longest stretch. In the southernmost part of the cliff, south of the so-called Sandpynt, it is rather more sandy than in the northernmost part conjoining the Zirphaea Pynt. On the latter the *Portlandia* clay is overlain by clayey sand, whose most prominent shell is *Pecten islandicus* (Horizon E).

When Horizon E was deposited the climate was of a nature similar to that prevailing now in the area. In the Zirphaea Pynt Horizon E is overlain by beach gravel with *Zirphaea crispata* and *Anomia squamula* (Horizon F). The thickness of this layer is 7 m and the presence of the boreal forms *Zirphaea crispata* and *Anomia squamula* makes it evident that the climate was much milder when Horizon F was laid down than it is today. In the southern section the layer that is characterized by *Macoma baltica* is placed to Horizon F.

The inland sediments.

The north shore of the river and the lake.

In conjunction with the detailed surveys around the Zirphaea Pynt, some explorations of a more reconnoitring nature were made along the shores of the western Orpigsûp tasia and those of the mouth of the river.

In the shore on the northern side of the river mouth was a low section, but with so much vegetation that it was impossible to see the structure of the layers. At some places, where there were gaps in the covering of vegetation, it was ascertained that the section consisted of sand with thin bands of clay. A very few shell fragments were seen on the beach. On the shore opposite the *Zirphaea* section was a small section, about 5 m high, of sand with clay bands. The stratification is very irregular, undulating and with a somewhat unconformable parallel structure. The sediments were undoubtedly laid down in running water. Overlying the sand was a bed of *Portlandia* clay, just under 1 m thick, which still seemed to have some slight horizontal stratification, for it splits into fragments which have their greatest dimension horizontally. In the clay were quite a number of stones, large and small. The following shells were collected:

Balanus hammeri Ascan. 28 shell fragments.
Saxicava arctica (L.). 23 specimens and 2 shells, 7.5—28 mm. Some of *pholadis*, others of an elongated *arctica* form.
Cardium ciliatum Fabr. 11 specimens and 9 shells, 7.5—27 mm.
Serripes groenlandicum (Chemn.). 1 specimen and 4 shells, 16.5—medium.
Macoma calcaria (Chemn.). 5 specimens and 1 shell, 13.5—20 mm.
Mya truncata (L.). 5 specimens and 1 shell, 16.0—just under medium.
Concretions.

From this section and in as far as the waterfall the river bank is covered with vegetation; above it is an evenly sloping face which apparently lies at the same height as the Zirphaea Plateau. From the waterfall and in to the big lake the river winds over the solid rock bot-

tom, and on the slopes down to it lie quantities of stones, so that one forms the impression that this is moraine material. Just below the point where the river leaves the lake there is in the northern bank a tall section of fine sand with quite a lot of small mica flakes. The sand contains subordinate, thin bands of clay which are numerous below. In the top of the section is a very thin layer of stones and gravel, from which some of the section slope is covered with the two components, the effect being that when seen from a short way off it may be mistaken for a relatively thick gravel deposit; on closer examination, however, one finds sand everywhere under it. Finally, the top is covered with a little coarse blown sand.

All the way along the bank of the lake is a low cliff, consisting of clay, sand and gravel. For long stretches the top of the cliff is formed of a stony plain; shells are found here and there among the stones. The clay is at the bottom of the cliff and is presumably without shells, though there are some in the overlying sand.

Just where the lake has its outlet into the river is the socalled-"Engell's Profil"[1]). It is formed of some low cliffs, rising to a height of about 3.5 m above the lake surface, which lies 36 m above sea level. On the top is a stony plain which rises slowly to about 4 m above the lake. The slope is covered with a very thin layer of scree consisting of stones and shells. A section was uncovered by digging. It was found that the cliff consists of sand of varying grades. It lies in layers dipping slightly, up to about 20°, in various directions around SW. In the sand were several horizons which are particularly conspicuous on account of their richness in shells, *Mytilus edulis* being especially remarked. In the lowest part of the deposit, consisting of sand a little more coarse than the rest, there are no such markedly *Mytilus* bands, but the species does occur as scattered shells. The entire deposit must be regarded as a beach deposit, or perhaps rather a deposit laid down in shallow water and at a place where there has been some considerable current. This agrees with the fact that it lies just at the place where the lake has its outlet and where there must have been a relatively narrow connection with the sea.

The following shells were collected:

Surface finds on the section slope.

Mytilus edulis L. Several whole shells, up to 92 mm long. On some the periostracum is preserved over larger or smaller areas of the shell; on one are traces of seaweed. On the whole it is possible to distinguish between two forms, one rather high and one relatively elongated. The measurements of a few specimens will show the difference:

[1]) Engell's Profil i. e. Engell's section.

Length in mm.....	75	73	70	74	71.5	69
Max. height in mm.....	32	31	30	37	35	36

Some shells are fairly thick, others proportionately thin; the elongated shells are thicker on the whole than the high ones. The concentric growth ridges are very distinct at intervals, the upper side displaying a number of more or less deep grooves; it would seem that the elongated specimens have more concentric grooves. Some shells have nacre on the inner side, produced presumably by encysted developmental stages of a Trematode: *Gymnophallus bursicola* ODHN.[1]).

Saxicava arctica (L.). Several hundred shells, maximum length 36 mm and of the *pholadis* form; a few of irregular form or "pinched".

Macoma baltica (L.). About 200 shells, length 1.5—21.5 mm.

Mya truncata (L.). About 100 shells, including about 50 medium to fairly large (largest specimen 63 mm). A few of the short variety *uddevallensis*, most of them a medium form between the latter and the typical elongated form, and one or two even approach the latter.

Pecten islandicus MÜLL. About 20 shells, the largest 70 mm high, 66 mm wide, the smallest 4 mm high.

Zirphaea crispata L. 11 left and 6 right shells, length 38—65 mm.

Macoma calcaria (CHEMN.). 10 shells, length 10—24 mm.

Axinopsis orbiculata G. O. SARS. 5 shells, length 3—4 mm, height 3.25—4.25 mm, periostracum preserved.

Modiolaria discors (L.) var. *laevigata* GRAY. 2 small shells, 3.5—5 mm.

Cardium ciliatum FABR. Fragments of 4 shells, the largest not of medium size.

Littorina saxatilis (OLIVI) var. *rudis* MATON. About 220 specimens, 1.25—14 mm.

Littorina palliata SAY. 3 specimens, 9—11.5 mm.

Acmaea testudinalis (MÜLL.). About 80 specimens, length 12—27 mm. In several cases there is an oval ring, the upper part of the shell having become separated from the lower. Sometimes the chequered colour is preserved.

Margarita helicina PH. 11 specimens. Height 1—2.5 mm. Also an *operculum*.

Trophon truncatus STRØM. 9 specimens, 11—21 mm.

Puncturella noachina (L.). 4 specimens, 6.5—10.5 mm.

Lacuna divaricata (FABR.). 1 specimen, 11.5 mm.

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[1]) Cf. ODHNER: Die Trematoden des arctischen Gebietes. Inaugeral-Dissertions, Jena 1905 (pp. 312—313).

Buccinum sp. I.
Buccinum sp. II.
Chiton marmoreus FABR. 2 dorsal plates, of a small and a medium specimen.
Micropora borealis BUSK. A small fragment of a branch.
Hippothoa hyalina L. Three small fragments.
Polydora. Holes bored by this polychaet Annelide occur in two shells of *Mya truncata*, one of *Buccinum* and one of *Trophon.* It is evident that these animals are very destructive to the shells, which they attack in large numbers.
Spirorbis vitreus FABR. 1(?2) specimen on a shell of *Mytilus edulis.* Easily recognizable, as the mouth is raised from the other part of the shell (var. *ascendentis* LEV.). The other tubes on the same shell are too far destroyed for definite identification, but they are of another species.
Bore holes of a mollusc (*Natica*?) in 4 shells of *Saxicava arctica* and 1 of *Acmaea testudinalis.*
Strongylocentrotus dröbachiensis (MÜLL.). About 50 spines and three shell fragments.
Balanus balanus DA COSTA. 2 shell fragments.
Balanus crenatus BRUG. Numerous shell fragments and 5 whole *Balanus* (but without *operculum*).
Balanus hammeri ASCAN. 1 shell fragment.
Otolith. One.
Fish vertebrae.
Phoca vitulina. 1 ossicle.

A special sample drawn from the layer with *Mytilus edulis* gave the following result:

Sample taken 0.4 m below the top of the section (i. e. 39.1 m above sea level).
Mytilus edulis L. The sample is full of fragments. 8 very small shells 4.5—11 mm.
Saxicava arctica (L.). Picked out several hundred shells, indeed contests with *Mytilus* in frequency in the sample. Length from quite small up to 30 mm. Of the elongated *pholadis* form. Some irregular in shape ("pinched").
Macoma baltica (L.). About 100 shells, some still hinged. Length 4—15 mm.
Mya truncata (L.). 35 shells, mostly quite small (4—17.5 mm), a few fragments of slightly larger, barely medium specimens. The shells all of the *ovata* form.

Balanus crenatus BRUG. Numerous (several hundred) shells.
Strongylocentrotus dröbachiensis (MÜLL.). About 60 spines and 12 shell fragments.
Otolith 1, of *Gadus* sp.
Puncturella noachina (L.). Fragment of a medium specimen.
Littorina saxatilis (OLIVI) var. *rudis* MATON. About 150 specimens. Greatest height 10.5 mm, least 1.5 mm.
Acmaea testudinalis (MÜLL.). 16 shells, length 4—15 mm.
Buccinum sp. 2 specimens and one or two fragments.
Lacuna divaricata (FABR.). 4 fragments of small specimens.
Margarita helicina PH. 3 specimens, diam. 2.5—3.5 mm.
Natica sp. A bore hole in a shell of *Saxicava arctica.*

Sample just less than 1 m below the top of the section, i. e. 38.8 m above sea level.

Mytilus edulis L. Numerous fragments of large and small specimens. Also very small individuals, down to 4.5 mm.
Saxicava arctica (L.). Over 150 shells picked out. Contests with *Mytilus edulis* in frequency. Quite small specimens among them; the largest is 27 mm long. The *pholadis* form easily predominates, almost always regularly developed (not "pinched" as in the following sample). Some shells still hinged in pairs.
Macoma baltica (L.). 40 shells, from 3 to 13 mm. Some still joined.
Mya truncata (L.). 6 very small shells and 3 fragments of larger specimens, but none over medium size.
Cardium ciliatum FABR. A fragment of a small shell.
Serripes groenlandicum (CHEMN.). Fragments of two medium shells.
(*Portlandia arctica* (GRAY). A cast of a specimen.)
Balanus crenatus BRUG. Numerous shell fragments, probably just as many as of *Saxicava.* A few specimens still have the shells adhering by means of the algae on which they grew.
Strongylocentrotus dröbachiensis (MÜLL.). 23 spines and 9 shell fragments.
Pectinaria (?*granulata* L.). Fragment of a tube formed of cemented sand grains.
Littorina saxatilis (OLIVI) var. *rudis* MATON. 33 specimens. Height 1.5—12 mm.
Acmaea testudinalis (MÜLL.). 7 specimens, 5—20 mm.
Margarita helicina PH. 4 small specimens, greatest height 1.5 mm.
Puncturella noachina (L.). 1 specimen, small, length 3.5 mm.
Buccinum sp. Several fragments.
Fish vertebrae, two.
Algae, rather many.

From almost the middle of the deposit.

Mytilus edulis L. The sample contains numerous fragments; of the whole shells the longest is 65 mm, and it has also most of the periostracum preserved as well as the seaweed remnants on it. Nevertheless, there are fragments of much larger specimens. Also many small individuals, down to about 10 mm.

Saxicava arctica (L.). About 100 shells picked out, but many fragments still remain in the sample. Next to *Mytilus*, it is the commonest shell in the sample and may even dispute its rank for frequency. The maximum length is 27 mm. They belong to the elongated *pholadis* form, but often have irregular shapes such as those of individuals living enclosed among the rhizoids of the *Laminariae*, unable to develop freely in all directions. There are very tiny individuals among them.

Macoma baltica (L.). About 20 shells, length 3—16 mm, one 21 mm long.

Macoma calcaria (CHEMN.). 2 related shells, length 19 mm. and a third, 16 mm.

Mya truncata (L.). 11 shells of quite small (maximum 10 mm long) specimens, and 3 shells (fragments) of slightly larger individuals, but still to be regarded as young. The small shells are not truncate but have a rounded posterior end, i. e. are almost ovate.

Littorina saxatilis (OLIVI) var. *rudis* MATON. About 20 specimens. Maximum height 8 mm, i. e. rather small specimens.

Acmaea testudinalis (MÜLL.). Maximum length 18.5 mm. Sometimes the chequered, brown and pale colour is still present.

Lacuna divaricata FABR. 1 specimen, 16 mm.

?*Natica* sp. A bore hole in a small *Mytilus* shell.

Balanus crenatus BRUG. At least 75 shell fragments. The most numerous shell besides *Mytilus* and *Saxicava*.

Strongylocentrotus dröbachiensis (MÜLL.). 4 spines and 7 shell fragments.

Hippothoa hyalina L. A small fragment of this Scandinavian bryozoa, which according to LEVINSEN occurs especially on seaweed. A somewhat larger piece of the same bryozoa on a shell of *Acmaea testudinalis*.

Algae.

From "Engell's Profil" northwards into the northwestern bay the coast is made up of gently sloping rocks and slipping clay, so that there is no marked coast-line. Here too the top of the clay cliff was flat and everywhere covered with a layer of stones similar to that described. This stone layer was particularly handsome over the clay, where it actually formed a fine pavement. It was also reminiscent of a pavement

that the stones did not jut up, as is so often the case, but down into the clay, so that the surface was almost plane. Somewhat more to the north the clay was overlain by sand.

The sand continues along the north side of the bay, interrupted at one place by rocks with a fine, ice-striated surface. East of the rock was clay.

After another stretch of rock a low point juts into the lake. It consists of clay with shells and a stone pavement on the top, which lies about 4 m above the water level of the lake.

The following shells were collected:

Mya truncata (L.). 32 shells, 5.5—52 mm. Of a rather elongated form, straight or from above rearwards truncated. Two of the smaller shells were of the *ovata* form.
Mytilus edulis L. Many fragments of large and small shells; down to 10 mm or less.
Macoma baltica (L.). 24 shells, 8.5—18.5 mm.
Saxicava arctica (L.). 13 shells, 5—29 mm. Of an elongated *arctica* form.
Macoma calcaria (CHEMN.). 9 shells of a small form, 3—20 mm.
Littorina saxatilis (OLIVI) var. *rudis* MATON.
Cylichna sp. 8 specimens, 3—10 mm, and a fragment.

From there follows rocky coast, where it is possible to walk on a shelf resembling a small, blasted-out gallery and running horizontal, with very small deviations because the gneiss does not strike quite parallel with the coast. This shelf is to be regarded as a former water-level line, the height at three different places being measured at 4 m above the level of the lake.

On arriving out at the great projection forming the separation between the northwestern and the northern bays, it is possible to look over the whole of the latter bay. Out on the point there is some clay, and more to the north there were still stretches of this clay, sliding almost everywhere. Then follows a length of shore with quite regular sand cliffs of a height of 4 m above the lake. After a rather irregular piece of shore with sliding clay and moraine material comes a stony terrace lying 4 m above the lake. In the bed of a brook it was possible to ascertain that the cliff consists of sand. The stony terrace is then succeeded by one covered with vegetation. It runs as far as to an area of rock extending right down to the shore. Thus along the lake bank from the northwestern corner to the peninsula at the middle of the north side of the lake there is a water line, broken only by sliding clay and a little moraine, which may also have slid a little. Its height is about 4 m above the lake surface, which corresponds to about 40 m above sea level. It seems probable that this is the coastline of the Zir-

phaea Sea. A feature in support of this suggestion is that this coast has succeeded in leaving distinct traces over long stretches in the solid rock.

The rock of the peninsula is separated from the high land on the north by a low area. Seen from a distance from the west end of the bay it described a horizontal line above the 4 m terrace. A closer examination revealed that the surface was not so even, a number of small rocks cropping out through the loose earth. Nevertheless there is hardly any doubt that this is a terrace. Furthermore, there is another terrace here, about 20 m above the lake surface, corresponding to about 56 m above the sea.

In the northeastern bay the shore slopes evenly down from the peninsula towards the lake. In it are areas of clay. From a distance one can see two terraces in the head of the bay, a low one corresponding to the 4 m terrace and one rather higher, lying about 20 m above the lake surface. The low terrace especially is very extensive and reaches right in to the innermost waterfall.

An examination of the clay just mentioned showed that it was probably *Portlandia* clay. At one point there was highly stratified, sandy clay with subordinate bands of sand and many plant remains. The upper terrace was also examined. At the peninsula its outer edge is 17 m above the surface of the lake, rising smoothly upwards to the rocks behind. The terrace is covered with vegetation everywhere. The 4 m terrace, which as stated can be followed right along to the waterfall and also can be seen on the south shore of the lake, consists generally of sand with subordinate layers of clay. At several places a little clay crops out at the surface and also a little in the foot of the cliff.

The south shore of the river and the lake.

The first sections encountered are two noses in the southern slope of the river valley west of the waterfall, between the lake and the bay. The section in the first nose consists below of *Portlandia* clay overlain by a clay deposit 2—3 m thick containing *Mytilus edulis* (fig. 11). The *Portlandia* clay is sandy and stratified and there is discordance between the two sediments. The other nose consists of *Portlandia* clay below, overlain by about 2 m of relatively coarse sand combined by clay. An analysis of the *Mytilus* clay showing the mechanical composition is given in the table page 85, No. 6.

The following shells were collected:

In the *Mytilus* layer itself:

Mytilus edulis L. 9 shells, up to about 82 mm in length.

Saxicava arctica (L.). 3 shells, 16.5—29 mm. Of an elongated *arctica* form.

Mya truncata (L.). 3 shells; two of them medium in size (fragments), the third 41.5 mm; all truncate.

Cardium ciliatum FABR. 2 shells, 35—45 mm.

Pecten islandicus MÜLL. 1 small shell, 21.5 mm.

Nucula tenuis (MONT.) var. *expansa* REEVE. 1 specimen, 7.5 mm.

Buccinum terrae-novae (BECK) MÖRCH. 1 specimen (fragment). Bored by *Polydora*.

Strongylocentrotus dröbachiensis (MÜLL.). 1 spine.

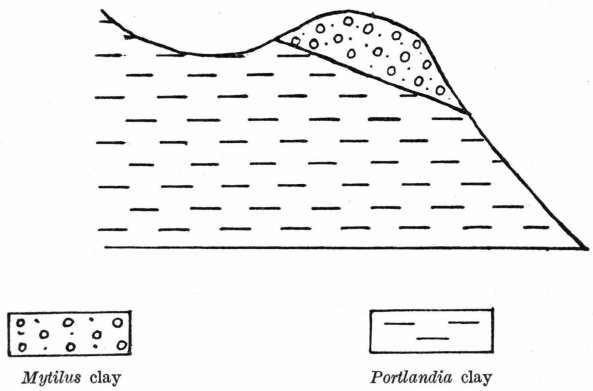


Fig. 11. Cross section of the first nose west of the waterfall.

Loose shells, collected rather high up on the slope:

Mya truncata (L.). 14 specimens and 10 shells, length 12—66 mm. Some with concretions. Most of the *ovata* form.

Macoma calcaria (CHEMN.). 12 specimens and 3 shells, length 17.5—26 mm. Some with concretions.

Saxicava arctica (L.). 7 shells, 21—40 mm. Of the *pholadis* form.

Mytilus edulis L. 6 shells, medium to large.

Pecten islandicus MÜLL. 4 shells of medium specimens.

Cardium ciliatum FABR. 3 specimens and 4 shells, 18—44 mm. Some with concretions.

Serripes groenlandicum (CHEMN.). Fragment of a small shell with concretion.

Macoma baltica (L.). 1 shell, length 13 mm.

Acmaea testudinalis (MÜLL.). 1 shell, length 13.5 mm. Colouring preserved completely.

Buccinum terrae-novae (BECK) MÖRCH. 12 specimens. Length (of the entire specimens) 55—75 mm. Characteristics: "The secondary striation consists of exceedingly delicate, closely disposed spiral striae, which, being intersected by numbers of delicate lines of

growth, give an almost shagreened appearance to the surface of the shell."[1])

Buccinum sp. 1 specimen.
Trophon sp. 1 shell, length 13 mm.
Balanus crenatus BRUG. 1 shell fragment.
Phoca sp. 1 axis.
Bones of a cod head.
Concretions.

In a small erosion gully debouching in the terrace just below the waterfall was a section, consisting below of clay with *Mya* and *Pecten* and overlain by sand which reaches the surface of the terrace over towards the waterfall.

The shells collected from the layers were:

Pecten islandicus MÜLL. 2 shells, 65—76 mm.
Mya truncata (L.). 2 specimens and 9 shells, 32—57 mm. Of a shorter or longer truncate form.
Saxicava arctica (L.). 3 shells, 25—33 mm. Of an elongated *arctica* form.
Macoma calcaria (CHEMN.). 4 shells, 21—28 mm.

On the south side of the erosion gully and just inside its mouth are some noses with very sandy *Portlandia* clay below and *Mya* layers on top. The following shells were collected:

South side of the gully.
Pecten islandicus MÜLL. 2 shells, 60 mm high.
Macoma calcaria (CHEMN.). 1 specimen and 1 shell, 21—24 mm.
Cardium ciliatum FABR. 3 specimens and 1 shell, 18—47 mm.
Mya truncata (L.). 1 specimen and 1 shell, 18—about 35 mm.
Serripes groenlandicum (CHEMN.). 2 shells, one small and one large (fragments).
Leda pernula (MÜLL.). 1 specimen, 13.5 mm.
Concretions.

North side of the gully.
Mytilus edulis L. Fragments of two adult shells.
Pecten islandicus MÜLL. 1 shell, height 71 mm.
Mya truncata (L.). 1 shell 50 mm, truncate, medium sized, elongated.
Saxicava arctica (L.). 4 shells, 20—24 mm. Almost of the *pholadis* form.
Macoma calcaria (CHEMN.). 3 shells, 16—26.5 mm.

On the south shore of the lake was the 4 m terrace again, "paved" like that on the north shore. Here and there the terrace is broken by

[1]) HERMAN FRIELE: Mollusca. I. *Buccinidæ*. Pag. 33. The Norwegian North-Atlantic Expedition 1876—1878. Christiania 1882.

rock which extends right down to the edge of the lake. On the loose slope of the terrace were clay and sand with shells. At places where the slope bore vegetation there were washed-out shells down on the beach. *Mytilus edulis*, which just at the waterfall was found in abundance, decreases gradually as one goes eastwards. In a small, clean section in the terrace it was possible to discern alternating layers of clay and sand.

A collection of shells contained the following species:

Mya truncata (L.). About 18 shells, including one of the *ovata* form, 75 mm long. Two more were of this form, the others truncate, some short, others more elongated.
Saxicava arctica (L.). 10 shells and 1 specimen, 17—26 mm. Of an elongated *arctica* form.
Macoma baltica (L.). 3 shells, 16—19 mm.
Macoma calcaria (CHEMN.). 1 shell, 22 mm.
Pecten islandicus MÜLL. Fragment of a medium sized shell.
Cardium ciliatum FABR. Fragments of a medium sized shell.
Mytilus edulis L. Fragments, few and small.

More towards the east the shells cease and fatter clay appears. At the same time the vegetation on the terrace surface ceases and the aforesaid "paved" top reappears. The fat, shell-free clay continues out on the point south of the small island in the middle of the lake and runs on into the next bay as far as the mouth of a small river. At the mouth there is a more sandy and moreover a stratified formation, though this must be assumed as having been laid down by the river. It has no shells. On the east side of the river mouth there is again shell-free clay, though here it is more sandy; all the same, it can stand with a perfectly vertical cliff face; indeed, at a small projection it was slightly overhanging; moreover at this spot there was a distinct stratification, there being very thin bands of fine sand here and there. A sample of the layer was taken (see table page 85, No. 7). Farther east the terrace top becomes a rather broad shelf with many stones on the surface and mostly clay on the slopes. Then follows rocky shore with a shelf having many large split-off stones. On the slope of the shelf were a few fragments of shells. A sample was collected and found to contain the following species:

Mya truncata (L.). Fragments of about 3 shells, large.
Mytilus edulis L. Fragments of large specimens.
Pecten islandicus MÜLL. Fragment of a large shell.
Saxicava arctica (L.). Fragment of a medium sized shell.
Macoma baltica (L.). Fragments of two adult shells.

From there the shore runs out in a small point, where again there is clay with shell fragments. The following species are represented in the material collected:

Mya truncata (L.). Fragments of 4 shells.
Pecten islandicus MÜLL. Fragment of a large shell.

Farther eastwards the 4 m terrace could be observed all the way to the waterway connecting with the lake to the east.

KANGERSUNEQ

General remarks.

Of the two fiords cutting in from Sydostbugten the northern one, Kangersuneq, extends from the mouth of Orpigsôq fiord northeastwards, which gives it a direction almost at right angles to that of the latter fiord. Kangersuneq is about 20 km long with a breadth of up to 4 km.

Whereas in Orpigsôq there is not much difference between the two sides of the fiord, because the ice cap, when it covered the land, moved more or less in the same direction as the fiord, Kangersuneq is characterized by the fact that the direction of the ice movement was across the fiord. The typical round-rock forms with stoss-and-lee sides, which recur everywhere in the landscape, large and small, appear here in the fact that the southeast side of the fiord forms a row of steep lee sides, enormous rock walls separated by valley-like depressions, falling precipitously to the water, whereas the northwest side is clearly revealed as a stoss side, for the terrain as a whole forms a smooth and evenly ascending inclined plane, even if there are naturally some irregularities in the details.

Sailing up the fiord one does not see much trace of the former higher water level. It is possible that here and there in the small valleys cutting into the country from the southeast side between the steep rocks there may be marine sediments; but from the fiord nothing is to be seen, and we made no landing anywhere. On the opposite side of the fiord, however, in the depressions between the small rock outcrops on the slopes one does now and then see fairly unimportant occurrences of clay. A hasty examination was made of one of these just northwest of Niaqornârssuaq, which is the point between the two fiords. In a small slope lying about 20 m above sea level we found fat clay. In it were *Portlandia arctica* (GRAY), 2 specimens and 1 fragment, all with the periostracum, and 1 cast; length 7.5—18 mm.

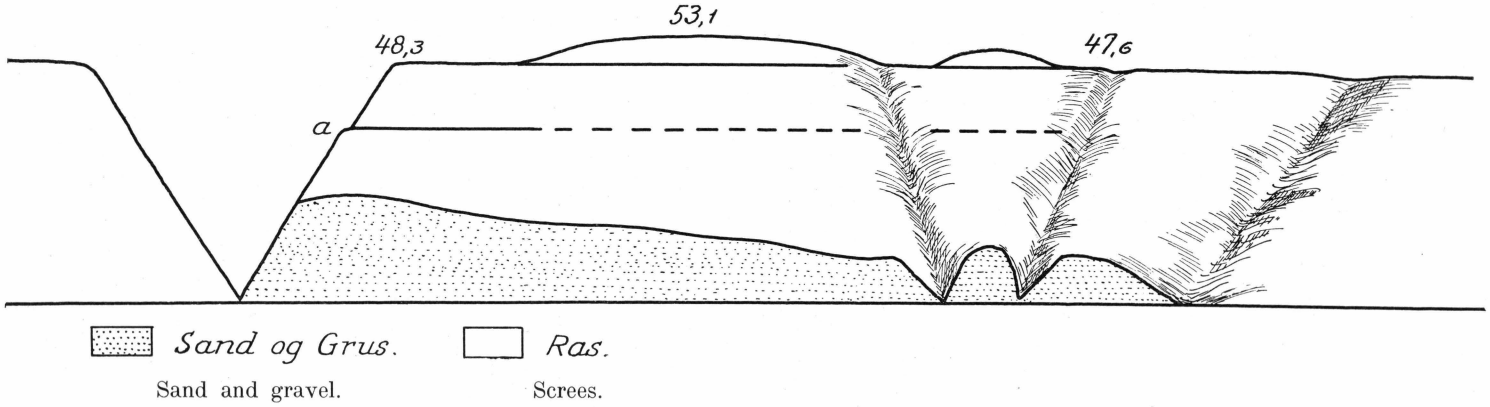


Fig. 12. The terrace at the head of Kangersuneq. See fig. 13.

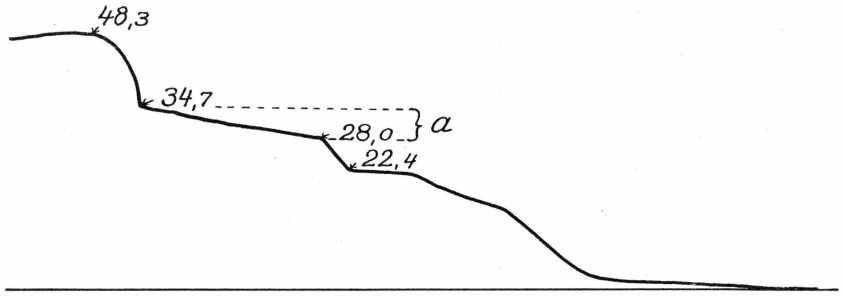


Fig. 13. Profile line at the corner of the river bed at the terrace at the head of Kangersuneq. See fig. 12.

Small erosion terraces inside the fiord.

The innermost part of this fiord is rather more irregular in form and deserves a more lengthy description, especially because in a bay on the northwest side at Sarfarssuit[1]) there are more important marine sediments than anywhere else in this fiord. But before describing them, we shall briefly mention two erosion terraces still further in.

The fiord depression does not continue in the form of a valley direct into the country, being closed at the head by a steep rock cliff which at its lowest part has a height of about 150 m. Its direction is almost north—south, the innermost end of the fjord bending slightly eastwards. Above it, however, there seems to be a valley-shaped depression continuing inland, and from it comes a small stream which dashes out over the rock wall and forms a beautiful little fall down it, until it reaches a narrow terrace which covers the lower third of the rock side.

The top of this terrace is formed of a fairly regular surface about 48 m above sea level. Above it rise a few rounded small peaks up to another 5 metres higher; a large quantity of large stones juts out of them and apparently they consist of moraine.

Towards the fiord the terrace is bounded by a rather abrupt slope, most of it covered with vegetation like the terrace top. On a short stretch from the mouth of a gully which the aforesaid small stream has cut through the terrace, southwards to some erosion channels there is a low cliff, though its top is covered with loose sand. This cliff is built up exclusively of sand and gravel of varying grades, sometimes so coarse that it is presumably moraine. The stones lying below on the beach give the impression of being moraine stones, and at any rate one was observed to be handsomely striated by ice. North of the gully and close to it was a small thin band of clay, and a little to the north of this there was a small vertical face some way up the slope, consisting of moraine sand. No shells were found anywhere.

It is imaginable that this terrace was formed as follows: When the land lay lower, the sea attacked a moraine deposit here, eroded into it and deposited the loosened material just outside, whereupon some sand and gravel perhaps were also carried there by the stream mentioned above. Even if the absence of shells prevents the terrace from being compared direct with the shell-bearing deposits elsewhere, it is nevertheless of interest by being a well-marked phase in the gradual uplift of the land corresponding to the characteristic terrace top at a little under 50 m. The subsequent, continued elevation of the land is also indicated by a number of small indentations in the slope down to

[1]) On the map Plate II, which is a part of 68 V 2 Christianshaab, the river is called Lakseelv.

the fiord. One of these indeed is particularly well marked and in places may even form a small, slightly sloping surface. Just south of the gully its height was measured at something over 30 m (28 m at the edge below and rising to just under 35 m inside the indentation). As will be seen later, these heights of about 50 m and just over 30 m recur on the much larger terraces at Sarfarssuit.

On following the northwest side of the fiord outwards from the place just described, we first pass a shallow bay, formed by a rocky area more to the southwest jutting out into the fiord. On this projection there is a good deal of moraine, as is also the case at the head of the shallow bay in a depression watered by a brook separating the landward continuation of the rock projection from the high land more to the east. At this latter place the moraine is being strongly attacked by the sea and forms a terrace like the one at the end of the fiord. Seen out from the fiord the most pronounced terrace top seems to be of exactly the same height as the upper surface of the inner terrace, i. e. about 50 m.

TERRACES AT SARFARSSUIT

Orientative remarks.

On coming from the inner end of the fiord and after passing the outermost, moraine-covered tip of the aforesaid projecting rock, we see that the coastline bends sharply back and opens into a bay, the inner limits of which over a long stretch running almost east—west are formed by the large terraces at Sarfarssuit. There is a good view of them from a low spur of the rocky projection, as it extends some way out in front of the terraces (Plate V).

A little west of the centre the regular coastline along the terraces is broken by a small inlet. Some way up the inlet and on its west side was a low, flat projection which is evidently used frequently by the Greenlanders as a camping ground. The authors also made camp here during the week of the investigations. Inside the inlet is the mouth of a river, the only watercourse of any size in this fiord and one that has given the locality its name (Sarfarssuit = the big streams). It arises from the confluence of two smaller streams. Of these, the one on the west forms the efflux of a lake lying in an extensive depression in behind the easily recognizable ridge shown on Plate V, the higher end of which stands out in dark relief against the bright sky. The steep mountain wall in the background and a little to the right of the ridge in the picture lies on its bank, which all the way along its east side is precipitous, but on the west side very gently sloping and apparently largely covered by moraine, but without terraces. Through the low notch immediately west of the ridge the efflux from the lake makes its way out to a wide, swampy depression in the terraces west of the stark, isolated rock which is so prominent (cf. Plate V) and has a height of 434 m, (cf. the map Plate II). In this depression it converges with the other river arm coming from a narrow valley which, behind the big rock, runs northeast and at Akiamiut connects with Tasiussaq, the large branch of Jakobshavn's Isfjord running southeast. The river resulting from the converging of the two streams runs in a curve out to the inner end of the

inlet—on the last stretch through a very stony, wide bed with a considerable fall.

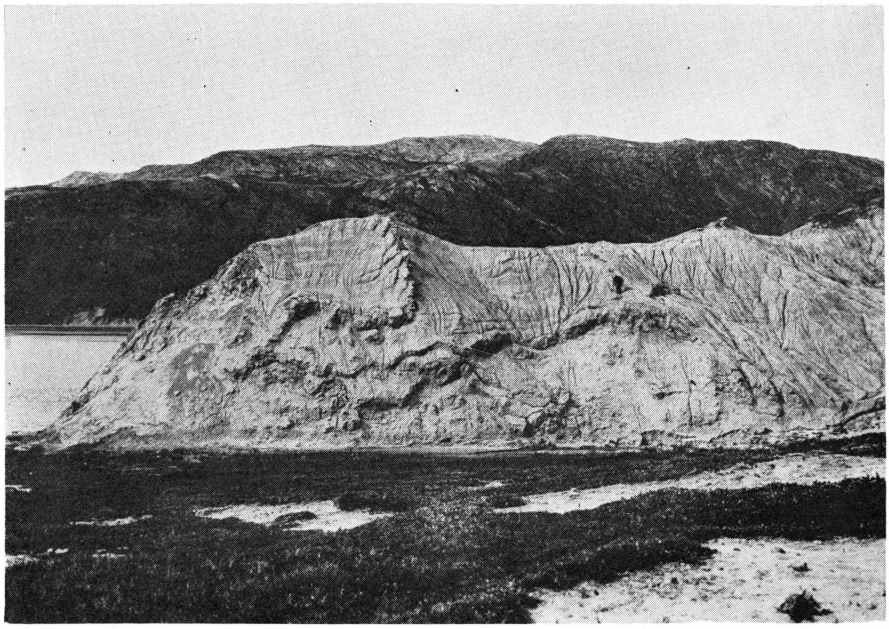
None of the terraces reach up above the rock threshold separating the large lake depression from the outer land, but they continue in the valley running northeast. In front of its entrance they spread out and cover all the ground between the aforesaid mountains and the coast. Westwards they rest against the mountain side on the extreme left of Plate V, which quickly reaches down to the coast. On the east they are still greater in extent, for east of the 434 m rock another but smaller depression stretches into the high land, but without continuing as a valley: it terminates with a rounded end and has merely a brook running through it.

At many places large and small erosion channels cut into the terraces. Several of them will be described in the following.

The photographs reproduced show in advance that the terrace landscape at Sarfarssuit is built up of greatly varying soils. For example it can be seen (Plate V) that the slopes west of the inlet are of gravel, and it is just as striking that the light-coloured areas at the coast east of the inlet consist of fat clay which, as will be seen later (fig. 14), is marine. In addition there are other and more sandy marine deposits, besides some moraine. It is clear that the marine sediments and the regularly formed gravel terraces must both have been laid down after the ice cap had melted away from there; in other words, that the moraine deposits are the earliest of the various sediments. After them in age come the marine sediments, and the latest is the gravel. This is evident from the fact that at many places the clay can be seen running in under the gravel deposits. In the following the various sediments will be described in the order in which they were laid down, the earliest first, the latest last.

Moraine deposits.

At the foot of the mountain side running out to the west side of the bay there is, at the place where it reaches the coast and where the terraces end, a low cliff in a moraine deposit which is unusually clayey for these parts; elsewhere it is very sandy. Nevertheless, it also contains numbers of stones and its nature is such that in Denmark a similar deposit would be called clayey, respectively sandy moraine gravel. On top of the cliff the surface of the moraine forms a fairly smooth slope stretching up the mountain side. It reaches a much greater height than any of the later deposited terraces and therefore its upper part can be followed along the mountain and into the area where the lower ground is covered with terraces, and it is presumable that it continues under them.



P. HARDER phot. 31/7 06.

Fig. 14. Section of *Portlandia* clay on a brook running into the bay east of the inlet.

Moraine was also observed at a place in the terraced terrain. On following the river from its mouth at the head of the inlet one notices that along the first length its fall is only fairly steep, but that further in it becomes steeper, and simultaneously the river bed becomes full of large glacial boulders, among which the river spreads and rushes along. This part of the river bed forms a kind of barrier outside the swampy, flat bottom of the depression west of the 434 m rock, and everything indicates that the river cuts through a moraine which here, and also on the ground to the southwest, must therefore rise to the surface. Thus the slide-covered erosion slopes on the left side of the river are much more irregular in form than the very regular slopes on the sand and gravel terraces. Quantities of large boulders in these slopes are also conspicuous, among them being several that are striated by ice. On the opposite side (the east side of the river) there are also two stony, small slopes, but there the stones are mostly rounded and give the impression of having been roughly treated by running water.

Above the latter small slopes and extending west and southwest is an area with a surface that is not of such a regular plane as otherwise everywhere else in the terraced terrain, but rather should be described as hummocky. Thus there are some small wet depressions and waterholes, and even a solitary little lake with a depth of up to 6 m. On the whole, however, the area is flat, and even these few irregularities are

generally no greater than those to be seen in the above-described section of the present river bed. So it is natural to regard this surface too as a terrace top or, to be more exact, an irregular erosion plane formed at a place where a river has flowed over an elevated moraine area. On the other hand, it is difficult to dismiss the thought that some of the larger depressions, and especially the small lake, were formed by subsidences at spots where the moraine once contained small blocks of ice which afterwards melted, i. e. dead ice, a process which may just have taken place in the distinctly warm period which set in *after* the formation of these terraces.

Marine sediments.

Sandy clay. At certain places inland a marine sediment has been observed, of a much more sandy character than the clays seen in the cliffs along the coast and probably of earlier date. For instance, along the western fork of the river there are some small scree covered sections in fine sand with thin bands of clay. Although the clay in all cases is subordinate, it suffices to give the sliding and rainwashed face a clayey appearance. There are no shells in these layers, or at least extremely few; at one place alone was a single shell fragment observed; it was on the east side of the river and opposite the outer tip of the terrace spit jutting out between the two river arms, the height of this section is about 9 m and the upper edge of the sediments is about 55 m above the sea.

A sediment which presumably is the same as the one just referred to—although it is not quite so sandy—is exposed in the gully extending into the eastern depression east of the 434 m rock. A good way up this gully, at a height of about 50 m above sea level and on the east side of the brook, there is a slope consisting of clayey fine sand, the surface of which is being covered. It can clearly be seen that it runs in under the gravel on the top of the terrace. The following shells were collected there:

Macoma calcaria (CHEMN.). 14 specimens and 17 shells, 13—31 mm.
Cardium ciliatum FABR. Fragments of 2 small shells.
Mya truncata (L.). 4 specimens, 17.5—36 mm.
Saxicava arctica (L.). 5 specimens, 16—22 mm. Of an elongated *arctica* form.

Continuing outwards along the brook from this locality one finds two more projections a little farther down, consisting of a very similar soil but overlain by a considerable quantity of gravel, easily recognizable in the very regular slopes rising above the clayey projections down by the brook. No shells were found at these places.

By their sandy character these sediments differ markedly from the fat clay found chiefly along the coast east of the inlet and to be described below. The fauna too, sparse though it is, differs from that of the clay; for instance it lacks *Portlandia arctica*, which is such a characteristic high-arctic element of the clay. Accordingly, there is reason for supposing that the two sediments are of different periods; and as the sandy deposits display no agreement with the layers observed in the vicinity overlying the *Portlandia*-bearing, fat clay, the most reasonable assumption is that they are earlier and form the earliest of the marine sediments found in this neighbourhood. The analogy with the above described sequence at Orpigsôq fiord is another argument in favour of this assumption. In that case the sandy strata would correspond to the lowest marine sediments in the terrace in Orpigsôq (Horizon B). On the other hand, at Sarfarssuit we know of no transitional layer between this sediment and the *Portlandia* clay—the horizon designated C in the Orpigsôq sediments.

Fat clay with *Portlandia*. At many places along the coast and in erosion gullies cutting inland from it, but only in the area west of the inlet, there are profiles in fat, greenish-blue clay. In character it is exactly the same as the fat clay in Orpigsôq fiord (Horizon D) and, as will be seen from the following, it bears a similar fauna, characterized especially by the frequent occurrence of *Portlandia arctica* and *Nucula tenuis* var. *expansa*. A number of localities where shells were collected will be described below.

The whole east side of the inlet is bordered by steep slopes, with heights generally decreasing from the head outwards from about 50 m to about 19 m at the outer point. Along a stretch right inside the inlet and also on the outermost, somewhat projecting part the slopes are regular in shape, steep, almost naked gravel slopes, but between them the greater part is green clad with contours characterized by small slides and evidently consisting of clay. This clay is exposed at four places, making it possible to collect shells from it. The species found are given below in groups, one for each of the four places designated by the letters a—d in the order from inside the inlet outwards.

a. *Serripes groenlandicum* (Chemn.). 1 specimen, 16 mm.
Cardium ciliatum Fabr. 1 cast (with part of the shell attached) of a specimen about 12 mm long.

b. *Portlandia arctica* (Gray). 1 cast of a specimen about 9 mm long.

c. *Macoma calcaria* (Chemn.). 3 specimens, 20—32 mm.
Idothea sabinei Kr. 1st, 2nd and parts of 3rd segment.

d. *Portlandia arctica* (Gray). 4 specimens and 7 shells, 6.5—16 mm.

Nucula tenuis (MONT.) var. *expansa* REEVE. 2 specimens, 7.5—9 mm.
Macoma calcaria (CHEMN.). 6 specimens, 15—26 mm.
Cardium ciliatum FABR. 1 shell, 10 mm.
Mya truncata (L.). 4 specimens, 28—45 mm. Of a truncate form.

In addition, approximately above locality d, up at the transition between the terrace top with its clay hummocks and the slope:

Nucula tenuis (MONT.) var. *expansa* REEVE. One shell in a concretion.
Mya truncata (L.). 10 specimens, in fragments, medium and small.

The coastal cliffs along the bay east of the inlet begin with a gravel point about 19 m high, then follows a stretch with fine sand with broad,

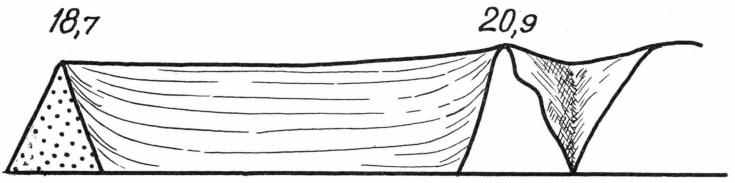


Fig. 15. Sketch of the pyramidal "nose" east of the inlet.

overhanging layers, westwards terminating at the gravel and eastwards at a clay nose about 21 m high (fig. 15). Eastwards from there is fat clay all the way, generally sliding and the rather irregular, only slightly steep slopes are faced with vegetation. Here and there, however, the clay is visible in large and small noses out towards the coast, or it is exposed in small erosion gullies cutting into the land. The following is a description of all the noses along the coast from west to east, numbered 1 to 14.

Nos. 1 and 2 form a continuous, large area of fairly pure clay rising to a height of about 21 m. The following shells were gathered:

Portlandia arctica (GRAY). 70 specimens and 53 shells, 4—18 mm.
Nucula tenuis (MONT.) var. *expansa* REEVE. 28 specimens and 2 shells, 4.5—13 mm.
Macoma calcaria (CHEMN.). 38 specimens, 7—26 mm.
Cardium ciliatum FABR. 1 specimen and 4 shells, 7—26 mm.

No. 3. is small and covered with gravel.

No. 4 is a small nose following after a depression which extends in towards the inner part of the inlet, or, more exactly, the point where the high gravel slope adjoins the green-clad clay slope. No. 4 contained the following shells:

Portlandia arctica (GRAY). 4 specimens and 7 shells, 6.5—16 mm.
Nucula tenuis (MONT.) var. *expansa* REEVE. 2 specimens, 7.5—9 mm.

Macoma calcaria (CHEMN.). 6 specimens, 15—26 mm.
Cardium ciliatum FABR. 1 shell, 10 mm.
Mya truncata (L.). 4 specimens, 28—45 mm. Of the *truncata* form.

No. 5 yielded the following:

Portlandia arctica (GRAY). 116 specimens and 38 shells, 9—20.5 mm.
Nucula tenuis (MONT.) var. *expansa* REEVE. 15 specimens and 1 shell, 8—13 mm.
Macoma calcaria (CHEMN.). 53 specimens, 10—30 mm.
Cardium ciliatum FABR. (1 specimen, 10 mm.)
Mya truncata (L.). 3 specimens, 21—28 mm.

No. 6 is separated from No. 5 only by a slight fall. It forms a conspicuous projection, with its top about 17 m above sea level. Immediately to the east of it an erosion gully runs inland, so that the east side of the nose continues in the form of a handsome slope of pure clay for some distance inwards. The following shells were collected on the point itself and the above continuation:

Portlandia arctica (GRAY). About 800 specimens, up to a length of 22.5 mm.
Nucula tenuis (MONT.) var. *expansa* REEVE. About 100 specimens, up to 14.5 mm long.
Macoma calcaria (CHEMN.). About 150 specimens, 12—32 mm.
Cardium ciliatum FABR. 4 specimens, small, 10—25 mm.
Saxicava arctica (L.). 1 shell, 26 mm, of the *pholadis* form.
Mya truncata (L.). 1 shell, short, cut off obliquely forwards.
Mya truncata (L.) forma *ovata* AD. S. JENSEN. 38 specimens and 13 shells. Length 12—63 mm.

As will be seen, this locality is extraordinarily rich in shells, *Portlandia arctica* being easily the most frequent species. Out on the point itself it occurs everywhere from foot to top; the largest specimens (up to 22.5 mm) were found high up on the gully side. Uppermost in the clay here *Mya truncata* f. *ovata* was frequent, whereas it was absent lower down, where *Mya* occurs only in the *truncata* form, and rather sparsely at that. The largest specimens of *Macoma calcaria* were found high up together with *Mya truncata* f. *ovata*. Similar conditions were observed further up the gully; uppermost, *Mya truncata* f. *ovata* was frequent, *Macoma calcaria* in large specimens and *Nucula tenuis* var. *expansa*. From the middle of the slope and downwards, however, only *Portlandia arctica*, *Nucula tenuis* var. *expansa* and *Macoma calcaria* were observed.

Nos. 7, 8, 9, and 12 together yielded the following:

Portlandia arctica (GRAY). 197 specimens and 3 shells, 4.5—16.5 mm.
Nucula tenuis (MONT.) var. *expansa* REEVE. 27 specimens and 1 shell, 4.5—13.5 mm.
Macoma calcaria (CHEMN.). 25 specimens, 7—33 mm.
Cardium ciliatum FABR. 1 specimen, 40 mm.
Serripes groenlandicum (CHEMN.). 1 specimen, 23 mm.
Mya truncata (L.). 18 specimens and 7 shells, greatest length 60 mm. Half (the larger) of the *ovata* form, the other half (the smaller) of short form, obliquely forwards truncated (*uddevallensis*); one, however, is of an elongated-truncate form (ovate truncated).
Saxicava arctica (L.). 2 specimens, 29—32.5 mm. Of an elongated *artica* form.

Regarding the individual noses and the distribution of the fossils the following may be added. Out towards the bay No. 7 is covered with screes, but outermost on the slopes in towards a small gully running inland were *Portlandia arctica*, *Nucula tenuis* var. *expansa*, *Macoma calcaria* and *Mya truncata*; farther in on the same slope, but at a high level, were numerous fairly large *Mya truncata* and a few *Mya truncata* f. *ovata*, besides *Macoma calcaria* of large size and a single *Saxicava arctica*. In Nos. 8 and 9 *Portlandia arctica* was numerous, besides *Nucula tenuis* var. *expansa*, *Mya truncata* and *Macoma calcaria*. In Nos. 10—11 there were a very few *Portlandia arctica* and *Macoma calcaria*. Nothing was collected here. No. 12 is large and, like No. 6, lies just west of the mouth of an erosion gully which extends a good way inland. Here again the east side of the nose continues inland in the form of a clay slope. On the side facing the bay there were only few *Portlandia arctica* and *Macoma calcaria*, but on the gully side there were again numerous *Portlandia arctica*, *Mya truncata* f. *uddevallensis*, *Macoma calcaria* and *Nucula tenuis* var. *expansa*. A good way up the gully at a high level were again *Mya truncata* f. *ovata* and large specimens of *Macoma calcaria*; a rather large specimen of *Cardium ciliatum* was also found and one of *Serripes groenlandicum*. As will be seen later, near the inner end of the same gully there are later deposits with shells indicating a higher sea temperature.

After the large nose No. 12 there are only two small ones before the clay comes to an end and the solid rock crops out to the beach. A few *Mya truncata* and *Macoma calcaria* were observed in No. 13, whereas no shells were found in No. 14.

On correlating all the foregoing details about the clay and its fossils into one general picture, one receives the impression of a very homogeneous sediment with a fauna that is poor but somewhat varying in

the composition of its species. It is particularly noteworthy that uppermost in the clay we encounter forms not otherwise found while other forms are absent. The following table visualizes this phenomenon:

	Occurring generally	Uppermost only
Portlandia arctica	+	..
Macoma calcaria	+	+ large
Nucula tenuis var. *expansa*	+	+
Mya truncata	+	+ fairly large
Mya truncata f. *uddevallensis*	+	..
Mya truncata f. *ovata*	..	+
Cardium ciliatum	+ small	+
Serripes groenlandicum	..	+
Saxicava arctica	+	+
Idothea sabinei	+	..

Of the species contained in the first column, *Portlandia arctica* is greatly in the majority; then follow *Macoma calcaria* and *Nucula tenuis* var. *expansa*. In the fauna shown in the second column the dominants are *Mya truncata* f. *ovata* and *Macoma calcaria*.

It will be seen that the fauna occurring generally in the clay is truly high-arctic, whereas in the upper layers it is precisely the extremely cold-loving forms that have disappeared and less markedly arctic forms make their appearance. Thus the fauna uppermost in the clay indicates the beginning of the subsequent climatic improvement.

Younger sediments of a milder period. At Sarfarssuit, only relatively little was found of younger sediments containing fossils indicating milder climatic conditions than those prevailing when the *Portlandia* clay was deposited; indeed, on the whole it is probable that only little of such sediments were formed, because, the regular deposition of marine sediments here was interrupted by considerable quantities of fluvial water which began to flow out into the fiord and deposit its sand and gravel in the form of delta sediments over the already existing marine layers, in other places eroding parts of them.

A slight trace of such a later deposition was found on the stretch of coast described above: lying loose on the surface at the top of nose No. 1 at a height of about 20 m were some shells, partly of species which did not occur even in the uppermost layers of the clay. Among them, *Pecten islandicus* was the most frequent, and it is so much the more curious as this species was found only at this locality, unless we include two loose finds, one of which (68 mm) was found on the surface

of nose 3, the other (45 mm) in the bed of the brook a little below the *Mytilus* occurrence described in the following. It was not possible to find the sediment from which these shells came. The species found were:

Pecten islandicus MÜLL. About 10 shells, about 25 mm.
Mya truncata (L.). Fragments (hinges) of 10 shells of adult specimens.
Macoma calcaria (CHEMN.). 1 shell (27 mm) and 1 fragment.
Astarte montagui (DILL.). 1 specimen with valves still joined, 13 mm.
Cardium ciliatum FABR. 1 specimen and 2 shells, 20 mm.
Leda minuta (MÜLL.). 1 specimen, 14.5 mm.

In the erosion gully which, as already stated, runs from nose No. 12 inland, was a remnant of some layers that differ distinctly from all the other marine strata hereabouts. This was near the inner end of the gully at a height of about 28 m above sea level. In a slope on the right side of the gully it was observed that a number of shells of *Mytilus edulis* were projecting just over half way up. On excavating through the layer of fallen material covering the entire slope was found, about 7 m below the land surface, a bed of blue clay rich in large *Mytilus* shells. This species was still present in the clay a little lower down, but only sparsely, and this was succeeded by a band of numerous *Saxicava arctica* and no other. Underlying this was shell-free, sandy, yellowish clay. This deposit could not be followed farther down, as the lower end of the slope was covered with a large mass of loose material, but it was recognizable in a small projection on the same side of the gully and a short distance out towards the coast. At the latter spot the sandy, yellowish bed reaches higher up, and both this and the underlying sediments were easily got at by excavating. Here, about 2 m below the top of the yellowish deposit, was *Mya truncata* f. *ovata* with the periostracum; 1,5 m lower the first *Nucula tenuis* var. *expansa* was found. Downwards from there the shells of *Portlandia arctica*, *Nucula tenuis* var. *expansa* and *Macoma calcaria* gradually become numerous. It will thus be seen that the yellowish clay lies directly upon the clay deposit described in the foregoing.

In the projection just mentioned the *Mytilus*-bearing sediment itself is missing, and the highly elevated yellowish clay is overlain directly by dark, distinctly small-fragmented clay. In the slope with the *Mytilus* bed, right at the top, is a thin band of sand and underlying it a very similar dark, small-fragmented clay which probably extends right down to the *Mytilus* deposit. This fragmented clay must be an older, rebedded sediment or, in other words, a clay conglomerate like the one described under Orpigsôq fiord and thus collateral with the gravel and sand deposits which cover the terrace surface to such

a great extent. This interpretation is supported by the fact that uppermost in the fragmented clay were fairly numerous concretion-filled shells of *Mya truncata* and *Macoma calcaria* which, in all probability, came from the *Portlandia* clay.

The following shells were recovered from the *Mytilus* layer:

Mytilus edulis L. 8 shells, length 50—72 mm, With periostracum, some also with algae adhering.

Macoma calcaria (CHEMN.). 4 specimens and 15 shells. 10—about 25 mm. With periostracum.

Serripes groenlandicum (CHEMN.). 2 shells, 15.5 mm. With periostracum.

Mya truncata (L.). 2 specimens and 3 shells, 12—30 mm. Moderately elongated; with periostracum.

Saxicava arctica (L.). 4 specimens and 18 shells, 5—26.5 mm. Some of an elongated *arctica* form, others of the *pholadis* form, a few of irregular form ("pinched"). With periostracum.

Littorina saxatilis (OLIVI) var. *groenlandica* MØLL. 10 specimens, 6.5—8.5 mm.

Littorina palliata SAY. 4 specimens.

This fauna differs in two respects from that of the older clay sediments, as it may be characterized as a markedly littoral fauna, and also it indicates a much milder climate—almost corresponding to what prevails today in the sea in this part of Greenland.

MARRAQ IN SYDOSTBUGTEN[1])

In the present context this name designates the low stretches of clay and sand along the south shore of Sydostbugten (Plate I).

The investigation was made on the tract between Sarpiussat and the land inside the island of Ujaralik, commencing at a point Niaqornârusuaq (fig. 16) lying midway between these two extremes.

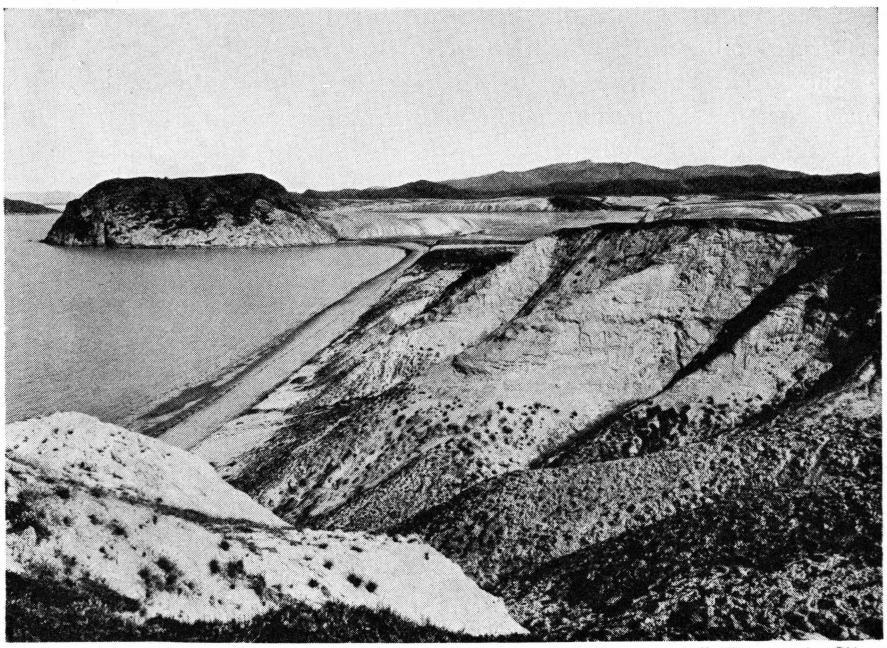
Just to the west of Niaqornârusuaq is the mouth of a river which forms a delta which in summer, when the river shrinks considerably and has a breadth no greater than an ordinary Danish stream, is regularly flooded at high water. In conjunction with the banks of the delta there is a low, sandy beach on which were large quantities of washed-up shells: *Serripes groenlandicum* (CHEMN.), *Mytilus edulis* L., *Macoma baltica* (L.), *Cardium* sp., *Modiolaria faba* (MÜLL.) FABR., *Modiolaria discors* (L.) var. *laevigata* (GRAY), *Astarte borealis* (CHEMN.), *Astarte* sp., *Lacuna divaricata* (FABR.), *Littorina* sp., *Bela* sp. and *Pectinaria* tubes. Washed out of the uplifted sediments were *Portlandia arctica* (GRAY), *Macoma calcaria* (CHEMN.) and *Pecten islandicus* MÜLL.

Just west of the river mouth the land has the form of a fairly flat clay plain without vegetation (Plate VII), where a number of shells were collected:

Macoma calcaria (CHEMN.). 14 specimens, 17—32 mm.
Portlandia arctica (GRAY). 6 specimens, 14.5—18 mm.
Yoldia hyperborea (LOVÉN). 5 specimens, 24—30 mm.
Cardium ciliatum FABR. 3 specimens, 13—22 mm.
Serripes groenlandicum (CHEMN.). 3 specimens, 11—24 mm.

Westwards from Niaqornârusuaq, on the first stretch is a low, somewhat sliding cliff of fat clay (fig. 16). A little more to the west the cliff begins to rise in height and at the same time sand begins to appear above. The boundary between clay and sand is marked by the clay noses projecting more forward than the overlying sand. Between these two sediments there is an intermediate bed of sandy clay, with

[1]) Now officially called Naternaq (Lersletten, the clay plain).



P. HARDER phot. $^{6}/_{8}$ 06.

Fig. 16. The coastal cliff west of Niaqornârusuaq, which is seen in the background.

no distinct boundary above or below. The cliff top rises rapidly to a funnel-shaped fall (Plate III, Fig. 2 and VII). Immediately west of this the solid rock crops out at the bottom of the cliff section. The surface of the rock bears ice striae (direction app. N. 60° E.). Adhering to the outer surface were remains of the clay which also covered the top. At this point the height of the cliff was about 49.5 m. Thereafter the rock rises steeply in the section and indeed appears through the clay high up in the section. Above this the clay continues right up to the top of the cliff and the sand disappears. This cliff projection is followed by a small green-clad part with a small clay nose, succeeded by a part where the clay bends up and now appears only in the form of small lumps on the top of the noses. The latter consist of moraine, the surface of which rises inwards, as can be seen in the falls between the noses. Thus the moraine seems to be associated with the rock jutting up inside the coastline. The moraine is rich in stones and on the beach lie large numbers of washed-out stones, some of them very large. For the rest it varies greatly in character; at places there is irregular moraine material of heterogeneous grain sizes, but as a rule the cliff is built up of regular, horizontal beds of well-assorted finer and coarser sand and small gravel, alternating with more moraine-like beds and everywhere containing large boulders. Rolled *Balanus* were found here in finely graded gravel.

Westwards again is another short length of cliff with clay, and this in turn is followed by a similar moraine with quantities of large stones on the beach. This part seems to adjoin the long rocky ridge inside the coast. Where this moraine ends a clay cliff begins and extends in almost a straight line, gradually decreasing in height, to the rock at the northeast corner of the bay inside Portussut[1]).

The east shore of the bay consists of fairly low clay noses with green falls in between. It is only towards the head of the bay that tall, bare sections appear, sections which also form most of the south shore. The west shore was surveyed. There, from the head of the bay and outwards were tall clay sections, though they decrease in height. The west shore terminated at a small rock spur connected with the ridge inland. North of the spur the shore turns slightly westwards and forms a small inlet.

At the rock were two small noses with a thin deposit of clay overlying sandy moraine. The clay was poor in shells of *Portlandia arctica* (GRAY) and *Macoma calcaria* (CHEMN.).

Unfortunately, there was no connection between these layers and the *Portlandia* clay more to the south, for rock ran out to the beach between the two sections of the cliff.

The southern part of the clay cliff has its northern part resting on rock, whereby it contrasts with the other cliffs in the neighbourhood. The rock substratum is not plane, but runs up and down and often disappears under the beach. Over the rock is a bed of stony and sandy moraine clay of varying thickness. At places where the rock rises high the moraine sometimes thins right out; at other places, where the rock disappears under the beach, moraine up to 5 m thick was observed. The top of the moraine clay is slightly undulating, and on it the *Portlandia* clay lies conformably, though there is a distinct filling of the depressions, so that very soon the stratification of the *Portlandia* clay is not influenced by the upper boundary of the moraine (fig. 17).

This clay, which was somewhat heterogeneous, had a thickness of about 1 m here. In a nose more to the north the overlying fossiliferous horizon was only about 10 cm thick, whereas the underlying clay reached a thickness of 2 m. This was more homogeneous and contained *Portlandia arctica* (GRAY) and *Macoma calcaria* (CHEMN.).

About 1 or 2 metres above the moraine in a short length of this northern part of the cliff was a thin bed of clay containing sand and small stones and also an abundance of shells. It was not very thick,

[1]) In his diary HARDER called this bay Padusarniarfik after HAMMER's map (Medd. om Grønl. Vol. 8, 1883) and added that his Greenlander companions did not know the name; nor is it used on the Geodetic Institute map (68. V 2. Christianshaab) (plate I).

the greatest measurement found being 30—40 cm. The following shells were taken from it:

Macoma calcaria (CHEMN.). 85 shells and 3 specimens. A large form, up to 39 mm long.

Mya truncata (L.). About 50 shells, length 17—67 mm. Most are of a short *uddevallensis* form and sharply cut off from above forwards; some are of a more elongated form, square or obliquely rearwards truncated. One shell bored by *Natica*.

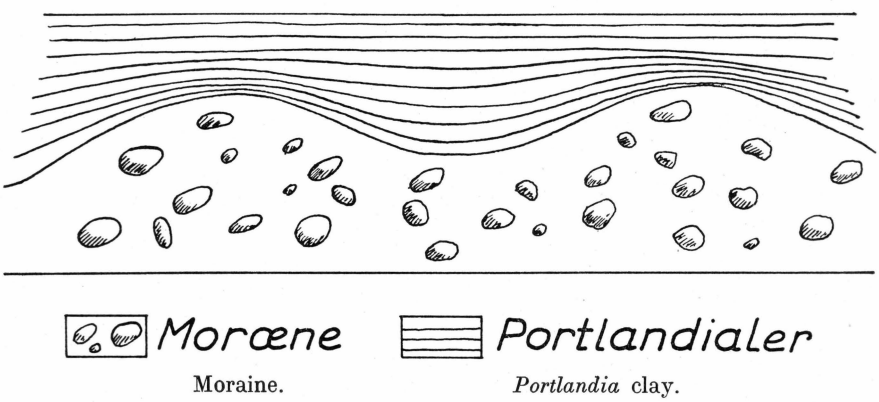


Fig. 17. Moraine clay overlain by *Portlandia* clay.

Saxicava arctica (L.). 11 shells and 2 specimens of an elongated *artica* form; the shell fairly substantial. Length up to 41 mm from 10 mm.

Cardium ciliatum FABR. Fragments of 9 shells, small and medium.

Macoma torelli (STP.). 1 specimen and 1 shell, length 15—18 mm.

Astarte montagui (DILL.). 1 shell and 2 specimens, 9.5—15 mm.

Serripes groenlandicum (CHEMN.). Fragment of a medium shell.

Lyonsia arenosa (MÖLL.). 1 fragment of the shell of an adult individual.

Utriculus pertenuis GOULD. 1 specimen.

Natica clausa (BROD. & SOW.). 1 specimen.

Balanus balanus DA COSTA. 5 specimens and some shells.

Balanus hammeri ASCAN. Numerous shells.

? *Membranipora* sp. A much damaged colony.

In spite of continued and energetic search, no *Portlandia artica* was found in this sediment, but above it the species was found in situ in the overlying *Portlandia* clay, which extended right up to the top of the cliff. In this layer the following fossils were collected:

Lyonsia arenosa (MÖLL.). 15 specimens and 1 shell, 5.5—25.5 mm.

Portlandia artica (GRAY). 4 specimens and 4 shells, 13—21 mm.

Yoldia hyperborea (LOVÉN). 3 specimens, 23—27 mm.
Nucula tenuis (MONT.) var. *expansa* REEVE. 1 specimen, 11 mm.
Sipho sp. 2 fragmentary specimens.
Buccinum sp. 1 specimen. On it were:
Hippothoa hyalina L. 1 colony, and
Polydora ciliata JOHNST.
Concretion with a fragment of a fish vertebra.

The following measurements can be given of the *Portlandia arctica* specimens found:

	length	height	height / length	breadth	breadth / length
a.	21	13	61.9 %	9	42.8 %
b.	19.5	13	66.7 -	10	51.3 -
c.	19	13	68.4 -	10	52.6 -

Specimen a comes nearest to the variety *portlandica* HITCHCOCK, whereas b and c with their short and rather curving form turn out to be of the variety *siliqua* REEVE.

The heights of the noses varied from about 20 to 27 m.

As already stated, there is an inlet just west of the bay. There its east coast is occupied entirely by clay cliffs containing *Portlandia*, though the shelly bed with *Pecten islandicus* lies westernmost. Above the cliff and inwards on the land, however, there is also *Portlandia* clay, and it would seem that the Pecten horizon belongs to a sediment laid down upon an inclined plane of *Portlandia* clay sloping into the sea. The cliff had slipped a good deal, however, so that the question could not be decided. At one point it was possible to find the sediments in situ and accessible, viz. in a small gully between the vertical rock on the west and the clay. Here were sloping clay beds with thin bands of sand. Upwards the latter gradually became layers about 2 cm in thickness with many shells:

Saxicava arctica (L.). Many, with a good number of joined valves. Some of the *pholadis* form, some of an elongated *arctica* form; a few "pinched". On the whole thick-shelled, though some few were rather thin. Length 3—43 mm.
Pecten islandicus MÜLL. 3 shells, maximum height 61 mm.
Mya truncata (L.). 1 specimen and 3 shells. 8.5—40 mm. Of a medium, elongated form.
Macoma calcaria (CHEMN.). 3 specimens and 10 shells, length 7—31.5 mm. 1 shell bored by *Natica*. Periostracum adhering to a large extent.
Modiolaria discors (L.) var. *laevigata* GRAY. 3 specimens, maximum length 38 mm. With periostracum.
Astarte montagui (DILL.) var. *striata* (LEACH) SARS. 2 shells, 8.25 mm.

Lacuna vincta MTG. 2 specimens, medium (defect).
Mytilus edulis L. juv. 1 shell, length 15.25 mm.
Leda minuta (MÜLL.). 1 shell, 15 mm.
Lepeta coeca MÜLL. 4 specimens, 10.25—19 mm.
Acmaea rubella (FABR.). 3 specimens, 5—8.5 mm.
Puncturella noachina (L.). 1 specimen, 6.5 mm.
Margarita groenlandica (CHEMN.). 4 specimens, medium.
Buccinum sp. 2 specimens and 2 fragments of small specimens.
Balanus balanus DA COSTA. Numerous specimens, many still joined.
Balanus hammeri ASCAN. 2 shell fragments.
Hemithyris psittacea (GML.). 1 ventral shell, adult.
Spirorbis affinis LEV.
Spirorbis borealis DAUD.
Spirorbis verruca FABR.
Spirorbis spirillum L.
Spirorbis carinatus MONT.
Chitinopoma Fabricii LEV.
Hippothoa hyalina L.
Myriozoum crustaceum SMITT. On *operculum* of *Balanus balanus* DA COSTA.
Stomatopora incrassata SMITT.
Discopora scabra (FABR.) SMITT.
Porella compressa SOW.
Membranipora catenularia JAMESON, on shell of *Balanus balanus* DA COSTA.
Membranipora unicornis FLEM. var. *americana* D'ORB.
Membranipora spatulifera SMITT. On *operculum* of *Balanus balanus* DA COSTA.
Membranipora (*Tegella*) *sophia* BUSK. 2 colonies on opercula of *Balanus balanus* DA COSTA.
Membranipora lineata L. 2 small colonies on tube of *Spirorbis borealis*.
Algae.

It is characteristic that the shells are in a good state of preservation, molluscs as well as barnacles; often they are joined, with well-preserved periostracum. Another remarkable feature is the large number of bryozoa and tubicoles.

An excavation was made in the cliff a little above this locality, resulting in a large number of fossils, although the material looked like screes. The following shells were found:

Macoma calcaria (CHEMN.). 17 shells, 22—30 mm. 3 were bored by *Natica*.
Mya truncata (L.). 13 shells, 24—50 mm. Some of a short, others of a medium-long form.

Saxicava arctica (L.). 6 shells of an elongated *arctica* form. About 12—37 mm.
Leda minuta (MÜLL.). 1 shell, 14 mm.
Serripes groenlandicum (CHEMN.). 3 fragments of small and medium specimens, and a young shell, 2.5 mm.
Cardium ciliatum FABR. 2 fragments of small specimens.
Balanus balanus DA COSTA. One specimen and some shell fragments.
Balanus hammeri ASCAN. 4 shell fragments.
Micropora borealis BUSK. About 10 branches lying in the clay inside *Balanus balanus.*

In the loose material lying on the cliff slope:
Mya truncata (L.). About 50 shells, 15—61 mm. Most of a short form, obliquely from above forwards truncated, a few of a medium form, elongated, square truncated.
Macoma calcaria (CHEMN.). About 35 shells, 14.5—44.5 mm. 5 of them bored by *Natica.*
Saxicava arctica (L.). 29 shells, 26.5—47 mm; most of an elongated *arctica* form, some very thick-shelled and "multi shelled", a few of the *pholadis* form.
Pecten islandicus MÜLL. 23 shells, 20—70 mm high.
Astarte montagui (DILL.). 23 shells, 14—23.5 mm. 1 shell bored by *Natica.*
Leda minuta (MÜLL.). 1 shell, 16 mm.
Lunatia pallida (BROD. & SOW.). 1 specimen, 15 mm.
Buccinum sp.
Bela sp.
Balanus balanus DA COSTA. Many shells and some specimens.
Balanus hammeri ASCAN. Many shells.
Porella concinna BUSK. On *Balanus hammeri.*
Membranipora unicornis FLEM. var. *americana* D'ORB. On *Pecten islandicus* and *Balanus balanus.*
Cheilopora sincera SMITT. Under the foot of *Balanus balanus.*

The thin sand bands were slightly weathered and red with rust on account of percolating water.

In the underlying clay the shells decrease in number downwards and it is probable that it passes straight into the *Portlandia* clay. Outside the inlet towards Sydostbugten a few shells were found in *Portlandia* clay:

Portlandia arctica (GRAY). 4 specimens and 13 shells, 15.5—21.5 mm.
Lyonsia arenosa MÖLL. 4 specimens, 16—22 mm.
Modiolaria discors (L.) var. *laevigata* GRAY. 1 specimen, 15 mm.
Serripes groenlandicum (CHEMN.). 1 specimen, 17.5 mm.

The following measurements were taken of *Portlandia arctica*:

	length	height	$\frac{\text{height}}{\text{length}}$	breadth	$\frac{\text{breadth}}{\text{length}}$
a.	21.5	12	55.8 %	9.75	45.3 %
b.	19	12.5	65.8 %	7.5	39.5 %
c.	19.5	12.5	64.1 %	9.75	50 %

Specimens a and b come nearest to var. *portlandica* HITCH., whereas specimen c approaches var. *nux* BRØGGER.

It was impossible to decide how the sediments continued upwards, but a little sand was observed in towards the rock.

The land behind the bay rises steadily towards a number of low rock areas. West of the bay lies a small ridge with two peaks separated by a small pass. Up the slope and at the middle of the pass was clay, but it was stony, suggesting moraine. At the top, out towards the sides from both the northern and the southern peak, however, there was fine gravel which must be assumed to be beach sediments. From the top of the southern rock there was a view of the somewhat smaller bay west of the one surveyed. The clay cliffs in it are only low and the clay slopes evenly upwards inland. A small stream empties into the bay; it comes from an extensive plain, apparently larger than the one south of Niaqornârusuaq, from which it is separated by a long, rather high ridge of rock. The plain extends far to the south, west about Tasiussarssuaq. The nose-formed clay sections can be seen everywhere (Plate VII).

The plain behind Niaqornârusuaq stretches southwards to the west end of Tasiussarssuaq. It is cut through by an old, broad erosion gully, its sides having the form of projecting clay noses. A small brook runs in the bottom. The gully was explored for most of its length. In its upper, rather shallow end, no shells were seen; it was only farther out towards the coast that a few were observed:

Macoma calcaria (CHEMN.). About 35 specimens and 5 shells, 16—30 mm.
Serripes groenlandicum (CHEMN.). 15 specimens, 11—36 mm.
Saxicava arctica (L.). 3 shells, about 18—35 mm.
Portlandia arctica (GRAY). 1 specimen, 14—21 mm.
Cardium ciliatum FABR. 1 specimen, about 23 mm.
Mya truncata (L.). 1 shell, 36 mm and 1 specimen, 7 mm.
Balanus hammeri ASCAN. Many shell fragments.

A little more to the north and, as it seemed, in a lower horizon, there was an abundance of shells. The following species were collected:

Macoma calcaria (CHEMN.). Several hundred specimens and a few shells.
Portlandia arctica (GRAY). 35 specimens and 2 shells. Length 10.5—22 mm. 1 specimen bored by *Natica*.

Mya truncata (L.). 34 specimens, 14—45 mm. Seem to have been of the *ovata* form (the largest are in fragments).
Serripes groenlandicum (CHEMN.). 26 specimens, 11—43 mm.
Macoma torelli (STP.). 18 specimens, 10—19 mm.
Cardium ciliatum FABR. 11 specimens, 10—25 mm.
Yoldia hyperborea (LOVÉN). 7 specimens, 18.5—25.5 mm.
Lyonsia arenosa MÖLL. 2 specimens, 16.5—24 mm.
(*Balanus hammeri* ASCAN. 1 shell fragment).

All the specimens that are whole are full of a stony core of hardened clay.

Somewhat more to the north the gully bends eastwards, where it receives a small tributary from the southwest. Just north of this spot the brook bends northwards and converges with the main watercourse of the plain, though this itself is quite insignificant. Just before the convergence there was a tall section in the west side of the gully.

Where the two waters meet the surface of the plain is covered with sand, a source of blown-sand deposits. In the sand was found:

Balanus hammeri ASCAN. 5 shell fragments and an *operculum.*

Downwards the sand passes into finer, clayey sand or sandy clay. This sediment is considerable and follows the main stream for a distance northwards and extends right down to the stream bed. No shells were seen in this sediment. Out towards the mouth of the stream there is fat clay below for the first time.

This clay rises northwards and is alone in forming the low cliff facing the stream.

In the bay east of Niaqornârusuaq there were clay cliffs as in the tract to the west. North of it two small erosion ravines run into the land. The area between them was examined. On the outermost part was the quite flatly rounded, smooth surface so common in this region. The only vegetation consisted of small isolated tufts of grass, scattered about and often in a row along the numerous small rain gullies. It is striking that the fresh tufts are not so high as the root sections of the dead ones, a circumstance showing that erosion here is in the form of a scaling of the surface. Farther inland is an area with clay circles.

A number of shells were gathered along the cliff in the bay. At the cliff foot:

Portlandia arctica (GRAY). 640 specimens and about 200 shells, 2.5—20.8 mm.
Macoma calcaria (CHEMN.). 27 specimens, 11—34 mm.

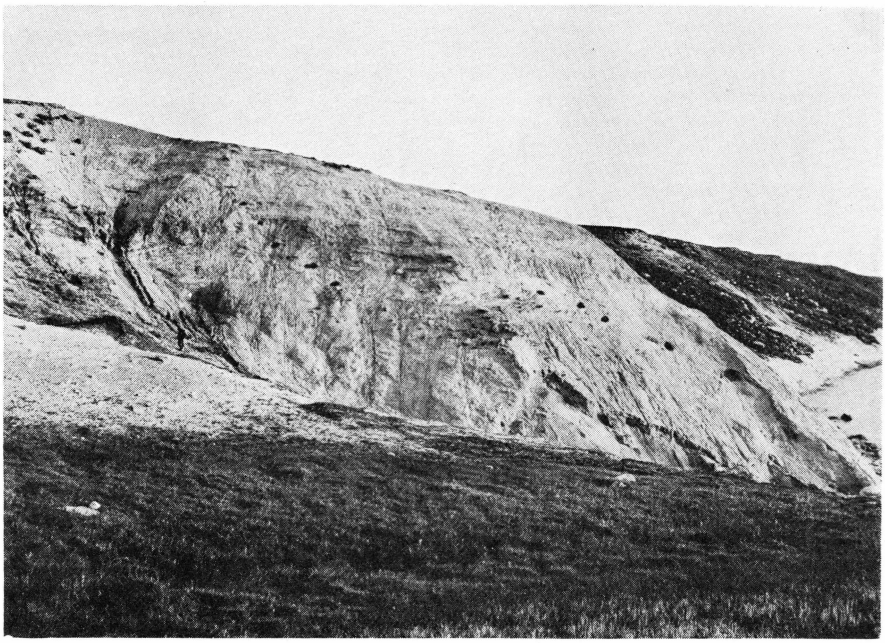
Saxicava arctica (L.). 13 specimens and 70 shells, 17.5—37 mm. Of the *arctica* form, elongated in varying degrees.
Serripes groenlandicum (CHEMN.). 8 specimens, 9—24 mm.
Yoldia hyperborea LOVÉN. 5 specimens, 21—28 mm.
Cardium ciliatum FABR. 2 specimens, 10—about 30 mm.
Lyonsia arenosa MÖLL. 1 specimen, 17 mm.
Nucula tenuis (MONT.) var. *expansa* REEVE. 1 shell, 9 mm.
Balanus sp.
Hippothoa hyalina L. The colony lies open from the dorsal side in the piece of clay.
Myriozoum crustaceum SMITT.
Lichenopora verrucaria FABR.
Spirorbis spirillum L. 7 tubes.
Polychaet Annelide.
Numerous clay concretions with skeletal parts of fishes and *Ophiurae.*

The specimens of *Portlandia arctica* are of the variety *portlandica* HITCHCOCK, or at any rate very near to it, as the following measurements show. A single specimen (k), however, approaches the variety *nux* BRØGGER. They are all in an excellent state of preservation, mostly with closed valves and completely preserved periostracum.

	length	height	$\frac{\text{height}}{\text{lenght}}$	breadth	$\frac{\text{breadth}}{\text{length}}$
a.	20.5	13	63.4 %	8	39 %
b.	20.5	12	58.5 %	7.5	36.6 %
c.	19	12	63.2 %	7.5	39.5 %
d.	18.5	11.8	63.8 %	7.7	41.6 %
e.	20.8	12	57.7 %	8.2	39.4 %
f.	16.5	10.75	65.2 %	7	42.4 %
g.	18.8	12.8	68.1 %	8	42.6 %
h.	18.8	12.2	64.9 %	7.4	39.4 %
i.	18.8	11.5	61.2 %	7.8	41.5 %
k.	15.8	10.3	63.5 %	7.8	40.4 %

The shells of *Yoldia hyperborea* are of a short form, the height (of two specimens) being 52.4—54.9 % of the length. They are relatively a little higher in the shell than the form now living in southern West Greenland, which is as it should be, as the colder the water in which the animal lives, the shorter is the form of the shell. At a high level:

Saxicava arctica (L.). 2 specimens and 50 shells, 20—37 mm. Some of the *arctica* form, some of a more elongated *arctica* form, a few "pinched", some thick, "multi-foliated".



P. HARDER phot. $^{17}/_{8}$ 06.

Fig. 18. Section of the clay layers with *Mya* and *Mytilus*. The southern bay, Lerbugten at Claushavn.

Portlandia arctica (GRAY). 1 specimen, 17 mm.
Balanus balanus DA COSTA. Some shell fragments.

On the top of the cliff, which corresponds to the bare ground west of the river mouth (see page 66), the following shells were collected:

Saxicava arctica (L.). 26 specimens, 13—40 mm. Of an elongated *arctica* form.
Serripes groenlandicum (CHEMN.). 2 specimens, 12—27 mm.
Mya truncata (L.). 1 specimen, about 35 mm.
Macoma calcaria (CHEMN.). 1 specimen, 24 mm.
Cardium ciliatum FABR. 1 specimen, 14 mm.
Portlandia arctica (GRAY). 1 specimen, 17 mm.
Balanus sp.

Sarpiussat—the whale's tail—has its name from its outline, a long rocky ridge lying parallel with the coast, being connected with the latter by a flat isthmus (Plate I). This consists of fat *Portlandia* clay, running with low cliffs out towards the bays on both sides of it. Only the western bay was visited. At the spot where the survey was made the foot of the cliff lay at about 7.5 m above sea level, and the cliff top about 14 m. At the middle the height of the isthmus was measured at

about 23 m. It is not flat, however, for it rises towards the northwest end where, ending at rock, it forms a section facing the water.

In the coastal section the following shells were collected:

Balanus hammeri Ascan. 1 shell fragment.
Balanus balanus Da Costa. 2 shell fragments.

In situ in the clay at the cliff foot:

Portlandia arctica (Gray). A number of shells and specimens, 3.5—15 mm.

The mechanical composition of the clay will be seen in the table page 85, No. 8.

LERBUGTEN AT CLAUSHAVN

The Marrait south of Claushavn is very similar to the Marraq in Sydostbugten. It has steep cliffs out to the sea, here and there cut by gullies eroded by running water. It stretches in the form of a flat plain from the sea up to an arm of Jakobshavns Isfjord: Tasiussaq. Out to the sea the occurrence lies in three parts, each at its own small bay. The three are very similar in structure. A section was surveyed in the middle bay:

0—10.3 m. Clay containing: *Macoma calcaria* (CHEMN.), *Portlandia arctica* (GRAY), *Yoldia hyperborea* (LOVÉN), *Nucula tenuis* (MONT.) var. *expansa* REEVE, *Mya truncata* (L.).

10.3—15.7 m. Clay and sand with *Mya truncata* (L.), *Serripes groenlandicum* (CHEMN.), *Nucula tenuis* (MONT.) var. *expansa* REEVE, *Macoma calcaria* (CHEMN.), *Saxicava arctica* (L.), *Cardium ciliatum* FABR., *Natica* sp., *Balanus* sp.

15.7—16.6 m. Clay and sand containing *Mya truncata* (L.), *Macoma calcaria* (CHEMN.), *Serripes groenlandicum* (CHEMN.) and *Mytilis edulis* L., few.

16.6—abt. 20 m. Clay and sand with *Mytilus edulis* L., many, *Mya truncata* (L.), *Macoma calcaria* (CHEMN.).

abt. 20—top of cliff (about 24 m). Sand without shells.

The following samples were collected:

Middle bay: shells in situ in the *Mya* layer.

Mya truncata (L.). Fragments with periostracum preserved.

Serripes groenlandicum (CHEMN.). 3 specimens with periostracum, length 28—30 mm.

Macoma calcaria (CHEMN.). 2 specimens and 15 shells, length 11.5—28.5 mm. Periostracum partly preserved. One specimen bored by *Natica*.

Saxicava arctica (L.). 1 shell with periostracum, length 35.5 mm, of an elongated *arctica* form.

Cardium ciliatum FABR. 1 fragment of a large shell and a small specimen, 10.5 mm. Periostracum preserved.

Nucula tenuis (MONT.) var. *expansa* REEVE. 2 specimens and 6 shells with well-preserved periostracum. Length 5—11.5 mm.
Leda minuta (MÜLL.). 1 fragment of an adult shell.
Lunatia pallida (BROD. & SOW.). 3 specimens, adult. On one is a *Serpula* tube.
Balanus sp.

Southern bay.

In situ in the *Portlandia* clay.

Portlandia arctica (GRAY). 2 specimens with periostracum preserved. Length 16.5—20 mm.

In the *Mytilus* layer:

Mytilus edulis L. Several shells, some joined. Periostracum partly preserved.
Mya truncata (L.). Several shells, several still joined. Periostracum often preserved, and not infrequently the siphon or parts of it.
Macoma calcaria (CHEMN.). 10 shells, length 4—25 mm. Periostracum partly preserved.
Serripes groenlandicum (CHEMN.). 10 shells, length 4.5—27.5 mm. Periostracum preserved.
Saxicava arctica (L.). 6 shells, length 6.5—27.5 mm. Of the *pholadis* form.
Pecten islandicus MÜLL. 5 shells, height 52—72 mm. Some bored by *Polydora*. Not so fresh in appearance as the other shells; may perhaps be secondary.
Balanus crenatus BRUG. 7 shell fragments.
Balanus balanoides L. 2 shell fragments.
Strongylocentrotus dröbachiensis (MÜLL.). Many spines and shell fragments.
Skenea planorbis FABR. 1 specimen.
Opercula of molluscs, 1 of *Littorina*, 15 of *Margarita*(?).
Micropora borealis BUSK. 1 piece of a branch.
Hippothoa hyalina L. Several small fragments.
Pectinaria. Several tubes.
Spirorbis sp.

Fish bones.

Plant remains, many.

Loose on the slope near the *Mytilus* layer.

Pecten islandicus MÜLL. 3 shells, height 67.5—69.5 mm.
Mytilus edulis L. 2 shells, 73 mm, with periostracum.

Serripes groenlandicum (CHEMN.). 2 shells, a pair, 52 mm.
Leda minuta (MÜLL.). 3 shells, 10 mm; partly with periostracum.
Nucula tenuis (MONT.) var. *expansa* REEVE. 2 shell fragments with periostracum.
Pectinaria. Several tubes.
Velutina sp. 1 specimen.

In situ in the *Mya* layer.
Macoma calcaria (CHEMN.). 1 specimen, with periostracum and ligamentum. Length 25 mm.
Nucula tenuis (MONT.) var. *expansa* REEVE. 6 specimens, with periostracum. Length 6—9 mm.
Axinopsis orbiculata G. O. SARS. 1 shell, 4 mm. Bored by *Natica.*

NORDENSKIÖLD[1]), who was in this locality in 1870, recorded among others *Cyrtodaria siliqua* (SPGL.). This species was also found, but not fossil; recent specimens alone were observed washed up on the beach from the bay, where it lives. The position is probably the same as regards *Tritonium undulatum* and *Tritonium groenlandicum*, which were found washed up on the beach, but not in the uplifted shelly sediments.

[1]) NORDENSKIÖLD: Redogörelse för en expedition till Grönland år 1870. Öfversikt af Kungl. Vetenskabs-Akademiens Förhdl. 1870. N:o 10. Stockholm. 1871.

SUMMARY

As was stated in the Preface (page 7), a preliminary account of the expedition's results was issued in 1910[1]). Only the conditions in Orpigsôq and Sydostbugten were described in detail, and the following schema was drawn up for the sediments at these localities:

	Orpigsôq	Sydostbugten
F.	Strand gravel with *Zirphaea*	
E.	Clayey sand with *Pecten*	
D.	Clay with *Portlandia*	Clay with *Portlandia*
C.	Clay with *Mya ovata*	Sandy clay with *Balanus hammeri* etc.
B.	Fine, clayey sand with *Balanus hammeri*	
A.	Glacial formation	Sandy clay with *Portlandia*

According to HARDER, the glacial formation (Horizon A) consisted either of moraine, as in the cliff along the river Ilulialik for a length of about 20 m between 370 and 390 m south of the Zirphaea Pynt, or of fluvioglacial sand, which it was stated was observed in the same cliff for about 50 m between 205 and 255 m south of the same point. According to HARDER, the glacial and fluvioglacial sediments may be absent entirely, in which case the marine sediments rest directly upon the ice-striated rock. As will be seen later, DAN LAURSEN does not agree with HARDER in the interpretation of the layers that are placed to Horizon A.

Horizon B. According to HARDER, the fluvioglacial sand is overlain by fine, clayey sand of varying thickness up to about 5 m. On account of the size of the grain, it is not presumable that it was deposited in very deep water. It must be assumed to be the earliest marine sediment in the cliff area. The fauna in the layer is somewhat sparse; it includes the commonly occurring forms *Cardium ciliatum*, *Serripes groenlandicum*,

[1]) AD. S. JENSEN and POUL HARDER: Post-Glacial Changes of Climate etc.

Mya truncata and *Saxicava arctica*, but the dominating form is *Balanus hammeri*. This barnacle does not live in the high-arctic seas but refers to a climate like that prevailing on the coast of southern West Greenland. Moreover, the sand bed overlying the coarse sand in the cliff at the mouth of the river about 110—130 m northwest of the Zirphaea Pynt must also be placed to Horizon B. What is more, the possibility cannot be ignored that the sand bed in the section in the river cliff opposite the Zirphaea Pynt (see page 39) belongs to Horizon B, as it is beyond question that *Balanus hammeri* cannot have come from the overlying *Portlandia* clay.

The suggested horizons are not always sharply delimited; in particular, there is a very smooth passage between the next two horizons, C and D, overlying Horizon B and having a thickness of up to 15 m. The lower parts of these horizons are sandy, but upwards the sediment becomes clayey. In the sandy horizon C the forms *Mya truncata* forma *ovata* and *Thyasira flexuosa* are predominant; other species occurring in it are *Serripes groenlandicum*, *Cardium ciliatum* and *Macoma calcaria*. In the clayey horizon D the high-arctic *Portlandia arctica* makes its appearance, accompanied by species like *Nucula tenuis* var. *expansa*, *Leda pernula*, *Cardium ciliatum*, *Saxicava arctica*, *Mya truncata* etc. This distribution of the species in the two horizons indicates that the temperature gradually became lower from Horizon B until the high-arctic element made its appearance in Horizon D. Simultaneously the fact is ascertained that a submergence took place, and this is confirmed by the petrographic conditions (cf. schema page 85).

The *Portlandia* clay is overlain by Horizon E—the *Pecten* layer—, a sand bed about 1 m in thickness, characterized, as the name implies, by the presence of *Pecten islandicus*, which is accompanied by a very rich fauna: *Mya truncata*, *Saxicava arctica*, *Macoma calcaria*, *Astarte montagui*, *Cardium ciliatum*, *Serripes groenlandicum*, *Modiolaria discors* var. *laevigata*, *Leda minuta*, *Lepeta coeca*, *Moelleria costulata*, *Bela violacea* var. *bicarinata*, *Balanus balanus*, *Balanus hammeri* and *Strongylocentrotus dröbachiensis*. Like the petrographic conditions, this fauna shows that there was again an emergence and also that the sea temperature became higher; the assumption is that the region lay about 50 m below the present level with a temperature similar to that prevailing today in these parts.

The youngest member of the series is the bed of beach gravel (Horizon F), 7 metres thick, overlying the *Pecten* layer. Its fauna is very rich. Among the forms occurring, the boreal species *Anomia squamula* and *Zirphaea crispata* are of particular interest, because they reveal a further rise in the temperature of the water. Moreover, it may be considered certain from the petrographic nature of the sediment

that the emergence already indicated by Horizon E continued, while simultaneously the climate became warmer.

The preliminary report mentions nothing of the conclusions to be drawn from the deposits at Kangersuneq compared with those at Orpigsôq. Judging from Harder's own manuscript, however, the sandy layers in the small gully in the eastern depression east of Point 434 were regarded as belonging to Horizon B (see page 58). The fat clay in the terrain east of the inlet at Sarfarssuit is shown as belonging to Horizon D, both petrographically and faunistically (see page 59). The sediments are characterized by the high-arctic form *Portlandia arctica* together with species such as *Nucula tenuis* var. *expansa*, *Macoma calcaria* and *Cardium ciliatum*. On the point (No. 6) in the coastal cliff (see page 61) was observed a section in which it is presumable that at the bottom there are sediments which must be placed to Horizon D, whereas at the top there is a transitional stratum to Horizon E, for the high-arctic element in the fauna disappears whereas more thermophile forms appear. Horizon E was not found in situ, but the occurrence of the loose shells on the top of nose No. 1 in the coastal cliff east of the inlet, with species such as *Pecten islandicus*, *Astarte montagui* and *Leda minuta*, suggests that Horizon E is present in situ in the Sarfarssuit area (see page 63). This is so much the more probable, as the sediments in the erosion gully at nose No. 12 at a height of 28 m above sea level are characterized by *Mytilus edulis*, which indicates a warmer climate than that represented by Horizon E. Harder places the *Mytilus* layer to Horizon F (see page 64).

The sediments at Marraq, the south coast of Sydostbugten, were correlated by HARDER himself with those at Orpigsôq, as will be seen from the schema (page 81). Horizon A at Orpigsôq is made up of glacial formations and is compared with sandy clay with *Portlandia* in Sydostbugten. This was done on the supposition that the Orpigsôq area was glaciated at the time when a high-arctic sea covered the region of the coast of Sydostbugten and the land to the south of it. It is a question, however, whether HARDER's theory is correct. In the summer of 1946 DAN LAURSEN visited the Orpigsôq locality and, inter alia, examined the *Zirphaea* section and its southern continuation. The sediments which HARDER determined as fluvioglacial layers and moraine clay, are regarded by DAN LAURSEN as delta deposits, laid down in the sea at the mouth of the river of that time. This view is supported by the enormous quantities of stratified gravel and sand beds at the same level as HARDER's moraine and fluvioglacial layers, partly on the opposite side of the river, partly somewhat higher up the Ilulialik valley. When furthermore it is taken into consideration that *Portlandia* clay is to be found directly overlying ice-striated gneiss in the small inlet (see

map, Plate I), there can scarcely be any objection to the sediments being correlated in the manner shown in the schema page 84.

With regard to the sediments in Lerbugten, according to the section and the material published by HARDER and JENSEN it looks as if the horizons D and E, and possibly F are represented there. If the stratigraphical sequence in the middle bay is taken as a criterion, the lower 10.3 m must be placed to Horizon D, which is characterized by *Portlandia arctica.* Upwards the *Portlandia* clay passes into a bed, about 5.5 m in thickness, where the fauna shows that the high-arctic element has disappeared, whereas other species which are scarcely so cold-loving have come in. This layer must be regarded as a transitional layer to Horizon E which, though in this section it does not contain the character animal *Pecten islandicus*, distinctly shows a rise of temperature which in the middle bay is characterized by *Mytilus edulis.* In the south bay, however, *Pecten islandicus* is found in the sediment. Possibly the interpretation of the sequence is that *Pecten islandicus* is to be found in the lower part of the uppermost horizon, where there are only few *Mytilus*, a species which, however, completely dominates the upper part of the sediment, which accordingly should be referred to Horizon F. As a matter of fact, however, the particulars gathered in 1906 are too few for anything definite to be said about the placing of the Lerbugt sediments in the schema.

If the sediments within the investigated area are to be placed in their mutual positions on the basis of the information at present available, it is possible to set up the following schema:

	Orpigsôq	Kangersuneq	Sydostbugten	Lerbugten
F.	Beach gravel with *Zirphaea crispata*	Clay with *Mytilus edulis*	..	?Clay and sand with *Mytilus edulis*
E.	Clayey sand with *Pecten islandicus*	Sediments with *Pecten islandicus*	..	?Clay and sand with *Pecten islandicus*
D.	Clay with *Portlandia arctica*	Clay with *Portlandia arctica*	Clay with *Portlandia arctica*	Clay with *Portlandia arctica*
C.	Clay with *Mya truncata* f. *ovata*	..	..	..
B.	Fine clayey sand with *Balanus hammeri*	Fine clayey sand with *Macoma calcaria*	Sandy clay with *Balanus hammeri*	..
A.	Delta sediments-Clay with *Portlandia arctica*	..	Sandy clay with *Portlandia arctica*	..

Regarding the level changes within the area in the period under review, nothing has emerged from the analysis of the material to change the picture given in the preliminary communication page 406.

Table.

	Locality	Percentage of grain sizes								
		> 5 mm	5.0—2.0 mm	2.0—1.0 mm	1.0—0.5 mm	0.5—0.2 mm	0.2—0.1 mm	0.1—0.05 mm	0.05—0.01 mm	< 0.01 mm
1	*Pecten* layer, Orpigsôq	8.3	3.0	3.2	9.3	26.7	22.1	4.5	4.3	18.6
2	*Portlandia* clay. Excavation I, Orpigsôq	0	0		0.2		0.5	2.8	20.7	75.8
3	Sand at river mouth, Orpigsôq	0	0.4	0.4	0.6	3.9	26.5	29.6	20.7	18.4
4	*Portlandia* clay, steep noses, Orpigsôq	0	0		0.2		0.4	2.5	27.0	69.9
5	Lower sandy *Portlandia* clay, Orpigsôq	0	0.1	0.1	0.3	0.3	0.6	11.5	36.7	50.4
6	*Mytilus* layer, waterfall noses, Orpigsôq	0	0.6	1.4	14.5	26.4	18.4	4.3	9.7	24.7
7	*Portlandia* clay, Orpigsûp tasia, Orpigsôq	0	0		0.1		0.3	2.1	24.4	73.1
8	*Portlandia* clay, Sarpiussat	0	0		0.03		0.1	1.3	8.6	90.0
9	Cryokonite, Orpigsôq	0	0		0.2		4.9	22.5	47.1	25.3
10	Dust from Rhône glacier	0	0		2.9		24.6	13.3	20.2	39.0

Mechanical composition of the samples. Also an analysis of cryoconite from the ice cap east of Orpigsôq. For comparison, an analysis of dust from the Rhône glacier.

Færdig fra trykkeriet den 31. december 1949.

PLATES

Plate I.

Map of the Orpigsôq region and the south coast of Sydostbugten (authorized reproduction).

1. Zirphaea Pynt.
2. Low sliding cliffs at the head of the bay at the precipice.
3. The inlet southwest of the island in Orpigsôq.
4. The waterfall.
5. Engell's Profil.
6. Niaqornârusuaq.

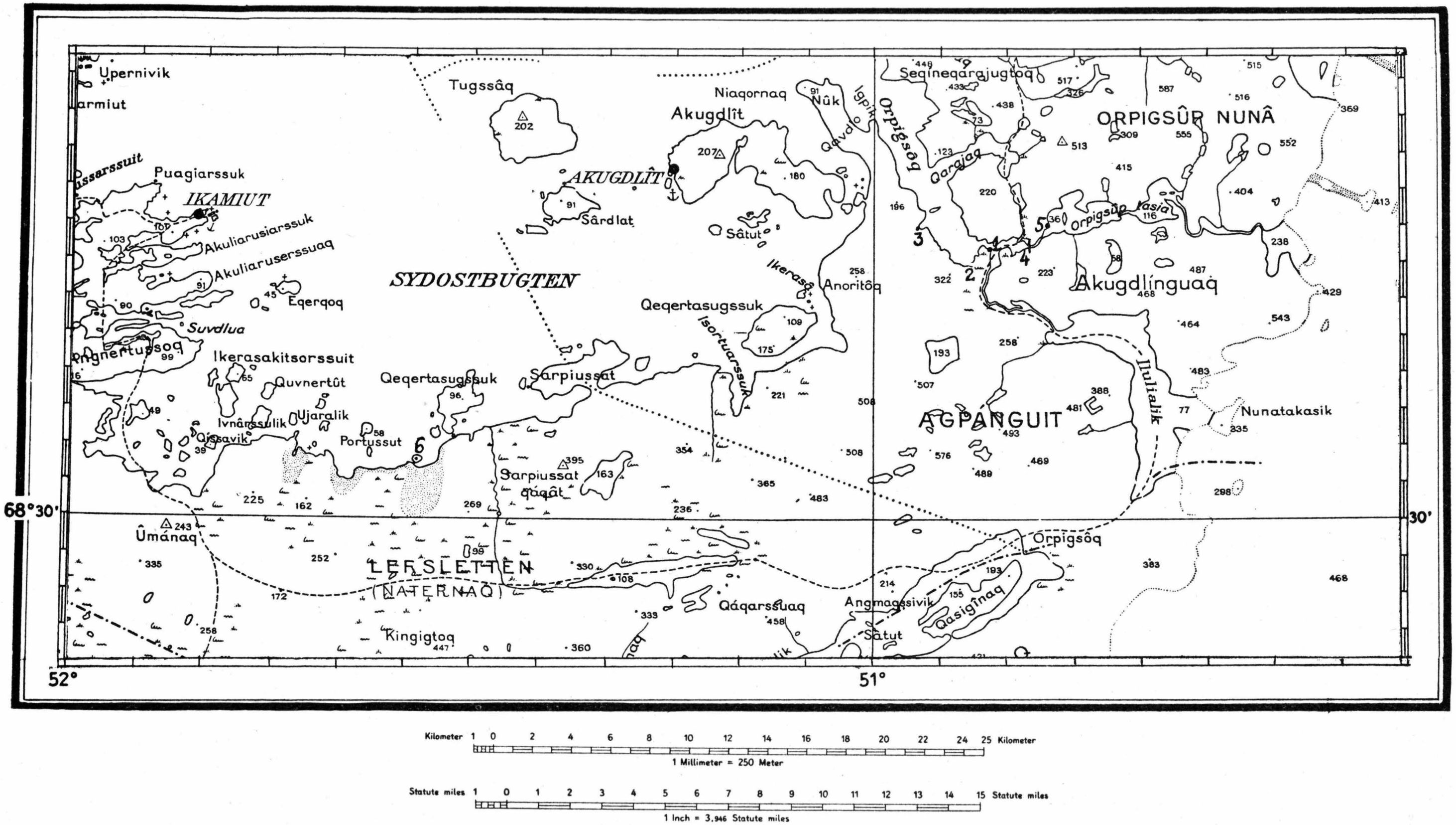
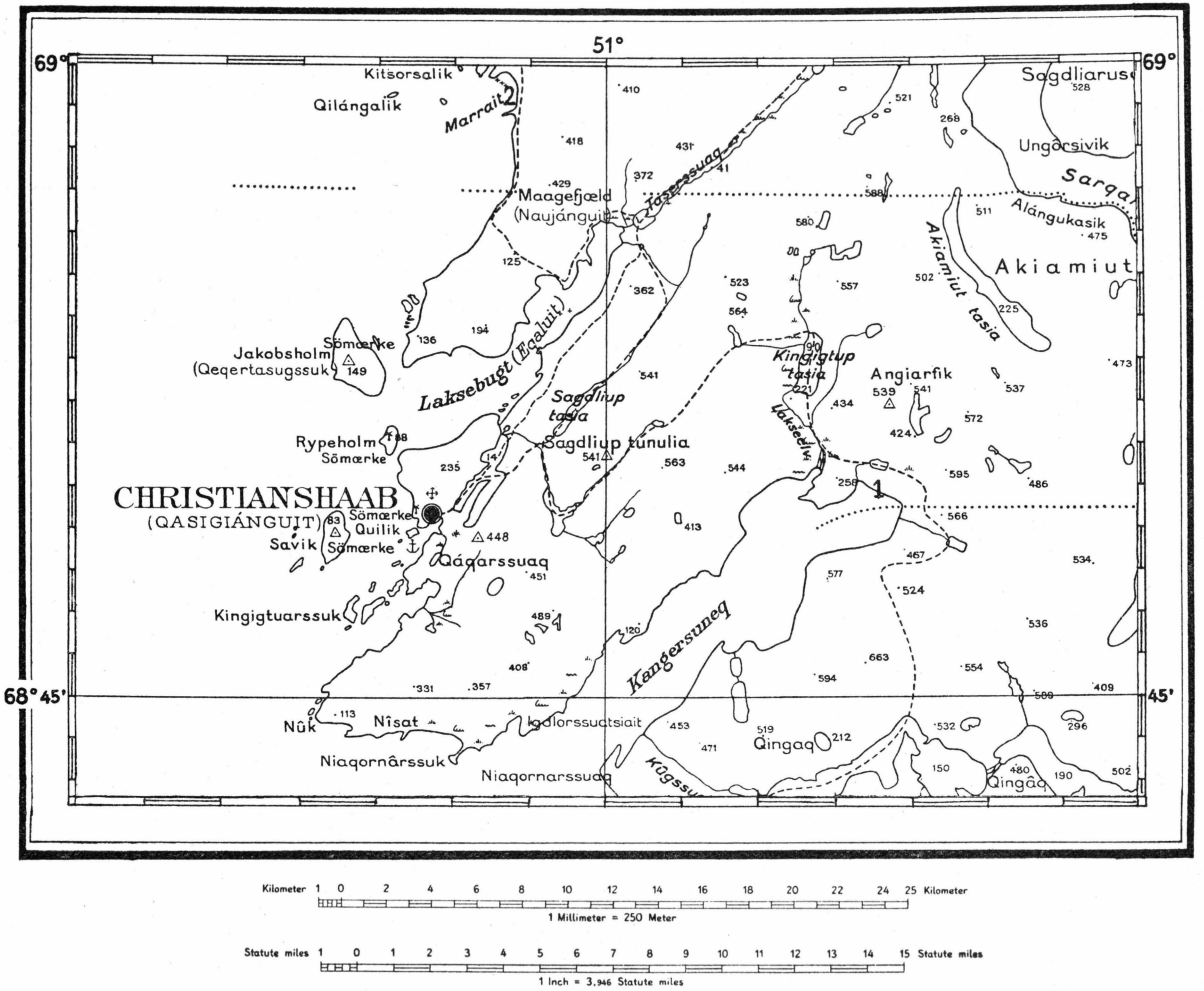

Upernivik
Tugssâq
Niaqornaq
Akugdlît
Nûk
Igpik
Orpigssoq
Qôqaq
Seqineqarajugtoq
ORPIGSÛP NUNÂ
Puagiarssuk
IKAMIUT
AKUGDLÎT
Sârdlat
Akuliarusiarssuk
Akuliaruserssuaq
Sâtut
Qargiaq
Orpigsûp tasia
Eqerqoq
SYDOSTBUGTEN
Ikerasâq
Anoritôq
Akugdlínguaq
Qeqertasugssuk
Suvdlua
Isortuarssuk
Ikerasakitsorssuit
Quvnertût
Qeqertasugssuk
Sarpiussat
Iluliatik
Ujaralik
Ivnârssulik
Qissavik
Portussut
AGPANGUIT
Nunatakasik
Sarpiussat qáqât
68°30'
30'
Ûmánaq
Orpigsôq
LERSLETTEN
(NATERNAQ)
Qáqarssuaq
Angmagssivik
Qasigînaq
Kingigtoq
Sâtut
52°
51°
Kilometer 1 0 2 4 6 8 10 12 14 16 18 20 22 24 25 Kilometer
1 Millimeter = 250 Meter
Statute miles 1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 Statute miles
1 Inch = 3.946 Statute miles

Plate II.

Map of Kangersuneq and Lerbugten (authorized reproduction).

Localities:

1. The terrace at the head of the bay at Sarfarssuit, Kangersuneq.
2. Lerbugten, south of Claushavn (Marrait).



Kilometer 1 0 2 4 6 8 10 12 14 16 18 20 22 24 25 Kilometer
1 Millimeter = 250 Meter

Statute miles 1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 Statute miles
1 Inch = 3,946 Statute miles

Plate III.

Fig. 1. Section of Zirphaea Pynt. Zero is at the N.E. corner of the peninsula, where the river Ilulialik converges with the river coming from the east. The upper drawing shows the section running northwest along the joint course of the two rivers; the lower drawing is of the section running south along the Ilulialik. Surveyed 24-7-06.

Fig. 2. Section of the cliff along the south shore of Sydostbugten westwards from Niaqornârusuaq. Surveyed from a boat 10-8-06.

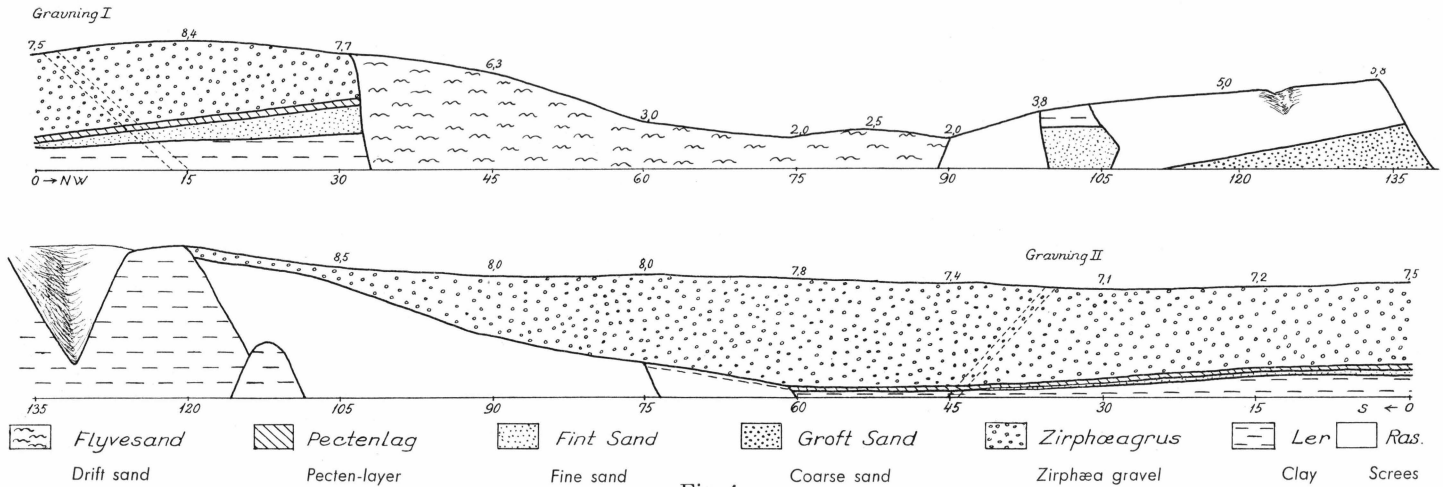

Gravning I
7,5
8,4
7,7
6,3
3,0
2,0
2,5
2,0
3,8
5,0
5,8
0 → NW
15
30
45
60
75
90
105
120
135
Gravning II
8,5
8,0
8,0
7,8
7,4
7,1
7,2
7,5
135
120
105
90
75
60
45
30
15
S ← 0
Flyvesand
Drift sand
Pectenlag
Pecten-layer
Fint Sand
Fine sand
Groft Sand
Coarse sand
Zirphœagrus
Zirphæa gravel
Ler
Clay
Ras.
Screes

Fig. 1.

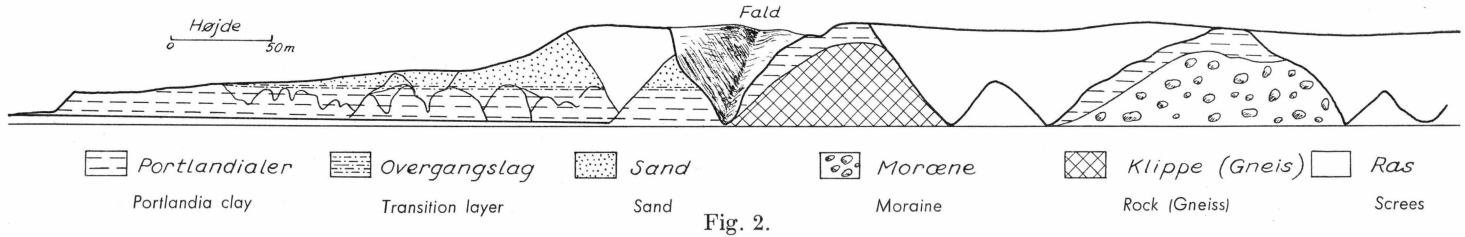

Højde
0
50m
Fald
Portlandialer
Portlandia clay
Overgangslag
Transition layer
Sand
Sand
Morœne
Moraine
Klippe (Gneis)
Rock (Gneiss)
Ras
Screes

Fig. 2.

Plate IV.

Orpigsôq. The Zirphaea section and the section to the south along the Ilulialik as far as the first solid gneiss in the section about 625 m from zero at the northeast corner of the peninsula. A little to the right of the middle of the picture is the first stone point, the second being a similar distance to the left of the middle.

P. HARDER phot. 17-7-06.

Plate IV.

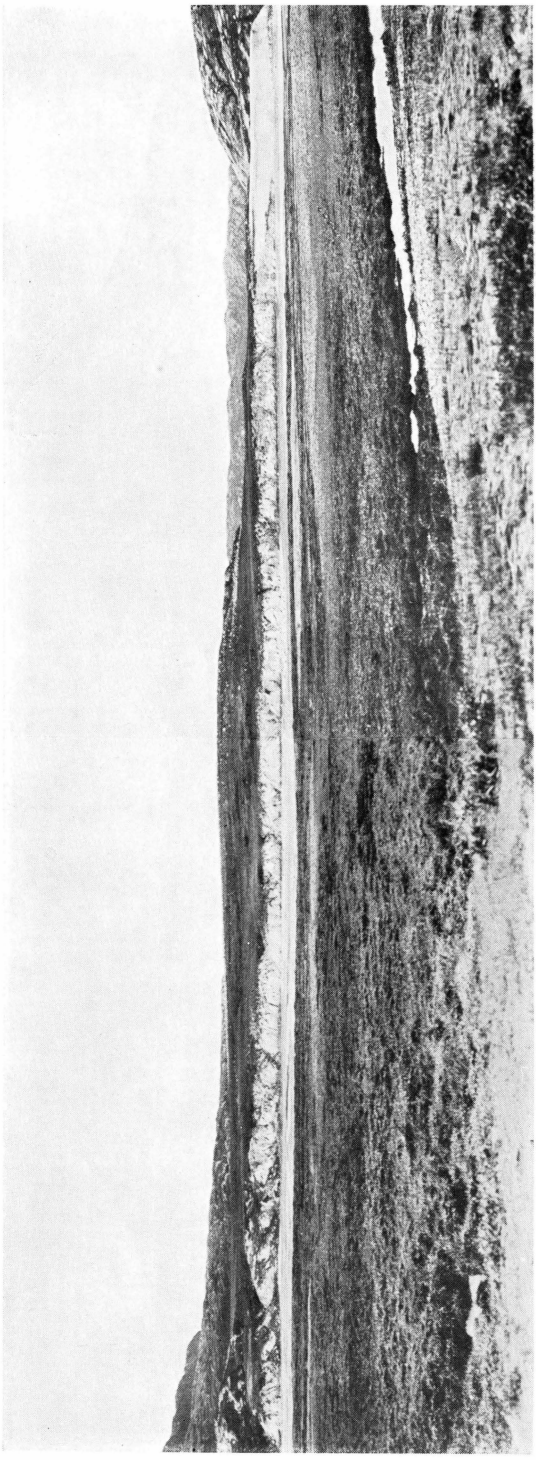


Plate V.

Sarfarssuit. General view of terraces and cliffs east and west of the inlet in which the river ends. The tall mountain in the middle back-ground to the right of the centre is 434 m high. The low mountain at the left centre is 221 m high and forms the south shore of Kingigtup tasia.

P. HARDER phot. 31-7-06.

Plate VI.

The south shore of Sydostbugten from Niaqornârusuaq to the bay behind Portussut.

P. HARDER phot. 8-8-06.

Plate V and VI.

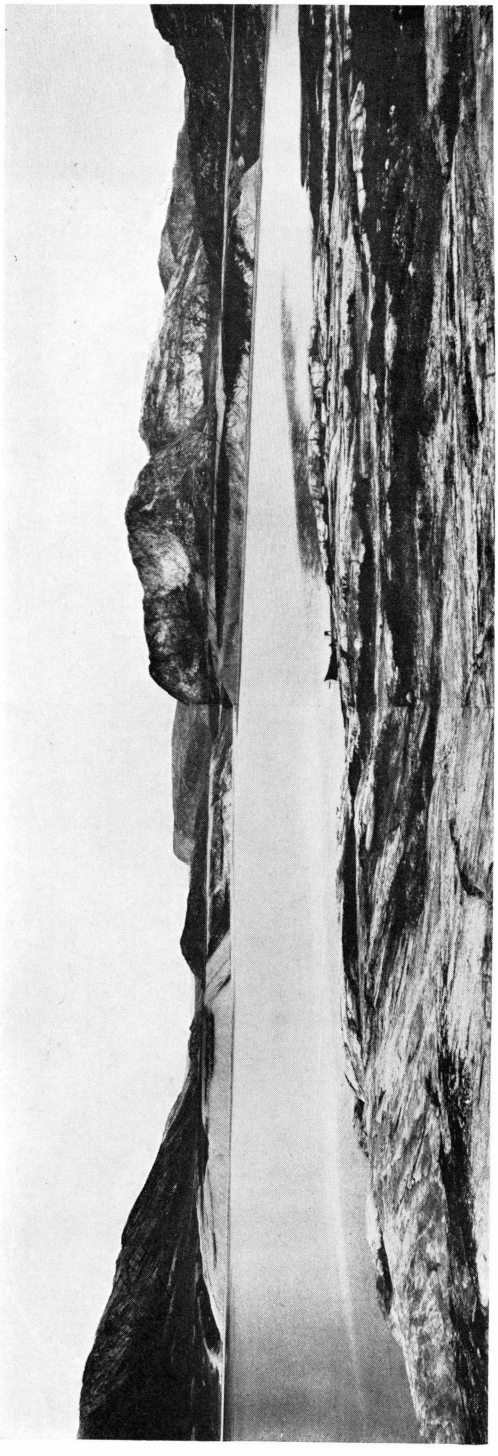


Plate V.

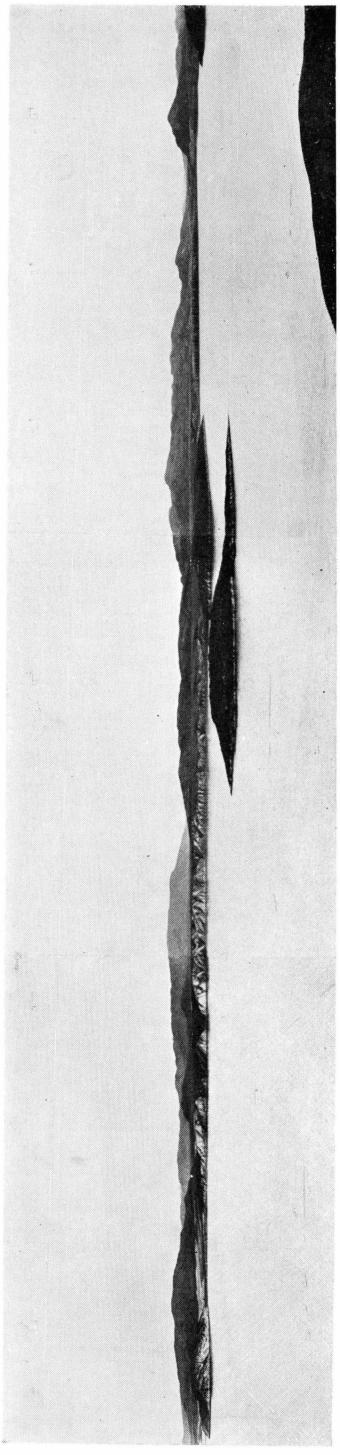


Plate VI.

Plate VII.

Panorama of the cliff along the south shore of Sydostbugten and the clay plains behind, taken from Niaqornârusuaq.

P. Harder phot. 10-8-06.

Plate VIII.

The two south bays in Lerbugten south of Claushavn. In the left background the mountain Pinguarssûp qáqâ, on the right Ugpiup qáqâ.

P. Harder phot. 17-8-06.

Plate VII and VIII.

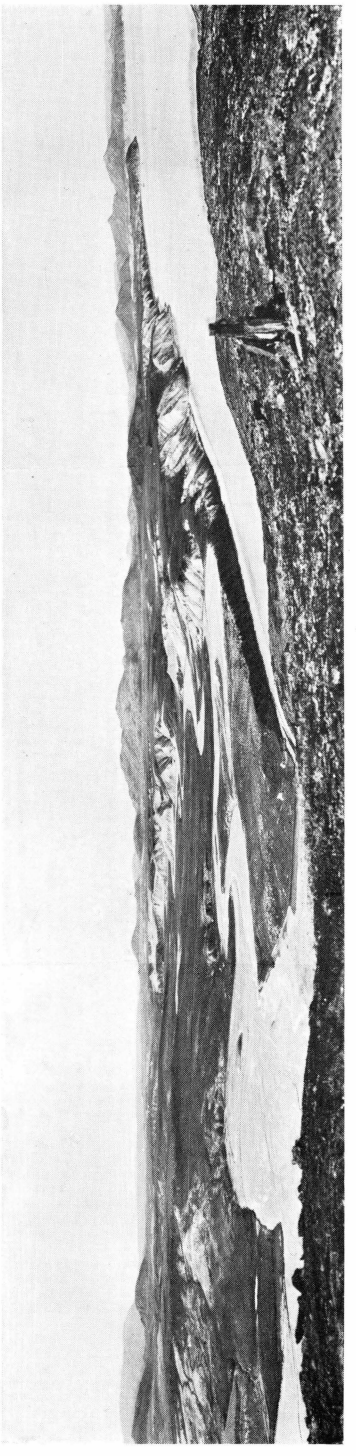


Plate VII.

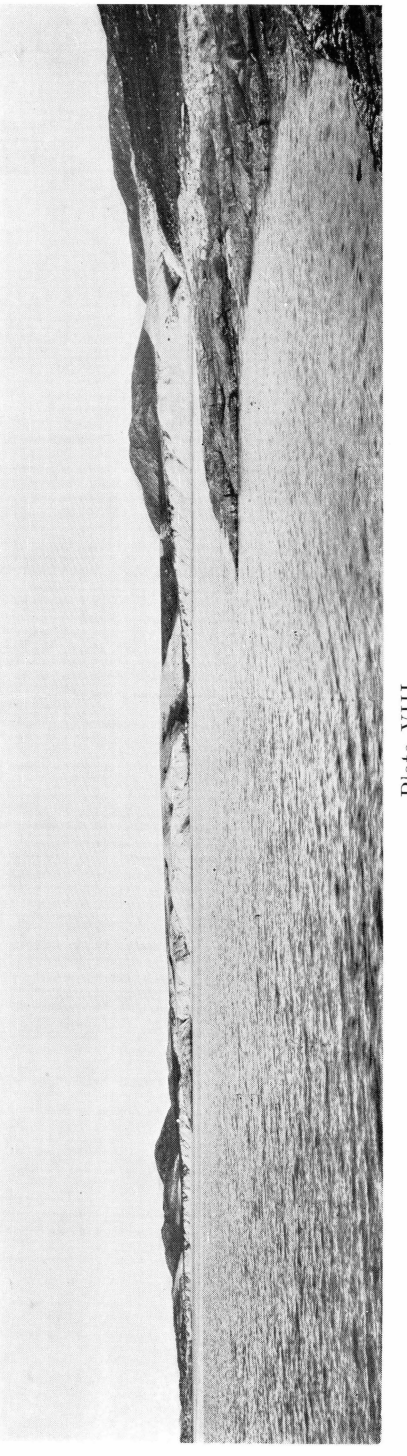


Plate VIII.