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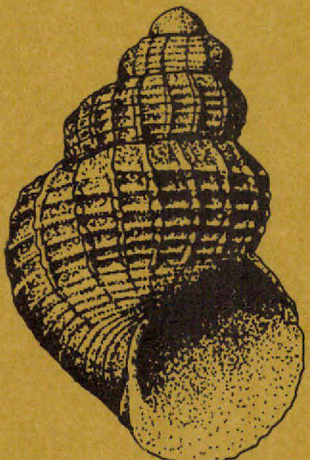
Bulletin No. 140

Upper Pleistocene and Holocene marine deposits and faunas on the north coast of Nûgssuaq, West Greenland

by

Leifur A. Símonarson



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Abstract

Field relations and the composition of the Quaternary molluscan and barnacle faunas at Pátorfik, Kûtsiaq and Sarfâgfik on the north coast of Nûgssuaq, West Greenland, are described.

The marine Quaternary deposits at Pátorfik are older than 35 000 years. The lower part of the deposits seems to represent a prodelta environment, whereas the middle and upper parts apparently correspond to a delta slope. The rich fauna and the field relations differ essentially from what we know from other localities in Greenland where Late Wisconsian or Holocene marine fossiliferous deposits have been found. The faunal composition indicates prevailing water temperatures during deposition similar to those at the boundary between the arctic and boreal faunal regions today and somewhat higher than those in Umanak Fjord at present. It is suggested that the Pátorfik deposits were formed during the last interglacial stage (Sangamon/Eemian).

The marine beds at Kûtsiaq and Sarfâgfik are of Early Holocene ages and apparently represent delta deposits.

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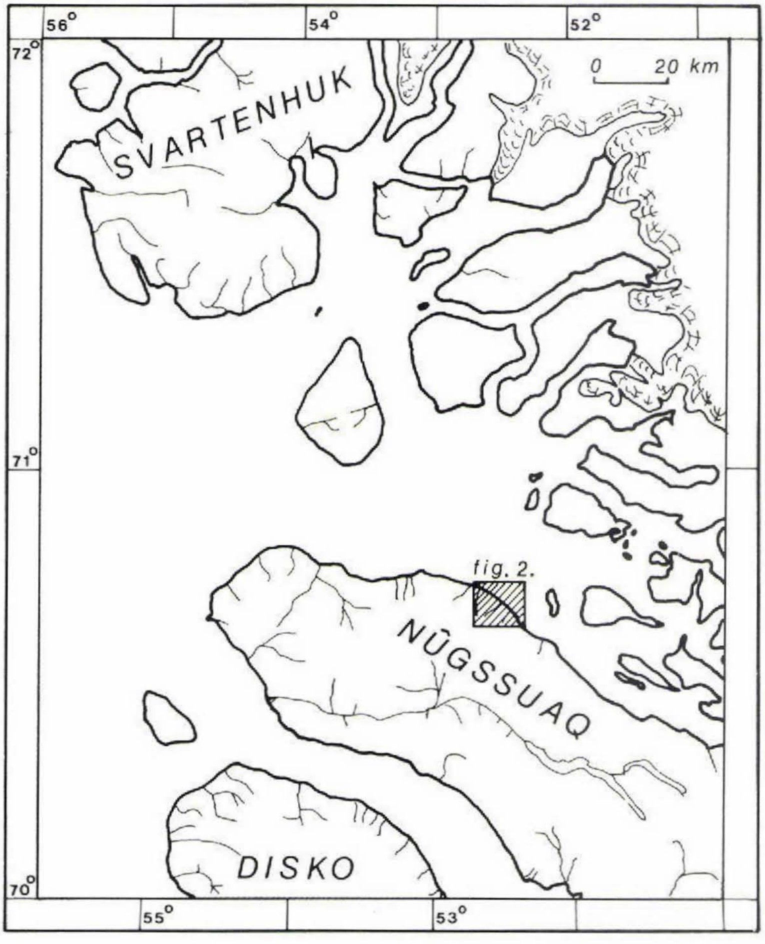


Fig. 1. Map of Nûgssuaq and Svartenhuk showing the regional setting of the marine deposits investigated (fig. 2).

INTRODUCTION

The present work deals with stratigraphical and palaeontological aspects of the marine Quaternary deposits on the north coast of Nûgssuaq, West Greenland. The investigation is based on field work carried out during an expedition to Nûgssuaq led by the late Professor A. Rosenkrantz in 1968 under the auspices of the Geological Survey of Greenland (GGU).

The stratigraphy is mainly based on changes in water temperatures as reflected by changes in the marine faunas. For the dating and correlation C-14 and amino acid datings have been useful tools.

A rather extensive collection of fossils was made, and the palaeontological part of this work deals with the gastropods, bivalves and barnacles collected. The variation in shape is demonstrated where the material makes it possible.

The recent distribution of the various species is recorded, and pertinent ecological and biological features are discussed. The zoogeographical division of the North Atlantic is in accordance with Feyling-Hanssen (1955a) (fig. 10). The division of the East Greenland coast into areas is that of Thorson (1944) and Ockelmann (1958).

The fossil occurrence of the different species is given. The division of the Pleistocene is in agreement with Woldstedt (1967) and Flint (1971).

The environmental aspects of the sediments and faunas are discussed.

The nomenclature used in this paper partly follows that of the 'Treatise on Invertebrate Paleontology' (Moore, 1960, 1969a, 1969b), with the addition of Thiele (1931) and Wenz (1938–1944) for prosobranchs, and Thiele (1931) and Lemche (1948) for the opisthobranchs.

HISTORICAL REVIEW

The earliest geological investigations in the region round Umanak Fjord were those of Giesecke, who travelled in West Greenland in the years 1806–1813. In 1811 he found a piece of conglomeratic sandstone containing bivalves at Ujaragtôrssuaq, east of Ikorfat on the north coast of Nûgssuaq (Giesecke, 1910). He considered these bivalves to be of Quaternary age and referred them to *Venus islandica* and *Mya truncata.* In 1970 they were given a close examination by Rosenkrantz. He pointed out that the bivalves belong to a species of *Venericor* from the Upper Danian Agatdal Formation in the central part of Nûgssuaq (Rosenkrantz, 1970).

In the years 1848–1851 Rink travelled in 'Northwest' Greenland. In his paper published in 1852 he briefly discussed the Quaternary formations in Umanak Fjord. Rink paid particular attention to the lithified lower part of the deposits at Pátorfik where he collected 13 species of molluscs. They were determined by Mörch, who found them to include *Glycimeris siliqua* Spgl. (= *Cyrtodaria siliqua*

(Spengler)) and *Panopæa norvegica* Spgl. According to Mörch the two species have not been found living off the coasts of Greenland. This, however, caused neither Rink nor Mörch to reflect on changes in water temperatures.

In 1869 Smith collected Quaternary fossils between Pátorfik and Sarfâgfik. The species were later determined by Jensen (Laursen, 1944). As they were found in lithified sand, Laursen (1944) assumed them to be derived from a cleft about 430 m east of the mouth of the Pátorfik river. According to Laursen lithified sand does not occur elsewhere in the Pátorfik area. Consequently he stated that 'the famous Pátorfik fossils' were collected in this cleft. However, in the summer of 1964 E. Nordmann and Rosenkrantz found several hard concretions in Kløft II about 110 m east of the mouth of the Pátorfik river (Rosenkrantz, 1968). The concretions were mainly found in the lower part of the section in Kløft II and enclose large shells, e.g. *Panopea (Panomya) norvegica* (Spengler).

Nordenskiöld (1871) visited Pátorfik in 1870 and mentioned Quaternary fossils found in basaltic sand which may be lithified. The fossils collected by Nordenskiöld were determined by Lovén. The material consisted of 15 species of bivalves and gastropods (Nordenskiöld, 1871).

A single specimen of *Clinocardium ciliatum* (Fabricius), found at Pátorfik in 1872 by Boye, is now preserved in the collections of the Geological Museum, Copenhagen (Laursen, 1944).

Steenstrup travelled extensively in West Greenland, at first together with Nordenskiöld in 1871, in the following year he visited Disko and Nûgssuaq, in the years 1878–1880 he investigated the coasts round Umanak Fjord, and in 1898 he visited Disko.

In a paper published in 1883 Steenstrup described the Quaternary deposits between Pátorfik and Sarfâgfik. At Pátorfik he noted particularly 'the very sandy boulder clay' which he found in the lowermost part of the Pátorfik cliff section. He brought home a large collection of fossils from this bed and mentioned some closed and empty shells with well preserved casts of the animals' entrails made of clay and sand. Steenstrup compared this 'very sandy boulder clay' with the Danish boulder clay, but remarked that the latter is without fossils. As he could not find any stratification in this 'boulder clay' and, furthermore, stated that the distribution of the fossils indicated that they 'do not normally belong to this bed', he inclined to the opinion that it should be characterized as a till. Mörch (*in* Steenstrup, 1883) was greatly impressed with the mudcasting of the soft tissues of the molluscs, and especially that of the intestine which he took as an indication that the animals had been suffocated in water mixed up with clay. On the other hand, Laursen (1944) claimed that the bed in question cannot be regarded as a till.

The present author could not find any sign of entrails in the new material and did not succeed in finding the specimens Steenstrup mentioned in the collections of the Geological Museum.

In 1874 Pfaff brought back some Quaternary fossils from Pátorfik and other localities in West Greenland. They were dealt with by Laursen (1944).

In 1888 Hansen visited Disko and Umanak Fjord. He collected some fossils in raised marine deposits at Ikorfat on the north coast of Nûgssuaq. They were treated by Laursen in 1944.

In 1898 White and Schuchert described the Cretaceous deposits of the west coast of Greenland. They investigated the Kome Formation between Pátorfik and Kûk and also briefly mentioned the Quaternary layers resting directly on the Kome Formation. At Pátorfik they collected 11 species of Quaternary fossils and compared their faunal list with that of Nordenskiöld (White & Schuchert, 1898).

In 1909 Ravn and Heim undertook various investigations in Umanak Fjord. Heim succinctly mentioned the Quaternary deposits (Heim, 1910).

Krueger visited Disko Bugt and Umanak Fjord in 1925. He briefly mentioned the Quaternary layers and commented upon isostatic movements (Krueger, 1928).

In 1938 Troelsen brought home some Quaternary fossils collected at Pátorfik. They were dealt with by Laursen in 1944.

In his paper published in 1944 Laursen treated the Quaternary material collected during the second Danish Nûgssuaq Expedition in 1939 and also included older collections in his work. In Umanak Fjord Laursen investigated several localities and considered (1944 p. 18) that the marine layers at Pátorfik were deposited "in the sea off a delta". One of his arguments for this was the fact that he had found some 'varves' in the upper part of the Pátorfik cliff section where basaltic sand and more fine-grained sediment alternate. As he found *Balanus* (*Chirona*) *hammeri* (Ascanius) Brown in the layers, he was of the opinion that the water temperatures had been somewhat higher at the time of deposition than they are now in Umanak Fjord. Laursen collected *Mytilus edulis* Linné in the upper sand beds at Pátorfik, but did not find this species in the subjacent beds. Therefore he pointed out "that it has immigrated at the time, when the sand was deposited owing to a rise of temperature" (Laursen, 1944 p. 24). In other words, Laursen supposed that changes in the water temperatures had taken place at the time when the beds at Pátorfik were deposited.

Jørgensen (*in* Laursen, 1944) examined the foraminifera from the Pátorfik deposits. His photograph of *Nodosaria pauperata* d'Orbigny incrustated in calcite is of interest. The specimen is from 'the lower clay layer of the Pátorfik cliff', showing that the layer is cemented.

Laursen (1944) considered all the Quaternary deposits in Umanak Fjord to be of Late Wisconsian and Holocene ages. He did not discuss the possibility that the Pátorfik layers could be interglacial or interstadial. He was probably of the opinion that if the ice had overrun the beds at Pátorfik they would have been completely removed.

Laursen also commented upon Late Wisconsian and Holocene changes of sea level in Umanak Fjord and stated (1944 p. 98) that the upper marine limit on the north coast of Nûgssuaq "may be put at 230 m above the present level of the sea". However, Weidick (1972a, 1975c) has called this in question.

In 1950 Laursen stressed that the stratigraphical division at Orpigsôq (south-east Disko Bugt) is applicable to the Umanak Fjord area and most likely to the whole West Greenland coast.

In 1938 Rosenkrantz had noticed the lithification and brecciation of the Pátorfik beds and from this he formulated the idea that they might be interglacial (Rosenkrantz, 1968). In the summer of 1964 E. Nordmann and Rosenkrantz collected fossil shells at Pátorfik and Qaersuarssuk kitdleq (about 7 km west of the Pátorfik river) to be analysed by the radiocarbon method. The samples were dated by H. Tauber, Carbon-14 Dating Laboratory, National Museum, Copenhagen, who obtained the following dates (Rosenkrantz, 1968): (1) Shells of *Saxicava arctica* and *Mya truncata* from Qaersuarssuk kitdleq were dated 8610±160 yr BP. (2) Shells of *Astarte borealis, Astarte elliptica, Cardium ciliatum* and *Mya truncata* from Kløft II, Pátorfik, were dated older than 35 000 years BP.

DESCRIPTION OF LOCALITIES

Pátorfik

This locality which is situated about 5 km east of the settlement of Qaersut on the north coast of Nûgssuaq has long been known as the richest source of Quaternary marine fossils in Greenland (figs 1, 2).

In the Pátorfik valley (fig. 3) deeply weathered Precambrian gneiss is directly overlain by non-marine deposits of the Kome Formation (Lower Cretaceous) consisting of alternating sandstones and shales. The Kome Formation is unconformably overlain by the Quaternary deposits. They are fossiliferous marine deposits with the exception of the uppermost part which consists of a solifluction sheet of variable thickness up to 2 m. At the Pátorfik river, the marine Quaternary deposits occur up to about 65 m above sea level. They were not observed west of the river, but disconnected exposures occur along the coast for about 2.4 km east of the river.

About 110 m east of the Pátorfik river (fig. 2) there is a well exposed section in a cleft into the coastal cliff, named Kløft II by Laursen in 1944. Only the section in

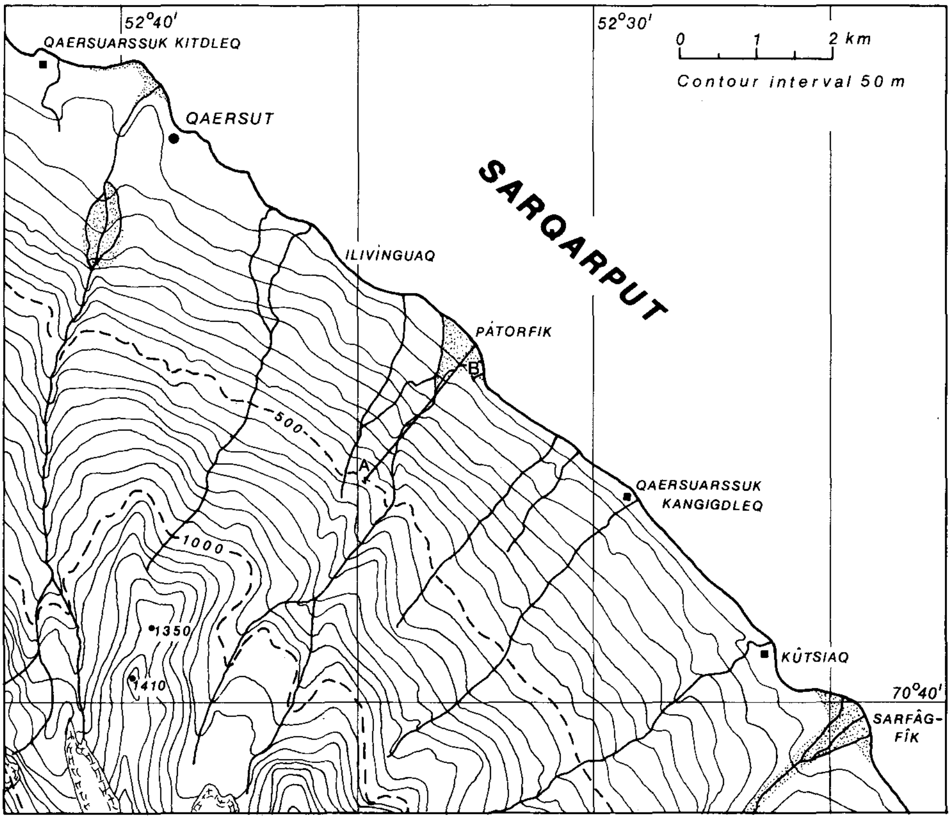


Fig. 2. Map of the north coast of Nûgssuaq showing the localities investigated. A: section fig. 3. B: position of Kløft II (fig. 4).

Kløft II was investigated in detail for this study. It was considered that a thorough examination of a single locality could give more valuable information than superficial investigations of many localities.

The Kome Formation at the base of the section in Kløft II is unconformably overlain by the Quaternary deposits which here start with a light-grey, unfossiliferous and somewhat calcareous gravel 90–100 cm thick (fig. 4).

Above the gravel layer is a fossiliferous sandy mud showing indistinct stratification. It contains some scattered pebbles, cobbles and boulders which mainly consist of gneiss and basalt. Here and there this bed is lithified and brecciated (fig. 5). In the lower part there are large concretions which, frequently, enclose shells of bivalves, e.g. *Chlamys* (*Chlamys*) *islandica* and *Panopea* (*Panomya*) *norvegica*. Otherwise, this bed contains scattered fossils, mainly bivalves and gastropods, the latter become more common upward. Some of the bivalves are in their life position.

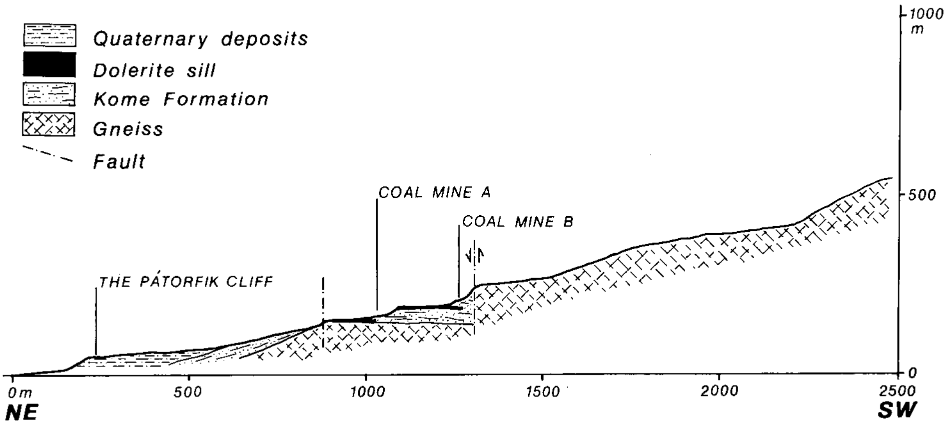


Fig. 3. Schematic section along the eastern bank of the Pátorfik river.

The shells are large and the ratios between thick- and thin-shelled molluscan individuals vary from 1.69:1.00 to 8.68:1.00. Thus, thick-shelled species dominate in this assemblage.

Sedimentary analysis showed that the carbonate content of the bed is 8.8 per cent and the grain size distribution is shown in table 1. The sediment is classified as sandy mud and should not be characterized as clay, as Laursen did in 1944. The facies appears similar to the fossiliferous marine 'Fjord-bottom sediment' recorded from Skeldal, Mesters Vig, East Greenland (Lasca, 1969).

The till-like aspect of this bed in Kløft II was very likely the reason why Steenstrup (1883) compared the Pátorfik deposits to the Danish boulder clay. Nevertheless, it is improbable that this sandy mud layer was deposited by a glacier that incorporated a large volume of marine fossiliferous sediments in its moraines. (1) The bed in question is hardly significantly older than the overlying fossiliferous layers since it interfingers with these. (2) The indistinct almost horizontal bedding as well as interfingering tongues of coarser sediments indicate a water lain deposit. (3) Hinged bivalves in the position of growth indicate *in situ* sediment. The brecciation may be due to ice pressure or post-depositional slumpings. The bed was probably a glaciomarine diamicton, the pebbles, cobbles and boulders were probably deposited from debris-loaded icebergs floating past sites where thick- and thin-shelled molluscs were living.

The lowermost sandy mud is alternately overlain by sand and gravel layers, dipping 25–30° to the north-east. The middle and upper parts of the section are generally of coarser sediments than the lower part and consist of grey silts, sands and gravels. In places these sediments alternate. The sand and gravel layers are generally structureless, and graded bedding was not observed. Here and there the most fine-grained sediments are cemented or lithified and brecciated.

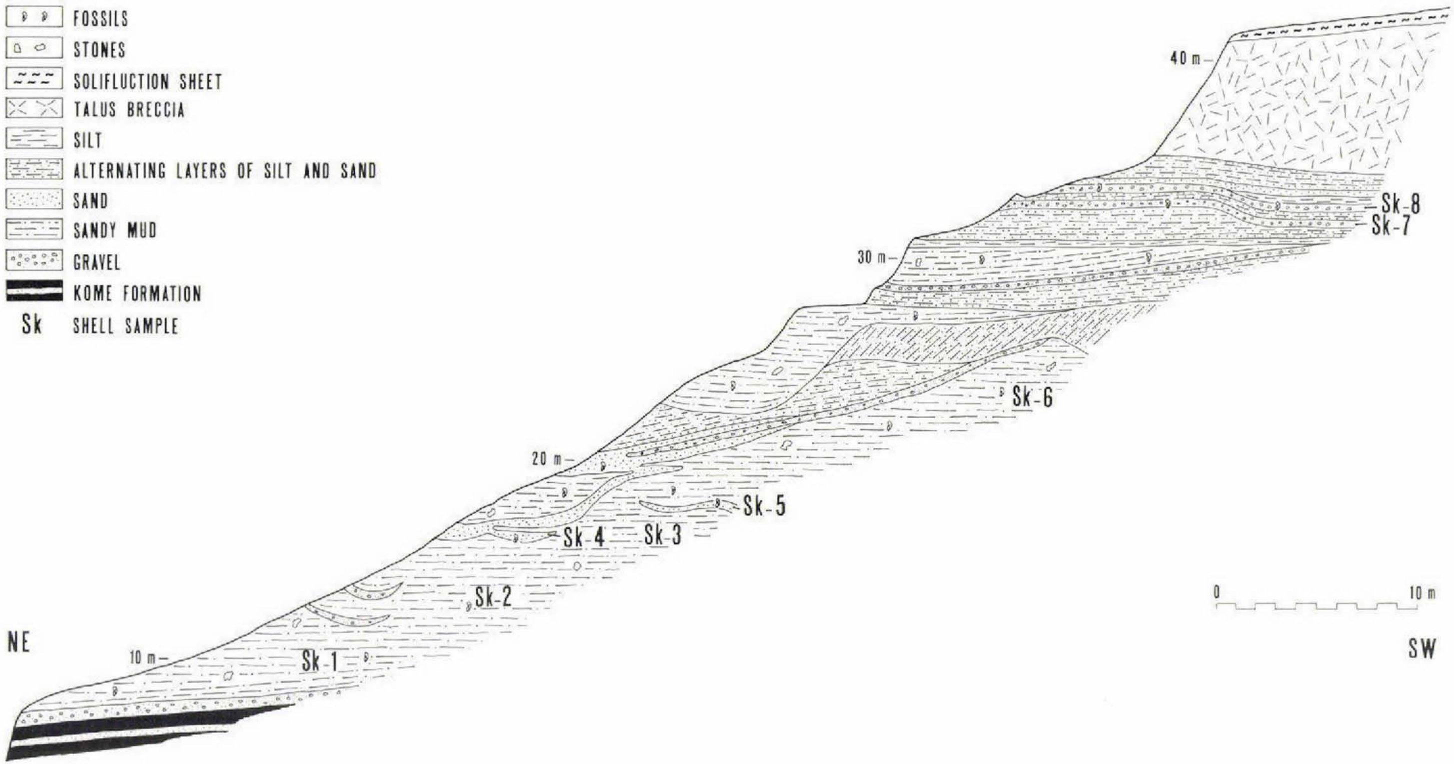


Fig. 4. Section on the eastern side of Kløft II, about 110 m east of the Pátorfik river. Sk–1 to Sk–8 are sites of shell samples (GGU 111717–111724 respectively).

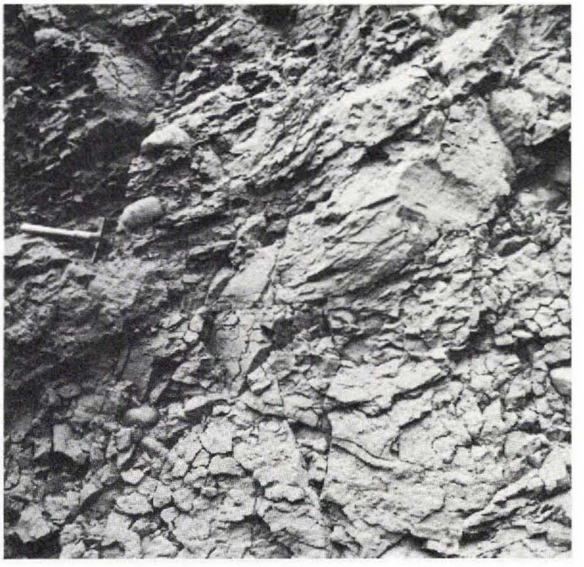


Fig. 5. Fossiliferous sandy mud, lithified and brecciated, in the lower part of the section in Kløft II, Pátorfik.

Channel-fill sediments and cross-beddings occur in the middle and upper parts of the section. A few slumped beds were found, mainly in alternating silt and gravel immediately overlying the lowermost sandy mud, 17–25 m above sea level. The slumps are all on a small scale – up to 20 cm – with a north-eastward direction of overturn.

Some of the sandy layers in the middle part of the section are very rich in well preserved fossils, especially gastropods and bivalves. All sizes and growth stages occur. Among the bivalves small thin-shelled individuals dominate.

Some of the sand and gravel layers were clearly buried rapidly beneath fine-grained sediment. The two sand tongues Sk–4 and Sk–5 (fig. 4) are very rich in well preserved fossils. Size frequency curves for various species found in them, e.g. *Alvania (Alvania) patorfikensis* and *Axinopsida orbiculata,* show skewness to the right, indicating an especially high death rate among the juveniles. On the other hand, it is of great importance that evidently some down-slope transport has taken place during deposition, as indicated by slumps in these layers. The great number

Table 1. The grain size distribution of the sandy mud in Kløft II, Pátorfik

Size grade in mm	Weight percentage
2–0.062	42
0.062–0.002	30
0.002>	28

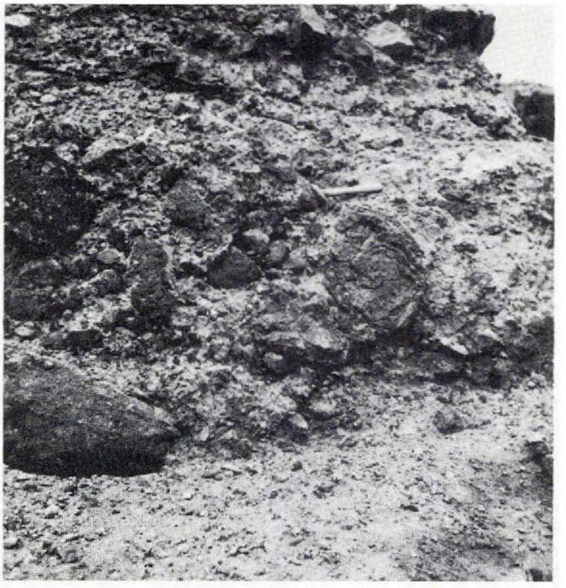


Fig. 6. Talus breccia in the uppermost part of the section in Kløft II, Pátorfik.

of paired bivalve shells, and the fact that the crushed shells were often found with the fragments *in situ,* emphasize that down-slope transport has only been on a small scale.

Cross-bedding and coarsening upward of the sediments in the middle and upper parts of the section suggest progressive shallowing. The channels were most likely cut by currents and slides in the sediments which apparently occurred during deposition. The slumps indicate a north-east sloping bottom with down-slope transport of sediments.

The fossiliferous series in Kløft II is overlain by lithified breccia up to 8 m thick. The bed consists mainly of large basalt boulders (basalt breccia and pillow lava) and only few gneiss boulders within a lithified matrix of basaltic sand and gravel. The matrix encloses fragments of zeolites which must be derived from the basalts. The matrix is brecciated and no stratification is visible (fig. 6).

The author does not regard this bed as a till, as gneiss is exposed at several places in the neighbourhood, and the basalts occur at a considerably higher level in Umanak Fjord. While Laursen (1944) termed this layer 'moving soil' the author prefers to characterize it as talus breccia in view of its composition and origin. The bed may have protected the underlying fossiliferous layers from ice erosion.

The section terminates with a solifluction sheet up to 1 m in thickness.

Steenstrup (1883) was of the opinion that the fossils "do not belong to these beds" and compared the Pátorfik deposits to the Danish boulder clay. In this connection the author would point out the following. (1) In the lower part of the section in Kløft II numerous specimens of bivalves with paired valves were collected, e.g. *Tridonta (Tridonta) borealis, T. (T.) elliptica, Panopea (Panomya) norvegica* and *Mya (Mya) pseudoarenaria.* (2) Some of the bivalves were found in the position of growth. (3) In the two tongues Sk–4 and Sk–5 there is a considerable number of bivalves with uncrushed paired valves, e.g. *Portlandia (Yoldiella) lenticula* and *Palliolum (Delectopecten) greenlandicum.* (4) The crushed shells were often found in the sediments (also the tongues) with the fragments *in situ,* thus showing that transport on a large scale has not occurred. (5) At a higher level in the section there are several almost horizontal layers which seem completely undisturbed. The entire deposits from the Kome Formation to the talus breccia show primary sedimentary structures indicating water-lain beds and seem too heterogenous to have been laid down during a glacier advance, i.e. to be considered a till. Furthermore, it seems unlikely that deposits of these dimensions (about 30 m in thickness and 2.4 km in length) could have been transported as a unit by ice to come to rest with the bedding planes almost horizontal. The field relations indicate that the deposits at Pátorfik were not transported by ice.

Laursen (1944 p. 18) was of the opinion that the Pátorfik marine beds were deposited "in the sea off a delta". One of his arguments for this was that he had found some 'varves' in the upper part of the Pátorfik cliff where basaltic sand and more fine-grained sediments alternate. According to Laursen the coarser material in these 'varves' represents a spring flood in a river, the finer sand summer deposition, whereas the 'clay' was deposited in the autumn and winter.

The present author is of the opinion that the lithology, grain size distribution, sedimentary structures, facies relations and in part the fauna of the marine coarsening upward sequence at Pátorfik, point to a development of a delta (cf. Selley, 1970; Pettijohn, 1975). The sandy mud in the lower part of the section appears to represent the upper part of a prodelta, whereas the middle and upper parts of the marine section, consisting of silts, sands and gravels, are apparently deposited on a delta slope. Thus, the sands and gravels in the middle part of the marine sequence are regarded as representing the first progradational phase of the delta pushing the delta slope north-eastward and extending the coarser sediments in that direction. There is no evidence that the uppermost marine layers were deposited on the subaqueous delta platform (topset). The uppermost part is not particularly complex and channels are not more frequent than in the middle part. Furthermore, the assemblage in the uppermost layers (Sk–7 and Sk–8) does not enclose species which could be characterized as littoral or brackish. These layers contain numerous plates of *Balanus (Chirona) hameri,* most commonly found in waters deeper than 40–50 m (Stephensen, 1933). Moreover, there is no indication of a fluvial fining upward cycle at the top of the marine part.

Fossils were collected at several levels in the section in Kløft II marked in fig. 4 as Sk–1 to Sk–8 (GGU 111717–111724). The samples Sk–1 to Sk–3 and Sk–6 were a general collection from the sandy mud beds. Sk–4 was 66.5 kg sand with

Table 2. Molluscs and barnacles at Pátorfik

Species	Sk–1 to Sk–3 (GGU 111717–111719)		Sk–4 (GGU 111720)		Sk–5 (GGU 111721)		Sk–6 (GGU 111722)		Sk–7 (GGU 111723)		Sk–8 (GGU 111724)	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Lepeta (Lepeta) caeca			24.0	0.12	2.0	0.03						
Margarites (Margarites) cf. *helicinus*			1.0	0.01	1.0	0.02						
Margarites (Margarites) groenlandicus			1.0	0.01	2.0	0.03						
Margarites (Pupillaria) cinereus			11.0	0.05	4.0	0.06						
Lacuna (Epheria) vincta			4.0	0.02								
Lacuna (Epheria) cf. *crassior*					1.0	0.02						
Putilla (Parvisetia) globula			3.0	0.02	1.0	0.02						
Alvania (Alvania) patorfikensis			217.0	1.08	73.0	1.17	1.0	0.56	1.0	0.36		
Alvania (Alvania) sp.			1.0	0.01								
Alvania (Frigidoalvania) janmayeni			1.0	0.01								
Tachyrhynchus erosus	1.0	0.12	2.0	0.01			1.0	0.56				
Natica (Lunatia) pallida			38.0	0.19	29.0	0.46	5.0	2.79	1.0	0.36		
Natica (Tectonatica) affinis	2.0	0.24	7.0	0.03	7.0	0.11	1.0	0.56				
Trophon (Boreotrophon) truncatus			10.0	0.05	5.0	0.08						
Trophon (Boreotrophon) clathratus			3.0	0.02	1.0	0.02						
Colus sp.	1.0	0.12										
Neptunea (Neptunea) despecta	1.0	0.12										
Buccinum undatum			1.0	0.01			1.0	0.56				
Buccinum cf. *groenlandicum*			1.0	0.01								
Oenopota bicarinata			2381.0	11.86	177.0	2.84						
Oenopota bicarinata var. *violacea*			3751.0	18.69	901.0	14.44	10.0	5.59				
Oenopota decussata			173.0	0.86	63.0	1.01						
Oenopota trevelliana			11.0	0.05	1.0	0.02						
Oenopota angulosa			1.0	0.01								
Oenopota nobilis			1820.0	9.07	835.0	13.39	4.0	2.23				
Oenopota nobilis var. *clathrata*			45.0	0.22	3.0	0.05						
Oenopota sp. undetermined			408.0	2.03	249.0	3.99						
Amaura candida			153.0	0.76	35.0	0.56						
Toledonia limnaeoides			28.0	0.14	57.0	0.91						
Diaphana minuta			3.0	0.02	2.0	0.03						
Retusa (Retusa) obtusa var. *pertenuis*			891.0	4.44	77.0	1.23						
Spiratella retroversa					2.0	0.03						
Nucula (Leionucula) tenuis expansa			274.0	1.37	188.0	3.01	5.5	3.07	43.5	15.54		
Nuculana (Nuculana) pernula buccata	1.0	0.12	1765.0	8.80	372.5	5.97	35.5	19.83	65.5	23.39	1.0	1.37
Portlandia (Yoldiella) lucida			0.5	0.01								
Portlandia (Yoldiella) lenticula			140.5	0.70	35.0	0.56			0.5	0.18		
Portlandia (Yoldiella) fraterna			8.0	0.04								
Mytilus (Mytilus) edulis	2.0	0.24										
Chlamys (Chlamys) islandica	4.0	0.49										
Palliolum (Delectopecten) greenlandicum			46.5	0.23	10.0	0.16			78.0	27.86	0.5	0.69
Tridonta (Tridonta) borealis	60.5	7.36	3.0	0.02			13.0	7.26				
Tridonta (Tridonta) elliptica	634.5	77.14	542.0	2.70	50.5	0.81	31.0	17.32				
Tridonta (Nicania) montagui	2.0	0.24	0.5	0.01								
Tridonta (Nicania) montagui var. *striata*	1.0	0.12			0.5	0.01	0.5	0.28				
Axinopsida orbiculata			981.0	4.89	98.0	1.57			3.0	1.07		
Serripes groenlandicus	7.0	0.85	1330.0	6.63	131.0	2.10	7.5	4.19	13.0	4.64	1.5	2.06
Clinocardium ciliatum	9.0	1.09	1880.0	9.37	342.0	5.48	42.5	23.74	27.5	9.82	2.5	3.43
Macoma (Macoma) calcarea			474.0	2.36	2201.5	35.29	12.0	6.70	13.5	4.82	52.5	72.02
Hiatella (Hiatella) arctica			161.0	0.80	10.0	0.16			4.5	1.61	2.5	3.43
Panopea (Panomya) norvegica	54.5	6.63										
Cyrtodaria siliqua	31.5	3.83	2.0	0.01			3.0	1.68				
Mya (Mya) truncata			2322.5	11.57	244.5	3.92	1.0	0.56	19.0	6.79	8.5	11.66
Mya (Mya) pseudoarenaria	10.5	1.28					3.5	1.96				
cf. *Lyonsia (Bentholyonsia) arenosa*			0.5	0.01								
Periploma sp.					5.5	0.09						
Balanus (Balanus) balanus			143.0	0.71	19.0	0.30	1.0	0.56			0.2	0.27
Balanus (Balanus) crenatus			2.0	0.01	1.0	0.02						
Balanus (Chirona) hameri			0.5	0.01	0.5	0.01			10.0	3.57	3.7	5.07
	822.5	99.99	20067.5	100.05	6237.5	99.98	179.0	100.00	280.0	100.01	72.9	100.00

shells, Sk–5 was 52.5 kg sand with shells, Sk–7 was 14 kg gravel with shells and Sk–8 was 3.5 kg gravel with shells. The collecting was limited by the ground ice which was encountered at a depth of 90–100 cm.

The sands and gravels were sieved with a 1 mm sieve. A few microfossils were found in the material passing the sieve.

The molluscs and barnacles found in the section in Kløft II in 1968 are summarized in table 2. Foraminifera, serpulids, ostracods, decapods, bryozoans, ophiuroids, echinoids, fishes, birds? and seals also occur in the Pátorfik beds, but are not dealt with in this paper. In tables 2–4 the frequency of the species was worked out as follows: whole gastropod shells and fragments with the top of the spire preserved were counted; valves and umbonal fragments of bivalves were counted and their number divided by two; parietal plates of barnacles were counted and their number divided by six.

A radiocarbon date has been obtained on marine bivalve shells taken in the lower part of the section in Kløft II. They were dated as older than 35 000 years (Rosenkrantz, 1968). Subsequently a sample (GGU 111601) of *Mya* (*Mya*) *truncata* and other bivalve species from the uppermost part of the section was radiocarbon dated as older than 35 000 years BP.

The results of the investigation of pollen samples and analyses of amino acid ratios in bivalves from Kløft II are given in the chapter on stratigraphy.

Kûtsiaq

This locality is situated about 5.3 km east of Pátorfik (fig. 2) where the small Kûtsiaq river cuts through the cliff.

On the western bank of the Kûtsiaq river, at an altitude of about 45 m, the Precambrian basement is overlain by a bed consisting of silt and sand with some fossils and scattered pebbles and cobbles (fig. 7). Four molluscan species were found in this layer (table 3). There is no doubt that the animals lived in the place as

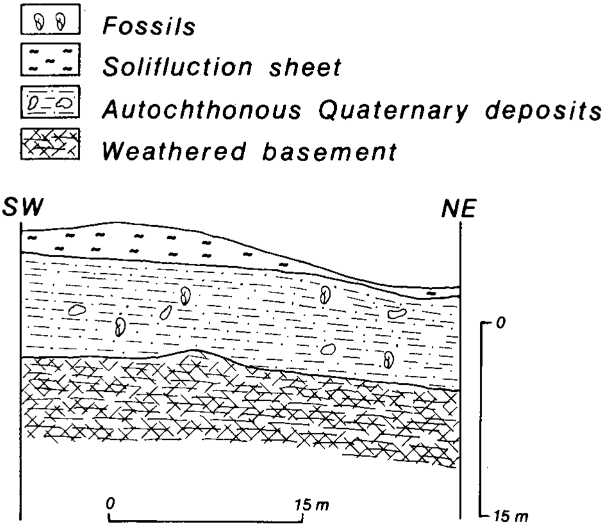


Fig. 7. Section in the western bank of the Kûtsiaq river. The figure is drawn from a polaroid photograph.

Table 3. Molluscs found at Kûtsiaq (GGU 111725)

Species	Frequency	Percentage
Cylichna occulta occulta var. *scalpta*	1.0	0.30
Macoma (Macoma) calcarea	9.0	2.72
Hiatella (Hiatella) arctica	308.5	93.06
Mya (Mya) truncata	4.0	1.21
Mya (Mya) trancata var. *uddevalensis*	9.0	2.72
	331.5	100.01

some of the specimens of *Hiatella (Hiatella) arctica* and *Mya (Mya) truncata* were in the position of growth. The triangular shape of the deposits indicates elevated delta material (?delta slope). The uppermost part of the section is covered by a solifluction sheet.

Numerous specimens of bivalves with paired valves were found in the sediment at 45 m. Quaternary sediments are also met with at lower altitudes at Kûtsiaq, but no fossils were found imbedded in these (cf. Laursen, 1944). A sample (GGU 111715) consisting of 50 g *Hiatella (Hiatella) arctica* was radiocarbon dated as 9490±150 yr BP.

The presence of the opisthobranch *Cylichna occulta occulta* var. *scalpta* indicates that the water temperatures prevailing during the deposition must have been similar to those present today in the arctic fauna region. The meagre fauna may indicate deposition near to an ice margin.

Sarfâgfîk

About 6.6 km east of the outlet of the Pâtorfik river the Sarfâgfîk river cuts through Quaternary deposits (fig. 2). On the western bank there is a well-exposed section. The author's measurements of the section are largely in accordance with those of Laursen (1944).

The lowermost 40 m of the section consist of sandy mud, stratified, with scattered pebbles, cobbles and boulders. The sediment is somewhat lithified and brecciated here and there, and its appearance is similar to the lithified and brecciated sandy mud in the lower part of the section in Kløft II, Pâtorfik. Unlike Laursen (1944) the author only found a single fragment of the bivalve *Serripes groenlandicus* in this sediment.

The sandy mud is overlain by 10 m of alternating sand and gravel layers, dipping to the north-east (fig. 8). Here three species of marine bivalves were collected (table 4). Numerous specimens of *Hiatella (Hiatella) arctica* and *Mya (Mya) truncata* were observed in the living position.

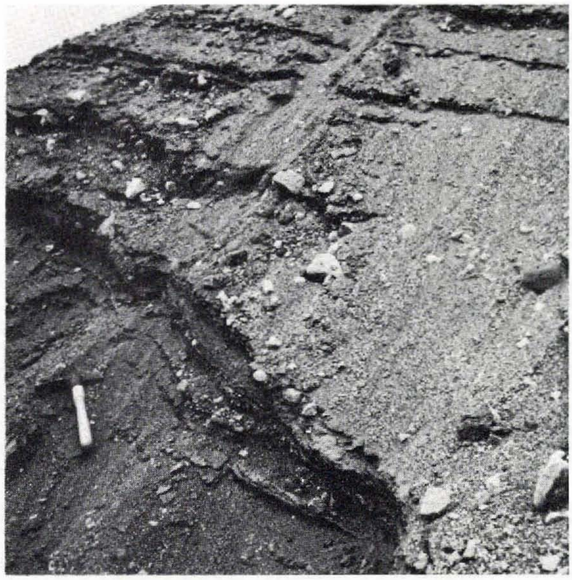


Fig. 8. Delta layers in the upper part of the section on the western bank of the Sarfâgfik river.

The section terminates with a solifluction sheet up to 2 m in thickness.

The triangular shape of the marine deposits at Sarfâgfik and the upward coarsening of the sequence are features to be expected in a delta. The sandy mud may represent a prodelta environment, whereas the alternating sand and gravel layers indicate deposition on a north-eastward facing delta slope.

A sample (GGU 111716) of 50 g *Hiatella (Hiatella) arctica* from the uppermost sand and gravel layers was radiocarbon dated as 9510±150 yr BP.

The fauna indicates water temperatures such as are found in the arctic fauna region today. In support of this is the dominance of var. *uddevalensis* among the *Mya (Mya) truncata* forms. The meagre fauna may indicate deposition near to an ice margin.

Table 4. Molluscs found at Sarfâgfik (GGU 111726)

Species	Frequency	Percentage
Serripes groenlandicus	0.5	0.07
Macoma (Macoma) calcarea	4.5	0.62
Hiatella (Hiatella) arctica	659.0	90.21
Mya (Mya) truncata	2.0	0.27
Mya (Mya) truncata var. *uddevalensis*	64.5	8.83
	730.5	100.00

STRATIGRAPHY

The first attempt to divide the Quaternary of Greenland stratigraphically was made by Jensen & Harder (1910), who based their zonation on the marine fossiliferous sequences at Orpigsôq and Sydostbugten in West Greenland. They assumed that the faunal changes in the sequences reflected climatic changes, and that their horizons A–F revealed the faunal succession: high arctic (A), arctic (B and C), high arctic (D), arctic (E), boreal (F). This zonation was generally adopted by later authors (Laursen, 1944; Harder *et al.,* 1949) and, finally, Laursen (1950) formally proposed that the zonation was valid for the whole of West Greenland. Laursen (1950) correlated horizons A–D with Older Dryas, Allerød and Younger Dryas of Late Wisconsian, whereas horizons E and F were considered Holocene.

Laursen (1944) correlated the Pâtorfik deposits with the arctic horizons B and C, but later he revised his opinion and referred the beds as a whole to the arctic horizon E (Laursen, 1950). Nevertheless, analyses of bivalve shells from both the lower and upper parts of the Pâtorfik sequence yielded radiocarbon ages of more than 35 000 yr BP. Moreover, investigation of amino acid ratios in bivalves from three different levels in the sequence indicates pre-Wisconsian age (table 5) (cf. Sugden & Miller, 1976). The Pâtorfik beds, therefore, cannot be correlated with the A–F zonation of Jensen & Harder.

The abundance of the rather thermophilic species *Panopea* (*Panomya*) *norvegica* in the lower and *Balanus* (*Chirona*) *hameri* in the upper part of the section in Kløft II, Pâtorfik, indicates higher water temperatures than at present in Umanak Fjord (see also later). If the present-day conditions in the fjord are considered interglacial in character, the faunal dependence on the water temperatures indicates interglacial rather than interstadial conditions during deposition. This is in agreement with the amino acid ratios and may be further stressed by the high faunal diversity and the high number of species in the samples. Therefore correlation with interstadial sediments in Greenland or elsewhere seems unlikely.

Table 5. Amino acid ratios in bivalves from Sarfâgfik and Pâtorfik

GGU No	Locality	Altitude, m above sea level	Species analysed	Age, C–14 yr BP	Alloisoleucine: Isoleucine ratio Combined	Free	Comments on age
111726	Sarfâgfik	45	*Hiatella (Hiatella) arctica*	9510±150	0.011–0.017	ND	Holocene
111800	Pâtorfik, Kløft II	32	*Hiatella (Hiatella) arctica*	>35000	0.45 –0.56	0.96–1.04	Early or Mid Quaternary?
111799	Pâtorfik, Kløft II	23	*Clinocardium ciliatum*	>35000	0.25	0.805–0.89	Last or pre-last interglacial
111798	Pâtorfik, Kløft II	17	*Clinocardium ciliatum*	>35000	0.186–0.240	0.781–0.935	Last or pre-last interglacial

ND: Not detectable

The modern character of the Pâtorfik fauna suggests that the deposits can be no older than Middle Pleistocene (?Aftonian). The molluscan fauna only contains one species that appears extinct, the prosobranch *Alvania (Alvania) patorfikensis,* in addition to the problematic *Alvania (Alvania)* sp. which cannot be referred to any recent species. On the other hand, there are no extinct species of the complex genera *Neptunea, Chlamys* and *Tridonta* which are all represented in the deposits (cf. Hopkins *et al.,* 1972).

The marine fauna of the Pâtorfik beds shows a distinctly ameliorated character indicating favourable environmental conditions (see also later). Similar conditions are indicated by the presence of *Mytilus (Mytilus) edulis* in a bed of pebbly sand, 6 m above sea level, on south-eastern Coburg Island, Arctic Canada (Blake, 1973). A radiocarbon dating of the shells indicated an age greater than 38 000 years. As the locality is about 350 km north of the present limit of *M. (M.) edulis*, and there is no indication that the species has lived at Coburg Island at any time since the last glaciation, the horizon was considered deposited during the warm interval equivalent to the Sangamon (Eemian) Interglacial. Feyling-Hanssen (1976a) has investigated foraminifera in the Quaternary Clyde Formation on eastern Baffin Island and correlated the ameliorated *Cassidulina teretis* Subzone with this interval. According to R. W. Feyling-Hanssen (personal communication, 1977) *Cassidulina teretis* Tappan also occurs in the Pâtorfik deposits, which indicates a pre-Wisconsian age.

These are conditions also met with on the Kola peninsula (Evzerov *et al.,* 1972), Chukotka peninsula (Petrov, 1967) and Alaska (Hopkins, 1967, 1973). According to Hopkins (1967) the Middle Pleistocene Aftonian fauna of the Einahnuhtan transgression and the Yarmouth fauna of the Kotzebuan transgression are nearly identical with the recent fauna in the area, whereas the Upper Pleistocene Sangamon fauna of the Pelukian transgression commonly contains species that are displaced northward from their present northern limit of distribution.

The Pâtorfik beds apparently predate the last glaciation and were deposited during a time of more favourable environmental conditions when the sea level was considerably higher than at present. In view of the above, the present author is inclined to regard the beds as correlatable with the Sangamon Interglacial of continental North America (Hopkins, 1967), the Kazantzevo Interglacial of Siberia (Troitsky, 1969) and the Fossvogur Interglacial in Iceland (Pjeturss, 1909; Einarsson, 1968). The Pâtorfik beds may also be correlatable with the interglacial marine deposits in the Baffin Bay area on Coburg Island (Blake, 1973), Broughton Island (Feyling-Hanssen, 1976b) and eastern Baffin Island (Andrews *et al.,* 1975; Feyling-Hanssen, 1976a).

Because of poor preservation and small numbers the pollen from the Pâtorfik deposits cannot be referred to species. The genera found in the samples taken in 1968 and some concretions collected in 1964 (table 6) are widely distributed in the northern hemisphere and cannot be regarded as indicators for any particular

Table 6. Pollen counted in samples from the Pátorfik beds

GGU No	Altitude, m above sea level	*Betula*	Cruciferae	Cyperaceae	Gramineae	*Lycopodium*	*Salix*	*Sedum*	*Thalictrum*	*Juniperus*	*Picea*-type	*Pinus*	Palynomorphs	Sporomorphs (reworked)	Total	Number of slides
111735	33.9												1	5	6	2
111734	31.1–32.3													2	2	1
111733	23.3–26.0		2	1				3		1			6	19	32	2
111732	23.0	1								1				12	14	1
111731	18.1–20.0	1												5	6	1
111730	18.1												1	8	9	1
111729	12.3–13.2	3		1		1	1		1				3	12	22	2
111728	9.3													8	8	1
111727	10–15	1		2	1			1	1		2	1	1	118	128	9
Total		6	2	4	1	1	1	4	2	2	2	1	12	189	227	20

climatic type. The Quaternary flora was doubtless arctic and apparently not very different from the recent flora of Greenland.

Sea level

The section at the Pátorfik river is not accessible along its entire length. However, marine shells have been found up to about 60 m above sea level. The shells found at the highest level were collected in sandy gravel, i.e. sediment indicating rather high energy environments which may refer to small depth. Unfortunately the shells give no indication of the depth of deposition of the uppermost preserved part of the sequence or the upper marine limit of the interglacial stage in question. It should be emphasized that the extent of erosion of the upper part of the beds is not known. It seems justifiable, however, to conclude that the relative sea level rise was at least 65 m (cf. Andrews *et al.,* 1975).

The ameliorated character of the Pátorfik fauna indicates that the beds were not deposited during the initial or final phase of the interglacial stage. The thickness of the delta in the coastal section emphasizes that the sea level was high and probably the land was not fully rebounded from the glacial depression.

At two localities in the Pátorfik area Laursen (1944) has recorded marine shell-carrying deposits at high levels, i.e. 190 and 200 m, respectively. Because of the high altitude and the presence of *Palliolum* (*Delectopecten*) *greenlandicum* in the one exposure, Laursen referred these deposits to the high arctic horizon A. As the species cannot be used to indicate high arctic water temperatures, there is no

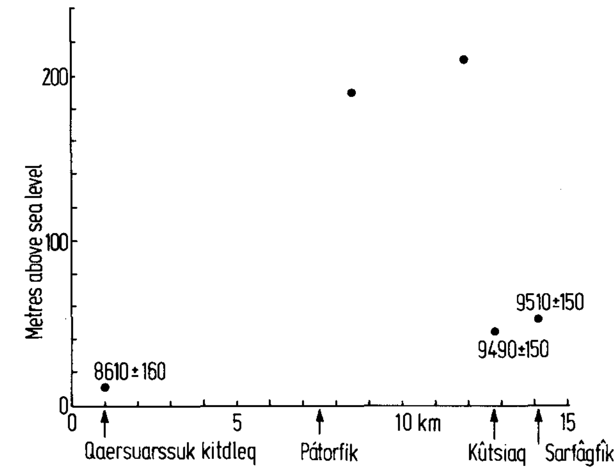


Fig. 9. Holocene marine deposits on the north coast of Nûgssuaq (see also fig. 2). The distances between the localities are plotted against the altitudes of the radiometric dated samples. The Qaersuarssuk kitdleq data are from Rosenkrantz (1968). The dated shells from Qaersuarssuk kitdleq, Kûtsiaq and Sarfâgfik were collected in sediments probably representing upper delta slope or subaqueous delta platform environments. Therefore the sediments were apparently not formed far below sea level. When the relatively high ages of the sediments are considered, it seems impossible to correlate the unusually high exposures referred to by Laursen (1944) at altitudes of 190 and 200 m with the Holocene deposits in the area. The general fluctuations of the Inland Ice margin in Late Wisconsian and Holocene (Weidick, 1975c) indicate that the high exposures cannot be correlated with Late Wisconsian deposits.

faunistic evidence that the beds were deposited under such severe conditions. Actually, all the seven species recorded from these exposures also occur in the Pátorfik beds.

Unfortunately we do not have sufficient shell material from the two localities for absolute dating. However, when the unusually high levels are taken into consideration (cf. Weidick, 1972a, 1976a; Löken, 1966; Andrews *et al.,* 1975) it seems difficult to consider these deposits as Late Wisconsian or Early Holocene (fig. 9). They are apparently older, either interstadial or interglacial, but it cannot be excluded that the small exposures represent interstadial or interglacial floes transported by ice advancing from the east.

Correlation with other deposits in Greenland

The Greenland Inland Ice existed at least in the last interglacial (Sangamon) as demonstrated by the occurrence of interglacial ice in the Camp Century core (Dansgaard *et al.,* 1969, 1971). Additionally, large scale features such as double cirques, U-shaped valleys, fjords and strandflats are indications of repeated glaciations of the outer coast of Greenland (Weidick, 1975c). Further evidence of successive glaciations is given by Funder & Hjort (1973). They reported radiocarbon dates older than 35 000–40 000 years obtained on shells from deposits on the outer coast of Jameson Land in East Greenland. Possible correlation of their Kap Mackenzie Stadial with the Illonian (Saale) Glaciation and the younger Flakkerhuk Stadial with Early Wisconsian indicates two glaciations separated by deposits of the

Sangamon Interglacial (cf. Funder, 1972b; Weidick, 1972a), but an Early Wisconsian age cannot be rejected for the Kap Mackenzie Stadial (Funder & Hjort, 1973). Tedrow (1970) has reported a somewhat doubtful high terrace in Inglefield Land, North-West Greenland, between two stages which are suggested to predate the last glaciation. Weidick (1976a) tentatively correlated the terrace with the Sangamon Interglacial.

Autochthonous interglacial marine deposits are not known with certainty elsewhere in Greenland. Krinsley (*in* Davies *et al.,* 1963) reported marine sediments with bivalves concentrated in three distinct layers on Saunders Ø in North-West Greenland. Shells from the lowermost and middle layers were dated older than 32 000 years, whereas shells from the uppermost layer gave an age of 8570±200 yr BP. As the older layers are imbedded in deposits that were described as marine till, the shells may be displaced and derived from older deposits removed by ice. Recently *Mytilus* (*Mytilus*) *edulis* has been found in these old layers, which may further indicate that they predate the last glaciation (Blake, 1975). Although the species is found alive at Dundas and Siorapaluq (close to 78° N), it has not been shown to live in Melville Bugt north of Tassiussaq at 73°22′ N (Madsen, 1940; Hjort & Funder, 1974). These two northern localities were probably sustained by larvae from the southern area, but since 1959 no settling of larvae has been observed there, and the species seems to be in the process of becoming extinct (Theisen, 1973; Hjort & Funder, 1974). In fact it seems difficult for the species to live in the northern area under present-day conditions. The presence of *M.* (*M.*) *edulis* in the deposits on Saunders Ø may, therefore, indicate favourable environmental conditions, apparently interglacial, and probably similar to those supposed to have prevailed in the area during the deposition of the *Mytilus*-bearing horizon on Coburg Island (Blake, 1975). Blake (1977) has also postulated that the *Chlamys* (*Chlamys*) *islandica* unit on Carey Øer, North-West Greenland, may correspond to this horizon. The sand unit in question contains many intact and paired valves of *C.* (*C.*) *islandica* with an age of more than 38 000 years. It is not unreasonable to correlate these sediments, older than 32 000 years on Saunders Ø and 38 000 years on Carey Øer, with the Pátorfik deposits. Furthermore, shells of *C. (C.) islandica* in a moraine-like deposit in Olrik Fjord, North-West Greenland, were dated as older than 33 000 years and may be of a similar age (cf. Weidick, 1978b).

In West Greenland old radiocarbon dates on shells have been obtained from Nordre Strømfjord and Svartenhuk Halvø (Weidick, 1976a). The deposits at Kugssineq on Svartenhuk appear autochthonous and contain *Portlandia* (*Portlandia*) *arctica* (Gray) which indicates low water temperatures and rapid deposition of fine-grained sediment (clay or silt) near to an ice margin. The Kugssineq deposits may be interstadial, but an interglacial age cannot be rejected (Weidick, 1976a).

The amino acid ratios in shells from a till north of Søndre Strømfjord, West Greenland, suggest that the shells are at least of Early Wisconsian age and possibly from the last interglacial or older (Sugden & Miller, 1976). Shells in marine sediments in Melville Bugt and Dundas, North-West Greenland, recorded by Kelly (1980) may be of a similar age.

Redeposited driftwood, possibly of interglacial age, reported from Peary Land in North Greenland by Trautman & Willis (1966) and Fredskild (1969) and from Washington Land, North-West Greenland, by Weidick (1978b) cannot be placed in any specific interglacial stage.

The presence of *Picea mariana* pollen in marl concretions collected at Frederikshåbs Isblink and at the head of the Godthåbsfjord in West Greenland indicates interglacial age for some of the concretions (Bryan, 1954). The occurrence of warmth-demanding species suggests a climate warmer than the present one, and the concretions may therefore be related to the Sangamon Interglacial and correlative with the Pátorfik deposits. However, Fredskild (1973) has reported long distance transport of *Picea* pollen in Holocene sediments in Greenland which may weaken Bryan's conclusion (Weidick, 1976a).

In conclusion it must be emphasized that sediments and fossils of pre-Late Wisconsian, but Quaternary age are known from several localities in Greenland. Some of them may be chronocorrelative with the Pátorfik deposits, but as long as their ages are not more accurately determined, a fuller picture of the stratigraphy cannot be ascertained.

PALAEONTOLOGY

A few explanations are necessary about terms used in this chapter. In dealing with gastropods the term 'diameter' always means the maximum outer diameter of the conispiral shell (cf. Cox *et al. in* Moore, 1960). The following abbreviations are used: d=diameter, h=height, hlw=height of last whorl, ha=height of aperture, l=length, b=breadth, wa=width of aperture, h/d=height/diameter ratio, h/l=height/length ratio and b/l=breadth/length ratio.

When dealing with bivalves the term 'paired' always means that the valves were found united (articulated) in the sediment, whereas 'single' means that they were not united (disarticulated) when collected.

Mollusca

Gastropoda, Prosobranchia

Class Gastropoda Cuvier, 1797. Subclass Prosobranchia Milne Edwards, 1848. Order Archaeogastropoda Thiele, 1925. Family Lepetidae Dall, 1869. Genus *Lepeta* Gray, 1847. Subgenus *Lepeta* Gray, 1847.

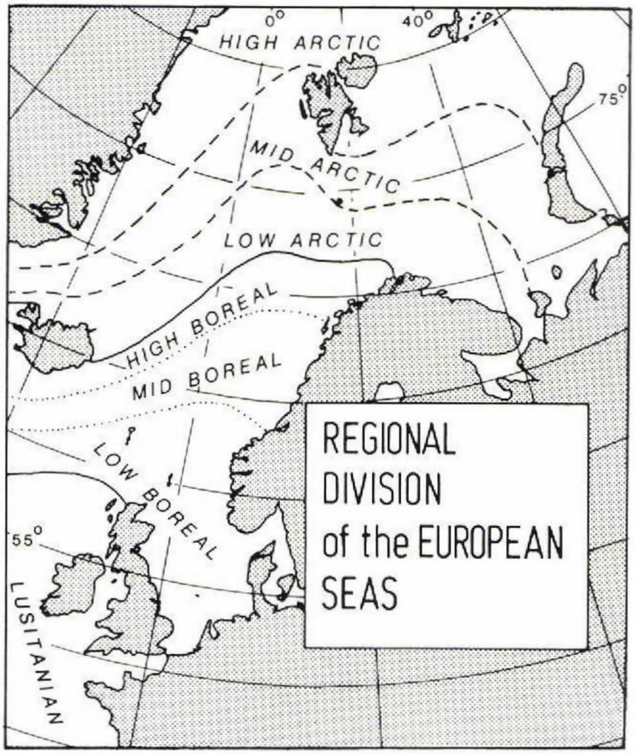


Fig. 10. Regional division of the northern European seas (from Feyling-Hanssen, 1955a).

Lepeta (*Lepeta*) *caeca* (Müller, 1776)

Plate 1, fig. 1A–B

1776 *Patella caeca* Müller, p. 237.

Material. Kløft II, Pátorfik: 14 complete and 10 fragmentary specimens from tongue Sk–4 (GGU 111720); 2 complete specimens from tongue Sk–5 (GGU 111721).

Remarks. The 5 largest specimens measure (1 × b): 11.0 × 8.3, 8.2 × 6.2, 7.2 × 5.3, 7.2 × 5.1 and 7.0 × 5.4 mm. The h/l ratios are relatively high, i.e. greater than 0.40.

Recent distribution. Panarctic, boreal, ?circumpolar (fig. 10). *L. (L.) caeca* is one of the most common gastropods in arctic seas. It occurs from Franz Josef Land, Novaya Zemlya, the Kara Sea, Parry Islands and Ellesmere Island south to the Aleutians, Cape Cod, Scotland and Denmark, and in the deep sea to the West Indies and the Azores. In West Greenland the species is widely distributed along the coast from Etah in the north to Julianehåb in the south. In East Greenland it has been found from Île de France in the north to south of Lindenows Fjord (Qeqertatsiaq)*. Vertical range: 0 m (Iceland) to 1229 m (?the Azores).

* An island without a modern authorised name at 60° 11′ N; 43° 04′ W (ed.)

Ecology. In East Greenland the species has been found on various types of bottom, but is mainly attached to the red algae epifauna at depths between 20 and 85 m, where it lives in water with temperatures below zero throughout the year (Thorson, 1944).

Fossil occurrence. Svalbard, the north coast of Russia, Arctic Canada, Iceland, Scandinavia and the British Isles. Stratigraphical range: Pliocene to Holocene.

Fossil in Greenland. *Lepeta coeca* (Müller): Steenstrup (1883), Noe-Nygaard (1932), Laursen (1944, 1950), Harder *et al.* (1949), Funder (1978). *Lepeta caeca:* Pjetursson (1898), Jensen & Harder (1910), Kelly (1973).

Family Trochidae d'Orbigny, 1837. Genus *Margarites* Gray, 1847. Subgenus *Margarites* Gray, 1847.

Margarites (*Margarites*) cf. *M.* (*M.*) *helicinus* (Phipps, 1774)

Plate 1, fig. 2

1774 Turbo helicina Phipps, p. 198.

Material. Kløft II, Pátorfik: One fragment from tongue Sk–4 (GGU 111720); one fragment from tongue Sk–5 (GGU 111721).

Remarks. The minute shell is thin and somewhat globular. The whorls are convex. The sutures are rather shallow. There are fine spiral striae on the base, otherwise the surface is smooth. The umbilicus seems wide and deep. The fragments are too incomplete to be measured.

The fragments can best be referred to *M.* (*M.*) *helicinus,* but the imperfect state of preservation prevents a close determination.

Recent distribution. Panarctic, boreal, circumpolar. *M.* (*M.*) *helicinus* is known from all areas investigated along the arctic coasts and is distributed from Franz Josef Land, the Kara Sea, the Siberian Arctic Sea and the Bering Sea southward to Amur Bay, Cape Cod, the British Isles and Kattegat. The species is very common in the littoral zone of West Greenland from Etah in the north to Julianehåb in the south. In East Greenland it has been collected from Scoresby Sund in the north and southward to Lindenows Fjord. Vertical range: 0 m (Iceland) to 407 m (Norway).

Ecology and biology. The species is mainly found associated with *Laminaria, Fucus, Desmarestia* and *Zostera* (Thorson, 1941). The eggs are deposited on algae and the larval development is non-pelagic (Thorson, 1944).

Fossil occurrence. Svalbard, the north coast of Russia, Canada, Iceland, Scandinavia, the British Isles and ?Holland. Stratigraphical range: ?Lower Pleistocene to Holocene.

Fossil in Greenland. *Margarita helicina* (Phipps): Laursen (1944, 1945, 1950), Harder *et al.* (1949).

Margarites (Margarites) groenlandicus (Chemnitz, 1781)

Plate 1, fig. 3

1781 Trochus grønlandicus Chemnitz, p. 108, plate 171, fig. 1671.

Material. Kløft II, Pátorfik: One complete specimen from tongue Sk–4 (GGU 111720); one complete and one fragmentary specimen from tongue Sk–5 (GGU 111721).

Remarks. The complete specimens measure (h × d): 12.1 × 12.0 and 8.8 × 8.6 mm respectively.

Recent distribution. Panarctic, boreal, circumpolar. *M. (M.) groenlandicus,* known from all arctic coastal areas investigated, extends from Franz Josef Land, Novaya Zemlya, the Kara Sea, the Siberian Arctic Sea, Parry Islands and Ellesmere Island southward to Cape Cod, Scotland and the North Sea. The species is one of the most common prosobranchs in West Greenland where it occurs from Etah in the north to Nanortalik in the south. In East Greenland the species is the most common shallow water prosobranch and has been found from Danmarkshavn in the north to south of Lindenows Fjord (Qeqertatsiaq)*. Vertical range: 0 m (Iceland) to 512 m (near Novaya Zemlya).

Ecology and biology. The species is mainly attached to *Fucus, Laminaria* and *Desmarestia* as well as *Delesseria* and other red algae (Thorson, 1944). The eggs are probably laid on algae and the larval development is non-pelagic (Thorson, 1941).

Fossil occurrence. Svalbard, the north coast of Russia, Siberia, Iceland, Scandinavia and the British Isles. Stratigraphical range: Lower Pleistocene to Holocene.

Fossil in Greenland. *Margarita groenlandica* (Chemnitz): Laursen (1944, 1950), Harder *et al.* (1949). ?*Margarites undulata* Sowerby: Washburn & Stuiver (1962).

Subgenus *Pupillaria* Dall, 1909.

Margarites (Pupillaria) cinereus (Couthouy, 1838)

Plate 1, figs 4 & 5A–C

1838 Turbo cinereus Couthouy, p. 99, plate 3, fig. 9.

Material. Kløft II, Pátorfik: 10 complete specimens and one fragment from tongue Sk–4 (GGU 111720); 4 almost complete specimens from tongue Sk–5 (GGU 111721).

Remarks. The specimens are generally well preserved, but many of them are overgrown with serpulids and bryozoans. Sometimes the shells are completely covered with bryozoan colonies. The 5 largest specimens measure (h × d): 13.6 × 11.2, 11.7 × 10.2, 11.2 × 11.7, 8.8 × 8.5 and 7.2 × 7.4 mm respectively.

* See footnote p. 24.

Recent distribution. Panarctic, mid boreal, circumpolar. *M.* (*P.*) *cinereus* occurs from Franz Josef Land, Novaya Zemlya, the Kara Sea, the Siberian Arctic Sea, Alaska and Ellesmere Island southward to Cape Cod and Bergen (Norway). It is distributed all along the coast of West Greenland from Etah in the north to Julianehåb in the south. In East Greenland its northernmost locality is the Pendulum Øer, and it is restricted to the outer coast southward to Lindenows Fjord. Vertical range: 0 m (Iceland) to 660 m (west of Norway).

Ecology and biology. The species prefers a bottom of stones and algae, especially *Laminaria* (Thorson, 1944). The eggs are deposited on algae and the larval development is non-pelagic (Thorson, 1944).

Fossil occurrence. Svalbard, the north coast of Russia, Siberia, Alaska, the east coast of Canada, Maine, Iceland, Scandinavia, the British Isles and ?California. Stratigraphical range: Lower Pleistocene to Holocene.

Fossil in Greenland. *Margarita cinerea* (Couthouy): Pjetursson (1898), Noe-Nygaard (1932), Laursen (1944, 1950).

Order Mesogastropoda Thiele, 1925. Family Lacunidae Gray, 1857. Genus *Lacuna* Turton, 1827. Subgenus *Epheria* Gray, 1847.

Lacuna (*Epheria*) *vincta* (Montagu, 1803)

Plate 1, fig. 6

1803 *Turbo vinctus* Montagu, p. 307, plate 20, fig. 3.

Material. Kløft II, Pátorfik: 4 fragments from tongue Sk–4 (GGU 111720).

Remarks. The spire is preserved in all the fragments. As the outer lip is damaged in them all, neither height nor diameter can be measured.

Recent distribution. Mid arctic, boreal, lusitanian. *L.* (*E.*) *vincta* extends from North Iceland, Novaya Zemlya and the Bering Sea southward to Japan, California, Cape Cod and the Bay of Biscay. In West Greenland it is distributed from Jakobshavn in the north to Julianehåb in the south. The species has never been found off the East Greenland coast. Vertical range: 0 m (Denmark) to 192 m (Iceland).

Ecology and biology. The substratum is stones, algae and *Zostera* (Thorson, 1941; Rasmussen, 1973). The egg masses are laid on stones and algae (*Laminaria* and *Fucus*) and the larval development is pelagic (Thorson, 1941).

Fossil occurrence. Svalbard, the north coast of Russia, North America, Iceland, Scandinavia and the British Isles. Stratigraphical range: Lower Pleistocene to Holocene.

Fossil in Greenland. *Lacuna divaricata* (Fabricius): Laursen (1944), Harder *et al.* (1949). *Lacuna vincta* (Montagu): Harder *et al.* (1949), Donner & Jungner (1975).

Lacuna (Epheria) cf. *L. (E.) crassior* (Montagu, 1803)

Plate 1, fig. 7

1803 *Turbo crassior* Montagu, p. 309, plate 20, fig. 1.

Material. Kløft II, Pátorfik: A single fragment from tongue Sk–5 (GGU 111721).

Remarks. As the last whorl is damaged, the height or diameter cannot be measured. The size of the fragment shows that the shell was more than 10 mm high and 7 mm in diameter, i.e. a rather large specimen of *Lacuna.* The fragment has been drilled by a carnivorous gastropod.

Discussion. The fragment has 5 whorls with fine, prosocline collabral striae, very similar to those of *L. (E.) vincta.* No groove is visible in the fragment which closely resembles *L. (E.) vincta,* but differs from it in having a stronger shell with a turreted spire. As these characteristics are in good agreement with those of *L. (E.) crassior,* the fragment is referred to that species, though with reservations. This, the largest species of *Lacuna,* is up to 18.5 mm high.

Recent distribution. Panarctic, boreal, lusitanian. *L. (E.) crassior* is known from Svalbard and southward to the British Isles and northern France. Moreover, it has been recorded from the north coast of Russia, the White Sea, the Gulf of St. Lawrence and the Sea of Okhotsk. In West Greenland the species has been found off Godhavn, Egedesminde and Godthåb. It has never been met with in East Greenland. Vertical range: 0 m (the British Isles) to 160 m (the Gulf of St. Lawrence).

Ecology. The species prefers muddy bottom (McMillan, 1968; Nordsieck, 1968).

Fossil occurrence. England. Stratigraphical range: Lower Pleistocene to Holocene. The species is new to the Greenland fossil fauna.

Family Rissoidae Adams & Adams, 1854. Genus *Putilla* Adams, 1867. Subgenus *Parvisetia* Monterosato, 1884.

Putilla (Parvisetia) globula (Møller, 1842)

Plate 1, fig. 8A–B

1842 *Rissoa globulus* Møller, p. 82.

Material. Kløft II, Pátorfik: 3 almost complete specimens from tongue Sk–4 (GGU 111720); one specimen from tongue Sk–5 (GGU 111721).

Remarks. The shell is small, ovoid, with a smooth surface. The protoconch is conical with flattened apex. The whorls of the teleoconch are convex. The sutures are rather deep. The aperture is roundly oval and there is no rib on the outer lip. There is a narrow umbilicus on the base. The largest shell has 4 whorls.

As the outer lip is somewhat damaged in the two largest specimens they cannot be measured. The two smallest specimens measure (h × d): 2.1 × 1.6 and 1.4 × 1.3 mm respectively.

Recent distribution. ?Panarctic. *P.* (*P.*) *globula* has been recorded from the eastern part of the Atlantic from Svalbard and Finnmark (Norway) and is also mentioned from Newfoundland. According to Warén (1972) all these records are uncertain. A few specimens have been found (?living) in deep water south-west of the Faeroe Islands. In West Greenland the species has been recorded from Godhavn in the north to Julianehåb in the south. It is not known from East Greenland. Vertical range: ?5 m (West Greenland) to ?900 m (south-west of the Faeroe Islands). The figures cited for the vertical range are uncertain as it does not appear from the records whether the specimens in the individual cases were living or dead.

Ecology. The species seems to prefer a bottom of clay, sand, shells and algae (Posselt, 1898).

Fossil occurrence. Unknown.

The species is new to the Greenland fossil fauna.

Genus *Alvania* Risso, 1826. Subgenus *Alvania* Risso, 1826.

Alvania (*Alvania*) *patorfikensis* Laursen, 1944

Plate 1, figs 9 & 10A–B

1944 *Alvania wyville-thomsoni* (Friele) var. *pátorfikensis* Laursen, p. 70, plate 6, figs 7a-b & 8a-b.

Type. The specimen figured by Laursen, 1944 plate 6, fig. 7a-b is the holotype. It is kept in the collections of the Geological Museum of the University of Copenhagen and numbered MGUH 5424.

Diagnosis. A large and scalarite *Alvania* with regular tubercles on the crossing points of the collabral ribs and the coarse spiral lines. The larval shell consists of 1.75 whorls. The aperture is oval and there is a narrow umbilicus on the base.

Material. Kløft II, Pátorfik: 214 complete specimens and 3 fragments from tongue Sk–4 (GGU 111720); 64 complete and 9 fragmentary specimens from tongue Sk–5 (GGU 111721); one specimen from Sk–6 (GGU 111722); one specimen from layer Sk–7 (GGU 111723).

Remarks. In figs 11–12 is shown the size frequency distribution of the measurable specimens from the tongues Sk–4 (214 shells) and Sk–5 (64 shells). The histograms clearly show skewness implying that the death rate is especially high among the young animals (see further discussion later).

The relationship between height and diameter in 100 specimens from tongue Sk–4 is shown in fig. 13. The regression equation was computed as $Y = 0.404 +$

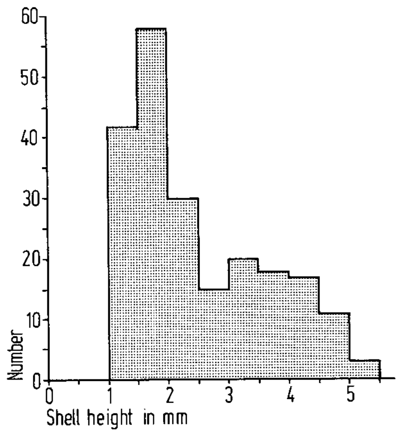


Fig. 11. *Alvania (Alvania) patorfikensis* Laursen. Histogram of the size frequency distribution of 214 measurable specimens from tongue Sk–4 (GGU 111720), Kløft II, Pátorfik.

0.598*X* and the coefficient of correlation was computed as r = 0.976. A *t*-test on the intercept with the *Y*-axis shows that the height-diameter growth of the species is allometric.

Discussion. In the material collected by Laursen at Pátorfik there were 8 shells showing close affinity with *Alvania (Alvania) wyvillethomsoni* (Friele, 1877). After a thorough examination the shells were referred to a new variety of *A. (A.) wyvillethomsoni* which Laursen (1944) named *pátorfikensis*. The variety differs from the typical form in having a more scalarite shell with coarser sculpture. Thus, regular tubercles are formed on the crossing points of the collabral ribs and the coarse spiral lines on the surface of the shell. The protoconch is about 1.75 whorls, whereas the typical form has a larval shell of 2.1–2.2 whorls. The aperture is roundly oval and very similar to that of the typical form. There is a narrow um-

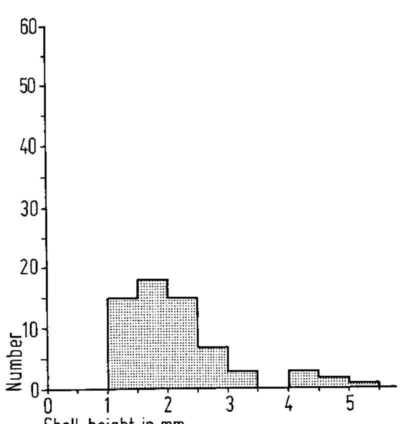
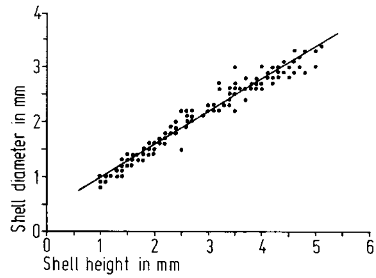


Fig. 12. *Alvania (Alvania) patorfikensis* Laursen. Histogram of the size frequency distribution of 64 measurable specimens from tongue Sk–5 (GGU 111721), Kløft II, Pátorfik.

Fig. 13. *Alvania (Alvania) patorfikensis* Laursen. Relationship between shell height and diameter in 100 specimens from tongue Sk–4 (GGU 111720), Kløft II, Pátorfik.



bilicus on the base. The variety becomes somewhat larger than the typical form, and Laursen (1944 p. 70) considered it as "a form, which has lived under more optimal conditions, than has been the case with the small typical specimens mainly restricted to the deep-sea areas poor in nourishment".

After comparison with few and rather poorly preserved specimens of *A.* (*A.*) *wyvillethomsoni,* which is rare, it is not easy to decide whether these shells from the Pátorfik beds belong to a distinct species. However, the problem still remains to be discussed from another point of view. *A.* (*A.*) *wyvillethomsoni* has never been met with at depths less than 95 m and is almost exclusively found at considerably greater depths. Faunistic as well as sedimentological evidence seems, however, to stress that the Pátorfik beds were deposited at considerably smaller depths, though off the littoral (subtidal) zone. If it really is *A.* (*A.*) *wyvillethomsoni,* it is unusual to find about 300 specimens in deposits that apparently were formed outside its present vertical range, especially as the concentration is greater than the whole present-day collection. It appears that either *A.* (*A.*) *wyvillethomsoni* had quite a different vertical range when the Pátorfik beds were deposited or that we actually are dealing with another species, somewhat similar in its appearance, but with different ecology. It must be emphasized that the specimens from the Pátorfik deposits probably lived under optimal conditions, but they are up to 0.8 mm (about 14 per cent) higher than recent *A.* (*A.*) *wyvillethomsoni.* On the whole, the present author is inclined to regard these shells from the Pátorfik beds as belonging to a distinct species, as hinted by Rosenkrantz (1968).

Recent distribution. A. (*A.*) *wyvillethomsoni* is mainly panarctic in its distribution. The species is known in the eastern Atlantic from Franz Josef Land and Svalbard in the north to north of Scotland in the south. In boreal waters it has only been met with at depths of several hundreds of metres (Warén, 1973). The species has never been found in West Greenland, but in East Greenland it is known from east of Bessels Fjord, Kejser Franz Josephs Fjord and Scoresby Sund. Vertical range: 95 m (East Greenland) to 2814 m (between Norway and Iceland).

Ecology. In East Greenland *A.* (*A.*) *wyvillethomsoni* seems to prefer clayey bottom (Thorson, 1944).

Fossil occurrence. Fossil specimens of *A.* (*A.*) *wyvillethomsoni* have been recorded from Holocene deposits at Giesecke Sø in West Greenland (Laursen, 1950) and the Bridlington Crag from the Holstein Interglacial in England (Harmer, 1920). However, according to Harmer's description the species from the Bridlington Crag is quite different (cf. Warén, 1973). Stratigraphical range: ?Holocene.

A. (*A.*) *patorfikensis* is apparently only met with in the interglacial deposits at Pátorfik and is not known living today.

Alvania (*Alvania*) sp.

Plate 2, fig. 1

Material. Kløft II, Pátorfik: A single specimen from tongue Sk–4 (GGU 111720).

Remarks. The specimen is rather well preserved, although the initial whorls are worn. The shell is conical with 3.5 convex whorls. The sutures are deep and slightly oblique. The surface of the teleoconch is covered by numerous collabral ribs which are slightly prosocline. There are 26 collabral ribs on the last whorl. They are crossed by distinct spiral lines and there are small tubercles at the intersections. The aperture is roundly oval. There is a narrow umbilicus on the convex base. The shell has the following measurements in mm: h=3.0, d=2.2, hlw=2.5, ha=1.6 and wa=1.3.

Discussion. It is evident that *Alvania* (*Alvania*) sp. shows the closest affinity to *A.* (*A.*) *patorfikensis.* The shell form as well as the aperture are very similar to those of the latter, but the sculpture is finer. The collabral ribs in *Alvania* (*Alvania*) sp. are not so coarse, neither as high nor broad as in *A.* (*A.*) *patorfikensis.* Furthermore, they are more numerous in the species in question; there are 26 collabral ribs on the last whorl in *Alvania* (*Alvania*) sp. (the shell comprises 3.5 whorls) versus 12–15 on the third whorl in *A.* (*A.*) *patorfikensis* which, moreover, only has 14–18 collabral ribs on the fourth whorl.

It is well known that arctic gastropod individuals belonging to the same species can vary considerably in shell form and sculpture. On the other hand, the author could not find any transitional forms between *Alvania* (*Alvania*) sp. and *A.* (*A.*) *patorfikensis* within the rather abundant material of the latter. Furthermore, it has not been possible to identify the present specimen with any of the *Alvania* species described so far. Therefore this specimen is referred to *Alvania* (*Alvania*) sp.

Subgenus *Frigidoalvania* Warén, 1974.

Alvania (Frigidoalvania) janmayeni (Friele, 1877)

Plate 2, fig. 2

1877 *Rissoa Jan-Mayeni* Friele, p. 4.

Material. Kløft II, Pátorfik: A single specimen from tongue Sk–4 (GGU 111720).

Remarks. The specimen measures (h ×d): ?3.4 × ?2.2 mm. The measurement is uncertain as the outer lip is somewhat damaged.

Recent distribution. Panarctic. *A.* (*F.*) *janmayeni* is recorded from Svalbard, Jan Mayen, the eastern part of Finnmark, the Barents Sea, the north coast of Russia, the White Sea, the Kara Sea, the western part of the Siberian Arctic Sea, Alaska (Point Barrow) and north-eastern Canada. Living specimens are not known from Iceland, but empty shells have been met with at considerable depths (more than 95 m) (Óskarsson, 1962). In West Greenland the species has been found at Upernavik, Umanak and Godhavn. In East Greenland it is distributed from Mackenzie Bugt in the north to Lindenows Fjord in the south. Vertical range: 5–8 m (East Greenland) to ?400 m (West Greenland).

Ecology. In East Greenland the species is frequent in the infauna; in the *Macoma calcarea* community (4–45 m on clay bottom), the *Astarte crenata* community (40–550 m on clay bottom) and the *Gomphina fluctuosa* community (9–20 m on sand bottom) (Thorson, 1944).

Fossil occurrence. East coast of Canada and Scandinavia. Stratigraphical range: Upper Pleistocene to Holocene.

In Denmark it has been found fossil in the Upper Pleistocene *Portlandia arctica* Zone in the Skærumhede sequence in Vendsyssel (Nordmann *in* Jessen *et al.*, 1910).

Fossil in Greenland. *Alvania jan-mayeni* (Friele): Laursen (1944, 1945, 1950).

Family Turritellidae Clarck, 1851. Genus *Tachyrhynchus* Mörch, 1868.

Tachyrhynchus erosus (Couthouy, 1838)

Plate 2, fig. 3

1838 *Turritella erosa* Couthouy, p. 103, plate 3, fig. 1.

Material. Kløft II, Pátorfik: One almost complete specimen from Sk–2 (GGU 111718); one complete juvenile specimen and one fragment of a spire from tongue Sk–4 (GGU 111720); one fragment with 5 whorls from Sk–6 (GGU 111722).

Remarks. With the exception of the juvenile shell the specimens are rather poorly preserved. The specimen from Sk–2 measures (h × d): 19.4 × 6.7 mm and the juvenile specimen from tongue Sk–4 is 1.4 × 1.1 mm.

Recent distribution. Panarctic, ?circumpolar. *T. erosus* occurs from Svalbard, Novaya Zemlya, the Siberian Arctic Sea and the Bering Sea southward to North Japan, Alaska (Sitka) and Cape Cod. The species is not known in Iceland at present. In West Greenland it is distributed along the coast from Melville Bugt in the north to Julianehåb in the south. In East Greenland it has only been found in the Sydøstkyst area (from Kap Gustav Holm in the north and south to Kap Farvel). Vertical range: 12.8 m (Bathurst Inlet) to 355 m (West Greenland).

Ecology. The species is a plankton-feeder and belongs most likely to the infauna (Thorson, 1944). It seems to prefer a bottom of mud (Posselt, 1898).

Fossil occurrence. Siberia, Alaska, Canada, Iceland, Scandinavia and the British Isles. Stratigraphical range: ?Pliocene to Holocene.

In Iceland the species has been found fossil only in the Lower Pleistocene deposits in Búlandshöfdi, West Iceland (Pjetursson & Jensen, 1905). In Denmark it is known fossil in the Upper Pleistocene *Portlandia arctica* Zone and the overlying glacigene deposits in the Skærumhede sequence and, furthermore, in the Upper Pleistocene Older *Yoldia* Clay, moraine sand and fluvioglacial gravel elsewhere in Vendsyssel (Nordmann *in* Jessen *et al.,* 1910; Petersen *in* Bahnson *et al.,* 1974).

Fossil in Greenland. *Turritella erosa* Couthouy: Laursen (1944, 1950).

Family Naticidae Forbes, 1838. Genus *Natica* Scopoli, 1777. Subgenus *Lunatia* Gray, 1847.

Natica (Lunatia) pallida Broderip & Sowerby, 1829

Plate 2, fig. 4

1829 *Natica pallida* Broderip & Sowerby, p. 372.

Material. Kløft II, Pátorfik: 24 complete and 14 fragmentary specimens from tongue Sk–4 (GGU 111720); 4 complete specimens and 25 fragments from tongue Sk–5 (GGU 111721); one almost complete and 4 fragmentary specimens from Sk–6 (GGU 111722); one fragmentary specimen from layer Sk–7 (GGU 111723).

Remarks. The largest specimen measures (h × d): 28.6 × 27.0 mm.

Recent distribution. Panarctic, boreal, circumpolar. *N.* (*L.*) *pallida* inhabits the eastern part of the Atlantic from Franz Josef Land and Svalbard southward to Denmark, Holland and Belgium. Furthermore, it is found in the Siberian Arctic Sea and off the north coast of America. The southern boundary in the western part of the Atlantic seems to be at New England and it extends into the Pacific southward to Japan and Puget Sound. The species is distributed along the coast of West Greenland from Dundas in the north to Julianehåb in the south. In East Greenland the species has its northernmost occurrence at Danmarkshavn and reaches to south of Lindenows Fjord (Qeqertatsiaq)*. Vertical range: 0 m (Norway) to 2430 m (North-West Atlantic).

* See footnote p. 24.

Ecology and biology. The species belongs to the infauna and in East Greenland it is the type-prosobranch for the *Macoma calcarea* community, but it lives also in the *Astarte crenata* community and the *Gomphina fluctuosa* community (Thorson, 1944). The egg rings, incrusted with clay or sand, are deposited on the bottom and the larval development is non-pelagic (Thorson, 1944).

Fossil occurrence. Svalbard, the north coast of Russia, Siberia, North America, Iceland, Scandinavia and the British Isles. Stratigraphical range: Pliocene to Holocene.

Fossil in Greenland. *Natica groenlandica* Möller: Steenstrup (1883), Holst (1886), Noe-Nygaard (1932), Flint (1948). *Lunatia pallida* (Broderip & Sowerby): Laursen (1944, 1950), Harder *et al.* (1949). *Natica pallida groenlandica* Möller: Sugden (1972).

Subgenus *Tectonatica* Sacco, 1890.

Natica (*Tectonatica*) *affinis* (Gmelin, 1790)

Plate 2, fig. 5

1790 *Nerita affinis* Gmelin, p. 3675.

Material. Kløft II, Pátorfik: 2 fragmentary specimens from Sk–2 (GGU 111718); 2 complete and 5 fragmentary specimens from tongue Sk–4 (GGU 111720); one complete specimen and 6 fragments from tongue Sk–5 (GGU 111721); one fragmentary specimen from Sk–6 (GGU 111722).

Remarks. The largest complete specimen measures (h × d): 10.8 × 9.5 mm.

Discussion. Collin (1887) discussed the classification of *Natica clausa* and *N. affinis.* After an examination of radulas belonging to the former (material from the Kara Sea) and comparison with radulas of *N. clausa* and *N. affinis* figured by Sars (1878 plate 5, figs 15–16) he doubted that they could be kept separate as two distinct species. Indeed, he arrived at the conclusion that the stated differences (e.g. difference in size) between them might be within the variation range of one single species. Since 1887 many authors have treated *N. clausa* and *N. affinis* as one and the same species, e.g. Thorson (1941, 1944, 1951) and Feyling-Hanssen (1955a) using the name *N. clausa* Broderip & Sowerby, 1829 and Nordsieck (1968) who made use of the name *N. affinis* (Gmelin, 1790). The present author also regards *N. clausa* and *N. affinis* as one single species. However, as the name *N. affinis* is older and is not found used before 1790 for any other species of *Natica* it seems to have priority to *N. clausa* and is therefore considered the valid species name.

The author has referred the species to the subgenus *Tectonatica* Sacco, 1890 which differs from the subgenus *Lunatia* Gray, 1847 in having the umbilicus filled up with callosity.

Recent distribution. Panarctic, boreal, lusitanian, circumpolar. *N.* (*T.*) *affinis* occurs in the area from Franz Josef Land, Novaya Zemlya, the Kara Sea, the Siberian

Arctic Sea, Alaska (Point Barrow) and Ellesmere Island southward to Japan, Vancouver, Cape Hatteras and the Mediterranean. In West Greenland it has been found along the coast from Etah in the north to Julianehåb in the south. In East Greenland the species occurs commonly along the outer coast from Shannon as the northernmost locality and southward to Lindenows Fjord. Vertical range: 0 m (Norway) to 2660 m (Algeria).

Ecology and biology. The species belongs to the infauna and in Iceland it is found in the *Macoma calcarea* community (in shallow water on clay or mud bottom) as well as in the *Yoldia hyperborea* community (45–160 m on clay bottom) (Spärck, 1937). The egg rings are laid freely on the bottom and the larval development is non-pelagic (Thorson, 1944).

Fossil occurrence. Svalbard, Novaya Zemlya, Kolguev Island (White Sea), the north coast of Russia, Siberia, Japan, North America, Iceland, Scandinavia and the British Isles. Stratigraphical range: Miocene to Holocene.

Fossil in Greenland. *Natica clausa* Broderip & Sowerby: Rink (1852), Nordenskiöld (1871), Steenstrup (1881), Laursen (1944, 1950), Harder *et al.* (1949), Weidick (1968), Sugden (1972). *Natica affinis* Gmelin: Steenstrup (1883), Jensen & Harder (1910), Jensen (1917).

Order Neogastropoda Wenz, 1838. Family Muricidae Fleming, 1828. Genus *Trophon* Montfort, 1810. Subgenus *Boreotrophon* Fischer, 1884.

Trophon (*Boreotrophon*) *truncatus* (Ström, 1768)

Plate 2, fig. 6A–B

1768 *Buccinum truncatum* Ström, p. 369, plate 16, fig. 26.

Material. Kløft II, Pátorfik: 9 complete specimens and one fragment from tongue Sk–4 (GGU 111720); 2 complete and 3 fragmentary specimens from tongue Sk–5 (GGU 111721).

Remarks. Five of the complete specimens from tongue Sk–4 are juvenile. They are excellently preserved, but only tentatively referred to this species. One of these specimens is shown in plate 2, fig. 6A–B. The largest complete specimens were measured (h and d) and the number of collabral ribs on each whorl counted:

		number of collabral ribs on whorl			
h in mm	d in mm	6	5	4	3
24.8	13.3	16	14	13	12
21.5	?11.1		13	11	
20.4	11.1	14	13	12	11
18.4	10.0	16	13	11	

Recent distribution. Panarctic, boreal. *T.* (*B.*) *truncatus* occurs from Svalbard, the Barents Sea, the north coast of Russia, the Siberian Arctic Sea and Alaska (Point Barrow) southward to the Gulf of Maine, the British Isles and Kattegat. The species is rather common in Iceland, but has not been found living off the south coast today. In West Greenland it is distributed from the south coast of Nûgssuaq in the north to Frederikshåb in the south. The species inhabits only the southernmost part of the East Greenland coast. Vertical range: 3 m (Iceland) to 950 m (?Greenland Sea).

Ecology. In East Greenland the species is found on mud, clay, sand, gravel, stones and algae (Thorson, 1944).

Fossil occurrence. Svalbard, the north coast of Russia, Iceland, Scandinavia and the British Isles. Stratigraphical range: Lower Pleistocene to Holocene.

Fossil in Greenland. *Trophon truncatus* (Strøm): Laursen (1944, 1945, 1950), Harder *et al.* (1949), Donner & Jungner (1975).

Trophon (Boreotrophon) clathratus (Linné, 1767)

Plate 2, fig. 7

1767 *Murex clathratus* Linné, p. 1223.

Material. Kløft II, Pátorfik: 3 almost complete specimens from tongue Sk–4 (GGU 111720); one complete specimen from tongue Sk–5 (GGU 111721).

Remarks. The specimens were measured (h and d) and the number of collabral ribs on each whorl counted:

		number of collabral ribs on whorl			
h in mm	d in mm	6	5	4	3
14.7	?7.0	12	10	11	10
12.0	6.2		12	11	10
11.3	?6.1		11	11	10
5.9	3.5			11	10

It is evident that the species has somewhat fewer collabral ribs on each whorl than *T. (B.) truncatus.*

Recent distribution. Panarctic, boreal, circumpolar. *T. (B.) clathratus* extends from Franz Josef Land, Novaya Zemlya, the Siberian Arctic Sea, Alaska and Baffin Island southward to ?Japan, ?Puget Sound (British Columbia), New England, the Hebrides and Bohuslän (Sweden). In West Greenland the species occurs along the coast from Prøven in the north to Julianehåb in the south. The typical species has not been found in East Greenland where *T. (B.) clathratus* var. *gunneri* (Lovén, 1846) seems to inhabit only the southernmost part of the coast. Vertical range: 8 m (Svalbard) to 1033 m (the Hebrides).

Ecology and biology. The substratum in Iceland is clay, sand, stones and algae (Thorson, 1941). The egg capsules are deposited on stones or mollusc shells and the larval development is non-pelagic (Thorson, 1944).

Fossil occurrence. Svalbard, the north coast of Russia, Siberia, Canada, Massachusetts, Iceland, Scandinavia, the British Isles and Holland. Stratigraphical range: Pliocene to Holocene.

Fossil in Greenland. *Trophon clathratum* L.: Steenstrup (1881). *Trophon clathratus* (Linné): Steenstrup (1883), J. A. D. Jensen (1889), Pjetursson (1898), Jensen (1917), Laursen (1944, 1945, 1950).

Family Buccinidae Latreille, 1825. Genus *Colus* Röding, 1798.

Colus sp.

Plate 2, fig. 8

Material. Kløft II, Pátorfik: A single fragmentary specimen from Sk–2 (GGU 111718).

Remarks. The fragment consists of a poorly preserved spire. The protoconch as well as the outer lip and the siphonal canal are broken off. The fragment measures (h and d): 75.6 and 32.4 mm and has about 6 whorls. The spire is elongated and the oblique sutures are rather shallow. There are numerous spiral ridges on the teleoconch whorls.

The fragmentary specimen undoubtedly belongs to the genus *Colus,* but it is too poor for further determination.

Genus *Neptunea* Röding, 1798. Subgenus *Neptunea* Röding, 1798.

Neptunea (*Neptunea*) *despecta* (Linné, 1758)

Plate 2, figs 9–10

1758 *Murex despectus* Linné, p. 754.

Material. Kløft II, Pátorfik: Some poorly preserved fragments from Sk–2 (GGU 111718).

Remarks. Only one of the fragments has the upper part of the spire preserved. The sculpture appears to be intermediate between the typical form and *N.* (*N.*) *despecta* var. *carinata* (Pennant, 1777). The diameter of the largest fragment is about 50 mm, but the material is too poor for further measurements.

Recent distribution. Panarctic, boreal, lusitanian. *N.* (*N.*) *despecta* occurs from Svalbard southward to Cape Cod and West Ireland. The species has been recorded from the seas north of Russia, Siberia and North America as well as in the North Pacific, but the latest investigations (e.g. Durham & MacNeil, 1967; Strauch, 1972) seem to indicate that it is bound to the Atlantic region. In West Greenland the species is known from Umanak in the north to Nanortalik in the south. In East Greenland it is found in the Kejser Franz Josephs Fjord area, the Scoresby Sund area and south of Kap Gustav Holm. Vertical range: 10 m (Svalbard) to 1203 m (between Svalbard and Bjørnøya).

Ecology and biology. In Iceland the species has been met with on a substratum of sand, gravel, stones, shells and algae (Thorson, 1941). The egg capsules are deposited on stones and the larval development is non-pelagic (Thorson, 1944).

Fossil occurrence. Svalbard, Kolguev Island, the north coast of Russia, Siberia, East Canada, Maine, Iceland, Scandinavia and the British Isles. Stratigraphical range: ?Lower Pleistocene to Holocene.

Fossil in Greenland. *Fusus despectus* Linn.: Rink (1852), Steenstrup (1883). *Fusus fornicatus* Fabr.: Steenstrup (1883). *Neptunea despecta* (Linné): Laursen (1944).

Genus *Buccinum* Linné, 1758.

Buccinum undatum Linné, 1758

Plate 2, fig. 11

1758 *Buccinum undatum* Linné, p. 740.

Material. Kløft II, Påtorfik: One somewhat fragmentary specimen from tongue Sk–4 (GGU 111720); one fragment from Sk–6 (GGU 111722).

Remarks. The fragmentary specimen from tongue Sk–4 measures (h × d): 11.7 × ?7.5 mm. The other one is too poorly preserved to be measured.

Recent distribution. Panarctic, boreal, lusitanian, ?circumpolar. *B. undatum* has been found in the eastern part of the Atlantic from Svalbard and Novaya Zemlya in the north to the Bay of Biscay in the south. At the east coast of North America the species is known from Newfoundland and New England. The occurrence in the Siberian Arctic Sea, the Bering Sea and Arctic Pacific is somewhat uncertain. In West Greenland it has been found in the following areas: Godhavn, Egedesminde and Godthåb. Thorson (1944) has excluded the species from the East Greenland fauna. Vertical range: 0 m (Iceland) to 624 m (Norway).

Ecology and biology. In Iceland the species has been found on a bottom of sand, gravel, stones, shells and algae (Thorson, 1941). In Isfjorden in Spitsbergen (Svalbard) it almost exclusively occurs on muddy bottom (Odhner, 1915). The larval development is non-pelagic (Thorson, 1941).

Fossil occurrence. Svalbard, Novaya Zemlya, the north coast of Russia, Siberia, ?Alaska, East Canada, Maine, Massachusetts, New Jersey, Iceland, Scandinavia, the British Isles, Holland, Belgium, France and Italy. Stratigraphical range: Lower Pleistocene to Holocene.

Fossil in Greenland. *Tritonium undatum* L.: Steenstrup (1883), Hammer (1889). *Buccinum undatum* Linné: Quervain & Mercanton (1925), Laursen (1944, 1950), Sugden (1972).

Buccinum cf. *B. groenlandicum* Chemnitz, 1788

Plate 2, fig. 12

1788 *Buccinum groenlandicum* Chemnitz, p. 182, plate 152, fig. 1448.

Material. Kløft II, Pátorfik: A single fragmentary specimen from tongue Sk–4 (GGU 111720).

Remarks. The fragment is about 3.0 mm high and comprises 2 protoconch whorls and a small part of the first teleoconch whorl. The apex is somewhat flattened and very similar to that of *B. belcheri* Reeve, 1855 (cf. Thorson, 1935 figs 25–26). The surface of the protoconch is smooth. The sutures are deep. The sculpture of the first teleoconch whorl consists of 5 rather low spiral ridges, but collabral ridges or ribs are not visible on the fragment. The greatest part of the teleoconch is broken off.

The shell fragment can best be referred to *B. groenlandicum.* However, the imperfect state of preservation prevents a close determination.

Recent distribution. Panarctic, circumpolar. *B. groenlandicum* is of common occurrence in the Arctic and extends from Franz Josef Land, Novaya Zemlya, the Siberian Arctic Sea and the Bering Strait southward to British Columbia, Nova Scotia, South-East Iceland and Finnmark. In West Greenland it is found along the coast from Etah in the north to Julianehåb in the south. In East Greenland the species is only known from the southernmost part of the coast where it is rather common. Vertical range: 0 m (Iceland) to 392 m (the Barents Sea).

Ecology and biology. In East Greenland the species is the typical prosobranch in the red algae epifauna off the south-east coast (Thorson, 1944). The larval development is non-pelagic (Thorson, 1944).

Fossil occurrence. Svalbard, Novaya Zemlya, the north coast of Russia, Siberia, ?Alaska, East Canada, Maine, Iceland, Scandinavia and the British Isles. Stratigraphical range: ?Pliocene to Holocene.

Fossil in Greenland. *Tritonium grönlandicum:* Nordenskiöld (1871). *Tritonium undulatum* Møll.: Steenstrup (1883). *Buccinum grønlandicum:* Helland (1876). *Buccinum groenlandicum* Chemnitz: Laursen (1944, 1950).

Family Turridae Melvill, 1917

Genus *Oenopota* Mörch, 1852.

The nomenclature of this genus is bewildering. A great number of species have been described, but many of them are probably destined to be synonyms. Several generic names have been proposed. The names *Bela* Gray, 1847 and *Lora* Gistel, 1848 have often been used, but they are not available (Bartsch, 1941; MacGinitie, 1959). Neither the older generic names *Pleurotoma* Lamarck, 1799, considered as a synonym of *Turris* Müller, 1766, nor *Defrancia* Millet, 1827, which also refers to another genus, are available for the genus in question. Other names, such as *Propebela* Iredale, 1918 and *Obesotoma* Bartsch, 1941, have also been used, but they are all younger than *Oenopota* Mörch, 1852. The latter name will be used in this work as a generic name for all the Turridae collected at Pátorfik in 1968. A thorough study of all fossil and recent species is required for a systematic clarification of this difficult genus.

Oenopota bicarinata (Couthouy, 1838)

Plate 3, figs 1–3

1838 *Pleurotoma bicarinata* Couthouy, p. 104, plate 1, fig. 11.

Material. Kløft II, Pátorfik: 2248 complete and 133 fragmentary specimens from tongue Sk–4 (GGU 111720); 137 complete and 40 fragmentary specimens from tongue Sk–5 (GGU 111721).

Remarks. Height of shell (h) and diameter (d) were measured for the 5 largest specimens and the h/d ratios calculated:

h in mm	d in mm	h/d
12.5	5.0	2.50
12.1	5.5	2.20
12.1	5.0	2.42
11.9	4.8	2.48
11.8	5.2	2.27

The relationship between height and diameter in 101 specimens from tongue Sk–5 is shown in fig. 14. The regression equation is $Y = 0.747 + 0.367X$ and the coefficient of correlation $r = 0.974$. A *t*-test on the intercept on the *Y*-axis shows that the height-diameter growth of the species is allometric.

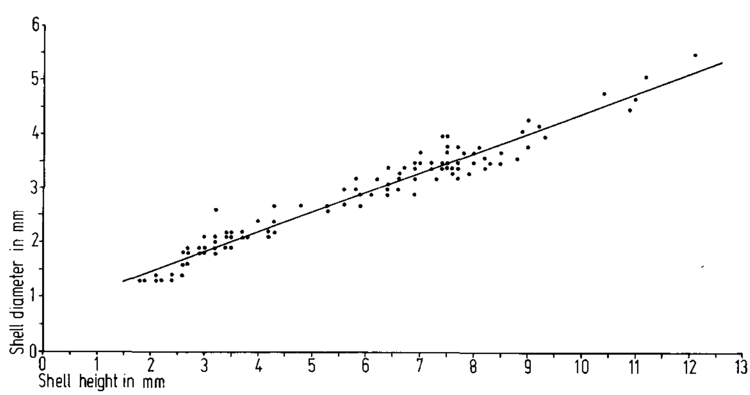


Fig. 14. *Oenopota bicarinata* (Couthouy). Relationship between shell height and diameter in 101 specimens from tongue Sk–5 (GGU 111721), Kløft II, Pátorfik.

Recent distribution. Panarctic, boreal, circumpolar. *O. bicarinata* is considered to have the same distribution as *O. bicarinata* var. *violacea* (Mighels & Adams, 1841). The typical form and this variety are found together in many localities and it seems impossible (e.g. in East Greenland) to see any relation between the abundance of the different forms and the surrounding conditions (Thorson, 1944). Vertical range: 0 m (Frobisher Bay) to ?1447 m (North Greenland Sea).

Ecology and biology. In East Greenland, where the species has been found on mud, clay, sand, gravel, stones and algae, it is common in the *Macoma calcarea* community (Thorson, 1933, 1944). The larval development is non-pelagic (Thorson, 1944).

Fossil occurrence. Svalbard, the north coast of Russia, ?Iceland, Scandinavia, the British Isles and California. Stratigraphical range: Lower Pleistocene to Holocene.

Fossil in Greenland. *Bela bicarinata:* Jensen & Harder (1910). *Bela violacea* (Mighel) var. *bicarinata* Couthouy: Laursen (1944), Harder *et al.* (1949).

Oenopota bicarinata (Couthouy, 1838) var. *violacea* (Mighels & Adams, 1841)

Plate 3, figs 4–6

1841 *Pleurotoma violacea* Mighels & Adams, p. 50.

Material. Kløft II, Pátorfik: 3701 complete and 50 fragmentary specimens from tongue Sk–4 (GGU 111720); 881 complete and 20 fragmentary specimens from tongue Sk–5 (GGU 111721); 10 fragmentary specimens from Sk–6 (GGU 111722).

Remarks. Height of shell (h) and diameter (d) were measured for the 5 largest specimens and the h/d ratios calculated:

h in mm	d in mm	h/d
8.6	4.3	2.00
8.6	4.2	2.05
8.6	4.1	2.10
8.5	4.2	2.02
8.5	3.8	2.24

The h/d ratios are somewhat lower than those of the typical form.

Recent distribution. Panarctic, boreal, circumpolar. *O. bicarinata* var. *violacea* extends from Svalbard, Novaya Zemlya, the Kara Sea, the Siberian Arctic Sea and Parry Islands southward to British Columbia, New England, Bohuslän (Sweden) and in the deep sea to western Ireland. In West Greenland it is found from Etah in the north to Julianehåb in the south. In East Greenland occurrences are common along the coast from Danmarkshavn to south of Lindenows Fjord. Vertical range: 0–4 m (East Greenland) to 761 m (Svalbard).

Ecology. In East Greenland it is commonly met with where the substratum is clay, sand, gravel and algae in the *Macoma calcarea* community (Thorson, 1944).

Fossil occurrence. Svalbard, the north coast of Russia, Alaska, East Canada, Iceland, Scandinavia, the British Isles and California. Stratigraphical range: Lower Pleistocene to Holocene.

In Denmark *O. bicarinata* var. *violacea* has been found in the Upper Pleistocene *Turritella terebra* Zone in the Skærumhede sequence in Vendsyssel (Nordmann *in* Jessen *et al.*, 1910).

Fossil in Greenland. *Pleurotoma violacea* Mich. & Ad.: Steenstrup (1883). *Bela violacea* (Mighel): Laursen (1944, 1950).

Oenopota decussata (Couthouy, 1839)

Plate 3, figs 7A–B & 8A–C

1839 *Pleurotoma decussata* Couthouy, p. 183, plate 4, fig. 8.

Material. Kløft II, Pâtorfik: 170 complete and 3 fragmentary specimens from tongue Sk–4 (GGU 111720); 61 complete and 2 fragmentary specimens from tongue Sk–5 (GGU 111721).

Remarks. Height of shell (h) and diameter (d) were measured for the 5 largest specimens and the h/d ratios calculated:

h in mm	d in mm	h/d
11.9	6.2	1.92
10.7	5.3	2.02
10.1	5.1	1.98
9.8	5.1	1.92
9.1	4.5	2.02

Recent distribution. Panarctic, high boreal, circumpolar. *O. decussata* occurs from Svalbard, Novaya Zemlya, the Kara Sea, the Siberian Arctic Sea, Parry Islands and Ellesmere Island southward to New England, north of Scotland (at great depths) and Finnmark. The species has been found along the West Greenland coast from Upernavik in the north to Julianehåb in the south. In East Greenland the typical form has been met with in the Kejser Franz Josephs Fjord area and the Scoresby Sund area. Vertical range: 3.5–4 m (East Greenland) to 1008 m (north of Scotland).

Ecology. The species seems to prefer muddy or clayey bottom (? in the *Macoma calcarea* community) (Thorson, 1941).

Fossil occurrence. Siberia, Iceland, Scandinavia, the British Isles and ?California. Stratigraphical range: Lower Pleistocene to Holocene.

Fossil in Greenland. *Pleurotoma viridula* Møll.: Steenstrup (1883). *Bela decussata* (Couthouy) var. *livida* Møller: Laursen (1944). *Bela tenuicostata* (M. Sars): Laursen (1944, in part). *Bela decussata* (Couth.): Laursen (1950).

Oenopota trevelliana (Turton, 1834)

Plate 3, fig. 9

1834 *Pleurotoma Trevellianum* Turton, p. 351.

Material. Kløft II, Pátorfik: 11 complete specimens from tongue Sk–4 (GGU 111720); one complete specimen from tongue Sk–5 (GGU 111721).

Remarks. Height of shell (h) and diameter (d) were measured for the 5 largest specimens and the h/d ratios calculated:

h in mm	d in mm	h/d
7.4	3.6	2.06
6.2	3.1	2.00
5.9	3.2	1.84
5.8	3.1	1.87
5.7	3.3	1.73

Recent distribution. Panarctic, boreal, lusitanian. *O. trevelliana* is widely distributed in arctic, boreal and lusitanian waters and extends from Svalbard, Bjørnøya, the Barents Sea, the Kara Sea and Baffin Bay southward to ?British Columbia (only empty shells), Cape Cod and the Bay of Biscay. In West Greenland it has been taken in the following areas: Melville Bugt, Umanak, Godhavn, Egedesminde, Godthåb and Frederikshåb. In East Greenland the species has been found from Store Koldeway in the north to Lindenows Fjord in the south. Vertical range: 9 m (Svalbard) to 337 m (north of the Hebrides).

Ecology and biology. In East Greenland the species is particularly collected from mud and clay bottom in the *Macoma calcarea* community (Thorson, 1944). The larvae have a short pelagic stage (Thorson, 1944).

Fossil occurrence. The north coast of Russia, Canada, Iceland, Scandinavia, the British Isles and France. Stratigraphical range: Lower Pleistocene to Holocene.

Fossil in Greenland. *Bela trevelyana* (Turton): Laursen (1944).

Oenopota angulosa (Sars, 1878)

Plate 3, fig. 10

1878 *Bela angulosa* Sars, p. 227, plate 16, fig. 16.

Material. Kløft II, Pátorfik: A single specimen from tongue Sk–4 (GGU 111720).

Remarks. The specimen is rather well preserved except that the protoconch is somewhat corroded. The shell is slender, turriculate and comprises 7 whorls. The teleoconch whorls are convex with rather well marked carina near the adapical suture. The sutures are oblique and deep-set. There are 14 highly prominent ribs on the last whorl. They are of similar breadth as the interspaces between them and continue down on the siphonal canal. The spiral threads are close-set, but distinct, crossing the collabral ribs. The aperture is oval. It tapers somewhat adapically, but passes abapically into rather a short siphonal canal. The shell has the following measurements in mm: h=8.7, d=3.5, hlw=4.9, ha=3.4 and wa=1.3. The h/d ratio is 2.56.

Recent distribution. Panarctic. *O. angulosa* is known from Svalbard, Finnmark, North and East Iceland and the area from Parry Islands and Ellesmere Island to Newfoundland. The species has not been found on the Greenland coasts at the present time. Vertical range: 17 m (Iceland) to 226 m (Norway).

Ecology. In Iceland the species has been found on a bottom of clay, sand and algae (Thorson, 1941).

Fossil occurrence. Iceland, Scandinavia and the British Isles. Stratigraphical range: Lower Pleistocene to Holocene.

The species is new to the Greenland fossil fauna.

Oenopota nobilis (Møller, 1842)

Plate 4, figs 1–3

1842 *Defrancia nobilis* Møller, p. 85.

Material. Kløft II, Pátorfik: 1774 complete and 46 fragmentary specimens from tongue Sk–4 (GGU 111720); 816 complete and 19 fragmentary specimens from tongue Sk–5 (GGU 111721); 4 complete specimens from Sk–6 (GGU 111722).

Remarks. Height of shell (h) and diameter (d) were measured for the 5 largest specimens and the h/d ratios calculated

h in mm	d in mm	h/d
16.7	6.5	2.57
16.5	7.0	2.36
15.6	6.3	2.48
13.3	5.9	2.25
12.7	5.4	2.35

The relationship between height and diameter in 106 specimens from the two tongues Sk–4 and Sk–5 is shown in fig. 15. The regression equation is $Y = 0.624 + 0.392X$ and the coefficient of correlation $r = 0.987$. A *t*-test on the intercept on the *Y*-axis shows that the height-diameter growth of the species is allometric.

Recent distribution. Panarctic, boreal, circumpolar. *O. nobilis* extends from Svalbard, the Barents Sea, the Kara Sea, the north coast of Russia, the Siberian Arctic Sea and the Bering Strait southward to North Japan, Cape Cod, the Faeroe Islands

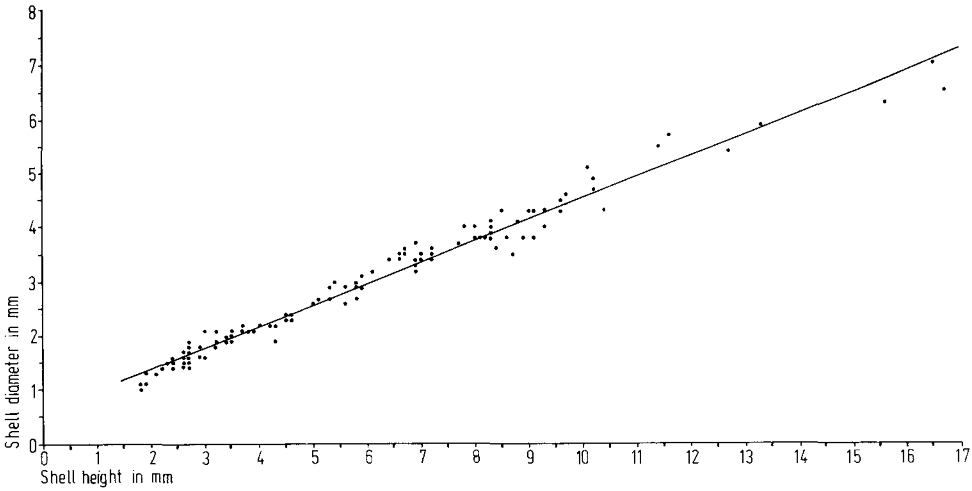


Fig. 15. *Oenopota nobilis* (Møller). Relationship between shell height and diameter in 106 specimens from tongues Sk–4 (GGU 111720) and Sk–5 (GGU 111721), Kløft II, Pátorfik.

and the Oslo Fjord. In West Greenland the species has been found along the coast from Dundas in the north to Nanortalik in the south. In East Greenland it has been taken at Danmarkshavn as the northernmost locality whence it reaches southward to Lindenows Fjord. Vertical range: 5 m (Svalbard) to 995 m (the Siberian Arctic Sea).

Ecology and biology. In Iceland the species is especially found on a bottom of mud (Thorson, 1941), but in East Greenland it seems to prefer a bottom of clay (Thorson, 1944). The larval development is non-pelagic (Thorson, 1944).

Fossil occurrence. Svalbard, Siberia, Canada, Iceland, Scandinavia and the British Isles. Stratigraphical range: Pliocene to Holocene.

In Denmark there is a questionable find in the Upper Pleistocene *Turritella terebra* Zone in the Skærumhede sequence in Vendsyssel (Nordmann *in* Jessen *et al., 1910).*

Fossil in Greenland. ?*Defrancia nobilis* Møller: Steenstrup (1883). *Bela nobilis* (Møller): Laursen (1944, 1950), Kelly (1973), Donner & Jungner (1975). *Lora nobilis* Müll.: Sugden (1972).

Oenopota *nobilis* (Møller, 1842) var. *clathrata* (Friele, 1886)

Plate 4, fig. 4

1886 *Bela rugulata* Troschel var. *clathrata* Friele, p. 4, plate 7, fig. 2.

Material. Kløft II, Pátorfik: 44 complete specimens and one fragment from tongue Sk–4 (GGU 111720); 3 complete specimens from tongue Sk–5 (GGU 111721).

Remarks. Height of shell (h) and diameter (d) were measured for the 5 largest specimens and the h/d ratios calculated:

h in mm	d in mm	h/d
7.0	3.5	2.00
6.6	3.5	1.89
6.6	3.4	1.94
6.4	3.4	1.88
5.5	2.8	1.96

Discussion. The variety differs from the typical form in having a coarser sculpture on the teleoconch whorls. The spiral ribs as well as the collabral ribs are prominent and there are large, round knobs at their intersections. Thus, the variety has more cancellated sculpture than the typical form.

Recent distribution. Panarctic, boreal, circumpolar. *O. nobilis* var. *clathrata* is regarded as having similar distribution as the typical form. Vertical range: Presumably similar to that of *O. nobilis.*

Fossil occurrence. Unknown outside Greenland.

Fossil in Greenland. ?*Pleurotoma turricula* Mont.: Steenstrup (1883). *Bela exarata* (Møller): Laursen (1944, in part).

Oenopota sp. undetermined

Material. Kløft II, Pátorfik: 408 fragmentary specimens from tongue Sk–4 (GGU 111720); 249 fragments from tongue Sk–5 (GGU 111721).

Remarks. The fragments are too poorly preserved for any closer identification, but they apparently belong to more than one species of *Oenopota.*

Gastropoda, Opisthobranchia

Subclass Opisthobranchia Milne Edwards, 1848. Order Pleurocoela Thiele, 1925. Family Pyramidellidae Gray, 1847. Genus *Amaura* Møller, 1842.

Amaura candida Møller, 1842

Plate 4, fig. 5A–C

1842 *Amaura candida* Møller, p. 80.

Material. Kløft II, Pátorfik: 123 complete and 30 fragmentary specimens from tongue Sk–4 (GGU 111720); 30 complete and 5 fragmentary specimens from tongue Sk–5 (GGU 111721).

Remarks. Fragments from the two tongues Sk–4 and Sk–5 do not show any signs of size selective crushing. The right-skewed histogram of the size frequency distribu-

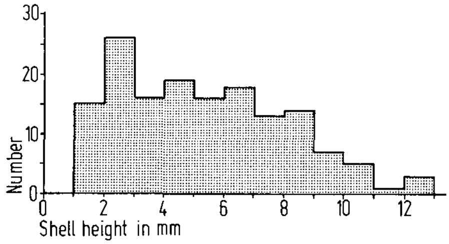


Fig. 16. *Amaura candida* Møller. Histogram of the size frequency distribution of 153 measurable specimens from tongues Sk–4 (GGU 111720) and Sk–5 (GGU 111721), Kløft II, Pátorfik.

tion of the 153 measurable shells, shown in fig. 16, may therefore indicate a high death rate among the young animals.

The relationship between height and diameter in 114 specimens from the tongues is shown in fig. 17. The regression equation is $Y = 0.775 + 0.459X$ and the coefficient of correlation $r = 0.964$. A t-test on the intercept with the Y-axis shows that the height-diameter growth of the species is allometric.

Recent distribution. ?Panarctic. *A. candida* seems to occur at Finnmark and in the Gulf of St. Lawrence, whereas the records from Franz Josef Land and the Bering Sea appear somewhat doubtful. In West Greenland the species has been found off Egedesminde and Godthåb, but it is not known from East Greenland. Vertical range: ?17–25 m (Finnmark) to ?120 m (West Greenland).

Only scarce information could be obtained from the literature about the recent geographical and vertical distribution of this species.

Ecology. In West Greenland the species has been found on clayey and sandy bottom (Posselt, 1898).

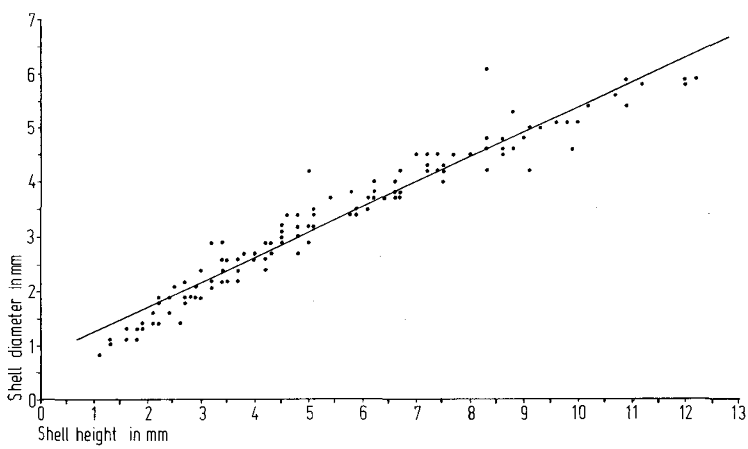


Fig. 17. *Amaura candida* Møller. Relationship between shell height and diameter in 114 specimens from tongues Sk–4 (GGU 111720) and Sk–5 (GGU 111721), Kløft II, Pátorfik.

Fossil occurrence. ?Iceland and the British Isles. Stratigraphical range: Lower Pleistocene to Holocene.

Fossil in Greenland. *Amaura candida* Møller: Laursen (1944).

Family Diaphanidae Odhner, 1914. Genus *Toledonia* Dall, 1902.

Toledonia limnaeoides (Odhner, 1913)

Plate 4, figs 6–7

1913 *Ptisanula limnæoides* Odhner, p. 329, figs 1–4.

Material. Kløft II, Pátorfik: 28 complete specimens from tongue Sk–4 (GGU 111720); 55 complete and 2 fragmentary specimens from tongue Sk–5 (GGU 111721).

Remarks. The shell is elongate ovate with turreted blunt-tipped spire. The protoconch axis is oblique in relation to the teleoconch axis (plate 4, fig. 7) and the oldest part of the protoconch is depressed. The whorls are slightly convex and the oblique sutures are deep-set. The glossy surface is smooth, only fine irregular growth lines are visible. The aperture is oval and less than half the height of the shell, tapering adapically, rounded abapically. The outer lip continues in an even curve to the columellar region directly passing into the inner lip. There is no fold on columella. There is a narrow umbilicus between the inner lip and the base.

Height of shell (h) and diameter (d) were measured for the 5 largest specimens and the h/d ratios calculated:

h in mm	d in mm	h/d
4.0	2.3	1.74
3.8	2.3	1.65
3.8	2.3	1.65
3.7	2.2	1.68
3.7	2.2	1.68

The right-skewed histogram of the size frequency distribution of the 83 complete specimens from the tongues Sk–4 and Sk–5 (fig. 18) indicate a high death rate among the young animals.

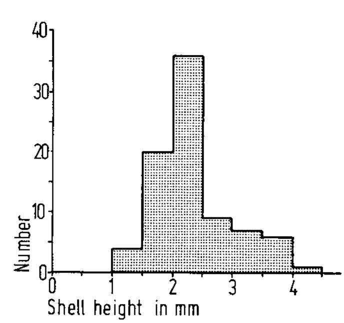


Fig. 18. *Toledonia limnaeoides* (Odhner). Histogram of the size frequency distribution of 83 measurable specimens from tongues Sk–4 (GGU 111720) and Sk–5 (GGU 111721), Kløft II, Pátorfik.

Discussion. According to Lemche (1941a, 1948) *Rissoella eburnea* Mörch, 1857 and *Ptisanula limnæoides* Odhner should be referred to one and the same species, viz. *Toledonia limnaeoides.* Comparing the specimens from Pátorfik with the figures of Sars (1878, plate 10, fig. 13) and Odhner (1913, figs 1–4) it seems evident that the species in question is the same as figured by Sars (1878) under the name *Liostomia eburnea* Stimpson. On the other hand, the specimens figured by Odhner have somewhat more rectangular aperture than the specimen figured by Sars. As the author cannot decide at present whether *L. eburnea* is distinct from *T. limnaeoides,* he follows Lemche (1948) in regarding the differences within the variation range of one species.

Recent distribution. Panarctic. *T. limnaeoides* has been found off the south-east coast of Spitsbergen (Svalbard) and is also known from East Finnmark. In West Greenland the species has been met with (?living) near Godthåb, and empty shells have been collected off Egedesminde. The only East Greenland record is from Sabine Ø. Vertical range: 5.5–9.5 m (East Greenland) to 80–120 m (Spitsbergen).

Ecology and biology. In Spitsbergen the species is associated with the epifauna at depths between 10 and 120 m, especially attached to stones and algae (Lemche, 1941a). The larval development is presumably non-pelagic (Lemche, 1941a).

Fossil occurrence. Sweden. Stratigraphical range: Upper Pleistocene to Holocene.
The species is new to the Greenland fossil fauna.

Genus *Diaphana* Brown, 1827.

Diaphana minuta Brown, 1827

Plate 4, fig. 8

1827 *Diaphana minuta* Brown, p. 11, plate 38, fig. 7.

Material. Kløft II, Pátorfik: 2 complete specimens and one fragment from tongue Sk–4 (GGU 111720); one complete and one fragmentary specimen from tongue Sk–5 (GGU 111721).

Remarks. The shell is thin, barrel-shaped with a visible spire. The last whorl is convex and smooth. Adapically it ends in a rounded-off edge whence the surface slopes down towards a circular depression in the middle of which the visible spire is situated. The aperture is tightened adapically and extended abapically. There is a distinct umbilicus between the inner lip and the base of the shell.

The complete specimens measure (h × d): 2.2 × 1.4, 1.6 × 1.0 and 1.5 × 1.0 mm.

Recent distribution. Panarctic, boreal, lusitanian. *D. minuta* occurs from Svalbard, the Bering Sea and north of Alaska southward to Massachusetts, Canary Islands and the Mediterranean. In West Greenland the species is known from Nordre

Strømfjord, Sukkertoppen and Godthåb, but records from several other localities along the coast make no distinction between empty shells or living animals. In East Greenland it has been found in the Kejser Franz Josephs Fjord area, the Scoresby Sund area and south of Kap Gustav Holm. Vertical range: 0 m (Norway) to 1500 m (North Atlantic at 60°37′N, 27°52′W).

Ecology and biology. In East Greenland the species is exclusively linked with the *Macoma calcarea* community, but in Iceland it has been found in this community as well as the *Yoldia hyperborea* community (Lemche, 1938, 1941b). The larval development is with a pelagic stage (Lemche, 1941a).

Fossil occurrence. East Canada, Scandinavia, the British Isles and Italy. Stratigraphical range: Pliocene to Holocene.

The species is new to the Greenland fossil fauna.

Family Retusiidae Thiele, 1931. Genus *Retusa* Brown, 1827. Subgenus *Retusa* Brown, 1827.

Retusa (*Retusa*) *obtusa* (Montagu, 1803) var. *pertenuis* (Mighels, 1843)

Plate 4, fig. 9A–B

1843 *Bulla pertenuis* Mighels, p. 346, plate 16, fig. 3.

Material. Kløft II, Pâtorfik: 776 complete and 115 fragmentary specimens from tongue Sk–4 (GGU 111720); 68 complete specimens and 9 fragments from tongue Sk–5 (GGU 111721).

Remarks. The 5 largest specimens measure (h × d): 3.9 × 2.2, 3.4 × 2.1, 3.4 × 2.0, 3.4 × 1.8 and 3.3 × 1.9 mm.

Discussion. Lemche (1948) examined thoroughly the genus *Retusa* from the North Atlantic. He arrived at the conclusion that *R.* (*R.*) *pertenuis* is only an ecological variety of *R.* (*R.*) *obtusa* and, thus, not a distinct species. Quoting Lemche (1948, p. 51): "The southern, larger and stronger *obtusa* is replaced by the smaller *pertenuis* in northern latitudes and in brackish waters, etc.". Lemche also wrote (p. 53): "It is concluded that *obtusa* is widely distributed in the Northern Atlantic; under optimal conditions it develops into typical *obtusa* with a shell length of 5–6 mm, whereas under less favourable circumstances (lower salinity – or difficulties in feeding?) it occurs as the dwarf variety *pertenuis*".

According to personal information from the late H. Lemche (summer 1973) it is probable that the Greenland *Retusa* should be referred to *R.* (*R.*) *semen* (Reeve, 1855). In this context it must be pointed out that the specimens from Pâtorfik appear to have distinctly larger h/d ratios than *R.* (*R.*) *semen* (?) figured by Lemche in 1948 (p. 53, fig. 54). Moreover, they deviate in outline. Therefore the author refers the specimens from Pátorfik to *R.* (*R.*) *pertenuis* which, in accordance with Lemche (1948), is regarded only as a variety of *R.* (*R.*) *obtusa.*

Recent distribution. Panarctic, boreal, circumpolar. *R.* (*R.*) *obtusa* var. *pertenuis* is distributed from Svalbard, Bjørnøya, the arctic coasts of Europe and Asia, the Bering Sea and Parry Islands southward to the Aleutians, Nova Scotia, Shetland Islands and the inner parts of the Danish waters. It occurs along the West Greenland coast northward to 72°38′N (near Prøven). In East Greenland the species has been found from Sabine Ø in the north to Lindenows Fjord in the south. Vertical range: 5–24 m (East Greenland) to 1300 m (North Atlantic at 63°36′N, 7°30′W).

Ecology. In East Greenland *R.* (*R.*) *obtusa* var. *pertenuis* seems exclusively bound to the *Macoma calcarea* community, especially the lower *Ophiocten* Zone (Lemche, 1941b).

Fossil occurrence. North America, Iceland, Scandinavia and the British Isles. Stratigraphical range: Middle Pleistocene to Holocene. The typical form has been recorded in deposits as old as Miocene.

Fossil in Greenland. *Utriculus* (*Retusa*) *pertenuis* (Mighel): Laursen (1944). *Utriculus pertenuis* Gould: Harder *et al.* (1949).

Family Scaphandridae Fischer, 1883. Genus *Cylichna* Lovén, 1846.

Cylichna occulta occulta (Mighels, 1841) var. *scalpta* (Reeve, 1855)

Plate 4, fig. 10

1855 *Bulla scalpta* Reeve, p. 392, plate 32, fig. 3.

Material. Kûtsiaq: One complete specimen. The deposits at Kûtsiaq are of Holocene age and disregarding *Mya* (*Mya*) *truncata* Linné var. *uddevalensis* Forbes this is the only species, dealt with in this paper, which was not found in the interglacial Pátorfik deposits.

Remarks. The specimen is excellently preserved. Its height is 7.7 mm and the diameter is 5.0 mm.

Discussion. It is evident from comparison with recent material that the shell at hand has a somewhat lower h/d ratio than the typical form. Therefore it is referred to *C. occulta occulta* var. *scalpta* in accordance with Lemche (1948) and Óskarsson (1962).

Recent distribution. Panarctic, circumpolar. *C. occulta occulta* has been recorded from Svalbard, Bjørnøya, North and East Iceland, Finnmark, the north coast of Russia, the White Sea, Novaya Zemlya, the Kara Sea, the Siberian Arctic Sea, Alaska from Point Barrow to the Aleutians and the east coast of North America southward to Cape Cod. In West Greenland it has been met with alive at 71°40′N and 66°35′N, but records from several other localities do not distinguish between capture of empty shells or living animals. In East Greenland the species has been found at Danmarkshavn in the north whence it reaches to Lindenows Fjord in the south. Vertical range: 0–10 m (East Greenland) to ?600 m (West Greenland).

Ecology. In East Greenland and Iceland *C. occulta occulta* is especially found in the *Macoma calcarea* community, but in Iceland it probably also occurs in the *Yoldia hyperborea* community (Lemche, 1938, 1941b).

Fossil occurrence. C. occulta occulta var. *scalpta* has been found fossil in Scandinavia and England. Stratigraphical range: Middle Pleistocene to Holocene.

In Denmark it has been met with in the Upper Pleistocene *Portlandia arctica* Zone and the lower glacigene deposits in the Skærumhede sequence in Vendsyssel (Nordmann *in* Jessen *et al.,* 1910).

Fossil in Greenland. *Cylichna scalpta* Reeve: Harder *et al.* (1949).

Order Pteropoda Cuvier, 1804. Family Spiratellidae Thiele, 1931. Genus *Spiratella* Blainville, 1817.

Spiratella retroversa (Fleming, 1823)

Plate 4, fig. 11A–B

1823 *Heterofusus retroversus* Fleming, p. 498, plate 15, fig. 2.

Material. Kløft II, Pátorfik: 2 somewhat fragmentary specimens from tongue Sk–5 (GGU 111721).

Remarks. The sinistral shell is small and thin-walled, somewhat glossy and globular, with a flattened apex. The whorls are convex and increase sharply in diameter as the animal grows. The sutures are deep-set. The larger shell has 4 whorls. They are smooth with no collabral threads, only faint growth lines are visible under the microscope. There is a deep, narrow umbilicus on the convex base. The aperture appears to be ear-shaped.

The larger specimen from Pátorfik, with slightly damaged aperture, is only about 0.7 mm high.

Discussion. The specimens from Pátorfik show close affinity with *S. retroversa* from the Holocene deposits at Strömstad, Sweden. However, the former seem to have a slightly less elevated spire, but unfortunately the h/d ratios cannot be calculated.

Recent distribution. Panarctic, boreal. *S. retroversa* occurs in the Arctic and the North Atlantic and extends southward to the British Isles and Kattegat. It is known from West and East Greenland and the east coast of America to Massachusetts in the south. Vertical range: 0–? m, pelagic. In Iceland it has been found from the surface of the sea to a depth of 70 m.

Information on this species is scarce in the literature.

Fossil occurrence. Scandinavia. Stratigraphical range: ?Upper Pleistocene to Holocene.

In Denmark it has been found in the Upper Pleistocene *Turritella terebra* Zone in the Skærumhede sequence in Vendsyssel (Nordmann *in* Jessen *et al.*, 1910).

The species is new to the Greenland fossil fauna.

Bivalvia

Class Bivalvia Linné, 1758. Subclass Palaeotaxodonta Korobkov, 1954. Order Nuculoida Dall, 1889. Family Nuculidae Gray, 1824. Genus *Nucula* Lamarck, 1799. Subgenus *Leionucula* Quenstedt, 1930.

Nucula (Leionucula) tenuis expansa Reeve, 1855

Plate 4, fig. 12A–B & plate 5, fig. 1

1855 *Nucula expansa* Reeve, p. 397, plate 33, fig. 2.

Material. Kløft II, Pátorfik: 68 specimens with paired valves, 90 left valves, 97 right valves and 225 umbonal fragments from tongue Sk–4 (GGU 111720); one specimen with paired valves, 36 left valves, 30 right valves and 308 umbonal fragments from tongue Sk–5 (GGU 111721); 2 specimens with paired valves, 2 left valves, 4 right valves and one umbonal fragment from Sk–6 (GGU 111722); 15 specimens with paired valves, one right valve and 56 umbonal fragments from layer Sk–7 (GGU 111723).

Remarks. Length of shell (l), height (h) and breadth (b) were measured for the 10 largest specimens with paired valves and the h/l and b/l ratios calculated:

l in mm	h in mm	b in mm	h/l	b/l
13.2	10.5	7.2	0.80	0.55
12.4	9.9	7.8	0.80	0.63
12.3	9.6	6.7	0.78	0.54
12.3	9.5	7.2	0.77	0.59
12.2	9.6	7.2	0.79	0.59
12.1	9.8	8.0	0.81	0.66
12.0	9.8	8.0	0.82	0.67
12.0	9.3	7.0	0.78	0.58
12.0	9.2	5.8	0.77	0.48
11.9	9.9	6.8	0.83	0.57

Recent distribution. N. (L.) tenuis including subspecies seems to be panarctic, boreal, circumpolar. The species occurs from Svalbard, Novaya Zemlya, the Kara Sea, the Siberian Arctic Sea, the Bering Strait, the Alaskan Arctic and Ellesmere Island southward to North Japan, South California, North Carolina, the British Isles, Denmark, ?Gibraltar and ?the Mediterranean. In West Greenland it has been found along the whole coast. In East Greenland the species is distributed from Jørgen Brønlund Fjord in the north to Lindenows Fjord in the south. Vertical range: 2 m (Svalbard) to 2250 m (off Ireland, ?alive).

Ecology and biology. In East Greenland the species inhabits a bottom of mud, clay, silt, sand and gravel in the *Macoma calcarea* community and the *Astarte crenata* community as well as in transitional zones (Thorson, 1934; Ockelmann, 1958). The pelagic larval stage is probably very short or completely lacking (Thorson, 1936).

Fossil occurrence. Svalbard, Siberia, Alaska, Canada, Maine, New Brunswick, Iceland, Scandinavia, the British Isles, Holland, California and Italy. Most of these records do not distinguish between the typical form and the subspecies. Stratigraphical range: Pliocene to Holocene.

Fossil in Greenland. *Nucula inflata* Hanc.: Steenstrup (1883). *Nucula tenuis* (Montagu): Steenstrup (1901), Jensen & Harder (1910), Noe-Nygaard (1932), Sugden (1972), Street (1977). *Nucula tenuis* (Montagu) var. *expansa* Reeve: Jensen (1905b), Laursen (1944, 1950), Harder *et al.* (1949).

Family Nuculanidae Adams & Adams, 1858. Genus *Nuculana* Link, 1807. Subgenus *Nuculana* Link, 1807.

Nuculana (Nuculana) pernula buccata (Møller, 1842)

Plate 5, figs 2A–B & 3

1842 *Leda buccata* Møller, p. 90.

Material. Kløft II, Pátorfik. One specimen with paired valves from Sk–2 (GGU 111718); 946 specimens with paired valves, 102 left valves, 128 right valves and 1408 umbonal fragments from tongue Sk–4 (GGU 111720); 138 specimens with paired valves, 40 left valves, 81 right valves and 348 umbonal fragments from tongue Sk–5 (GGU 111721); 13 specimens with paired valves, 14 left valves, 9 right valves and 22 umbonal fragments from Sk–6 (GGU 111722); 9 specimens with paired valves, one left valve, 2 right valves and 110 umbonal fragments from layer Sk–7 (GGU 111723); 2 umbonal fragments from layer Sk–8 (GGU 111724).

Remarks. Length of shell (l), height (h) and breadth (b) were measured for the 10 largest specimens with paired valves and the h/l and b/l ratios calculated:

l in mm	h in mm	b in mm	h/l	b/l
18.1	9.8	7.0	0.54	0.39
16.0	9.8	7.0	0.61	0.44
15.5	8.3	5.5	0.54	0.35
15.0	7.9	6.2	0.53	0.41
14.8	8.6	5.9	0.58	0.40
14.6	8.3	5.5	0.57	0.38
14.5	8.1	5.7	0.56	0.39
14.5	7.6	5.6	0.52	0.39
14.2	7.8	5.1	0.55	0.36
13.9	8.0	5.2	0.58	0.37

Discussion. The question whether *L. buccata* is a distinct species has often been discussed. Leche (1878) concluded that it should be regarded as a variety of *L. pernula* (Müller, 1779) which here will be named *Nuculana (Nuculana) pernula,* since *Leda* Schumacher, 1817 is a junior synonym. Several authors, especially in North America (e.g. Richards, 1962; Hopkins *et al.*, 1972), have treated it as a distinct species, whereas the present author regards it as a subspecies: *N.* (*N.*) *pernula buccata.*

The specimens from Pátorfik differ from *N.* (*N.*) *pernula costigera* Leche, 1883 in having a less strongly upward-curved posterior end and a less distinct longitudinal rib on the interior of the shell. Moreover, the shell is relatively shorter. Some of the specimens show a superficial resemblance to *N.* (*N.*) *minuta* (Müller, 1776) in possessing a rather distinct concentric striation on the surface of the shell and similar shell ratios. As the more prominent concentric ridges are developed only in smaller specimens and early growth stages, they seem to represent a juvenile characteristic. The number of teeth is clearly greater than in *N.* (*N.*) *minuta,* and the author could not with certainty refer any of the specimens from the Pátorfik beds to that species.

Recent distribution. *N.* (*N.*) *pernula* including subspecies appears to be panarctic, boreal, circumpolar. The species extends from Franz Josef Land, Novaya Zemlya, the Kara Sea, the Siberian Arctic Sea, the Bering Strait and Ellesmere Island southward to south of Cape Cod, the English Channel and Denmark. In West Greenland it has been found from Etah in the north to Julianehåb in the south. In East Greenland Lille Pendulum is the northernmost locality from where it is distributed to south of Lindenows Fjord (Qeqertatsiaq)*. Vertical range: 3–9 m (East Greenland) or 4 m (Svalbard) to 1275 m (Jan Mayen).

Ecology and biology. In East Greenland *N.* (*N.*) *pernula costigera* lives mainly on mud or clay bottom, sometimes mixed with sand and gravel, and attains its greatest abundance in the *Macoma calcarea* community (Thorson, 1934; Ockelmann, 1958). The larval development is either non-pelagic or the pelagic stage is very short (Thorson, 1936).

Fossil occurrence. Svalbard, the north coast of Russia, Siberia, North America, Iceland, Scandinavia, the British Isles, Holland and Germany. Stratigraphical range: Lower Pleistocene to Holocene.

Fossil in Greenland (*N.* (*N.*) *pernula* including subspecies). *Nuculana buccata* Stp.: Steenstrup (1883). *Nuculana pernula* Müll.: Steenstrup (1883). *Leda pernula* (Müller): Nordenskiöld (1871), Steenstrup (1901), Jensen (1905b), Jensen & Harder (1910), Noe-Nygaard (1932), Laursen (1944, 1950), Harder *et al.* (1949), Sugden (1972), Kelly (1973), Funder (1978).

* See footnote p. 24.

Genus *Portlandia* Mörch, 1857. Subgenus *Yoldiella* Verrill & Bush, 1897.

Portlandia (Yoldiella) lucida (Lovén, 1846)

Plate 5, fig. 4A–B

1846 *Yoldia lucida* Lovén, p. 188.

Material. Kløft II, Pátorfik: A single left valve from tongue Sk–4 (GGU 111720).

Remarks. The small shell is slightly oblong, inequilateral with the beak in front of the midline. The posterior end is somewhat angular and obliquely truncated. The surface is smooth, showing only fine concentric growth lines. Lunule is small and indistinct. The valve has 10 anterior teeth, but number of teeth behind the beak cannot be counted because of damage. The shell margin is smooth. Pallial sinus and muscle scars are indistinct.

The length of the valve is 2.5 mm and the height is 1.9 mm.

Recent distribution. Mid arctic, boreal, abyssal in the southern part of the North Atlantic. *P.* (*Y.*) *lucida* occurs from Svalbard and Novaya Zemlya southward to North Carolina, Scotland, Bohuslän (Sweden), and at great depths to West Ireland, France and the Mediterranean. In West Greenland it has been found in the following areas: Melville Bugt, Upernavik, Umanak, Godthåb and Julianehåb. In East Greenland the species is only known from the southernmost part of the coast. Vertical range: 28–47 m (East Iceland) to 2740 m (West Mediterranean).

Ecology. Information on the ecology of this species is scarce, but it seems to prefer a bottom of clay (Ockelmann, 1958; Nordsieck, 1969).

Fossil occurrence. Scandinavia and Scotland. Stratigraphical range: Upper Pleistocene to Holocene.

The species is new to the Greenland fossil fauna.

Portlandia (Yoldiella) lenticula (Møller, 1842)

Plate 5, fig. 5

1842 *Nucula lenticula* Møller, p. 90.

Material. Kløft II, Pátorfik: 113 specimens with paired valves, 10 left valves, 8 right valves and 37 umbonal fragments from tongue Sk–4 (GGU 111720); 23 specimens with paired valves, 3 left valves, 3 right valves and 18 umbonal fragments from tongue Sk–5 (GGU 111721); one umbonal fragment from layer Sk–7 (GGU 111723).

Remarks. The relationship between length and height in 91 specimens with paired valves from tongue Sk–4 is shown in fig. 19. The regression equation is $Y = 0.133 + 0.677X$ and the coefficient of correlation $r = 0.977$. A t-test on the intercept with the Y-axis shows that the length-height growth of the species must be considered as isometric at the 5 per cent level.

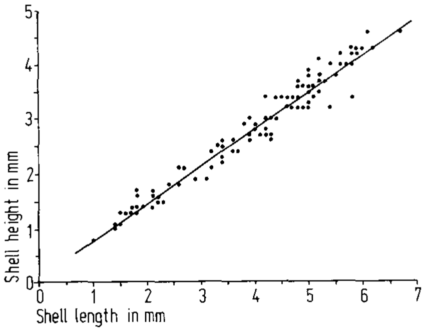


Fig. 19. *Portlandia (Yoldiella) lenticula* (Møller). Relationship between shell length and height in 91 specimens with paired valves from tongue Sk–4 (GGU 111720), Kløft II, Pátorfik.

The 5 largest specimens with paired valves measure (l × h × b): 6.7 × 4.6 × 3.5, 6.2 × 4.3 × 3.8, 6.1 × 4.6 × 3.4, 6.0 × 4.3 × 3.9 and 5.9 × 4.3 × 4.3 × 3.1 mm.

Recent distribution. Panarctic, boreal, ?circumpolar. *P.* (*Y.*) *lenticula* occurs from Svalbard, Novaya Zemlya, the Kara Sea, the Siberian Arctic Sea and Parry Islands southward to Shetland and Bodø (Norway). Only empty shells are known from the eastern coast of North America (from deep water north of Cape Cod) and the lusitanian faunal region. In West Greenland it has been found in the following areas: Umanak, Godhavn, Egedesminde, Sukkertoppen, Godthåb and Julianehåb. In East Greenland the species is known from about 76°N southward to Ikerasaussaq* near Angmagssalik. Vertical range: 0–13 m (East Greenland) to about 1400 m (north of the Shetland Islands).

Ecology and biology. In East Greenland the species mainly inhabits a bottom of mud or clay which may sometimes be mixed with sand and gravel, and here it attains its greatest abundance in the *Astarte crenata* community (Thorson, 1934; Ockelmann, 1958). The larval development is either non-pelagic or the pelagic stage is very short (Thorson, 1936).

Fossil occurrence. Svalbard, Siberia, East Canada, Maine, New Jersey, Iceland, Scandinavia and Scotland. Stratigraphical range: Middle Pleistocene to Holocene.

In Denmark it is known fossil in the Upper Pleistocene *Turritella terebra* Zone and the *Portlandia arctica* Zone in the Skærumhede sequence in Vendsyssel (Nordmann *in* Jessen *et al.*, 1910; Petersen *in* Bahnson *et al.*, 1974).

Fossil in Greenland. *Portlandia lenticula* (Møller): Noe-Nygaard (1932), Laursen (1944, 1950).

Portlandia (Yoldiella) fraterna (Verrill & Bush, 1898)

Plate 5, figs 6 & 7A–B

1898 *Yoldiella fraterna* Verrill & Bush, p. 867, plate 80, fig. 5; plate 82, fig. 8.

Material. Kløft II, Pátorfik: 8 specimens with paired valves from tongue Sk–4 (GGU 111720).

* Modern name Ikâsaulaq (ed.).

Remarks. The small shell is globular, equivalve and inequilateral with the beak just in front of the midline. The posterior end is somewhat rounded, not distinctly truncated. The dorsal edge is rather straight. The surface is smooth, only fine concentric lines and ridges are visible under the microscope. Lunule is indistinct. The specimens have up to 8 teeth on each side of the beak. The shell margin is smooth. Pallial sinus and muscle scars are indistinct.

The 4 largest specimens measure (l × h × b): 3.3 × 2.5 × 2.2, 3.3 × 2.3 × 2.2, 3.3 × 2.3 × 2.1 and 3.0 × 2.3 × 2.0 mm. The shell ratios vary somewhat, but all the specimens are more convex than those from East Greenland measured by Ockelmann (1958).

Recent distribution. Panarctic, boreal. *P.* (*Y.*) *fraterna* is known from Svalbard, the Kara Sea, Matotschkin Schar, North and East Iceland, Norway (?southward to Bergen), the Faeroe Islands, between Scotland and the Hebrides and north-eastern America from the Gulf of St. Lawrence to Georgia. In West Greenland the species has been found south-west of Holsteinsborg (66°35′N) and south-west of Sukkertoppen (65°16′N). In East Greenland it is distributed from Moskusoksefjord in the north to Kap Dalton in the south. Vertical range: 5.5 m (East Greenland) to 2900 m (New England).

Ecology and biology. In East Greenland the species seems to prefer clayey bottom (Ockelmann, 1958). The pelagic larval stage is short or entirely lacking (Ockelmann, 1958).

Fossil occurrence. Siberia, Iceland and ?Norway. Stratigraphical range: Middle Pleistocene to Holocene.

The species is new to the Greenland fossil fauna.

Subclass Pteriomorphia Beurlen, 1944. Order Mytiloida Férussac, 1822. Family Mytilidae Rafinesque, 1815. Genus *Mytilus* Linné, 1758. Subgenus *Mytilus* Linné, 1758.

Mytilus (*Mytilus*) *edulis* Linné, 1758

Plate 8, fig. 1

1758 *Mytilus edulis* Linné, p. 705.

Material. Kløft II, Pâtorfik: One fragmentary left valve and one fragmentary right valve from Sk–2 (GGU 111718); one fragmentary specimen with paired valves from Sk–3 (GGU 111719).

Remarks. The specimens are too incomplete to be measured exactly. The largest shell has been about 80 mm in length and 40 mm in height.

Recent distribution. Mid arctic, boreal, lusitanian. *M.* (*M.*) *edulis* has been found around Jan Mayen and Iceland, is at present not known from Svalbard, and lives sublittorally in Novaya Zemlya. The species reaches southward along the coasts of

Europe into the Baltic and the Mediterranean. In the North-West Atlantic it occurs from Baffin Island (Padloping Island) to North Carolina. From the Beaufort and Chukchi Seas it extends into the Pacific southward to Japan and southern California. In West Greenland the species has been collected from Dundas and Siorapaluq (close to 78°N), but it has not been met with alive in the central part of the Melville Bugt north of Tassiussaq at 73°22'N (Madsen, 1940; Hjort & Funder, 1974). According to Madsen (1940) there is no well-defined littoral fauna north of Tassiussaq in West Greenland and therefore the species probably lives sublittorally north of this limit. From Tassiussaq the species extends southward along the coast to Julianehåb, and the northern localities were probably sustained by larvae from the southern area, but no larval settling has been observed at Dundas and Siorapaluq since 1959 (Theisen, 1973). In East Greenland it is known in the Angmagssalik district north to 66°30'N and again further south at 61°05'N. Vertical range: 0 m (several localities) to 180 m (Jan Mayen).

Ecology and biology. In East Greenland the young animals belong to the algal epifauna, whereas the adults belong to the epifauna associated with gravel, stones and rocks (Ockelmann, 1958). The species is mainly littoral and attached to the substratum by byssus threads and is sometimes living in dense masses where there are suitable surfaces for attachment. On rocky coasts it migrates frequently out to greater depths when getting older (Jensen & Spärck, 1934). The larval development is pelagic (Thorson, 1936).

Fossil occurrence. The species has been found fossil almost everywhere within the present area of distribution and in many localities outside it: Franz Josef Land, Svalbard, Novaya Zemlya, the north coast of Siberia, the central part of the Canadian Arctic Archipelago and East Greenland north of 66°30'N. Stratigraphical range: Pliocene to Holocene.

Fossil in Greenland. *Mytilus edulis* Linné: Nordenskiöld (1871), Helland (1876), Steenstrup (1883), Holst (1886), J. A. D. Jensen (1889), Nansen (1890), Pjetursson (1898), Nathorst (1901), Jensen (1905b), Jensen & Harder (1910), Quervain & Mercanton (1925), Noe-Nygaard (1932), Bøgvad (1940), Laursen (1944, 1945, 1950), Flint (1948), Harder *et al.* (1949), Washburn & Stuiver (1962), Krinsley *in* Davies *et al.* (1963), Weidick (1963, 1968, 1972a, 1972b, 1972c, 1973, 1974, 1976b), Lasca (1966), Funder *in* Weidick (1968), Funder (1971a, 1971b, 1972b, 1978), Tauber (1968), TenBrink (1971), Sugden (1972), Hjort (1973), Kelly (1973, 1975, 1977, 1979), Hjort & Funder (1974), Håkansson (1974), Blake (1975), Donner & Jungner (1975), Donner (1978).

Order Pterioida Newell, 1965. Family Pectinidae Rafinesque, 1815. Genus *Chlamys* Röding, 1798. Subgenus *Chlamys* Röding, 1798.

Chlamys (Chlamys) islandica (Müller, 1776)

Plate 8, fig. 2

1776 *Pecten islandicus* Müller, p. 248.

Material. Kløft II, Pátorfik: 2 fragmentary right valves from Sk–1 (GGU 111717); 2 almost complete specimens with paired valves from Sk–2 (GGU 111718); 2 fragmentary left valves from Sk–3 (GGU 111719). Thus, the species was only found in the lower part of the section. However, several fragmentary shells in the uppermost layers in the first cleft east of Kløft II show that the species is not restricted to the lower part of the deposits.

Remarks. Most of the specimens are enclosed in hard concretions, but generally poorly preserved. The 4 largest specimens measure (l × h): 84.0 × ?, 72.4 × 79.5, ? × 72.1 and 63.8 × 65.5 mm.

Recent distribution. Mid arctic, mid boreal, discontinuously circumpolar. *C.* (*C.*) *islandica* is lacking in high arctic seas and occurs from Svalbard, west of Novaya Zemlya, the Kara Sea, Kamchatka and the Bering Strait southward to Korea, North Japan, Puget Sound, Cape Cod, the Faeroe Islands (at great depths) and Stavanger (Norway). However, MacNeil (1967) has divided the species into a series of subspecies and stated that typical *C.* (*C.*) *islandica islandica* does not live in the Pacific at present. In West Greenland the species is distributed along the coast to Etah in the north. In East Greenland it is hitherto only known alive in the inner part of Kong Oscars Fjord and in the southernmost part of the south-east coast. As the occurrence in the Kong Oscars Fjord seems isolated, it may be regarded as a relic from Holocene time when the conditions were somewhat milder than now (Thorson, 1951; Ockelmann, 1958). Vertical range: 2 m (Iceland) to 356 m (West Greenland).

Ecology and biology. In East Greenland the species is associated with the algal epifauna. The young animals mostly live with *Fucus* in shallow water, whereas the adults migrate out to greater depths, i.e. the zone with red algae (Thorson, 1933; Ockelmann, 1958). In Iceland the bottom is mostly clay, sand and shells (Madsen, 1949). The larval development is probably pelagic (Ockelmann, 1958).

Fossil occurrence. Svalbard, Novaya Zemlya, Kolguev Island, the north coast of Russia, ?Siberia, North America, Iceland, Scandinavia, Scotland and the Mediterranean region. Stratigraphical range: ?Miocene to Holocene.

In Denmark it has been found fossil in the upper glacigene deposits in the Upper Pleistocene Skærumhede sequence and the so-called 'diluvial gravel' elsewhere in Vendsyssel (Nordmann *in* Jessen *et al.*, 1910).

Fossil in Greenland. *Pecten islandicus* Müller: Rink (1852), Nordenskiöld (1871), Kornerup (1879, 1881), Steenstrup (1881, 1883, 1901), Holst (1886), J. A. D. Jensen (1889), Hartz *in* Bay (1896), White & Schuchert (1898), Pjetursson (1898), Jensen (1905b, 1917, 1942), Jensen & Harder (1910), Quervain & Mercanton (1925), Noe-Nygaard (1932), Laursen (1944, 1945, 1950), Harder *et al.* (1949), Weidick (1968, 1972b, 1975a), Kelly (1973, 1975), Funder (1978). *Chlamys islandicus* (Muller): Krinsley *in* Davies *et al.* (1963), Sugden (1972), Blake (1977), Kelly (1979, 1980). *Chlamys* (=*Pecten*) *islandicus:* Weidick (1974). *Chlamys* (*Pecten*) *islandicus:* Håkansson (1974). *Chlamys islandica* (Müller): Funder (1971b, 1972b), Weidick (1972a, 1972c, 1973, 1976b, 1977a), Donner & Jungner (1975), Donner (1978). *Chlamys* (=*Pecten*) *islandica* (Müller): Weidick (1975b), Street (1977).

Genus *Palliolum* Monterosato, 1884. Subgenus *Delectopecten* Stewart, 1930.

Palliolum (*Delectopecten*) *greenlandicum* (Sowerby, 1842)

Plate 6, figs 1A–B & 2

1842 *Pecten greenlandicus* Sowerby, p. 57, plate 13, fig. 40.

Material. Kløft II, Pâtorfik: 31 specimens with paired valves, 10 left valves, 9 right valves and 12 umbonal fragments from tongue Sk–4 (GGU 111720); 6 specimens with paired valves, 4 left valves and 4 right valves from tongue Sk–5 (GGU 111721); one specimen with paired valves, 2 left valves, 4 right valves and 148 umbonal fragments from layer Sk–7 (GGU 111723); one right valve from layer Sk–8 (GGU 111724).

Remarks. The 5 largest specimens with paired valves measure (l × h): 11.8 × 11.7; 11.0 × 10.4; 10.3 × 10.0; 9.6 × 9.0 and 8.6 × 8.2 mm.

Recent distribution. Jensen (1942) and Laursen (1944) were of the opinion that *Pecten groenlandicus* var. *major* Collin, 1887 is high arctic and living under similar conditions as *Portlandia* (*Portlandia*) *arctica*. Conversely a smaller form referred to as *P. groenlandicus* var. *minor* Lochard, 1898 was reported in the North Atlantic southward to North-West Africa. These forms were thoroughly examined by Ockelmann (1958) who concluded that the smaller form must be regarded as a distinct species, resembling *P.* (*D.*) *greenlandicum* in the appearance of the shell, but with a different anatomy.

According to Ockelmann (1958) *P.* (*D.*) *greenlandicum* is mainly panarctic (?circumpolar). The present author is also of the opinion that the species is not restricted to the high arctic subregion. In the Pâtorfik deposits it occurs together with species that certainly do not extend northward into high arctic seas. The species is known from Franz Josef Land, Svalbard, Novaya Zemlya, the Siberian Arctic Sea, Ellesmere Island, Baffin Island, Jones Sound, Jan Mayen, the Barents Sea, the north coast of Russia, Finnmark, North and East Iceland, the North Atlantic (63°15′N, 9°35′W, at great depths), ?the Gulf of St. Lawrence and ?off Newfoundland. In West Greenland the species has been found from Kap York in the north to Umanak in the south. In East Greenland it is very common, being distributed northward to Danmarkshavn. Vertical range: 4–5 m (East Greenland) to 2000 m (between East Greenland and Jan Mayen).

Ecology and biology. In East Greenland where the species prefers a bottom of clay with gravel, stones and shells it is especially abundant in the lower *Ophiocten* Zone of the *Macoma calcarea* community (Thorson, 1933; Ockelmann, 1958). The pelagic larval stage is apparently very short or almost lacking (Thorson, 1936).

Fossil occurrence. Alaska, Ellesmere Island, Siberia, Scandinavia, Scotland and ?Maine. Stratigraphical range: Miocene to Holocene.

In Denmark the species has been found fossil in the Upper Pleistocene *Portlan-*

dia arctica Zone in the Skærumhede sequence in Vendsyssel (Nordmann *in* Jessen *et al.,* 1910).

Fossil in Greenland. *Pecten groenlandicus* Sow.: Steenstrup (1883), Jensen (1942). *Pecten groenlandicus* Sowerby var. *major* Collin: Laursen (1944, 1950, 1954). *Propeamussium groenlandicum* (Sowerby): Kelly (1973), Funder (1978).

Subclass Heterodonta Neumayr, 1884. Order Veneroida Adams & Adams, 1856. Family Astartidae d'Orbigny, 1844. Genus *Tridonta* Schumacher, 1817. Subgenus *Tridonta* Schumacher, 1817.

Tridonta (Tridonta) borealis (Chemnitz, 1784)

Plate 8, fig. 3

1784 *Venus borealis* Chemnitz, p. 26, plate 39, figs 412–413.

Material. Kløft II, Pâtorfik: One specimen with paired valves and 2 right valves from Sk–1 (GGU 111717); 29 specimens with paired valves, one left valve and 4 right valves from Sk–2 (GGU 111718); 26 specimens with paired valves, one left valve and one right valve from Sk–3 (GGU 111719); one specimen with paired valves, 2 left valves, one right valve and one umbonal fragment from tongue Sk–4 (GGU 111720); 8 specimens with paired valves, one left valve, 3 right valves and 6 umbonal fragments from Sk–6 (GGU 111722).

Remarks. Length of shell (l), height (h) and breadth (b) were measured for the 10 largest specimens with paired valves and the h/l and b/l ratios calculated:

l in mm	h in mm	b in mm	h/l	b/l
43.2	36.5	18.6	0.84	0.43
38.3	31.7	16.4	0.83	0.43
37.3	31.4	16.6	0.84	0.45
36.5	30.7	16.0	0.84	0.44
36.0	30.1	15.1	0.83	0.42
35.4	29.0	15.0	0.82	0.42
34.8	26.2	13.1	0.75	0.38
34.0	27.0	13.0	0.79	0.38
33.8	30.0	15.5	0.89	0.46
33.0	26.1	11.9	0.79	0.36

Recent distribution. Panarctic, boreal, circumpolar. *T.* (*T.*) *borealis* extends from Franz Josef Land, Novaya Zemlya, the Kara Sea, the Siberian Arctic Sea, the Bering Strait, Parry Islands and Ellesmere Island southward to northern Japan, the Aleutians, Massachusetts, Iceland, Bergen (Norway) and the northern part of the North Sea. It also occurs in the south-western part of Kattegat into the Baltic to east of Bornholm. Jensen & Spärck (1934) and Thorson (1951) regarded this occurrence as a relic, but according to Rasmussen (1973) it is not isolated and consequently represents the southernmost outpost of the mainly arctic area of distribution. In West Greenland the species is known from Etah in the north to

Julianehåb in the south. It is common in East Greenland where it has been met with in Jørgen Brønlund Fjord as the northernmost locality and reaches to south of Lindenows Fjord (Qeqertatsiaq)*. Vertical range: 0 m (East Finnmark) to 463 m (north of Svalbard).

Ecology and biology. In Iceland the bottom is clay, sand, gravel, shells and mixed bottom (Madsen, 1949). In East Greenland where the substratum varies from clayey to stony bottom it is abundant in the *Gomphina fluctuosa* and the *Macoma calcarea* communities (Thorson, 1933, 1934; Ockelmann, 1958). The larval development is with a short pelagic stage or it is entirely lacking (Thorson, 1936).

Fossil occurrence. Franz Josef Land, Svalbard, Novaya Zemlya, Kolguev Island, the north coast of Russia, Siberia, North America, Iceland, Scandinavia and the British Isles. Stratigraphical range: Lower Pleistocene to Holocene.

Fossil in Greenland. *Astarte corrugata* Brown: Rink (1852), Nordenskiöld (1871). *Astarte semisulcata* Leach: Rink (1852), Steenstrup (1883), White & Schuchert (1898). *Astarte arctica* Gray: White & Schuchert (1898), Nathorst (1901). *Astarte borealis* (Chemnitz): Holst (1886), Jensen (1905b, 1917, 1942), Noe-Nygaard (1932), Laursen *in* Rosenkrantz *et al.* (1942), Laursen (1944, 1945, 1950, 1954), Flint (1948), Rubin & Alexander (1960), Washburn & Stuiver (1962), Rosenkrantz (1968), Funder (1971b, 1978), Weidick (1972b, 1976b), Sugden (1972), Kelly (1979). *Tridonta (=Astarte) borealis* Chemnitz: Funder (1972a), Funder & Hjort (1973), Weidick (1973, 1974, 1977b). *Tridonta (Astarte) borealis:* Håkansson (1972, 1974). *Tridonta borealis:* Hjort (1973), Weidick (1978a).

Tridonta (Tridonta) elliptica (Brown, 1827)

Plate 8, fig. 4

1827 *Crassina elliptica* Brown, plate 18, fig. 3.

Material. Kløft II, Pátorfik: 5 specimens with paired valves, one left valve and one right valve from Sk–1 (GGU 111717); 348 specimens with paired valves, 32 left valves and 8 right valves from Sk–2 (GGU 111718); 260 specimens with paired valves and one left valve from Sk–3 (GGU 111719); 97 specimens with paired valves, 360 left valves, 347 right valves and 183 umbonal fragments from tongue Sk–4 (GGU 111720); one specimen with paired valves, 29 left valves, 28 right valves and 42 umbonal fragments from tongue Sk–5 (GGU 111721); 25 specimens with paired valves, 6 left valves, 4 right valves and 2 umbonal fragments from Sk–6 (GGU 111722).

Remarks. The specimens from the sandy mud layers are well preserved and large, with paired valves, and were found scattered in the sediment. Those from the two tongues are also well preserved, but generally small and many of them are juvenile. The ratio between paired and single valves is considerably lower in the tongues than in the sandy mud.

Length of shell (l), height (h) and breadth (b) were measured for the 10 largest specimens with paired valves and the h/l and b/l ratios calculated:

* See footnote p. 24.

l in mm	h in mm	b in mm	h/l	b/l
31.5	23.5	11.3	0.75	0.36
30.0	24.1	12.4	0.80	0.41
27.9	22.6	12.4	0.81	0.44
27.6	21.4	10.2	0.78	0.37
27.0	22.0	9.7	0.81	0.36
26.7	20.9	11.0	0.78	0.41
26.0	21.0	9.5	0.81	0.37
25.2	22.2	9.7	0.88	0.38
24.8	20.4	8.9	0.82	0.36
24.8	18.5	9.4	0.75	0.38

The bell-shaped size frequency distribution of all measurable specimens with paired valves and all the single valves from Sk–6 is shown in fig. 20.

Astarte (Astarte) sulcata (da Costa, 1778) which may resemble the species in question in the appearance of its shell was not met with in the material.

Recent distribution. Panarctic, boreal. *T. (T.) elliptica* occurs from Franz Josef Land, Novaya Zemlya and the Kara Sea southward to Massachusetts, the British Isles, ?France and the western Baltic to Bornholm. In West Greenland the species has been found from Melville Bugt in the north to Julianehåb in the south. In East Greenland Île de France is recorded as the northernmost locality and it reaches to south of Lindenows Fjord (Qeqertatsiaq)*. Vertical range: 2 m (East Greenland) to 442 m (West Greenland).

Ecology and biology. In East Greenland where the substratum is mainly mud, clay (sometimes mixed with sand, gravel and stones) and sand the species is abundant in the *Macoma calcarea* community (Thorson, 1933; Ockelmann, 1958). The pelagic larval stage is either very short or entirely lacking (Thorson, 1936).

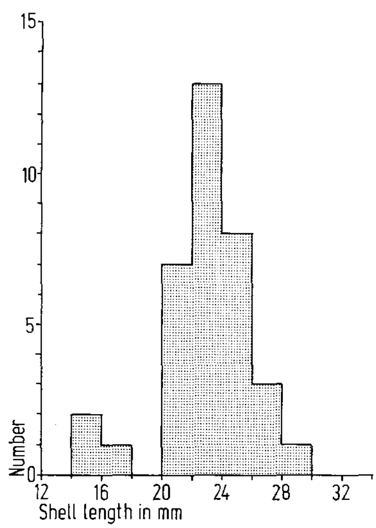


Fig. 20. *Tridonta (Tridonta) elliptica* (Brown). Histogram of the size frequency distribution of 35 measurable specimens with paired valves and single valves from Sk–6 (GGU 111722), Kløft II, Pátorfik.

* See footnote p. 24.

Fossil occurrence. Svalbard, Novaya Zemlya, Kolguev Island, the north coast of Russia, Siberia, North America, Iceland, Scandinavia, the British Isles, Holland, Belgium, ?France and Italy. Stratigraphical range: Pliocene to Holocene.

Fossil in Greenland. *Astarte elliptica* Brown: Nordenskiöld (1871), White & Schuchert (1898), Jensen (1905b), Noe-Nygaard (1932), Laursen *in* Rosenkrantz *et al.* (1942), Laursen (1944), Ives *et al.* (1964), Sugden & John (1965), Rosenkrantz (1968), Funder (1971b, 1978). *Astarte compressa* L.: Steenstrup (1883). *Tridonta* (=*Astarte*) *elliptica* Brown: Funder & Hjort (1973), Weidick (1977b), Funder (1977). *Tridonta elliptica:* Funder (1973), Weidick (1978a).

Subgenus *Nicania* Leach, 1819.

Tridonta (Nicania) montagui (Dillwyn, 1817)

Plate 6, fig. 3

1817 *Venus montagui* Dillwyn, p. 167.

Material. Kløft II, Pátorfik: One specimen with paired valves from Sk–2 (GGU 111718); one specimen with paired valves from Sk–3 (GGU 111719); one left valve from tongue Sk–4 (GGU 111720).

Remarks. Length of shell (l), height (h) and breadth (b) were measured for the found specimens and the h/l and b/l ratios calculated:

l in mm	h in mm	b in mm	h/l	b/l
16.7	15.3	8.5	0.92	0.51
16.6	14.7	9.2	0.89	0.55
13.1	12.3		0.94	

Recent distribution. Panarctic, boreal, circumpolar. *T.* (*N.*) *montagui* occurs from Franz Josef Land, Novaya Zemlya, the Kara Sea, the Siberian Arctic Sea, the Bering Strait, Parry Islands and Ellesmere Island southward to the Aleutians, British Columbia, Massachusetts, the British Isles, France, Denmark and the western Baltic. In West Greenland it has been found from Foulke Fjord in the north to Julianehåb in the south. In East Greenland Jørgen Brønlund Fjord is the northernmost locality whence it reaches to south of Lindenows Fjord (Qeqertatsiaq)*. Vertical range: 0 m (western Baltic) to 445 m (West Greenland).

Ecology and biology. In East Greenland the species inhabits a bottom varying from mud to rocks and here it is common in the *Macoma calcarea* community as well as in the *Gomphina fluctuosa* community, but may also occur in the *Astarte crenata* community (Thorson, 1933, 1934; Ockelmann, 1958). The pelagic larval stage is very short or entirely lacking (Thorson, 1936).

Fossil occurrence. Svalbard, Novaya Zemlya, Kolguev Island, the north coast of Russia, Siberia, North America, Iceland, Scandinavia, the British Isles and Holland. Most of these records do not distinguish between the typical form and the varieties. Stratigraphical range: ?Pliocene to Holocene.

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* See footnote p. 24.

Fossil in Greenland. *Astarte banksii* Leach: Holst (1886), Bay (1896), Pjetursson (1898), Jensen (1905b, 1917), Jensen & Harder (1910), Noe-Nygaard (1932). *Astarte (Nicania) banksii:* Quervain & Mercanton (1925). *Astarte montagui* (Dillwyn): Laursen *in* Rosenkrantz *et al.* (1942), Laursen (1944, 1950), Harder *et al.* (1949), Weidick (1972b), Kelly (1973, 1979), Funder (1978). ?*Astarte pulchella:* Trautman (1963). *Nicania montagui:* Hjort (1973). *Nicania (Astarte) montagui:* Håkansson (1974).

Tridonta (Nicania) montagui (Dillwyn, 1817) var. *striata* (Leach, 1819)

Plate 6, fig. 4

1819 *Astarte striata* Leach, p. 176.

Material. Kløft II, Pátorfik. One specimen with paired valves from Sk–2 (GGU 111718); one right valve from tongue Sk–5 (GGU 111721); one left valve from Sk–6 (GGU 111722).

Remarks. Length of shell (l), height (h) and breadth (b) were measured for the specimens and the h/l and b/l ratios calculated:

l in mm	h in mm	b in mm	h/l	b/l
17.2	14.6		0.85	
16.6	14.2		0.86	
16.5	14.7	7.7	0.89	0.47

Generally *T. (N.) montagui* var. *striata* is more elongated and less tumid than the typical form, but they are connected by intermediates.

Recent distribution. Jensen (1912) has pointed out that the variation in *T. (N.) montagui* occurs with a certain regularity; the shell becomes more elongated and less tumid as the conditions grow more severe. According to Ockelmann (1958) this is in good agreement with the distribution pattern in East Greenland where *T. (N.) montagui* var. *striata* is lacking on the north-east coastal area and almost absent in the Kejser Franz Josephs Fjord area, while it is dominant among these forms on the south-east coastal area. On the other hand, the still more elongated *T. (N.) montagui* var. *warhami* (Hancock, 1846) predominates on the north-east coastal area, in Kejser Franz Josephs Fjord and Scoresby Sund and must consequently be regarded as the most arctic form. The former is by far the most predominant form in West Greenland.

The southern limit for *T. (N.) montagui* var. *striata* in the North Atlantic seems to be in North-West and East Iceland, i.e. close to the boundary between the arctic and boreal faunal regions.

Fossil occurrence. See *T. (N.) montagui.*

Fossil in Greenland. *Astarte striata* Leach: Nordenskiöld (1871), Kornerup (1881), Steenstrup (1881), Flint (1948), Donner & Jungner (1975), Donner (1978). *Astarte montagui* (Dillwyn) var. *striata* (Leach) Sars: Laursen *in* Rosenkrantz *et al.* (1942), Laursen (1944, 1950), Harder *et al.* (1949).

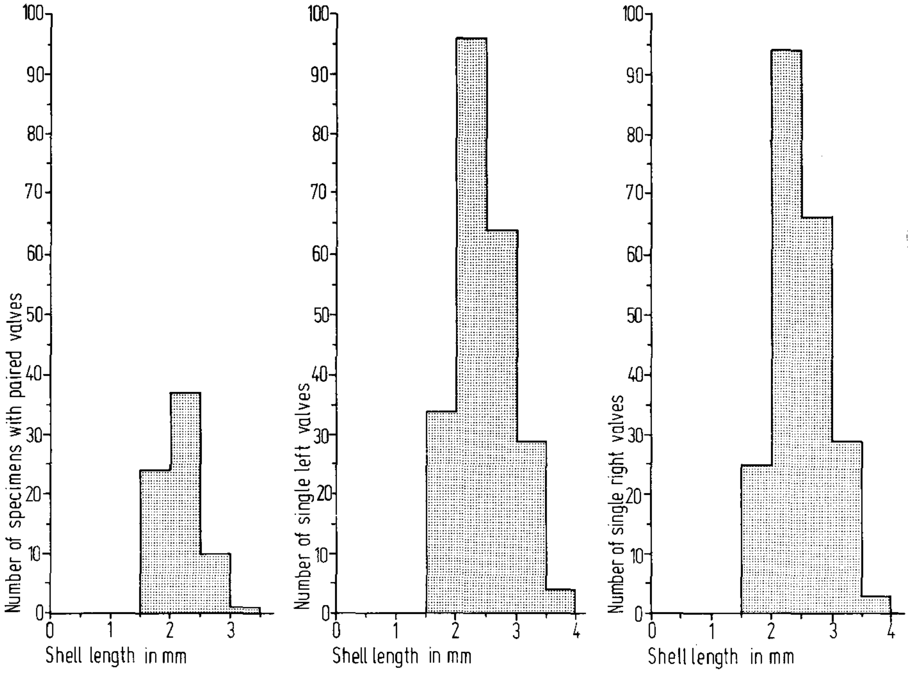

Fig. 21. *Axinopsida orbiculata* (Sars). Histogram of the size frequency distribution of 72 specimens with paired valves as well as 227 single left valves and 217 right valves from tongue Sk–4 (GGU 111720), Kløft II, Pátorfik.

Family Thyasiridae Dall, 1901. Genus *Axinopsida* Kenn & Chavan, 1951.

Axinopsida orbiculata (Sars, 1878)

Plate 6, fig. 5A–B

1878 *Axinopsis orbiculata* Sars, p. 63, plate 19, fig. 11.

Material. Kløft II, Pátorfik: 72 specimens with paired valves, 227 left valves, 217 right valves and 1374 umbonal fragments from tongue Sk–4 (GGU 111720); 5 specimens with paired valves, 35 left valves, 27 right valves and 124 umbonal fragments from tongue Sk–5 (GGU 111721); one specimen with paired valves, 2 left valves and 2 umbonal fragments from layer Sk–7 (GGU 111723).

Remarks. The size frequency distribution of the specimens with paired valves (72) as well as disarticulated left valves (227) and right valves (217) from tongue Sk–4 is shown in fig. 21. The curves have the modes in the same position. However, they indicate that paired valves are proportionally more frequent in the small specimens. The histograms are right-skewed and the death rate seems especially high among the young animals. The umbonal fragments were also considered and their size frequency distribution, based on the length of the hinge line, is also right-skewed, apparently with the mode in the same position (2–2.5 mm) as for the paired and single valves. As the measurements on the fragments were extremely difficult, no histogram is presented. Apparently some size selective crushing has taken place, the larger shells are proportionally more frequently crushed, although it did not significantly change the size frequency distribution. It should be emphasized that the crushed shells were often found with the fragments *in situ* and many umbonal fragments are of paired valves, i.e. only the shell margin is damaged. The ratio of opposite valves is close to 1 as found in fossil unwinnowed communities (Fagerstrom, 1964), whereas the ratio of paired to single valves is rather low. There are no signs of size selective dissolution.

Length of shell (l), height (h) and breadth (b) were measured for the 10 largest specimens with paired valves and the h/l ratios calculated:

l in mm	h in mm	b in mm	h/l
3.9	3.9	2.1	1.00
3.7	3.6	2.1	0.97
3.6	3.7	2.2	1.03
3.6	3.2	2.1	0.89
3.5	3.7	2.0	1.06
3.5	3.4	2.1	0.97
3.5	3.2	2.2	0.91
3.4	3.5	1.9	1.03
3.4	3.4	2.1	1.00
3.4	3.4	1.9	1.00

The h/l ratios are close to 1 and no specimens were found that could be referred to *A. orbiculata* var. *inequalis* (Verrill & Bush, 1898).

Some of the shells are drilled by carnivorous gastropods.

Recent distribution. Panarctic, high boreal. *A. orbiculata* extends from Svalbard, Novaya Zemlya, the Kara Sea and the Siberian Arctic Sea southward to north of Cape Cod, north of the Hebrides and Bodø (Norway). In Alaska it has been collected off Point Barrow. In West Greenland the species has been found from Umanak in the north to Frederikshåb in the south. In East Greenland it is distributed from Danmarkshavn as the northernmost locality to south of Lindenows Fjord (Qeqertatsiaq)*. Vertical range: 2–3 m (several localities in the Arctic) to 944 m (north of the Hebrides).

Ecology and biology. In East Greenland where the species seems to prefer a bottom of silt it has been found in the *Macoma calcarea* and the *Gomphina fluctuosa* communities as well as the *Yoldia hyperborea* community (in Lindenows Fjord; 45–48 m on clay bottom) (Ockelmann, 1958). The pelagic larval stage is very short or entirely lacking (Ockelmann, 1958).

Fossil occurrence. Svalbard, Siberia, Alaska, Iceland and Scandinavia. Stratigraphical range: Middle Pleistocene to Holocene.

* See footnote p. 24.

In Denmark the species has been found fossil in the Upper Pleistocene *Portlandia arctica* Zone in the Skærumhede sequence in Vendsyssel (Nordmann *in* Jessen *et al.*, 1910).

Fossil in Greenland. *Axinopsis orbiculata* G. O. Sars: Holst (1886), Jensen (1905b), Laursen (1944, 1950), Harder *et al.* (1949), Kelly (1973, 1979).

Family Cardiidae Lamarck, 1809. Genus *Serripes* Gould, 1841.

Serripes groenlandicus (Chemnitz, 1782)

Plate 6, fig. 6

1782 *Cardium groenlandicum* Chemnitz, p. 202, plate 19, fig. 198.

Material. Kløft II, Pátorfik: 3 specimens with paired valves, 3 left valves, 2 right valves and one umbonal fragment from Sk–2 (GGU 111718); one specimen with paired valves from Sk–3 (GGU 111719); 52 specimens with paired valves, 380 left valves, 382 right valves and 1794 umbonal fragments from tongue Sk–4 (GGU 111720); 2 specimens with paired valves, 21 left valves, 17 right valves and 220 umbonal fragments from tongue Sk–5 (GGU 111721); 15 umbonal fragments from Sk–6 (GGU 111722); 26 umbonal fragments from layer Sk–7 (GGU 111723); 3 umbonal fragments from layer Sk–8 (GGU 111724).

Sarfâgfik: One internal cast with a fragment of the one valve from the lower part of the section.

Remarks. The larger shells from Kløft II are generally crushed, whereas the smaller ones are more frequently intact. The crushed shells were often found in the sediment with the fragments *in situ* and many umbonal fragments are from paired valves.

The 3 largest complete valves measure (l × h): 66.5 × 54.5, 57.1 × 46.0 and 53.3 × 41.7 mm.

Recent distribution. Panarctic, high boreal, circumpolar. *S. groenlandicus* occurs from Franz Josef Land, Novaya Zemlya, the Kara Sea, the Siberian Arctic Sea, the Bering Strait, Parry Islands and Baffin Island southward to Hakodadi (Japan), Puget Sound, Cape Cod, South Iceland and Porsangerfjord (Finnmark, Norway). In West Greenland the species is known from Etah in the north to Julianehåb in the south. In East Greenland it extends from Danmarkshavn to south of Lindenows Fjord (Qeqertatsiaq)*. However, it has not been met with in the Kangerdlugssuaq area. Vertical range: 0 m (Iceland) to 303 m (West Greenland).

Ecology and biology. According to Ockelmann (1958) the species has been found in East Greenland on various kinds of bottom, i.e. mud, clay, ?silt, sand and gravel, but it seems to prefer ?silt or sand. Here the species lives mainly in the *Gomphina fluctuosa* community as well as in the transitional zone between this and the *Macoma calcarea* community, whereas it is rarely found in a true *Macoma calcarea* community (Thorson, 1933, 1934; Ockelmann, 1958). The larval development has probably a pelagic stage (Ockelmann, 1958).

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* See footnote p. 24.

Fossil occurrence. Franz Josef Land, Svalbard, Novaya Zemlya, Kolguev Island, the north coast of Russia, Siberia, North America, Iceland, Scandinavia, the British Isles and Holland. Stratigraphical range: ?Miocene to Holocene.

In Denmark it has been found fossil in the Upper Pleistocene *Turritella terebra* Zone and the *Abra nitida* Zone in the Skærumhede sequence in Vendsyssel (Nordmann *in* Jessen *et al.,* 1910).

Fossil in Greenland. *Cardium grönlandicum* Chemnitz: Rink (1852), Nordenskiöld (1871), White & Schuchert (1898). *Cardium grønlandicum:* Helland (1876). *Cardium groenlandicum* Chemnitz: Steenstrup (1883, 1901), Holst (1886), Hammer (1889), J. A. D. Jensen (1889), Bay (1896), Nathorst (1901), Jensen (1905b, 1917), Jensen & Harder (1910), Noe-Nygaard (1932). *Serripes groenlandicum* (Chemnitz): Laursen (1944, 1950), Harder *et al.* (1949), Weidick (1968, 1972b, 1972c, 1974), Sugden (1972), Kelly (1980). *Serripes groenlandica* (Bruguière): Flint (1948), Washburn & Stuiver (1962), Funder & Hjort (1973), Håkansson (1974), Kelly (1975), Weidick (1977b, 1978a). *Serripes groenlandicus* (Bruguière): Krinsley *in* Davies *et al.* (1963), Sugden & John (1965), Kelly (1973, 1979), Donner & Jungner (1975), Donner (1978), Funder (1978). *Serripes grønlandicus* (Bruguière): Lasca (1966). *Serripes* sp. Weidick (1972b).

Genus *Clinocardium* Keen, 1936.

Clinocardium ciliatum (Fabricius, 1780)

Plate 8, fig. 5

1780 *Cardium ciliatum* Fabricius, p. 410.

Material. Kløft II, Pâtorfik: 2 specimens with paired valves and one umbonal fragment from Sk–1 (GGU 111717); 2 left valves and one right valve from Sk–2 (GGU 111718); 3 specimens with paired valves and 4 left valves from Sk–3 (GGU 111719); 416 specimens with paired valves, 732 left valves, 720 right valves and 1476 umbonal fragments from tongue Sk–4 (GGU 111720); 41 specimens with paired valves, 102 left valves, 102 right valves and 398 umbonal fragments from tongue Sk–5 (GGU 111721); 19 specimens with paired valves, 9 left valves, 8 right valves and 30 umbonal fragments from Sk–6 (GGU 111722); one specimen with paired valves and 53 umbonal fragments from layer Sk–7 (GGU 111723); 5 umbonal fragments from layer Sk–8 (GGU 111724).

Remarks. The larger shells are generally more fragmented than the smaller ones. The 4 largest complete valves measure (l × h): 57.6 × 44.8, 49.4 × 46.3, 46.0 × 39.3 and 45.8 × 43.4 mm.

The size of different years of young *C. ciliatum* from tongue Sk–4 and the sandy mud at Sk–6 is shown in fig. 22. Growth rings were measured in the 10 best preserved specimens from Sk–4 and Sk–6 respectively. Frequency distribution of the growth rings revealed potential year rings as distinct peaks on the histograms, marked 1 to 5 in the figure. This method, used by Craig & Hallam (1963), seems appropriate to compensate for the occurrence of disturbance rings. The curve in fig. 22 was then worked out by the method described by Sheldon (1965). H_t is the height at one year and it is plotted against H_{t+1} which refers to the height of the following year. The curve indicates that the 10 specimens from Sk–6 (II in the figure) had a considerably greater initial growth rate than the 10 specimens from

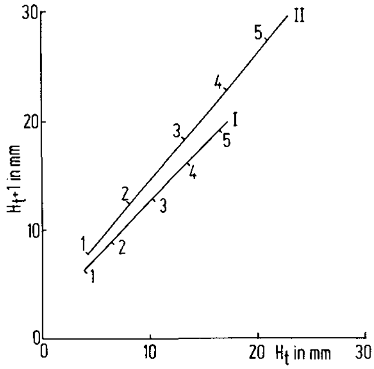


Fig. 22. *Clinocardium ciliatum* (Fabricius). Shell height at one year H_t against height the following year H_{t+1}. Due to crowding at greater ages the growth rings have only been measured in young and well preserved specimens. Numbers 1–5 refer to year rings estimated on the basis of size frequencey distribution of the growth rings. I is based on material from tongue Sk–4 (GGU 111720) (10 specimens) and II on material from Sk–6 (GGU 111722) (10 specimens), Kløft II, Pátorfik. The method is described in the text.

Sk–4 (I in the figure). The growth rate seems to increase up to the 2-group (animals in the third year of their life) which apparently corresponds to the age in which the sexual organs first reach maturity (cf. Thorson, 1936). After the third year the growth rate decreases and at higher ages the growth rings become crowded (cf. plate 6, fig. 7A). According to Thorson (1957) the species becomes at least 12–14 years old.

Recent distribution. Panarctic, high boreal, ?circumpolar. *C. ciliatum* extends from Franz Josef Land, Novaya Zemlya, the Kara Sea, the Bering Strait, Parry Islands and Ellesmere Island southward to northern Japan, Puget Sound, Cape Cod, southern Iceland and East Finnmark. In West Greenland the species is known along the coast from Etah in the north to Julianehåb in the south. In East Greenland it has been found off Clavering Ø as the northernmost locality reaching south to Lindenows Fjord. Vertical range: 0 m (Iceland) to 677 m (West Greenland).

Ecology and biology. In East Greenland the species seems to prefer more clayey bottom than *Serripes groenlandicus,* and here it is especially found in the *Macoma calcarea* community and the transitional zones between this and the adjoining communities (Thorson, 1933, 1934; Ockelmann, 1958). The larval development is supposed to have a pelagic stage of some length (Ockelmann, 1958).

Fossil occurrence. Svalbard, the north coast of Russia, Siberia, North America, Iceland, Scandinavia and ?England. Stratigraphical range: Lower Pleistocene to Holocene.

In Denmark the species has been found fossil in all the Upper Pleistocene zones in the Skærumhede sequence in Vendsyssel except the lower glacigene deposits (Nordmann *in* Jessen *et al.,* 1910; Petersen *in* Bahnson *et al.,* 1974).

Fossil in Greenland. *Cardium islandicum* Chem.: Rink (1852), Nordenskiöld (1871), Helland (1876), White & Schuchert (1898). *Cardium ciliatum* Fabricius: Kornerup (1881), Steenstrup (1883, 1901), Holst (1886), J. A. D. Jensen (1889), Bay (1896), Nathorst (1901), Jensen (1905b, 1917, 1942), Jensen & Harder (1910), Quervain & Mercanton (1925), Noe-Nygaard (1932), Laursen (1944, 1950, 1954), Flint (1948), Harder *et al.* (1949), Washburn & Stuiver (1962), Rosenkrantz (1968), Weidick (1968, 1972a, 1972b, 1972c, 1973, 1974), Kelly (1973, 1975, 1980), Funder (1978). *Cardium edule:* Weidick (1963). *Clinocardium ciliatum* (Fabricius): Washburn & Stuiver (1962), Trautman (1963), Sugden (1972), Funder & Hjort (1973), Håkansson (1974), Blake (1975), Donner & Jungner (1975), Weidick (1978a), Kelly (1979).

Family Tellinidae de Blainville, 1814. Genus *Macoma* Leach, 1819. Subgenus *Macoma* Leach, 1819.

Macoma (Macoma) calcarea (Chemnitz, 1782)

Plate 6, fig. 7A–B

1782 *Tellina calcarea* Chemnitz, p. 140, plate 13, fig. 136.

Material. Kløft II, Pátorfik: 3 specimens with paired valves, 24 left valves, 25 right valves and 893 umbonal fragments from tongue Sk–4 (GGU 111720); 2 specimens with paired valves, 5 left valves, 6 right valves and 4388 umbonal fragments from tongue Sk–5 (GGU 111721); 3 specimens with paired valves, 2 left valves, 3 right valves and 13 umbonal fragments from Sk–6 (GGU 111722); 27 umbonal fragments from layer Sk–7 (GGU 111723); 2 specimens with paired valves, 2 left valves, one right valve and 98 umbonal fragments from layer Sk–8 (GGU 111724).

Kûtsiaq: 3 left valves, one right valve and 14 umbonal fragments.

Sarfâgfîk: One specimen with paired valves and 7 umbonal fragments from the upper part of the section.

Remarks. The species has a thin and fragile shell and the material from Pátorfik is fragmented, but size selective crushing was not observed. The crushed shells were often found in the sediment with the fragments *in situ.*

The 4 largest complete valves from Kløft II measure (l × h): 33.3 × 23.1, 33.0 × 23.2, 31.5 × 22.8 and 30.8 × 21.7 mm. The 4 complete valves from Kûtsiaq measure (l × h): 31.7 × 24.3, 30.3 × 22.4, 26.6 × 19.8 and 26.5 × 20.2 mm. The specimen with paired valves from Sarfâgfîk measures (l × h × b): 29.8 × 21.5 × 8.6 mm.

Recent distribution. Panarctic, mid boreal, circumpolar. *M. (M.) calcarea* is known from all arctic seas and occurs from Franz Josef Land, Novaya Zemlya, the Kara Sea, the Siberian Arctic Sea, the Bering Strait and the American Arctic southward to northern Japan, Monterey (California), Long Island Sound and the Faeroe Islands. The occurrence in the Oslofjord, Kattegat and the Baltic is possibly a relic (Petersen, 1888; Jensen 1905a). Tebble (1966) and McMillan (1968) did not report it from the British Isles. In West Greenland the species has been found from Etah in the north to Julianehåb in the south. In East Greenland it is of common occurrence and has been collected in Jørgen Brønlund Fjord as the northernmost locality extending southward to Lindenows Fjord. Vertical range: 0 m (Iceland) to 677 m (West Greenland, ?alive).

Ecology and biology. The species is of common occurrence in all arctic seas where it mainly lives in shallow waters. In East Greenland the species is generally found to inhabit a bottom of clay or mud which may be mixed with sand, gravel and stones (Ockelmann, 1958). It is one of the most characteristic animals in the *Macoma calcarea* community (Thorson, 1957). The larval development probably has a pelagic stage (Ockelmann, 1958).

Fossil occurrence. Svalbard, Novaya Zemlya, Kolguev Island, the north coast of Russia, Siberia, North America, Iceland, Scandinavia, the British Isles, Holland and ?Italy. Stratigraphical range: Pliocene to Holocene.

Fossil in Greenland. *Tellina lata* Gm.: Rink (1852), Kornerup (1879). *Tellina sabulosa* Spgl.: Nordenskiöld (1871). *Tellina tenua* Leach: Nordenskiöld (1871). *Tellina calcaria* Chemnitz: Helland (1876), Steenstrup (1901), Noe-Nygaard (1932), Jensen (1942). *Tellina (Macoma) calcaria* Chemnitz: Jensen (1905b, 1917). *Tellina (Macerna) calcarea* Chemnitz: Quervain & Mercanton (1925). *Tellina calcarea* Chemnitz: Kornerup (1881), Steenstrup (1881, 1883), Holst (1886), Hammer (1889), J. A. D. Jensen (1889), Weidick (1973). *Macoma sabulosa* Spengler: White & Schuchert (1898). *Macoma calcaria* (Chemnitz): Bay (1896), Harder *et al.* (1949), Laursen (1950), Funder (1971b, 1978), Kelly (1973). *Macoma calcarea* (Chemnitz): J. A. D. Jensen (1889), Laursen *in* Rosenkrantz *et al.* (1942), Laursen (1944, 1945), Flint (1948), Trautman (1963), Sugden & John (1965), Lasca (1966), Weidick (1968, 1969, 1972a, 1972b, 1972c, 1973, 1974, 1975a, 1976b, 1977b), Henriksen & Watt (1968), TenBrink (1971), Sugden (1972), Håkansson (1972, 1974), Blake (1975), Donner & Jungner (1975), Kelly (1975, 1979, 1980), Street (1977), Donner (1978).

Subclass Desmodonta Neumayr, 1883. Order Myoida Stoliczka, 1870. Family Hiatellidae Gray, 1824. Genus *Hiatella* Bosc, 1801. Subgenus *Hiatella* Bosc, 1801.

Hiatella (Hiatella) arctica (Linné, 1767)

Plate 6, fig. 8

1767 *Mya arctica* Linné, p. 1113.

Material. Kløft II, Pátorfik: 3 specimens with paired valves, 76 left valves, 68 right valves and 172 umbonal fragments from tongue Sk–4 (GGU 111720); 3 left valves, 3 right valves and 14 umbonal fragments from tongue Sk–5 (GGU 111721); one specimen with paired valves and 7 umbonal fragments from layer Sk–7 (GGU 111723); one specimen with paired valves and 3 umbonal fragments from layer Sk–8 (GGU 111724).

Kûtsiaq: 233 left valves, 175 right valves and 209 umbonal fragments.

Sarfâgfik: One specimen with paired valves, 515 left valves, 457 right valves and 344 umbonal fragments from the upper part of the section.

Remarks. The largest valve from Kløft II is (l × h): 45.2 × 25.0 mm, but most of the shells from Pátorfik are juvenile. On the other hand, only a few juvenile shells were found in the samples from Kûtsiaq and Sarfâgfik where the valves were generally paired in the sediment, but separated when collected. The largest valve from Kûtsiaq measures (l × h): 47.4 × 20.0 mm and the largest one from Sarfâgfik is 51.4 × 23.3 mm.

Discussion. The systematic details of the genus *Hiatella* have often been discussed. Opinions have been vastly different, e.g. on the decisive question whether the North Atlantic *Hiatella* comprises one or more species.

Jensen (*in* Thorson, 1951 p. 83–87), familiar with the study of northern bivalves, stated: "Having now examined shell for shell, the large collections from the Faroes, Iceland, Jan Mayen, W. and E. Greenland I feel convinced that *S. arctica* and *S. pholadis* cannot be kept separate, since not a single of the characters normally used to distinguish between them will hold good in all cases". Moreover, he wrote: "My impression is that *arctica* and *pholadis* do not represent distinct species, not even varieties". Thus, Jensen arrived at the conclusion that the North Atlantic '*Mya arctica*', '*Mytilus rugosus*' and '*Mytilus pholadis*', all of Linné, 1767, belong to one and the same species, viz. *Saxicava arctica.* Furthermore, Meyer & Möbius (1872) were of the opinion that there is only one species of the genus in the North Sea and the Baltic.

Forbes & Hanley (1853) described *Saxicava rugosa* and *S. arctica* in British waters, and Lamy (1923) distinguished between three species of the genus in the North Atlantic, namely *Saxicava arctica, S. rugosa* and *S. pholadis.* They were all said to live in Iceland and the latter two to occur in Greenland. Winckworth (1932) mentioned three species living in British waters, viz. *Hiatella arctica, H. gallicana* (=*H. rugosa*) and *H. pholadis,* whereas Tebble (1966 p. 173) concluded: "At the present state of our knowledge I do not think it is possible to separate shells of *Hiatella* found in British waters into distinct species, . . .". Jeffreys (1869) was of the opinion that there is only one species, *Saxicava rugosa,* with a number of varieties, e.g. *S. rugosa* var. *arctica.*

These authors, using the shape and structure of juvenile and adult shells as a basis for their studies, actually arrived at vastly different conclusions.

Investigation on bivalve larvae in the North Atlantic has revealed that at least two different forms of *Hiatella* larvae do occur there. These two forms are a more rounded larva which has been referred to *H.* (*H.*) *rugosa* and a more triangular one referred to as *H.* (*H.*) *arctica.* The two larval types have been observed in the Adriatic Sea (Odhner, 1914), at Plymouth (Lebour, 1938), in Danish waters (Jørgensen, 1946), in the Clyde area (Hunter, 1949), in the North Sea (Rees, 1950) and according to A. Sigurdsson (personal information) they have been met with in Faxaflói, south-western Iceland. Besides, Rees (1950) has described one further type of *Hiatella* larvae from the North Sea and considered it might belong to *H. pholadis.*

Two types of *Hiatella* larvae are known from the above-mentioned areas, whereas only one of these forms, the rounded *H.* (*H.*) *rugosa* type, is known from the arctic region of the North Atlantic. Thorson (1936) found the rounded type as the only *Hiatella* larva in the East Greenland plankton and Sullivan (1948) found it also as the only *Hiatella* larva in Malpeque Bay, East Canada, although she referred it to *Saxicava arctica.*

Ockelmann (1958 p. 141) also referred to these *Hiatella* larvae: "The possibility of regarding the two different larval forms observed in the N. Atlantic *Hiatella* as non-genetic modifications cannot be accepted, because of the differences in distribution of these larval forms, and also because of the apparent lack of intermediate larval forms". Regarding the existence of these different larval forms as evidence of different species of *Hiatella,* the distribution of the larvae indicates that *H.* (*H.*) *arctica* is a more southern form than *H.* (*H.*) *rugosa* which seems to be the only representative of the genus yet found in arctic waters (cf. Thorson, 1951).

Some authors have stated that one species of *Hiatella,* viz. *H.* (*H.*) *rugosa* (=*H.* (*H.*) *gallicana*), is a borer, whereas *H.* (*H.*) *arctica* never bores. If correct this might be useful in separating the species when dealing with adult animals. Hunter (1949 p. 273–274), who observed the two *Hiatella* larvae in the Clyde area, stressed the improbability of this: "These are easily distinguished, corresponding to size and description to those figured by Jørgensen, and can be separated to a certain extent after metamorphosis, but become indistinguishable in shell form after about two weeks of post-larval growth. The larvæ attributed to *H. gallicana* do not necessarily become borers, those to *H. arctica* may settle and begin to bore. The character of the larva does not determine the boring or non-boring habit of the adult. That is determined by the nature of the substratum upon which settlement takes place". The two species seem to become indistinguishable as they mature because of an extreme convergence.

Considering the faunas and their relationship to the water temperatures, it seems most justifiable to refer the species from the marine Quaternary deposits in the Umanak Fjord to *H.* (*H.*) *rugosa* which, according to Thorson (1951), should be referred to as *H.* (*H.*) *pholadis.* However, the present author has, in accordance with Thorson (1951) and Ockelmann (1958), referred the *Hiatella* in these deposits to *H.* (*H.*) *arctica* as it is impossible to discern the larval forms in the material available.

Strauch (1968) has discussed the possible use of *H.* (*H.*) *arctica* as a temperature indicator. He pointed out that numerical distribution, shell form and growth are temperature dependent and produced a curve where the size/age ratios were used to derive quantitative temperature values from size measurements of adult fossil populations. Rowland & Hopkins (1971) have remarked upon Strauch's conclusions and pointed out that with Pacific *H.* (*H.*) *arctica,* the shell length is governed by the mode of life of each population. The author has not used Strauch's temperature curve on the material dealt with here because various factors other than temperature may contribute to determine the size of *H.* (*H.*) *arctica.*

Recent distribution. H. (*H.*) *arctica* (including *H.* (*H.*) *gallicana* and *H.* (*H.*) *pholadis*) is panarctic, boreal, lusitanian, circumpolar. Sometimes it is regarded as a cosmopolite. It is widely distributed and extends from Franz Josef Land, Novaya Zemlya, the Kara Sea, the Siberian Arctic Sea, the Bering Strait and the seas north of America southward, especially at greater depths, into the warmer parts of the large oceans. As already discussed, the species has often been confused with other related species and therefore its cosmopolitan distribution may be doubted. The species inhabits the whole coast of West Greenland. In East Greenland it has been found from Jørgen Brønlund Fjord in the north to Lindenows Fjord in the south. Vertical range: 0 m (several localities) to 2190 m (west of Ireland, ?alive).

Ecology and biology. In East Greenland the species belongs to the epifauna, and the young animals are found in large numbers attached to algae in shallow water, whereas the adults are mainly attached to stones or small irregularities on the level sea floor (Ockelmann, 1958). The larval development is pelagic and the rounded *Hiatella* larva was found to be the most numerous bivalve larva in the East Greenland plankton (Thorson, 1936).

Fossil occurrence. H. (H.) arctica (including *H. (H.) gallicana* and *H. (H.) pholadis*) has been found fossil in numerous places spread over the northern hemisphere. Stratigraphical range: Oligocene to Holocene.

Fossil in Greenland. *Saxicava rugosa* L.: Rink (1852), Helland (1876), Kornerup (1879, 1881), Steenstrup (1881, 1883), Hammer (1889), Pjetursson (1898), Noe-Nygaard (1932). *Saxicava arctica* (Linné): Nordenskiöld (1871), Steenstrup (1883, 1901), Holst (1886), Bay (1896), Hartz *in* Bay (1896), Nathorst (1901), Jensen (1905b, 1917, 1942), Jensen & Harder (1910), Quervain & Mercanton (1925), Laursen *in* Rosenkrantz *et al.* (1942), Laursen (1944, 1945, 1950, 1954), Flint (1948), Harder *et al.* (1949), Weidick (1963, 1968, 1969, 1975a), Rosenkrantz (1968), Birkelund & Perch-Nielsen (1969), Tauber (1970). *Saxicava pholadis* L.: Holst (1886), J. A. D. Jensen (1889). *Saxicava:* Tarr (1897). *Hiatella arctica* (Linné): Rubin & Alexander (1960), Davies (1961), Washburn & Stuiver (1962), Krinsley *in* Davies *et al.* (1963), Trautman (1963), Ives *et al.* (1964), Sugden & John (1965), Cruickshank & Colhoun (1965), Lasca (1966), Trautman & Willis (1966), Stuiver (1969), Funder (1971b, 1973, 1977, 1978), TenBrink (1971), Weidick (1972a, 1972b, 1972c, 1974, 1975b, 1976b, 1977b, 1978a), Sugden (1972), Hjort (1973), Håkansson (1973, 1974), Kelly (1973, 1975, 1979, 1980), Blake (1975, 1977), Donner & Jungner (1975), Donner (1978). *Hiatella (=Saxicava) arctica* (Linné): Funder (1972a), Funder & Hjort (1973), Weidick (1973), Street (1977). *Hiatella (Saxicava) arctica:* Håkansson (1972).

Genus *Panopea* Menard, 1807. Subgenus *Panomya* Gray, 1853.

Panopea (Panomya) norvegica (Spengler, 1793)

Plate 8, fig. 6

1793 *Mya norvegica* Spengler, p. 46, plate 2, fig. 18.

Material. Kløft II, Pátorfik: 9 specimens with paired valves and one left valve from Sk–1 (GGU 111717); 30 specimens with paired valves, 5 left valves and 3 right valves from Sk–2 (GGU 111718); 11 specimens with paired valves from Sk–3 (GGU 111719). The species was only found in the lower part of the section.

Remarks. The valves are generally paired, but some of them are fragmented and with the fragments *in situ*. The 5 largest specimens with paired valves measure (l × h): 89.1 × 60.1, 88.5 × 56.2, 85.0 × 59.8, 81.9 × 55.1 and 76.7 × 43.0 mm.

Recent distribution. Jensen (1942) and Strauch (1972) have investigated the recent distribution of *P.* (*P.*) *norvegica.* The species seems boreal, occurring in the eastern part of the North Atlantic from southern Iceland and Finnmark in the north to the English Channel in the south. Only empty shells have been found in West, North and East Iceland as well as round Jan Mayen, in Greenland and in the Mediterranean area. The species also lives off the American east coast from the southernmost part of Labrador to Georges Bank off Cape Cod. In Alaska it is distributed from Shumagin Island to Unalaska (the Aleutians), but only empty shells have been collected off the north coast of Alaska. Vertical range: 17 m (North-West Atlantic) to ?500 m (Norway).

Ecology. Tebble (1966) reported the species from the British Isles on a bottom of mud and muddy and sandy gravel. It belongs to the infauna and lives buried deep in the bottom.

Fossil occurrence. Svalbard, Kolguev Island, the north coast of Russia, north-eastern America (Labrador to Maine), Iceland, Scandinavia, Scotland, France and Italy. Strauch (1972) has referred the fossil specimens from France and Italy to a distinct subspecies *P.* (*P.*) *arctica biconvae* (Philippi, 1836). Stratigraphical range: Lower Pleistocene to Holocene.

Fossil in Greenland. *Panopæa norvegica* (Spengler): Rink (1852), Steenstrup (1883), Holst (1886), Laursen (1944). *Saxicava norvegica* Spgl.: Nordenskiöld (1871). *Panopaea norvegica* Spengl.: Jensen (1942), Laursen (1950).

Genus *Cyrtodaria* Reuss, 1801.

Cyrtodaria siliqua (Spengler, 1793)

Plate 9, figs 1 & 2A–B

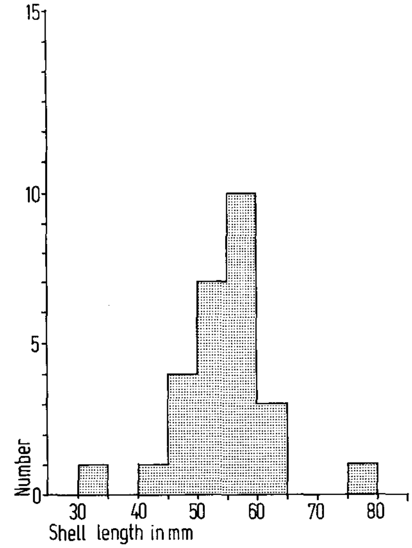
1793 *Mya siliqua* Spengler, p. 48.

Material. Kløft II, Pátorfik: 5 specimens with paired valves and one right valve from Sk–1 (GGU 111717); 18 specimens with paired valves from Sk–2 (GGU 111718); 8 specimens with paired valves from Sk–3 (GGU 111719); 4 umbonal fragments from tongue Sk–4 (GGU 111720); 3 specimens with paired valves from Sk–6 (GGU 111722).

Remarks. Some of the specimens with paired valves are crushed, but generally with the fragments *in situ.* They are rather well preserved and in some cases the ligament is intact. The 5 largest specimens with paired valves measure (l × h): 67.1 × 31.2, 65.0 × 25.6, 60.0 × 23.0, 56.5 × 23.3 and 55.2 × 24.9 mm.

The slightly left-skewed size frequency distribution of the 27 measurable specimens with paired valves from Sk–1, Sk–2 and Sk–3 is shown in fig. 23.

Fig. 23. *Cyrtodaria siliqua* (Spengler). Histogram of the size frequency distribution of 27 measurable specimens with paired valves from Sk–1 (GGU 111717), Sk–2 (GGU 111718) and Sk–3 (GGU 111719), Kløft II, Pâtorfik.



Recent distribution. High boreal, mid boreal, only in the North-West Atlantic. *C. siliqua* is restricted to the Newfoundland, Nova Scotia, Cape Cod area where it has been found on the Great Newfoundland Bank and the Banquereau Bank, in the Gulf of St. Lawrence and the Gulf of Maine and on the Georges Bank off Cape Cod. Thus, the species does not belong to the recent Greenland fauna. Feyling-Hanssen (1955b) has reported the species from the recent shore of Kapp Wijk, Isfjorden, West Spitsbergen, but the specimen in question should be referred to *C. kurriana* Dunker, 1862. Vertical range: 4 m to 500 m. It mainly occurs at depths between 50 and 150 m (Nesis, 1965).

Ecology. The species belongs to the infauna and prefers a bottom of fine-grained sand, but its burrowing depth is only a few centimetres as the siphon is rather short (Nesis, 1965).

Fossil occurrence. East Canada: Quebec and Newfoundland. Stratigraphical range: Upper Pleistocene to Holocene.

The fossil occurrence of *C. siliqua* is apparently restricted to West Greenland and East Canada. In an earlier paper the author has offered the suggestion that in Greenland it has been met with only in the interglacial deposits at Pâtorfik (Símonarson, 1974). In East Canada, on the other hand, the species has been found only in deposits younger than the maximum of the Wisconsian Glaciation. Therefore it is concluded that *C. siliqua* did not spread northward to West Greenland during the Holocene climatic optimum as stated by some authors (cf. Nesis, 1965; Strauch 1972). The species was driven southward to the Newfoundland, Nova Scotia, Cape Cod area due to the Wisconsian Glaciation and did not return to

Greenland. In fact it could not reach Greenland during the Holocene on account of the vast areas of deep sea surrounding the island and the strong south moving cold Labrador current which represents a barrier to the larvae of this southern infauna bivalve.

Fossil in Greenland. *Glycimeris siliqua* Spgl.: Rink (1852). *Cyrtodaria siliqua* (Spengler): Nordenskiöld (1871), Steenstrup (1883), White & Schuchert (1898), Laursen (1944), Símonarson (1974).

Family Myidae Lamarck, 1809. Genus *Mya* Linné, 1758. Subgenus *Mya* Linné, 1758.

Mya (Mya) truncata Linné, 1758

Plate 9, fig. 3

1758 *Mya truncata* Linné, p. 670.

Material. Kløft II, Pátorfik: 86 specimens with paired valves, 523 left valves, 470 right valves and 3480 umbonal fragments from tongue Sk–4 (GGU 111720); 5 specimens with paired valves, 29 left valves, 20 right valves and 430 umbonal fragments from tongue Sk–5 (GGU 111721); 2 umbonal fragments from Sk–6 (GGU 111722); 38 umbonal fragments from layer Sk–7 (GGU 111723); 17 umbonal fragments from layer Sk–8 (GGU 111724).

Kûtsiaq: One left valve and 7 umbonal fragments.

Sarfâgfîk: 4 umbonal fragments from the upper part of the section.

Remarks. The largest valve from Kløft II is (l × h): 49.3 × 38.0 mm, but most of the shells found here are juvenile. On the other hand, the valve and the umbonal fragments from Kûtsiaq and Sarfâgfîk are from rather large shells. The complete valve from Kûtsiaq measures (l × h): 35.7 × 23.0 mm.

Discussion. The systematic details of the genus *Mya* seem to have been discussed more than those of any other bivalve. The genus comprises two or three subgenera and several species, one of which is *Mya (Mya) truncata.* This species has, since Linné established it in 1758, been split into different forms, the typical form and two varieties *uddevalensis* Forbes, 1846 and *ovata* Jensen, 1900.

Another species of *Mya,* i.e. *Mya (Arenomya) arenaria* Linné, 1758, has sometimes been recorded, alive as well as fossil, from arctic areas. In 1900 Jensen published a paper on *Mya* and stressed that all '*Mya arenaria*' recorded from the Arctic actually are a variety of *M. (M.) truncata.* Jensen named this variety *ovata,* because the posterior end is ovate and not truncate as in the other forms. Apparently Jensen never regarded *M. (M.) truncata* var. *ovata* to be more than an infraspecies (Laursen, 1966) and some authors have followed him in this, e.g. Laursen (1944, 1950, 1966), Madsen (1949), Feyling-Hanssen (1955a) and Ockelmann (1958).

Several authors have raised *M. (M.) truncata* var. *ovata* to the rank of either a subspecies or a species. Schlesch (1931 p. 137) raised it to the rank of species when he claimed: "Ich kann in dieser charakteristischen, im Nordatlantik sehr stark zurückgegangenen oder vielleicht bereits ausgestorbenen – Ad.S. Jensen als *Mya truncata* f. *ovata* bezeichneten (Jensen, 1900 S. 139) Art – nur eine spezifisch "gute" Art erkennen; auch Brögger (1901 S. 608) erklärt, dass sie "eine eigene Form" ist, die *M. truncata* L. näher steht. Da aber *Mya ovata* Jensen homonym mit *M. ovata* Donovan (1802, pl. 122) (=*Unio tumidus* Retz.) ist und daher durch einen neuen Namen ersetzt werden muss, benenne ich sie *Mya pseudoarenaria*". From this quotation it is evident that Schlesch used the name *ovata* sometimes as a variety name, sometimes as a species name. Several authors have followed Schlesch in regarding *M.* (*M.*) *truncata* var. *ovata* as a distinct species, e.g. Foster (1946), Soot-Ryen (1951), MacGinitie (1959), MacNeil (1965), Durham & MacNeil (1967) and Strauch (1972), while Merklin *et al.* (1962) and Nordsieck (1969) treated it as a subspecies.

The other variety, *M.* (*M.*) *truncata* var. *uddevalensis*, has also been raised to the rank of a species, e.g. by Hancock (1846), whereas Laursen (1954) and Merklin *et al.* (1962) dealt with it as a subspecies. In a later paper Laursen (1966), however, considered this form of no higher rank than infraspecific.

There is a marked difference between typical *M.* (*M.*) *truncata* and typical *M.* (*M.*) *truncata* var. *uddevalensis*. However, a complete series of intermediates within a given population leaves no doubt that the latter is only a variety of the former. The taxonomical rank of *M.* (*M.*) *truncata* var. *ovata* is more problematic.

The outline of the shell in typical *M.* (*M.*) *truncata* is intermediate between the two varieties mentioned, and a complete series of intergradations can be demonstrated (cf. Feyling-Hanssen, 1955a; Ockelmann, 1958). The relationship between length of shell and length from umbo to posterior end is shown in fig. 24. These two parametres seem to bring out well the differences in shape. There is an obvious divergence, the smaller specimens, i.e. those less than 25 mm in length, are concentrated in a group, whereas the larger ones are split into three main trends with some scattered transitional specimens. The measurements were made

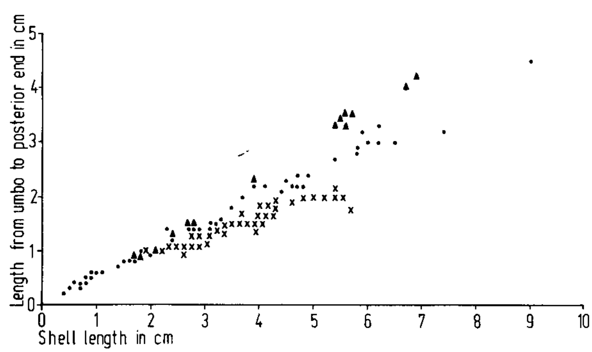


Fig. 24. Relationship between shell length and length from umbo to posterior end in *Mya* (*Mya*) *truncata* Linné (●), *Mya* (*Mya*) *truncata* Linné var. *uddevalensis* Forbes (×) and *Mya* (*Mya*) *pseudoarenaria* Schlesch (▲).

on material from different localities to prevent the influence of local variations. In the pallial sinus all grades of transitional stages occur between the three forms. On the other hand, the chondrophore appears to be less symmetrical in *M.* (*M.*) *truncata* var. *ovata* than in the other two forms and intermediates seem to be rare. MacGinitie (1959) has stressed that in living *M.* (*M.*) *truncata* var. *ovata* collected off Point Barrow (Alaska) the sheath that extends onto the siphon is more like that of *M.* (*A.*) *arenaria* than *M.* (*M.*) *truncata.* This sheath is not nearly so tough, wrinkled and extensive as in *M.* (*M.*) *truncata.* It might also be pointed out that according to A. Sigurdsson (personal information, 1975), living specimens of *M.* (*M.*) *truncata* var. *ovata* collected in Iceland are decidedly more pigmented, reddish-blue than those of the other forms. This is worth mentioning, even if colour pattern seems generally to be only of minor differential value.

Thus, there are difficulties in deciding if the differences in morphology between *M.* (*M.*) *truncata* var. *ovata* and the two other forms are sufficient to establish a new species.

The problem should also be discussed from another point of view. Jensen (1900) pointed out that the two varieties are more northerly forms than the typical *M.* (*M.*) *truncata* and considered them adapted to less optimal conditions. Were that true, the contrasting varieties, having evolved from the same species, would not be expected to occur together in the same biotope, as they often do, both fossil and recent. This coexistence is not easy to explain and might indicate two distinct species. A further confirmation is that pure populations of fossil as well as recent *M.* (*M.*) *truncata* and *M.* (*M.*) *truncata* var. *ovata* have in fact been observed together without transitional specimens (Strauch, 1972).

On the whole, the author of this paper is inclined to consider Jensen's *M.* (*M.*) *truncata* var. *ovata* as a distinct species and, until further proof is given, the name *M.* (*M.*) *pseudoarenaria* Schlesch, 1931 will be used.

The evolution of the *M.* (*M.*) *truncata* group has been dealt with by several authors, e.g. Jensen (1900), Schlesch (1931), MacNeil (1965), Fujie (1957) and Strauch (1972). The opinions differ somewhat, but will not be discussed further here. Most probably *M.* (*M.*) *pseudoarenaria* evolved from the *M.* (*M.*) *truncata* line during the transition of the Pliocene to the Pleistocene.

Jensen (1900) stressed that all juvenile specimens of the *M.* (*M.*) *truncata* forms closely resemble *M.* (*M.*) *pseudoarenaria* in the appearance of the shell. In this context it must be mentioned that numerous small and thin shells of *M.* (*M.*) *truncata* with an ovate posterior end were collected by A. Rosenkrantz and E. Nordmann at Qaersuarssuk kitdleq (7 km west of the Pátorfik river) in the summer of 1964. Not a single one of the larger shells collected at the same place can be referred to *M.* (*M.*) *pseudoarenaria,* because they all belong either to the typical *M.* (*M.*) *truncata* or the skew *M.* (*M.*) *truncata* var. *uddevalensis.* This makes it clear that the small specimens cannot be referred to *M.* (*M.*) *pseudoarenaria* simply because they have an ovate posterior end (cf. fig. 24). There is no doubt that the fact has not always been taken into consideration that the shell form alters with maturity. Therefore some misidentifications must be expected and a thorough revision of several older records is required.

Recent distribution. Panarctic, boreal, circumpolar. *M.* (*M.*) *truncata* extends from Franz Josef Land, Novaya Zemlya, the Kara Sea, the Siberian Arctic Sea, the Bering Strait and the seas north of America southward to Hakodadi (Japan), Port Orchard (Washington), Massachusetts, the English Channel and the western Baltic. According to W. K. Ockelmann (personal information, 1970) it does not live in lusitanian waters. In West Greenland the species is distributed along the entire coast. In East Greenland it has been found in Jørgen Brønlund Fjord in the north whence it reaches to south of Lindenows Fjord (Qeqertatsiaq).* Vertical range: 0 m (several localities) to 625 m (West Greenland).

Ecology and biology. In East Greenland the species has been found living on various types of bottom, viz. mud, clay, sand, gravel and stones. The young animals are often found attached to algae in large numbers, whereas the adults belong to the *Macoma calcarea* community of the infauna (Ockelmann, 1958). The larval development is with a long pelagic stage (Thorson, 1936).

Fossil occurrence. The species has been found fossil in numerous places spread over the northern hemisphere. The southernmost records are from Japan, California, Massachusetts and the Mediterranean area. Stratigraphical range: Miocene to Holocene.

Fossil in Greenland. *Mya truncata* Linné: Rink (1852), Nordenskiöld (1871), Helland (1876), Kornerup (1879, 1881), Steenstrup (1881, 1883, 1901), Holst (1886), Hammer (1889), J. A. D. Jensen (1889), Bay (1896), Hartz *in* Bay (1896), White & Schuchert (1898), Pjetursson (1898), Nathorst (1901), Jensen (1905b, 1917, 1942), Jensen & Harder (1910), Quervain & Mercanton (1925), Noe-Nygaard (1932), Laursen *in* Rosenkrantz *et al.* (1942), Laursen (1944, 1945, 1950, 1954), Flint (1948), Harder *et al.* (1949), Rubin & Alexander (1960), Davies (1961), Washburn & Stuiver (1962), Trautman (1963), Krinsley *in* Davies *et al.* (1963), Weidick (1963, 1968, 1972a, 1972b, 1972c, 1973, 1974, 1975a, 1975b, 1976b, 1977b, 1978a), Ives *et al.* (1964), Sugden & John (1965), Levin *et al.* (1965), Cruickshank & Colhoun (1965), Trautman & Willis (1966), Lasca (1966), Rosenkrantz (1968), Henriksen & Watt (1968), Birkelund & Perch-Nielsen (1969), Stuiver (1969), Tauber (1970), Funder (1971b, 1972a, 1973, 1977, 1978, 1979), TenBrink (1971), Sugden (1972), Håkansson (1972, 1973, 1974), Funder & Hjort (1973), Hjort (1973), Kelly (1973, 1975, 1979, 1980), Blake (1975), Donner & Jungner (1975), Street (1977), Donner (1978).

Mya (*Mya*) *truncata* Linné, 1758 var. *uddevalensis* Forbes, 1846

Plate 9, fig. 4A–B

1846 *Mya truncata* var. *uddevalensis* Forbes, p. 407.

Material. Kûtsiaq: 3 left valves, 7 right valves and 8 umbonal fragments.

Sarfâgfik: 31 left valves, 28 right valves and 70 umbonal fragments from the upper part of the section. It is noteworthy that this variety was not found in the interglacial deposits at Pátorfik.

* See footnote p. 24.

Remarks. The valves were generally paired in the sediment, but separated when collected. Most of the shells are large and only a few are juvenile. The two largest complete valves from Kûtsiaq measure (l × h): 42.0 × 31.5 and 37.3 × 26.5 mm. The two largest complete valves from Sarfâgfîk measure (l × h): 44.3 × 30.5 and 43.3 × 28.8 mm.

Recent distribution. Panarctic, circumpolar, with boreal outposts. *M.* (*M.*) *truncata* var. *uddevalensis,* of common occurrence in arctic seas, is known from West and East Greenland, Franz Josef Land, Svalbard, Jan Mayen, Novaya Zemlya, the Barents Sea, Ponds Inlet, Baffin Island, Hudson Strait, Labrador, the Gulf of St. Lawrence, Iceland and northern Norway. Only empty shells have been found in Alaska. The variety is a more northerly form than the typical *M.* (*M.*) *truncata.*

Fossil occurrence. Svalbard, Siberia, Canada, Iceland and Scandinavia. Stratigraphical range: Lower Pleistocene to Holocene.

Fossil in Greenland. *Mya truncata* Linné var. *uddevallensis* Forbes: Holst (1886), Jensen (1905b, 1917), Laursen *in* Rosenkrantz *et al.* (1942), Laursen (1944, 1950), Harder *et al.* (1949), Sugden & John (1965). *Mya truncata uddevallensis* (Hanc.): Laursen (1954).

Mya (*Mya*) *pseudoarenaria* Schlesch, 1931

Plate 9, fig. 5

1931 *Mya pseudoarenaria* Schlesch, p. 136, plate 13, figs 10–12.

Material. Kløft II, Pâtorfik: One specimen with paired valves and one left valve from Sk–1 (GGU 111717); 9 specimens with paired valves from Sk–2 (GGU 111718); 3 specimens with paired valves and one right valve from Sk–6 (GGU 111722). The species was neither found at Kûtsiaq nor Sarfâgfîk and was only met with in the interglacial deposits at Pâtorfik.

Remarks. The two largest specimens with paired valves measure (l × h × b): 57.2 × 43.4 × ? and 56.7 × 40.7 × 21.6 mm.

Recent distribution. Panarctic, ?circumpolar. *M.* (*M.*) *pseudoarenaria* is known from West and East Greenland, Franz Josef Land, Svalbard, the Barents Sea, the White Sea, Novaya Zemlya, the Kara Sea, the Sea of Okhotsk, Alaska, Newfoundland, Iceland and northern Norway. Thus, the species has a more northerly occurrence than *M.* (*M.*) *truncata.* Vertical range: 6 m (West Greenland) to ?80 m (West Greenland). Nordsieck (1969) stated the vertical range as 6–185 m, but this record is apparently cited from Soot-Ryen (1958) and probably refers to the vertical range of *M.* (*M.*) *truncata* in East Greenland.

Ecology. The adults apparently prefer muddy or clayey bottom. They live deeply immersed in the sediment within the *Macoma calcarea* community. In Norway the species is typically found at localities with low temperatures during early spring and rather low salinities (Soot-Ryen, 1951).

Fossil occurrence. Franz Josef Land, Svalbard, Novaya Zemlya, Siberia, Alaska, Canada, Maine, Iceland and Scandinavia. Stratigraphical range: Lower Pleistocene to Holocene.

Fossil in Greenland. *Mya arenaria* Linné: Nordenskiöld (1871), Helland (1876), Kornerup (1881), Steenstrup (1883), Holst (1886), J. A. D. Jensen (1889), Bay (1896), Flint (1948), Washburn & Stuiver (1962), Lasca (1966). *Mya truncata* Linné var. *ovata* Jensen: Steenstrup (1901), Nathorst (1901), Jensen (1905b, 1917), Jensen & Harder (1910), Laursen (1944, 1950), Harder *et al.* (1949), Weidick (1972b), Kelly (1973).

Order Pholadomyoida Newell, 1965. Family Lyonsiidae Fischer, 1887. Genus *Lyonsia* Turton, 1822. Subgenus *Bentholyonsia* Habe, 1952.

Lyonsia cf. *Lyonsia* (*Bentholyonsia*) *arenosa* (Møller, 1842)

Plate 6, fig. 9

1842 *Pandorina arenosa* Møller, p. 93.

Material. Kløft II, Pátorfik: A single umbonal fragment of a left valve from tongue Sk–4 (GGU 111720).

Remarks. The sculpture on the surface of the fragment consists of radial granules, but not ribs. The growth lines are irregular. The hinge is somewhat damaged and the interior of the fragmentary valve is too badly preserved for further determination. The fragment is derived from a valve which has been about 5 mm in length and 3.7 mm in height.

The fragment can best be referred to *L.* (*B.*) *arenosa,* but the imperfect state of preservation prevents a safe determination.

Recent distribution. Panarctic, circumpolar. *L.* (*B.*) *arenosa* occurs from Svalbard, Novaya Zemlya, the Kara Sea, the Siberian Arctic Sea, the seas north of America and Ellesmere Island southward to Japan, the Aleutians, Massachusetts, North and East Iceland and West Finnmark. In West Greenland it has been found from Etah in the north to Julianehåb in the south. In East Greenland it is distributed from Danmarkshavn as the northernmost locality to south of Lindenows Fjord (Qeqertatsiaq).* Vertical range: 3 m (Novaya Zemlya) to 200 m (West Greenland).

Ecology and biology. In East Greenland the species has been found on a bottom of mud, clay, sand, gravel and stones (Ockelmann, 1958). In the larval development the pelagic stage is very short or missing (Thorson, 1936).

Fossil occurrence. North America and Scandinavia. Stratigraphical range: ?Upper Pleistocene to Holocene.

In Denmark it has been found fossil in the Upper Pleistocene *Portlandia arctica* Zone in the Skærumhede sequence in Vendsyssel (Nordmann *in* Jessen *et al.,* 1910; Petersen *in* Bahnson *et al.,* 1974).

Fossil in Greenland. *Lyonsia arenosa* (Møller): Nordenskiöld (1871), Laursen (1944, 1950), Harder *et al.* (1949).

* See footnote p. 24.

Family Periplomatidae Dall, 1895. Genus *Periploma* Schumacher, 1817.

Periploma sp.

Plate 6, figs 10–11

Material. Kløft II, Pátorfik: 11 umbonal fragments from tongue Sk–5 (GGU 111721).

Remarks. The shell is thin with a smooth surface. The characteristic hinge is well preserved in some of the fragments. The massive, spoon-like chondrophor is rather shallow and supported by a long clavicle which runs in a vertical direction on the interior of the valve.

After a discussion with W. K. Ockelmann the fragments are all referred to *Periploma* sp. Species determination is not possible, because of the imperfect state of preservation.

Recent distribution. The genus *Periploma* is widely distributed in the Pacific. In the Atlantic it is restricted to the North American east coast and is not known in European waters at the present time. It seems safe to state that the genus does not belong to the recent fauna of Greenland.

Fossil occurrence. The genus is new to the Greenland fossil fauna.

Arthropoda

Class Crustacea Pennant, 1777. Subclass Cirripedia Burmeister, 1834. Order Thoracica Darwin, 1854. Family Balanidae Leach, 1817. Genus *Balanus* da Costa, 1778. Subgenus *Balanus* da Costa, 1778.

Balanus (*Balanus*) *balanus* (Linné, 1758)

Plate 7, figs 1–3

1758 *Lepas balanus* Linné, p. 667.

Material. Kløft II, Pátorfik: 858 parietal plates and several scuta and terga from tongue Sk–4 (GGU 111720); 114 parietal plates and some scuta and terga from tongue Sk–5 (GGU 111721); 6 parietal plates from Sk–6 (GGU 111722); one parietal plate from layer Sk–8 (GGU 111724).

Remarks. Several intact shells were collected, but generally the plates were found singly (separated). Some of the parietal plates from the tongues are fragmentary.

Recent distribution. Panarctic, boreal, circumpolar, ?bipolar. *B.* (*B.*) *balanus* is common in the northern hemisphere and occurs from about 82°N southward to Kurile Islands and Puget Sound in the Pacific and Long Island Sound and the English Channel in the Atlantic. The species is distributed along the coast of West

Greenland north to 81°41′N (Nyboe Land). In East Greenland it has been found at Danmarkshavn as the northernmost locality whence it reaches to south of Lindenows Fjord (Qeqertatsiaq).* Vertical range: ?1 m (the Faeroe Islands) to about 300 m (?).

Ecology. The species seems to prefer places with comparatively strong current (Rasmussen, 1973). Poulsen (1935) pointed out that salinity, above 14–15‰, is an important factor determining the occurrence in interior Danish waters.

Fossil occurrence. Svalbard, Kolguev Island, the north coast of Russia, Siberia, Alaska, Oregon, East Canada, Iceland, Scandinavia, the British Isles and Germany. Stratigraphical range: Pliocene to Holocene.

Fossil in Greenland. *Balanus porcatus* da Costa: Helland (1876), Kornerup (1879), Steenstrup (1883), Holst (1886), Hammer (1889), J. A. D. Jensen (1889), Jensen & Harder (1910), Jensen (1917), Quervain & Mercanton (1925). *Balanus sulcatus:* Steenstrup (1881). *Balanus (Eubalanus) balanus* (Linné) Da Costa: Laursen (1944). *Balanus balanus* (Linné): Laursen (1945, 1950), Harder *et al.* (1949), Weidick (1968, 1972a, 1972b, 1973, 1975b), Kelly (1973, 1975, 1979, 1980), Blake (1975, 1977), Funder (1978).

Balanus (Balanus) crenatus Bruguière, 1789

Plate 7, figs 4–5

1789 *Balanus crenatus* Bruguière, p. 168.

Material. Kløft II, Pátorfik: 12 parietal plates from tongue Sk–4 (GGU 111720); 6 parietal plates from tongue Sk–5 (GGU 111721).

Remarks. The shells were broken and separated when collected.

Recent distribution. Panarctic, boreal, lusitanian, circumpolar. *B. (B.) crenatus* extends from the Arctic (?about 82°N) southward to Japan, California, New Jersey and the Mediterranean. In West Greenland it has been found northward to Inglefield Bugt. From East Greenland there is only one questionable record from the north-east coastal area (Stephensen, 1943). Vertical range: 0 m (several localities) to 168 m (the Faeroe Islands).

Fossil occurrence. Svalbard, Kolguev Island, the north coast of Russia, Alaska, East Canada, Iceland and Scandinavia. Stratigraphical range: Pliocene to Holocene.

Fossil in Greenland. *Balanus crenatus* Bruguière: Quervain & Mercanton (1925), Laursen (1945, 1950), Harder *et al.* (1949), Weidick (1968), Kelly (1973). *Balanus (Eubalanus) crenatus* Bruguière: Laursen (1944).

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* See footnote p. 24.

Subgenus *Chirona* Gray, 1835

Balanus (Chirona) hameri (Ascanius, 1767)

Plate 7, figs 6–7

1767 *Lepas hameri* Ascanius, p. 8.

Material. Kløft II, Pátorfik: 3 parietal plates from tongue Sk–4 (GGU 111720); 3 parietal plates from tongue Sk–5 (GGU 111721); 60 parietal plates and some scuta and terga from layer Sk–7 (GGU 111723); 22 parietal plates and some scuta and terga from layer Sk–8 (GGU 111724). The species was mainly found in the middle and upper parts of the section.

Remarks. Generally the plates were found singly (separated) in the sediment and some of the larger plates are fragmentary.

Recent distribution. Low arctic, boreal. *B.* (*C.*) *hameri* occurs, on the European side of the Atlantic, from the White Sea in the north to the English Channel in the south. The species is known from the east coast of North America from Hamilton Inlet south to North Carolina. The northern limit in West Greenland seems to be in Nordre Strømfjord. It has never been found alive in East Greenland. Vertical range: ?5 m (North-East America) to ?492 m (Iceland). The species is very seldom found at depths less than 40–50 m.

Fossil occurrence. Kolguev Island, East Canada, Iceland, Scandinavia and Germany. Stratigraphical range: ?Upper Pleistocene to Holocene.

Fossil in Greenland. *Balanus Hameri* Ascanius: Steenstrup (1883), Hammer (1889), J. A. D. Jensen (1889), Pjetursson (1898), Jensen & Harder (1910), Quervain & Mercanton (1925). *Balanus hammeri* Ascan.: Jensen (1942), Harder *et al.* (1949), Laursen (1950), Weidick (1972b, 1974), Sugden (1972), Kelly (1973, 1979). *Balanus (Chirona) hammeri* (Ascanius) Brown: Laursen (1944).

FAUNA AT PÁTORFIK

Review of the fauna

In the present survey 54 species of marine invertebrates from the Quaternary deposits in Kløft II at Pátorfik have been treated, i.e. 24 prosobranchs, 5 opisthobranchs, 22 bivalves and 3 barnacles. Other groups; foraminifera, serpulids, ostracods, decapods, bryozoans, echinoderms (ophiuroids and echinoids), fishes and mammals (a seal) were also found, but they are not dealt with in this paper.

Molluscan species previously recorded from the Pátorfik area (Laursen, 1944), but not found during the present investigation, are disregarded in the following discussion. The main reason for this is that it is not known exactly in what part of the deposits most of them were collected.

In this investigation 10 species are recorded from the Quaternary of Greenland for the first time:

Lacuna (Epheria) cf. *L. (E.) crassior*
Putilla (Parvisetia) globula
Alvania (Alvania) sp.
Oenopota angulosa
Toledonia limnaeoides
Diaphana minuta
Spiratella retroversa
Portlandia (Yoldiella) lucida
Portlandia (Yoldiella) fraterna
Periploma sp.

In addition 5 species have not been recorded earlier from the Pátorfik beds:

Margarites (Margarites) helicinus
Margarites (Margarites) groenlandicus
Margarites (Pupillaria) cinereus
Lacuna (Epheria) vincta
cf. *Lyonsia (Bentholyonsia) arenosa*

With the exception of *Alvania (Alvania) patorfikensis* and probably *Alvania (Alvania)* sp. all the species collected in the Pátorfik deposits in 1968 are living today and the majority are still found in West Greenland waters. In addition to the *Alvania* species only *Oenopota angulosa, Panopea (Panomya) norvegica, Cyrtodaria siliqua* and the *Periploma* species are missing in the present West Greenland fauna, although *P. abyssorum* Bush, 1893 has been recorded from north of Baffin Island (Thorson, 1951).

The fauna of the Pátorfik deposits has many species in common with the recent Icelandic fauna. About 76 per cent of the gastropod species, 82 per cent of the bivalve species and all the barnacle species are known to live around Iceland today. *Cyrtodaria siliqua* and the genus *Periploma* are restricted to the West Atlantic and have not been recorded from Greenland or Europe. Thus, the fauna consists predominantly of species known to live in the North Atlantic east of Greenland, mingled with a few, but distinct, West Atlantic species.

The Pátorfik fauna differs significantly from all marine Quaternary faunas in Greenland known so far. The difference may be seen in the infauna elements as well as those belonging to the epifauna. The high frequency of individuals belonging to the genus *Oenopota* is remarkable and, moreover, species such as *Alvania (Alvania) patorfikensis, Amaura candida, Toledonia limnaeoides, Portlandia (Yoldiella) lenticula* and *Cyrtodaria siliqua,* all of common occurrence in the Pátorfik beds, have not been found elsewhere in Quaternary deposits in Greenland.

Table 7. Recent geographical distribution of the molluscs and barnacles at Pátorfik

Species	LUSI-TANIAN	BOREAL Low	BOREAL Mid	BOREAL High	ARCTIC Low	ARCTIC Mid	ARCTIC High
Lepeta (Lepeta) caeca		x	x	x	x	x	x
Margarites (Margarites) helicinus		x	x	x	x	x	x
Margarites (Margarites) groenlandicus		x	x	x	x	x	x
Margarites (Pupillaria) cinereus			x	x	x	x	x
Lacuna (Epheria) vincta	x	x	x	x	x	x	
Lacuna (Epheria) crassior	x	x	x	x	x	x	x
Putilla (Parvisetia) globula					x	x	x
Alvania (Alvania) patorfikensis							
Alvania (Alvania) sp.							
Alvania (Frigidoalvania) janmayeni					x	x	x
Tachyrhynchus erosus					x	x	x
Natica (Lunatia) pallida		x	x	x	x	x	x
Natica (Tectonatica) affinis	x	x	x	x	x	x	x
Trophon (Boreotrophon) truncatus		x	x	x	x	x	x
Trophon (Boreotrophon) clathratus		x	x	x	x	x	x
Colus sp.							
Neptunea (Neptunea) despecta	x	x	x	x	x	x	x
Buccinum undatum	x	x	x	x	x	x	x
Buccinum groenlandicum					x	x	x
Oenopota bicarinata		x	x	x	x	x	x
Oenopota decussata				x	x	x	x
Oenopota trevelliana	x	x	x	x	x	x	x
Oenopota angulosa					x	x	x
Oenopota nobilis		x	x	x	x	x	x
Amaura candida					x	x	x
Toledonia limnaeoides					x	x	x
Diaphana minuta	x	x	x	x	x	x	x
Retusa (Retusa) obtusa var. pertenuis		x	x	x	x	x	x
Spiratella retroversa		x	x	x	x	x	x
Nucula (Leionucula) tenuis expansa		x	x	x	x	x	x
Nuculana (Nuculana) pernula		x	x	x	x	x	x
Portlandia (Yoldiella) lucida		x	x	x	x	x	
Portlandia (Yoldiella) lenticula		x	x	x	x	x	x
Portlandia (Yoldiella) fraterna		x	x	x	x	x	x
Mytilus (Mytilus) edulis	x	x	x	x	x	x	
Chlamys (Chlamys) islandica			x	x	x	x	
Palliolum (Delectopecten) greenlandicum					x	x	x
Tridonta (Tridonta) borealis		x	x	x	x	x	x
Tridonta (Tridonta) elliptica		x	x	x	x	x	x
Tridonta (Nicania) montagui		x	x	x	x	x	x
Axinopsida orbiculata				x	x	x	x
Serripes groenlandicus				x	x	x	x
Clinocardium ciliatum				x	x	x	x
Macoma (Macoma) calcarea			x	x	x	x	x
Hiatella (Hiatella) arctica	x	x	x	x	x	x	x
Panopea (Panomya) norvegica		x	x	x			
Cyrtodaria siliqua			x	x			
Mya (Mya) truncata		x	x	x	x	x	x
Mya (Mya) pseudoarenaria					x	x	x
Lyonsia (Bentholyonsia) arenosa					x	x	x
Periploma sp.							
Balanus (Balanus) balanus		x	x	x	x	x	x
Balanus (Balanus) crenatus	x	x	x	x	x	x	x
Balanus (Chirona) hameri		x	x	x	x		

Zoogeography and water temperatures

From table 7, showing the recent zoogeographical distribution of the molluscs and barnacles found at Pátorfik, it appears that ten species are distributed in the arctic fauna region only, while seven species do not extend into the high arctic subregion. One species is of low arctic, boreal distribution and two species do not extend northward into the arctic region and must be characterized as boreal. On balance of the evidence from the present day distribution it seems reasonable to assume that the water temperatures at the time when the Pátorfik deposits were formed were similar to those of the boundary between the arctic and boreal regions today (cf. fig. 10).

It is evident from comparison of the fauna from the Pátorfik deposits with the recent fauna in the Umanak Fjord that some of the species found in the beds no longer live in the fjord. *Panopea* (*Panomya*) *norvegica* and *Balanus* (*Chirona*) *hameri* are of particular interest as the former has not been found living in Greenland today, whereas the northern limit for *B.* (*C.*) *hameri* in West Greenland at present seems to be in Nordre Strømfjord (between 67° and 68°N). As both species are rather thermophilic the abundance of *P.* (*P.*) *norvegica* in the lower and *B.* (*C.*) *hameri* in the upper part of the section in Kløft II indicates higher water temperatures than at present in Umanak Fjord, adding to the conclusion reached above.

It might be useful to regard the zoogeographical significance of the Pátorfik fauna from another point of view. It has been shown that arctic prosobranchs and bivalves have a strong tendency to reproduce without a pelagic larval stage (Thorson, 1941; Ockelmann, 1958). Furthermore, the percentage distribution of species with a pelagic and those with a non-pelagic larval development in Denmark, the Faeroe Islands, southern Iceland, western Iceland, north-western Iceland, northern Iceland, eastern Iceland and northern East Greenland show an explicit regularity in decreasing pelagic larval development from south to north. The mode of reproduction is known in 13 of the 24 prosobranchs found in the Pátorfik beds and of these only two have a pelagic larval stage. In the case of the bivalves, reproduction is known in 17 of the 22 species seven of which have a pelagic larval development. These figures are most closely related to those demonstrated by Thorson (1941) and Ockelmann (1958) for north-western Iceland close to the boundary between the arctic and boreal regions and support the transitional character of the fauna.

The assemblages found in the Pátorfik deposits show no gradual changes corresponding to increase or decrease in water temperatures and it appears impossible to establish a zonation based on faunal changes reflecting such fluctuations. This is not surprising if the lower part of the marine sequence represents the upper part of a prodelta, whereas the middle and upper parts are apparently formed contemporaneously on a delta slope.

Laursen (1944) did not find *Mytilus* (*Mytilus*) *edulis* in the lower part of the

Pátorfik beds and suggested that it immigrated to Umanak Fjord owing to a rise of the water temperatures at the time when 'the upper sand beds' at Pátorfik were deposited. Since the present author found this species, exclusively large specimens, in the lower part of the section in Kløft II, Laursen's conclusion seems unwarranted.

Water depth

The minimal water depths indicated by the vertical range of the molluscs and barnacles vary from 0 m (several species) to ?17–25 m (*Amaura candida*) or 28–47 m (*Portlandia* (*Yoldiella*) *lucida*). The maximum depths range from ?80 m (*Mya* (*Mya*) *pseudoarenaria*) or 80–120 m (*Toledonia limnaeoides*) to 2900 m (*Portlandia* (*Yoldiella*) *fraterna*). *Panopea* (*Panomya*) *norvegica,* of common occurrence in the lower part of the section in Kløft II, does not at present live in water depths less than about 17 m. *Oenopota nobilis, Toledonia limnaeoides* and *Retusa* (*Retusa*) *obtusa* var. *pertenuis* are all abundant in the two tongues Sk–4 (GGU 111720) and Sk–5 (GGU 111721), but at present these species live at depths greater than 5 m. Moreover, *Balanus* (*Chirona*) *hameri* which is rather common in the upper part of the section is most commonly found in water deeper than 40–50 m, although it is occasionally found up to 5 m.

Definite littoral (intertidal) species were not met with in the fauna. However, two large specimens of *Mytilus* (*Mytilus*) *edulis* were found in the sandy mud in the lower part of the section, but it should be borne in mind that the vertical range of the species is 0–180 m, although it is most commonly found in the littoral zone. Furthermore, the specimens in question could have been carried out to a greater depth from that zone.

The vertical range of the species indicates that the Pátorfik beds were being formed outside the littoral zone (cf. Laursen, 1944). The lower part of the deposits appears to have been laid down at somewhat greater depths than were the middle and upper parts, which is in accordance with the described facies relations.

Salinity

The exact degree of salinity in Umanak Fjord at the time when the Pátorfik beds were deposited is not known. There is nothing to indicate abnormality in the salinity and apparently it did not deviate significantly from what it is today. All the assemblages are marine and enclose no brackish species. Although the euryhaline *Macoma* (*Macoma*) *calcarea* dominates in the uppermost fossiliferous layer (Sk–8, GGU 111724) the assemblage as a whole does not deviate significantly from typically marine assemblages. Nothing indicates decreasing salinity upward to the uppermost layers. This may also add to the conclusion reached above that these layers are not deposited on a subaqueous delta platform (topset).

Ecological assemblages and bottom conditions

The Pátorfik fauna comprises epifaunal and infaunal species. Species belonging to the infauna are common in all the samples, whereas the epifaunal species were mainly found in the tongues Sk–4 (GGU 111720) and Sk–5 (GGU 111721) and in the upper gravel layers Sk–7 (GGU 111723) and Sk–8 (GGU 111724). Thus, the epifaunal species were mainly found in the assemblages in the middle and upper parts of the section, i.e. the delta slope sediments.

The molluscs and barnacles collected in Kløft II can be referred to four ecological assemblages:

I. Assemblage dominated by infaunal benthos, essentially burrowing bivalves, with intermediate number of species, and epifaunal individuals less than 5 per cent. This includes Sk–1 (GGU 111717), Sk–2 (GGU 111718), Sk–3 (GGU 111719) and Sk–6 (GGU 111722).
II. Assemblage with both infaunal and epifaunal species, including a large number of species and individuals. The tongues Sk–4 and Sk–5 belong to this category.
III. Assemblage dominated by infaunal benthos, essentially burrowing bivalves, with rather few species, but epifaunal individuals exceeding 5 per cent. This contains Sk–7 and Sk–8.
IV. Pelagic molluscs. Only found in tongue Sk–5.

Assemblage I consists mainly of shallow and deep burrowing bivalves typically found in muds or sandy mud, i.e. sediment indicating relatively low energy environments. The infaunal species are members of the recent *Macoma calcarea* community which, according to Thorson (1957), is widely distributed in arctic seas and extends southward to Peter the Great Bay (Japan Sea), northern Norway and the Faeroe Islands. It inhabits a mixed bottom at depths from 0–4 m to 50–60 m.

A few epifaunal species were met with in this assemblage. The occurrence of *Mytilus* (*Mytilus*) *edulis* is already mentioned, the other species include *Colus* sp., *Neptunea* (*Neptunea*) *despecta, Buccinum undatum, Chlamys* (*Chlamys*) *islandica* and *Balanus* (*Balanus*) *balanus.* They occur in the subtidal epifauna on granular sediments, stones or other benthos of the level sea bottom. As already hinted, coarser material such as pebbles, cobbles and boulders was scattered over the soft bottom, probably deposited from debris-loaded icebergs.

Thick-shelled individuals dominate in this category. The ratio between thick- and thin-shelled molluscan individuals vary from 1.69:1.00 to 8.68:1.00. The shells are generally large and only a few juvenile specimens were found.

Assemblage II shows the widest species diversity, including infaunal and epifaunal species. The infaunal benthos consists mainly of shallow burrowing gastropods and shallow and deep burrowing bivalves in sand, i.e. sediment indicating higher energy environments than the sediment inhabited by assemblage I. The majority of the species and individuals are members of the recent *Macoma calcarea* community. About 99 per cent of the bivalve individuals found in tongue Sk–4 are known to live in this community and 96 per cent of those in tongue Sk–5.

The epifaunal species belong to the subtidal epifauna which lives attached either to the vegetation or coarser bottom constituents as stones and other benthos of the level sea bottom. The most prominent constituents of the epifauna are juvenile specimens of *Mya (Mya) truncata* and *Hiatella (Hiatella) arctica.* These bivalves together with the *Margarites* species are characteristic members in the epifaunas of the *Desmarestia* and *Fucus* vegetation which Thorson (1933, 1934) described from East Greenland at depths between 3 and 35 m. The sand bottom seems to be in favour of the *Fucus* epifauna, but *Desmarestia* lives almost exclusively on mud or clay (Thorson, 1933; Bertelsen, 1937).

The three *Balanus* species represent the epifauna attached to stones or other benthos of the level sea bottom and *Hiatella (Hiatella) arctica* is also a frequent member in this type of epifauna.

Thin-shelled individuals dominate among the bivalves in this assemblage. There are many juvenile and small shells as well as large ones.

Assemblage III consists mainly of shallow and deep burrowing bivalves in gravel, i.e. sediment appropriate to a high energy environment. The infaunal species are all members of the recent *Macoma calcarea* community.

The most prominent constituents of the epifauna are the bivalve *Palliolum (Delectopecten) greenlandicum* and the two *Balanus* species. These are species representing the epifauna attached to stones or other benthos of the level bottom.

Thin-shelled individuals dominate in this assemblage. The shells are generally large and only a few juvenile specimens were found.

Assemblage IV includes only one species, the pelagic opisthobranch *Spiratella retroversa,* found in two specimens in tongue Sk–5. The species is small (0.7 mm high) and very thin-shelled.

The fossil assemblages

In assemblage I several bivalves were observed in their life position. Numerous specimens have paired valves and the ratio of paired and single valves (articulated/disarticulated) is high. There are 638 specimens with paired valves, but only 55 single valves of the heterodont *Tridonta (Tridonta) elliptica,* and 50 specimens with paired valves and only 9 single valves of the desmodont *Panopea (Panomya) norvegica.* This indicates a low degree of reworking, and the assemblage seems consequently to compare closely with the living community (Fagerstrom, 1964; Craig, 1967).

However, the size frequency distribution is remarkable as juvenile specimens are rare. *Tridonta (Tridonta) elliptica* in Sk–6 (fig. 20) has bell-shaped distribution, and *Cyrtodaria siliqua* in Sk–1, Sk–2 and Sk–3 (fig. 23) has even a slightly left-skewed distribution. There is nothing to indicate that size selective removal of small shells by current transport (in this low energy environment), dissolution or crushing has taken place in this category. The shells of the various species are of quite different mean size, and generally they are better preserved the smaller they are since dissolution only occurs in large shells. The shells may be crushed, but they are almost exclusively found with the fragments *in situ,* which may indicate that crushing by compaction of the sediment or by post-depositional slumpings was more important than preburial crushing. Therefore a low juvenile mortality seems more important than post-mortal factors.

Growth ring analysis (fig. 22) seems to show a considerably greater initial growth rate of the animals in assemblage I (Sk–6) than in assemblage II (Sk–4) which have a quite different size frequency distribution. Together with a small recruitment, this may explain a low juvenile mortality in assemblage I, as a greater initial growth rate allows a faster passage of the vulnerable early stages (cf. Surlyk, 1972). This may be a function of lower competition in the muddy bottom (prodelta), inhabited by scattered individuals.

In assemblage II no bivalves were observed in their life position. The sand in tongues Sk–4 and Sk–5 appears as channel fills without high-angle cross-bedding, but low-angle tabular and wedge-planar cross-stratification may represent initial dip and convergence on channel margins. Small scale slumping structures occur here and there, especially where sand is replaced by alternating silt and gravel. This indicates a short distance down-slope transport of sediment with shells on a delta slope.

The assemblage contains no ecologically incompatible individuals, and the faunal diversity is very high. As was the case in assemblage I there are no signs of size selective removal of shells by current transport or dissolution, and the shells are better preserved the smaller they are. However, some size selective crushing has been observed, e.g. in the case of the bivalves *Axinopsida orbiculata, Serripes groenlandicus* and *Clinocardium ciliatum,* where the smaller shells are more frequently intact than the larger ones. Furthermore, paired valves are proportionally more frequent in small specimens (fig. 21). However, the size frequency distribution of the umbonal fragments of *Axinopsida orbiculata,* based on the length of the hinge line, seems also right-skewed, apparently with the mode in the same position as for the paired and single valves. Therefore the crushing is not regarded as having significantly influenced the size frequency distribution of *A. orbiculata* in Sk–4. The crushed shells were sometimes found with the fragments *in situ.* Therefore, as was the case in assemblage I, compaction of the sediment or post-depositional slumpings may be more important than preburial crushing. Small scale down slope transport may explain why no bivalves were found in their life position.

The ratios of whole to broken shells and paired to single valves varies significantly in this assemblage. Generally there are many crushed shells and single valves. However, in Sk–4 there were found 113 specimens with paired valves, 18 single valves and 37 umbonal fragments of the taxodont *Portlandia* (*Yoldiella*) *lenticula* and 31 specimens with paired valves, 19 single valves and 12 umbonal fragments of the thin-shelled and fragile dysodont *Palliolum (Delectopecten) greenlandicum*. It must be emphasized that the ratio of opposite valves (left and right), whole or crushed, is close to 1 for all the bivalves found.

Size frequency curves have been constructed for three common gastropod species and one common bivalve species in assemblage II (figs 11, 12, 16, 18, 21). These curves show strong skewness to the right, and secondary peaks seem rare. As size selective current transport, dissolution or crushing did not remove certain size classes, the right-skewed distribution may be indicative of a high juvenile mortality. As already stated, the initial growth was apparently slower in this assemblage than in assemblage I (fig. 22) and this of course influences the size mortality pattern. The lower initial growth rate may refer to considerable competition, indicated by the high number of species and individuals, crowding, in the samples.

Assemblage II is therefore regarded as adequately representing a living community that has been subjected to only small scale down-slope transport within the sediment and post-depositional crushing.

In assemblage III (Sk–7 and Sk–8) some of the bivalves were found in their life position. The shells are generally crushed, but usually with paired valves and the fragments *in situ*. The ratio of opposite valves is close to 1.

The fragmentary state of the material does not allow size frequency analysis, but only a few juvenile specimens were found. The dominance of the thin-shelled and light epifaunal bivalve *Palliolum (Delectopecten) greenlandicum* in Sk–7 (27.86 per cent of the individuals) does not indicate a removal of small shells by currents. Therefore, as there are no signs of size selective dissolution or crushing, the scarcity of small individuals may indicate a low juvenile mortality in the gravel bottom with rather few and scattered individuals. Thus, the author is inclined to consider that the fossils in Sk–7 represent a living community.

Apparently Sk–8 represents a living community subjected to selective removal of shells. The small and light epifaunal species, frequent in Sk–7, are almost lacking, only one valve of *Palliolum (Delectopecten) greenlandicum* was found. Of the other epifaunal constituents, only thick and heavy plates of *Balanus* were found. This may indicate removal of small shells by currents in a high energy environment, although there is no megascopic evidence for strong currents during deposition. However, a low juvenile mortality might as well have influenced the size distribution.

Encrusting epifauna and borings

The most common encrusting epifaunal organisms are serpulids, bryozoans and foraminifera. In assemblage I encrusting species are only rarely found, since it is dominated by infaunal bivalves and apparently does not contain suitable substrates for such organisms. In assemblage II encrusting organisms are sometimes abundant, and in a few cases the shells are almost covered with overgrowth. Generally the encrusting epifauna is on the exterior surface of the bivalves, mainly concentrated on the central part. However, in some cases it was also found on the interior side, which emphasizes attachment after the animal's death. Orientation of epifauna, relative to inhalant current, was not observed. Therefore it is not possible to decide whether the epifauna was attached to the shells while the animals were still alive, although it is very likely. In assemblage II encrusting epifauna was also found on the infaunal species, but they are not *in situ* and by small scale down-slope transport within the sediment some of them apparently become suitable substrates for encrusting organisms. In assemblage III encrusting organisms seem absent. This might be due to a rather high rate of sedimentation and rapid burial in the gravel bottom (cf. Surlyk, 1972).

Only gastropod borings have been found with certainty in the material. The holes were found in assemblages I–III, but only in a few shells. The holes are funnel-shaped (plate 1, fig. 7), which indicates boring naticid gastropods (Carriker *et al.,* 1963). On the whole, predation by gastropods may be regarded as insignificant.

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Plates

Plate 1

Fig. 1A. *Lepeta (Lepeta) caeca* (Müller). MGUH 14794, from GGU 111720. Specimen from tongue Sk–4, Kløft II, Pátorfik. × 8.

Fig. 1B. *Lepeta (Lepeta) caeca* (Müller). Enlarged part of the surface of the same specimen. × 33.

Fig. 2. *Margarites (Margarites)* cf. *helicinus* (Phipps). MGUH 14795, from GGU 111721. Fragmentary specimen from tongue Sk–5, Kløft II, Pátorfik. × 17.

Fig. 3. *Margarites (Margarites) groenlandicus* (Chemnitz). MGUH 14796, from GGU 111721. Specimen from tongue Sk–5, Kløft II, Pátorfik. × 4.

Fig. 4. *Margarites (Pupillaria) cinereus* (Couthouy). MGUH 14797, from GGU 111720. Specimen from tongue Sk–4, Kløft II, Pátorfik. × 4.

Fig. 5A–C. *Margarites (Pupillaria) cinereus* (Couthouy). MGUH 14798, from GGU 111720. Juvenile specimen from tongue Sk–4, Kløft II, Pátorfik. × 17.

Fig. 6. *Lacuna (Epheria) vincta* (Montagu). MGUH 14799, from GGU 111720. Fragmentary specimen from tongue Sk–4, Kløft II, Pátorfik. × 8.

Fig. 7. *Lacuna (Epheria)* cf. *crassior* (Montagu). MGUH 14800, from GGU 111721. Fragmentary specimen from tongue Sk–5, Kløft II, Pátorfik. × 4.

Fig. 8A–B. *Putilla (Parvisetia) globula* (Møller). MGUH 14801, from GGU 111720. Specimen from tongue Sk–4, Kløft II, Pátorfik. × 17.

Fig. 9. *Alvania (Alvania) patorfikensis* Laursen. MGUH 14802, from GGU 111720. Specimen from tongue Sk–4, Kløft II, Pátorfik. × 8.

Fig. 10A–B. *Alvania (Alvania) patorfikensis* Laursen. MGUH 14803, from GGU 111720. Juvenile specimen from tongue Sk–4, Kløft II, Pátorfik. × 17.

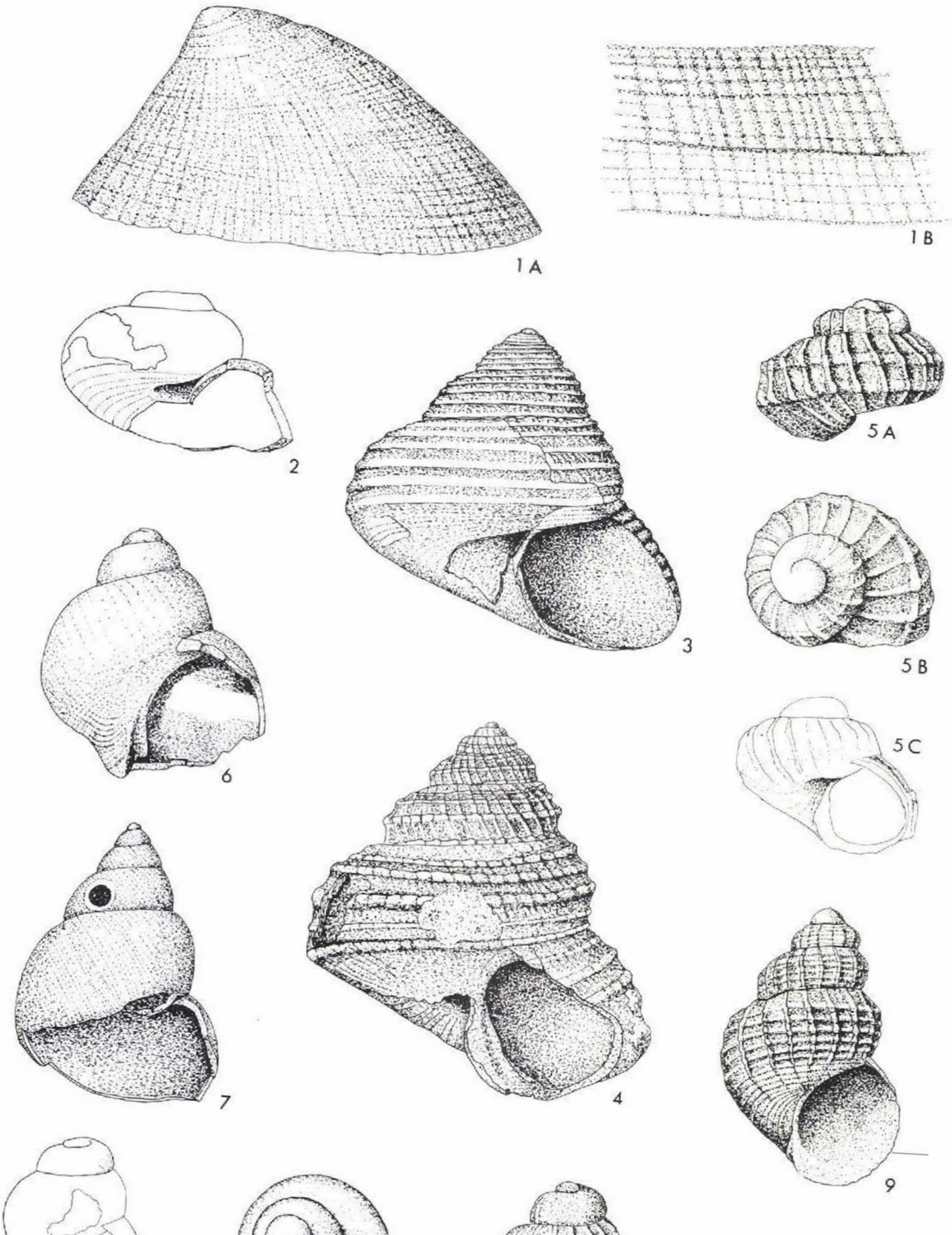
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Plate 2

Fig. 1. *Alvania (Alvania)* sp. MGUH 14804, from GGU 111720. Specimen from tongue Sk–4, Kløft II, Pátorfik. × 8.

Fig. 2. *Alvania (Frigidoalvania) janmayeni* (Friele). MGUH 14805, from GGU 111720. Fragmentary specimen from tongue Sk–4, Kløft II, Pátorfik. × 8.

Fig. 3. *Tachyrhynchus erosus* (Couthouy). MGUH 14806, from GGU 111720. Juvenile specimen from tongue Sk–4, Kløft II, Pátorfik. × 17.

Fig. 4. *Natica (Lunatia) pallida* Broderip & Sowerby. MGUH 14807, from GGU 111721. Specimen from tongue Sk–5, Kløft II, Pátorfik. × 1.

Fig. 5. *Natica (Tectonatica) affinis* (Gmelin). MGUH 14808, from GGU 111721. Specimen from tongue Sk–5, Kløft II, Pátorfik. × 4.

Fig. 6A–B. *Trophon (Boreotrophon) truncatus* (Ström). MGUH 14809, from GGU 111720. Juvenile specimen from tongue Sk–4, Kløft II, Pátorfik. × 17.

Fig. 7. *Trophon (Boreotrophon) clathratus* (Linné). MGUH 14810, from GGU 111720. Specimen from tongue Sk–4, Kløft II, Pátorfik. × 4.

Fig. 8. *Colus* sp. MGUH 14811, from GGU 111718. Fragmentary specimen from Sk–2, Kløft II, Pátorfik. × 1.

Fig. 9. *Neptunea (Neptunea) despecta* (Linné). MGUH 14812, from GGU 111718. Fragment from Sk–2, Kløft II, Pátorfik. × 1.

Fig. 10. *Neptunea (Neptunea) despecta* (Linné). MGUH 14813, from GGU 111718. Fragment from Sk–2, Kløft II, Pátorfik. × 1.

Fig. 11. *Buccinum undatum* Linné. MGUH 14814, from GGU 111720. Fragmentary specimen from tongue Sk–4, Kløft II, Pátorfik. × 4.

Fig. 12. *Buccinum* cf. *groenlandicum* Chemnitz. MGUH 14815, from GGU 111720. Fragmentary specimen from tongue Sk–4, Kløft II, Pátorfik. × 17.

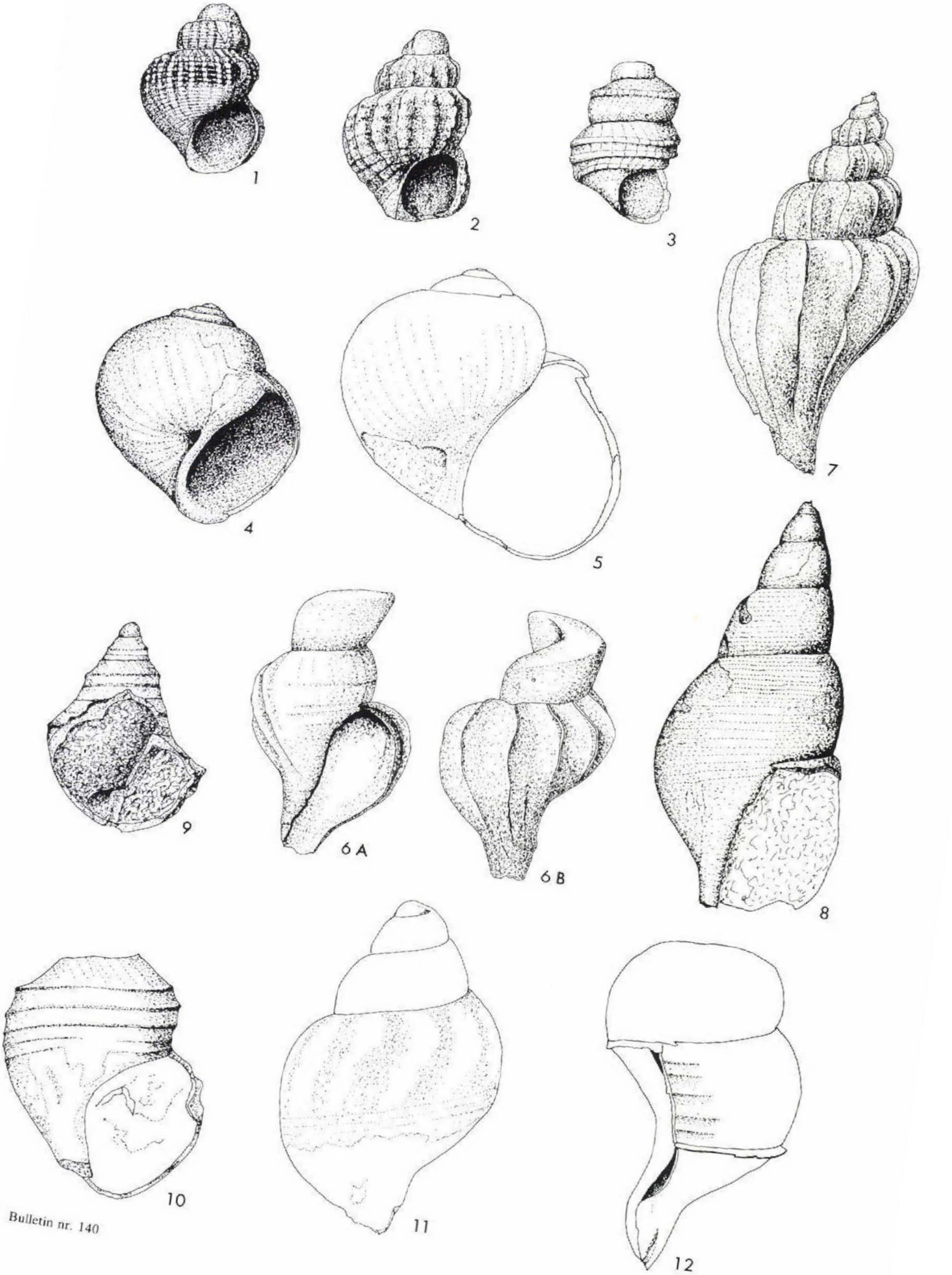
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Plate 3

Fig. 1. *Oenopota bicarinata* (Couthouy). MGUH 14816, from GGU 111720. Juvenile specimen from tongue Sk–4, Kløft II, Pátorfik. × 17.

Fig. 2. *Oenopota bicarinata* (Couthouy). MGUH 14817, from GGU 111720. Juvenile specimen from tongue Sk–4, Kløft II, Pátorfik. × 17.

Fig. 3. *Oenopota bicarinata* (Couthouy). MGUH 14818, from GGU 111720. Specimen from tongue Sk–4, Kløft II, Pátorfik. × 8.

Fig. 4. *Oenopota bicarinata* (Couthouy) var. *violacea* (Mighels & Adams). MGUH 14819, from GGU 111720. Juvenile specimen from tongue Sk–4, Kløft II, Pátorfik. × 17.

Fig. 5. *Oenopota bicarinata* (Couthouy) var. *violacea* (Mighels & Adams). MGUH 14820, from GGU 111720. Juvenile specimen from tongue Sk–4, Kløft II, Pátorfik. × 17.

Fig. 6. *Oenopota bicarinata* (Couthouy) var. *violacea* (Mighels & Adams). MGUH 14821, from GGU 111720. Specimen from tongue Sk–4, Kløft II, Pátorfik. × 8.

Fig. 7A–B. *Oenopota decussata* (Couthouy). MGUH 14822, from GGU 111720. Specimen from tongue Sk–4, Kløft II, Pátorfik. × 17.

Fig. 8A–C. *Oenopota decussata* (Couthouy). MGUH 14823, from GGU 111720. Juvenile specimen from tongue Sk–4, Kløft II, Pátorfik. × 17.

Fig. 9. *Oenopota trevelliana* (Turton). MGUH 14824, from GGU 111720. Specimen from tongue Sk–4, Kløft II, Pátorfik. × 8.

Fig. 10. *Oenopota angulosa* (Sars). MGUH 14825, from GGU 111720. Specimen from tongue Sk–4, Kløft II, Pátorfik. × 8.

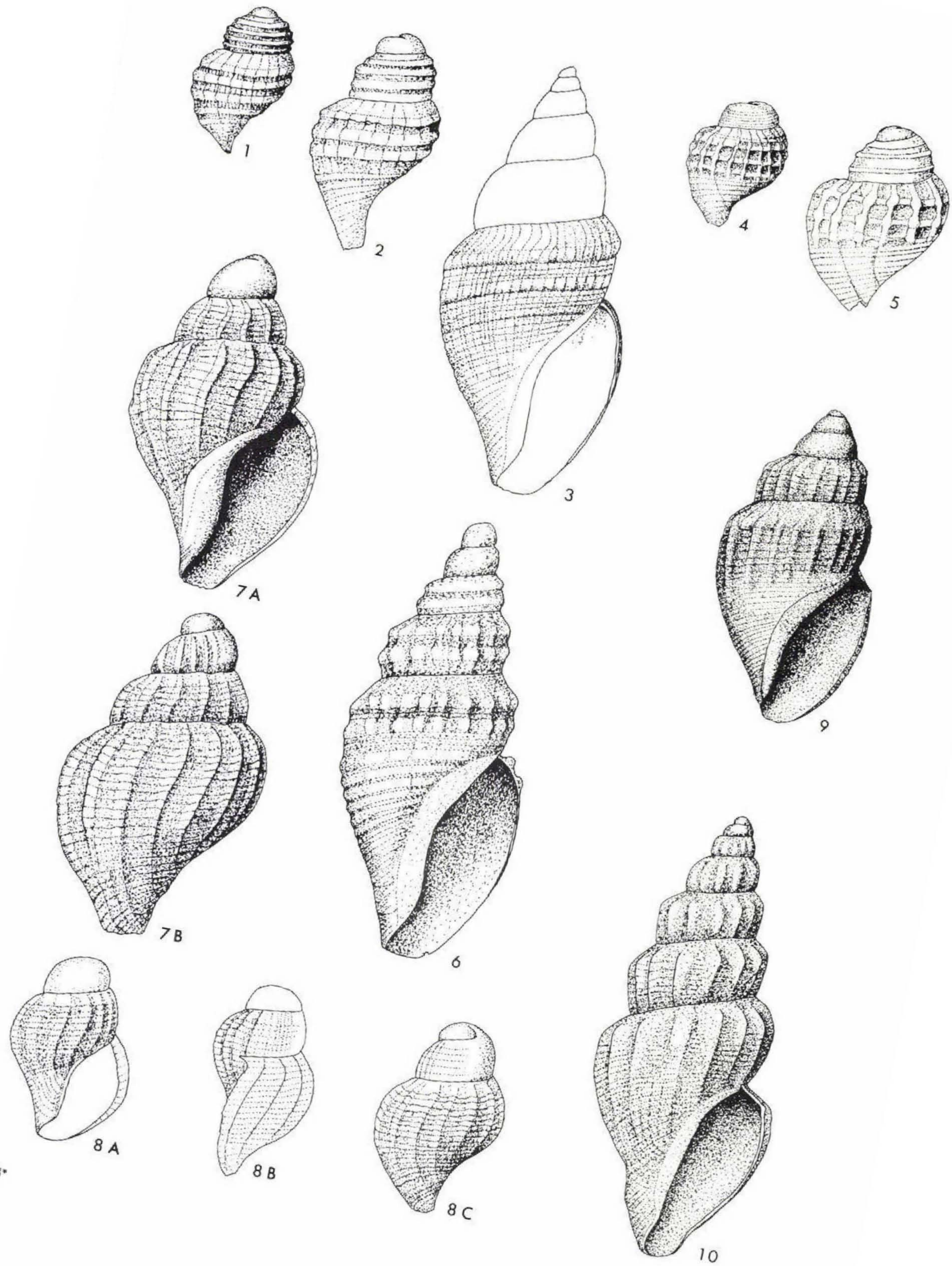

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Plate 4

Fig. 1. *Oenopota nobilis* (Møller). MGUH 14826, from GGU 111720. Juvenile specimen from tongue Sk–4, Kløft II, Pátorfik. × 17.

Fig. 2. *Oenopota nobilis* (Møller). MGUH 14827, from GGU 111720. Specimen from tongue Sk–4, Kløft II, Pátorfik. × 8.

Fig. 3. *Oenopota nobilis* (Møller). MGUH 14828, from GGU 111720. Juvenile specimen from tongue Sk–4, Kløft II, Pátorfik. × 17.

Fig. 4. *Oenopota nobilis* (Møller) var. *clathrata* (Friele). MGUH 14829, from GGU 111720. Specimen from tongue Sk–4, Kløft II, Pátorfik. × 8.

Fig. 5A–C. *Amaura candida* (Møller). MGUH 14830, from GGU 111720. Specimen from tongue Sk–4, Kløft II, Pátorfik. × 4.

Fig. 6. *Toledonia limnaeoides* (Odhner). MGUH 14831, from GGU 111720. Specimen from tongue Sk–4, Kløft II, Pátorfik. × 8.

Fig. 7. *Toledonia limnaeoides* (Odhner). MGUH 14832, from GGU 111720. Specimen showing the top of the spire, with the oblique protoconch axis, from tongue Sk–4, Kløft II, Pátorfik. × 17.

Fig. 8. *Diaphana minuta* Brown. MGUH 14833, from GGU 111720. Specimen from tongue Sk–4, Kløft II, Pátorfik. × 17.

Fig. 9A–B. *Retusa* (*Retusa*) *obtusa* (Montagu) var. *pertenuis* (Mighels). MGUH 14834, from GGU 111720. Specimen from tongue Sk–4, Kløft II, Pátorfik. × 17.

Fig. 10. *Cylichna occulta occulta* (Mighels) var. *scalpta* (Reeve). MGUH 14835, from GGU 111725. Specimen from Kûtsiaq. × 4.

Fig. 11A–B. *Spiratella retroversa* (Fleming). MGUH 14836, from GGU 111721. Specimen from tongue Sk–5, Kløft II, Pátorfik. × 33.

Fig. 12A–B. *Nucula* (*Leionucula*) *tenuis expansa* Reeve. MGUH 14837, from GGU 111721. Left valve from tongue Sk–5, Kløft II, Pátorfik. × 4.

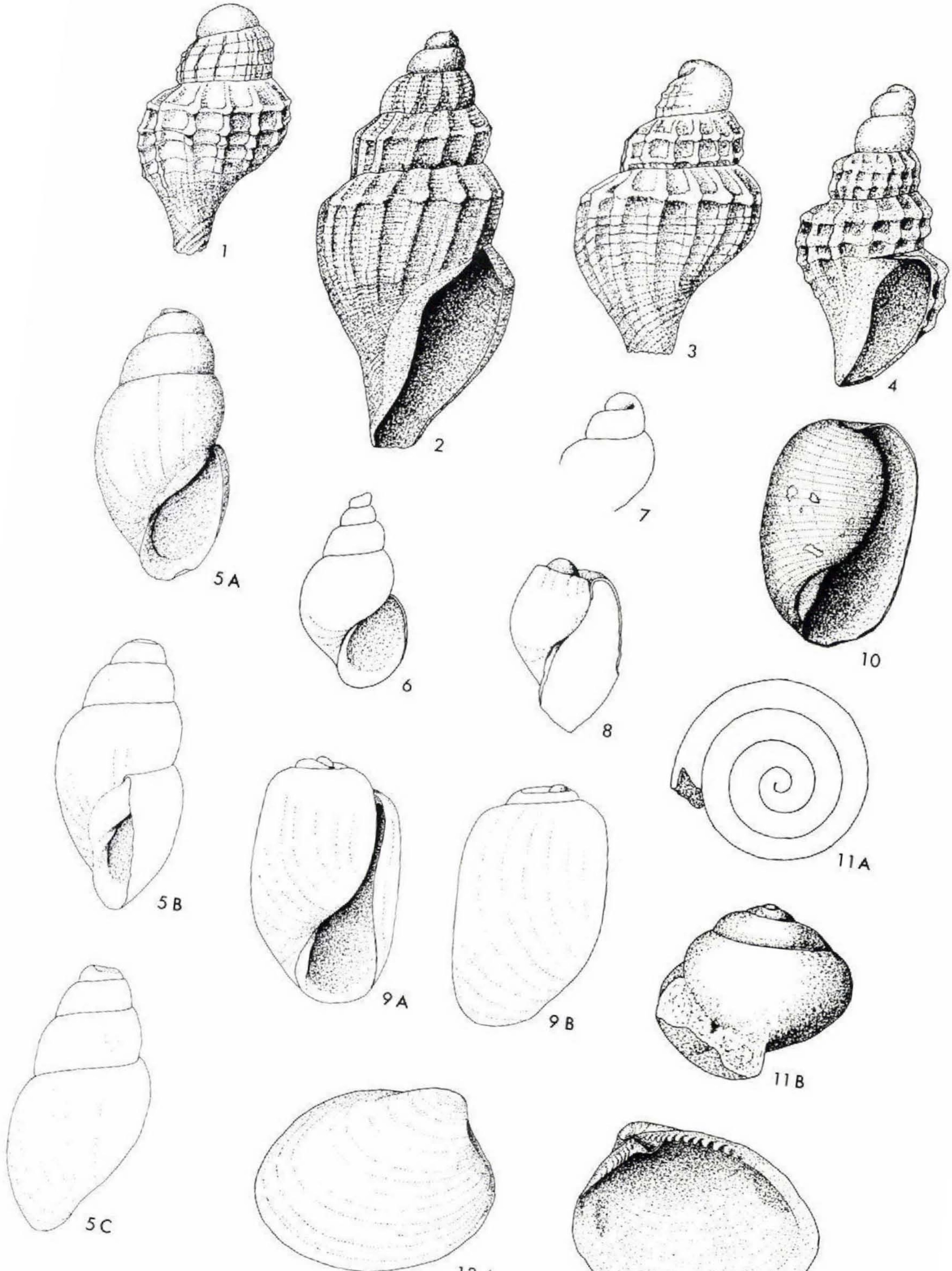
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Plate 5

Fig. 1. *Nucula (Leionucula) tenuis expansa* Reeve. MGUH 14838, from GGU 111720. Dorsal view of specimen with paired valves from tongue Sk–4, Kløft II, Pátorfik. × 4.

Fig. 2A–B. *Nuculana (Nuculana) pernula buccata* (Møller). MGUH 14839, from GGU 111720. Left valve from tongue Sk–4, Kløft II, Pátorfik. × 4.

Fig. 3. *Nuculana (Nuculana) pernula buccata* (Møller). MGUH 14840, from GGU 111720. Dorsal view of specimen with paired valves from tongue Sk–4, Kløft II, Pátorfik. × 4.

Fig. 4A–B. *Portlandia (Yoldiella) lucida* (Lovén). MGUH 14841, from GGU 111720. Left valve from tongue Sk–4, Kløft II, Pátorfik. × 17.

Fig. 5. *Portlandia (Yoldiella) lenticula* (Møller). MGUH 14842, from GGU 111720. Left valve from tongue Sk–4, Kløft II, Pátorfik. × 8.

Fig. 6. *Portlandia (Yoldiella) fraterna* (Verrill & Bush). MGUH 14843, from GGU 111720. Dorsal view of specimen with paired valves from tongue Sk–4, Kløft II, Pátorfik. × 17.

Fig. 7A–B. *Portlandia (Yoldiella) fraterna* (Verrill & Bush). MGUH 14844, from GGU 111720. Left valve from tongue Sk–4, Kløft II, Pátorfik. × 17.

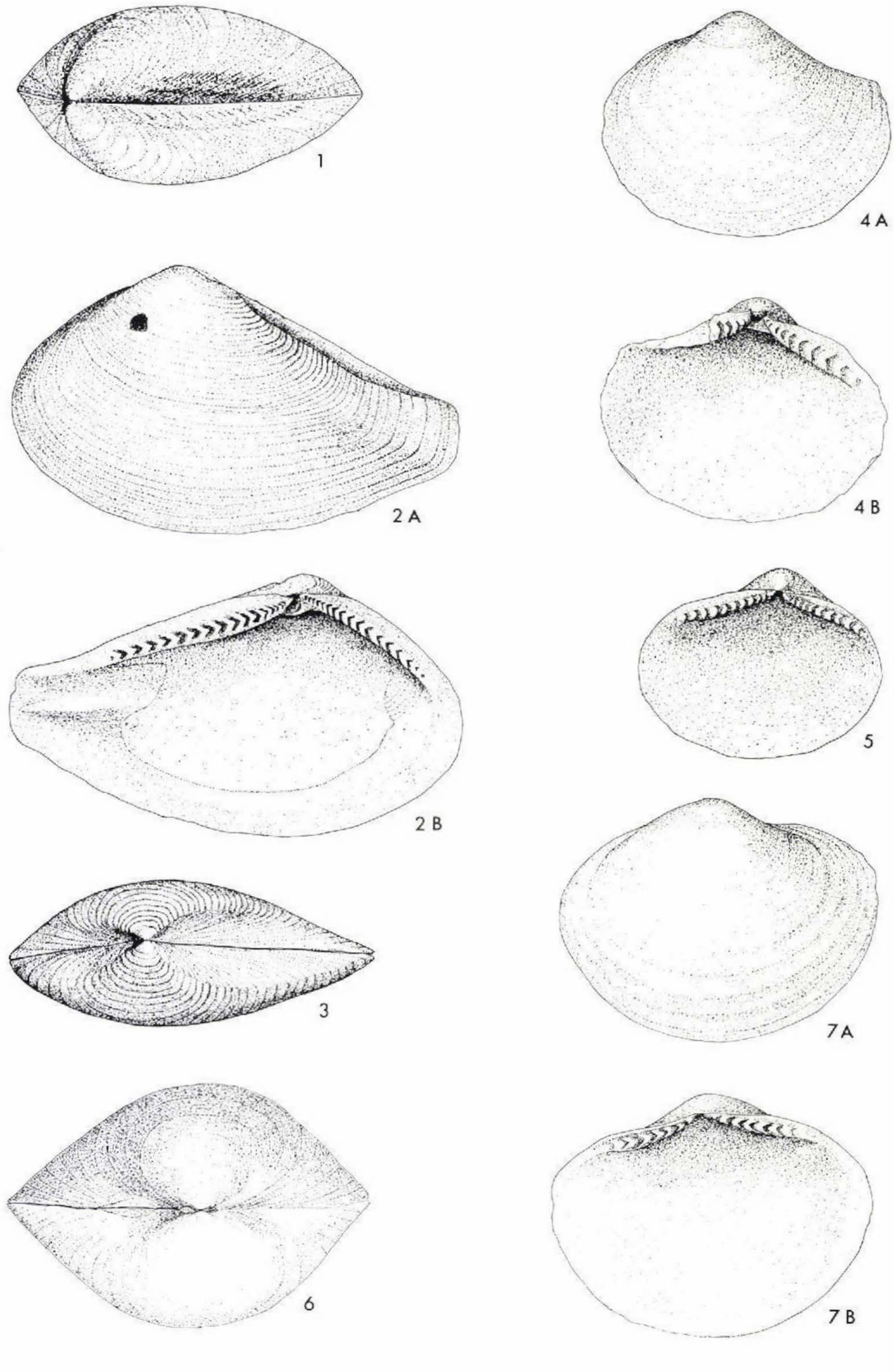
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Plate 6

Fig. 1A–B. *Palliolum (Delectopecten) greenlandicum* (Sowerby). MGUH 14845, from GGU 111720. Right valve from tongue Sk–4, Kløft II, Pátorfik. × 4.

Fig. 2. *Palliolum (Delectopecten) greenlandicum* (Sowerby). MGUH 14846, from GGU 111723. Right valve from layer Sk–7, Kløft II, Pátorfik. × 8.

Fig. 3. *Tridonta (Nicania) montagui* (Dillwyn). MGUH 14847, from GGU 111720. Left valve from tongue Sk–4, Kløft II, Pátorfik. × 3.

Fig. 4. *Tridonta (Nicania) montagui* (Dillwyn) var. *striata* (Leach). MGUH 14848, from GGU 111718. Left view of specimen with paired valves from Sk–2, Kløft II, Pátorfik. × 3.

Fig. 5A–B. *Axinopsida orbiculata* (Sars). MGUH 14849, from GGU 111720. Right valve from tongue Sk–4, Kløft II, Pátorfik. × 8.

Fig. 6. *Serripes groenlandicus* (Chemnitz). MGUH 14850, from GGU 111720. Juvenile left valve from tongue Sk–4, Kløft II, Pátorfik. × 4.

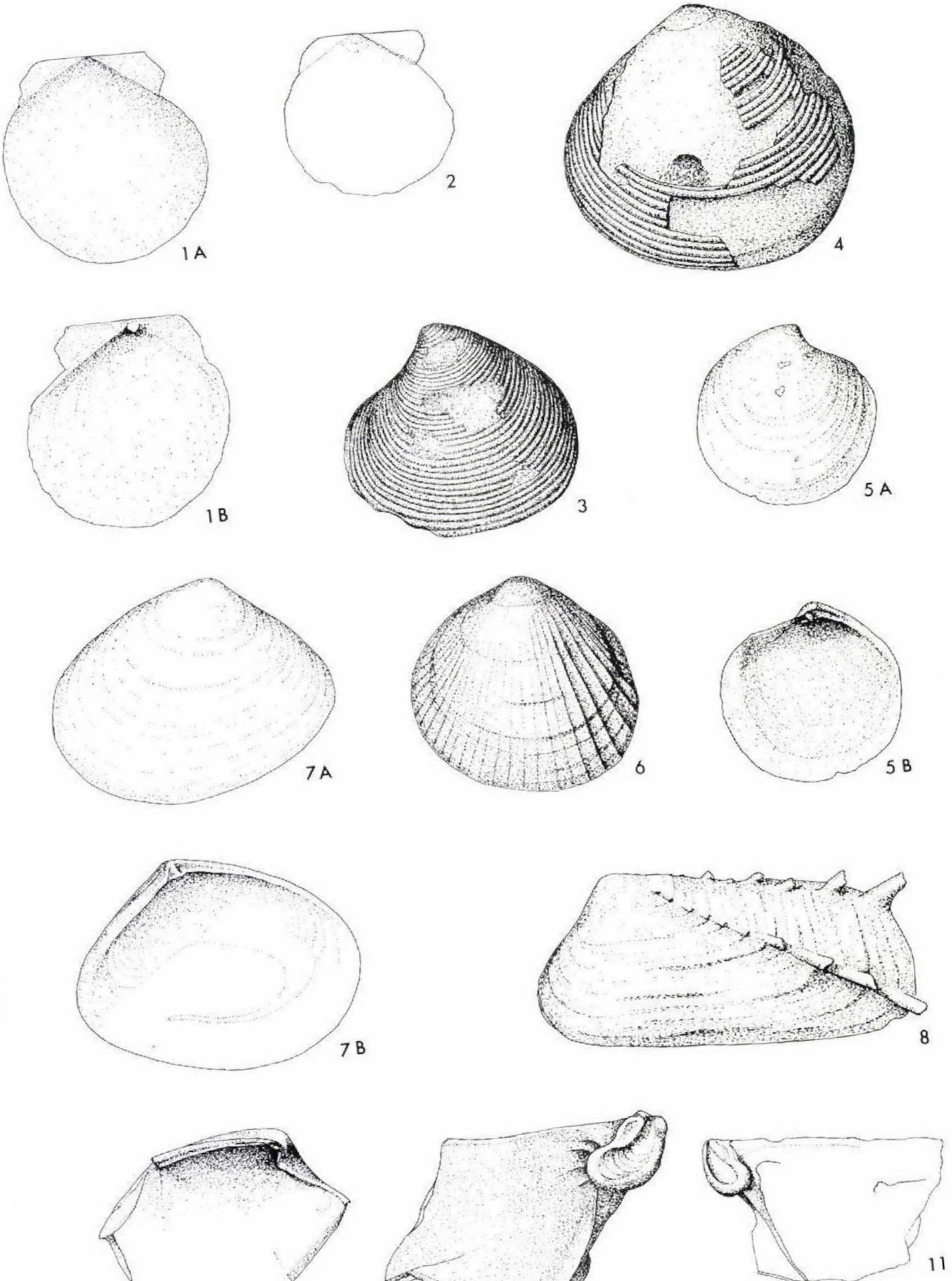
Fig. 7A–B. *Macoma (Macoma) calcarea* (Chemnitz). MGUH 14851, from GGU 111720. Halfgrown left valve from tongue Sk–4, Kløft II, Pátorfik. × 3.

Fig. 8. *Hiatella (Hiatella) arctica* (Linné). MGUH 14852, from GGU 111721. Juvenile left valve from tongue Sk–5, Kløft II, Pátorfik. × 17.

Fig. 9. cf. *Lyonsia (Bentholyonsia) arenosa* (Møller). MGUH 14853, from GGU 111720. Fragmentary left valve from tongue Sk–4, Kløft II, Pátorfik. × 8.

Fig. 10. *Periploma* sp. MGUH 14854, from GGU 111721. Fragment from tongue Sk–5, Kløft II, Pátorfik. × 4.

Fig. 11. *Periploma* sp. MGUH 14855, from GGU 111721. Fragment from tongue Sk–5, Kløft II, Pátorfik. × 4.


1A
2
4
1B
3
5A
7A
6
5B
7B
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9
10
11

Plate 7

Fig. 1. *Balanus* (*Balanus*) *balanus* (Linné). MGUH 14856, from GGU 111720. Scutum from tongue Sk–4, Kløft II, Pátorfik. × 4.

Fig. 2. *Balanus* (*Balanus*) *balanus* (Linné). MGUH 14857, from GGU 111720. Tergum from tongue Sk–4, Kløft II, Pátorfik. × 4.

Fig. 3. *Balanus* (*Balanus*) *balanus* (Linné). MGUH 14858, from GGU 111721. Parietal plate from tongue Sk–5, Kløft II, Pátorfik. × 3.

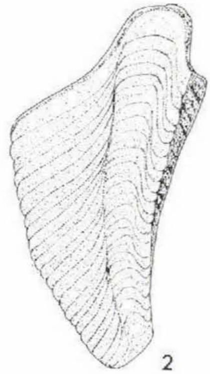
Fig. 4. *Balanus* (*Balanus*) *crenatus* (Bruguière). MGUH 14859, from GGU 111721. Fragmentary parietal plate from tongue Sk–5, Kløft II, Pátorfik. × 4.

Fig. 5. *Balanus* (*Balanus*) *crenatus* (Bruguière). MGUH 14860, from GGU 111721. Part of the surface of parietal plate from tongue Sk–5, Kløft II, Pátorfik. × 17.

Fig. 6. *Balanus* (*Chirona*) *hameri* (Ascanius). MGUH 14861, from GGU 111723. Tergum from layer Sk–7, Kløft II, Pátorfik. × 3.

Fig. 7. *Balanus* (*Chirona*) *hameri* (Ascanius). MGUH 14862, from GGU 111723. Fragmentary parietal plate from layer Sk–7, Kløft II, Pátorfik. × 3.

1



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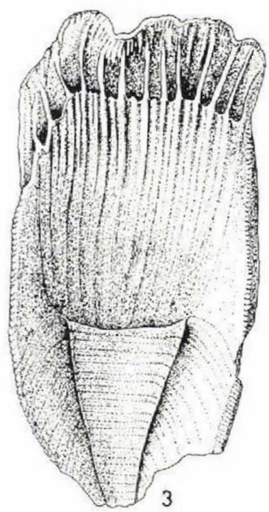

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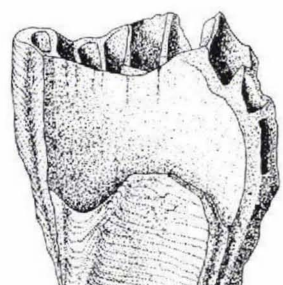

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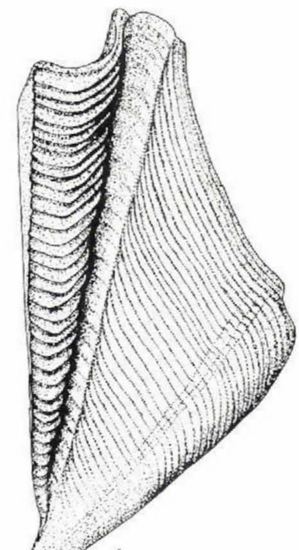

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7

Plate 8

Fig. 1. *Mytilus (Mytilus) edulis* Linné. MGUH 14863, from GGU 111719. Fragmentary specimen with paired valves from Sk–3, Kløft II, Pátorfik. × 1.

Fig. 2. *Chlamys (Chlamys) islandica* (Müller). MGUH 14864, from GGU 111717. Fragmentary right valve from Sk–1, Kløft II, Pátorfik. × 1.

Fig. 3. *Tridonta (Tridonta) borealis* (Chemnitz). MGUH 14865, from GGU 111719. Right view of specimen with paired valves from Sk–3, Kløft II, Pátorfik. × 1.

Fig. 4. *Tridonta (Tridonta) elliptica* (Brown). MGUH 14866, from GGU 111719. Right view of specimen with paired valves from Sk–3, Kløft II, Pátorfik. × 1.

Fig. 5. *Clinocardium ciliatum* (Fabricius). MGUH 14867, from GGU 111720. Left valve from tongue Sk–4, Kløft II, Pátorfik. × 1.

Fig. 6. *Panopea (Panomya) norvegica* (Spengler). MGUH 14868, from GGU 111718. Fragmentary right valve in a concretion from Sk–2, Kløft II, Pátorfik. × 1.

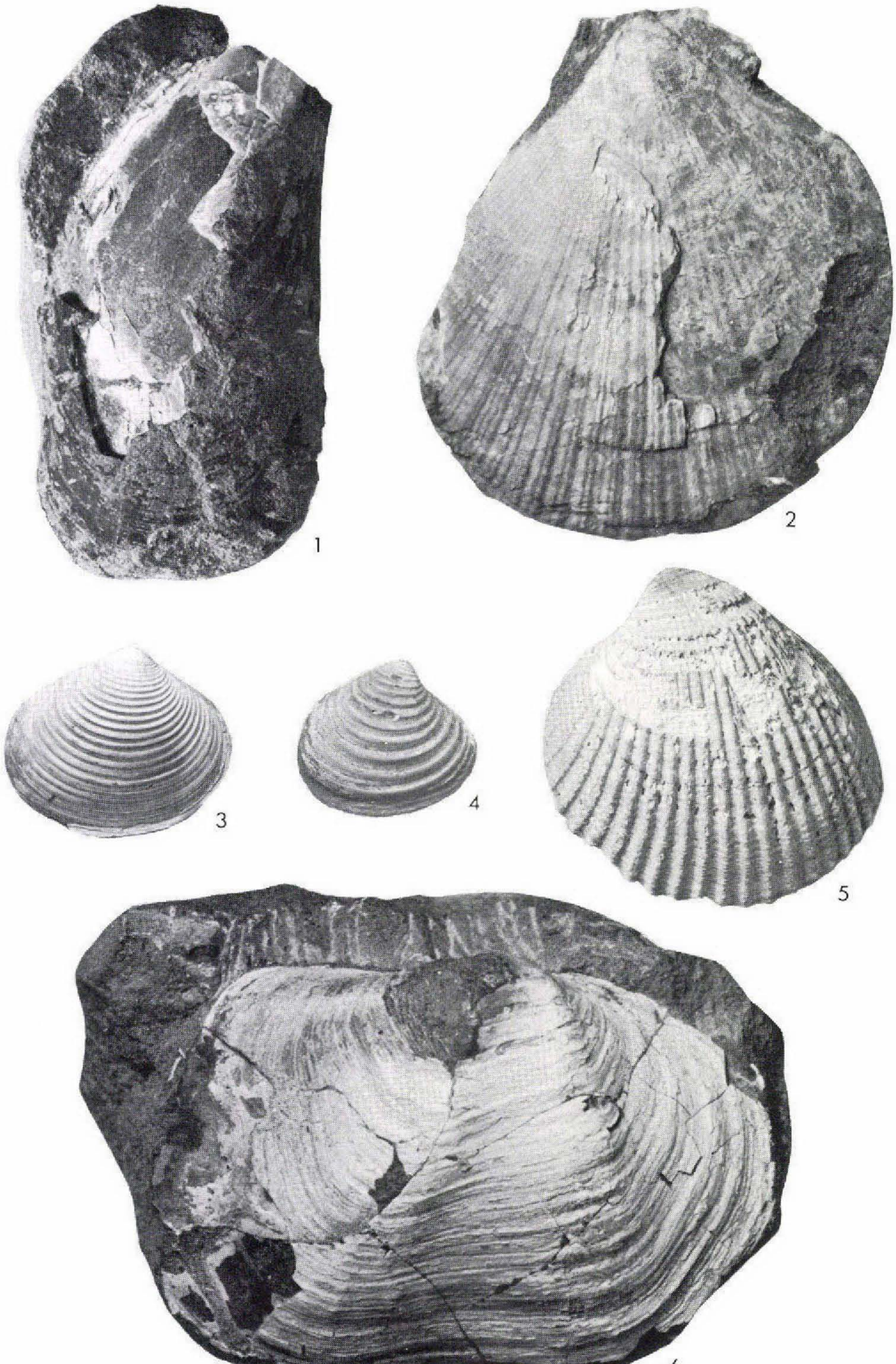
1
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Plate 9

Fig. 1. *Cyrtodaria siliqua* (Spengler). MGUH 14869, from GGU 111718. Right valve in a concretion from Sk–2, Kløft II, Pátorfik. × 1.

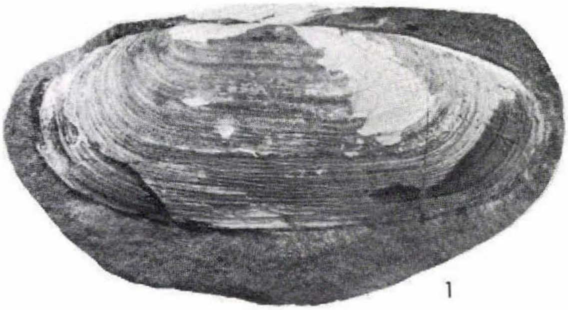
Fig. 2A. *Cyrtodaria siliqua* (Spengler). MGUH 14870, from GGU 111718. Dorsal view of specimen with paired valves from Sk–2, Kløft II, Pátorfik. × 1.

Fig. 2B. *Cyrtodaria siliqua* (Spengler). Enlarged part of the surface of the same specimen, with striated periostracum. × 2.

Fig. 3. *Mya (Mya) truncata* Linné. MGUH 14871, from GGU 111722. Right view of fragmentary specimen with paired valves from Sk–6, Kløft II, Pátorfik. × 1.

Fig. 4A–B. *Mya (Mya) truncata* Linné var. *uddevalensis* Forbes. MGUH 14872, from GGU 111726. Right valve from Sarfâgfîk. × 1.

Fig. 5. *Mya (Mya) pseudoarenaria* Schlesch. MGUH 14873, from GGU 111718. Right view of specimen with paired valves from Sk–2, Kløft II, Pátorfik. × 1.



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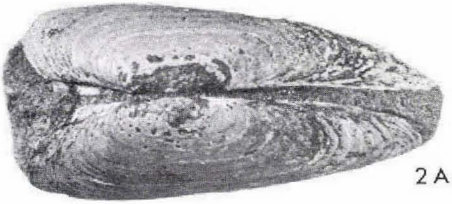

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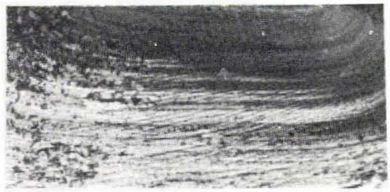
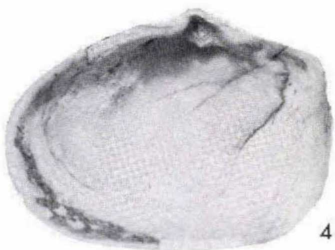
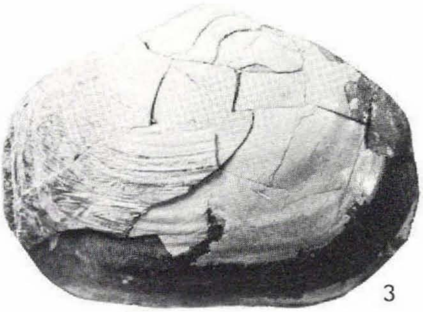


2 B



4 A



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4 B

5

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