

# An illustrated catalogue of the Paleocene Bivalvia from Nuussuaq, Northwest Greenland: Their paleoenvironments and the paleoclimate

G. HØPNER PETERSEN & ANNIE VEDELSBY

Steenstrupia



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One hundred and fifteen bivalve taxa represented by 2357 specimens are recorded from the Danian deposits at Nuussuaq (formerly Nügssuaq or Nugssuak), Northwest Greenland. The material was mainly collected in the 1950s. Most of the species are new and unnamed, but formal description is not attempted here. Comparisons with Recent material allow inferences about the paleoenvironment and paleoclimate. The population parameters obtained here indicate that the bivalves are from different marine habitats, from deep water to the tidal zone. The boring bivalves show that the deep-water Kangilia Formation was uplifted and made up the shores of the shallow-water sea in which the Agatdal Formation was deposited. The majority of the species are very similar in morphology to modern tropical species in the Panama-Pacific, Indo-Pacific, Caribbean and Mediterranean Seas, and only a few of the Danian species are related to modern boreal species. The species composition, the life history, and the biodiversity indicate a tropical kind of climate and light regime.

Keywords: Bivalvia, marine ecosystems, Northwest Greenland, Paleocene tropical climate, light regimes

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## INTRODUCTION

The fauna and flora of the Late Cretaceous-Early Tertiary period in Northwest Greenland have been studied well, with the exception of the bivalves. This Paleocene bivalve material was collected by the late Professor Alfred Rosenkrantz and his co-workers in the course of 18 expeditions. A summary of the expeditions and their results was given by Rosenkrantz (1970). Many fossil groups have been described and published from the Nuussuaq expeditions (summaries in Henderson et al. 1976, Collins & Rasmussen 1992, Kollmann & Peel 1983). Professor Rosenkrantz's plan to publish the Paleocene molluscs was thwarted by his death in 1974, although he completed the illustrations of the Paleocene gastropods, which were later published by Kollmann & Peel (1983). Rosenkrantz and his assistants had started to sort the bivalves into species, but generally without identifications or illustrations. At his death only a few notes and illustrations were completed, and the work was discontinued.

The material of Paleocene bivalves was first superficially examined for specimens suitable for investigation of growth rings. Bivalve shells often show growth rings caused by seasons, tides, and diurnal variation (day-night periods) (Petersen 1958, 1966, 1978; Farrow 1971). This study was hampered because the modern relatives of the Paleocene species are tropical-subtropical ones, in which studies of growth rings are scarce; possible recrystallization in the fossil material was also a problem. The next step was to compile a catalogue of the material. Finally, the bivalve fauna was analyzed for information on palaeoenvironment and palaeoclimate. The bivalves will not be compared with other Paleocene faunas, except for a note on the Ocean Point fauna of northern Alaska (Marincovich 1993).

Bivalves are important components in many marine ecosystems, except in the Antarctic. Hence this study of tropical types of fossil bivalves from an arctic region may substantiate a change in the light periods and climate during the Tertiary. The energy flows in modern arctic and tropical waters show that the controlling parameter for life is the light regime (Petersen 1984a, b,

1985, 1986, 1989, 1990). Further, arctic ecosystems developed during the Late Tertiary, while tropical ecosystems can be traced back to the Early Tertiary. The many tropical kinds of fossils in both polar regions are taken as evidence that the tropical temperature belt was previously much broader than today. The question of the tropical light regime is usually ignored. Plate tectonics give no answers on the questions.

The manuscript was completed in 1993 but was delayed because the editors of the geological periodicals, who were the first to receive the manuscript, would only publish the catalogue, but not the conclusions on climate and light regimes based on comparisons with modern marine situations.

## LOCALITIES

Comprehensive and detailed descriptions of the

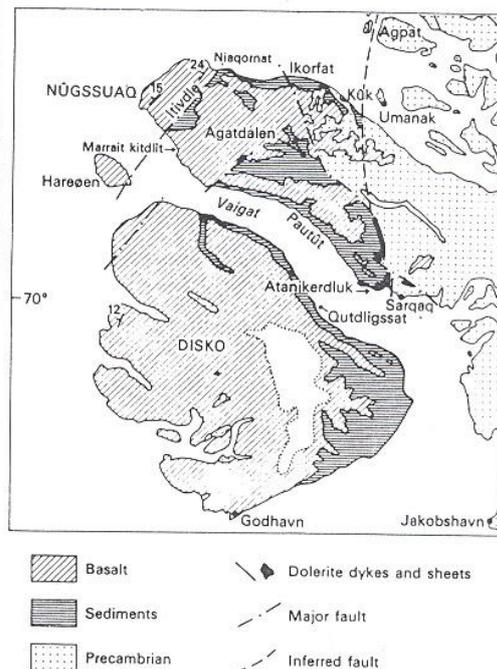


Fig. 1. Map of Nuussuaq peninsula and Disko Island indicating the Upper Cretaceous-Lower Tertiary sediments, Tertiary basalts and Precambrian rocks. Detail of fig. 301 in Escher & Watt (1976).

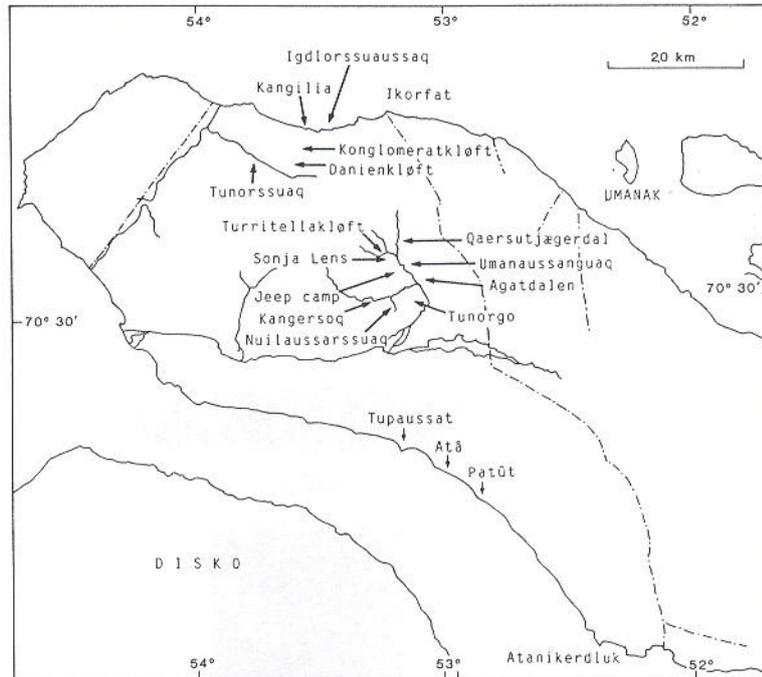
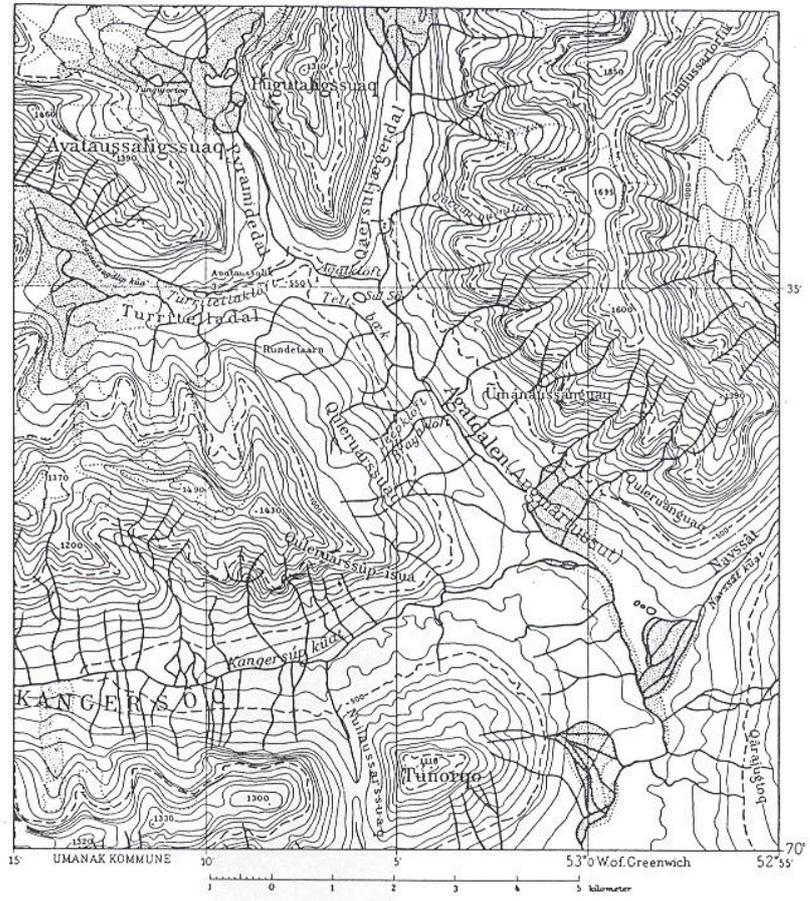


Fig. 2. Map of Nuussuaq showing the localities mentioned in the text.

outcrops sampled during these expeditions to the Cretaceous Tertiary sedimentary rocks in North-west Greenland are given in Koch (1959, 1963), Birkelund (1965), Hansen (1970), Rosenkrantz (1970) and Floris (1972). These authors have included many other localities than those treated here, as several formations are exposed both along the shores in the region and in inland valleys and canyons. The present material comes mainly from the interior of Nuussuaq (new spelling, formerly Nugssuaq or Nûgssuaq), and was mainly collected in the three canyons: Turritlellakløft (*Turritella* Gorge), Agatkløft (Agate Gorge) and Qaersutjægerdal (Qaersut Hunters' Valley). They are the upper and northern offshoots of the larger Agatdal (Agate Valley). A few bivalves were collected at different localities in Agatdal, in the more southern Kangersôq, and on the northern and southern shores of the Nuussuaq peninsula. The maps in Figs 1-3 show the localities. Paleocene bivalves are reported from other localities (Rosenkrantz 1970), but these specimens

were not available. The original field descriptions of the localities and samples were lost, and only information from earlier papers is available, as shown in Figs 4-6. The sections at the main localities: Turritlellakløft and Qaersutjægerdal, shown in Fig. 7, were reconstructed from the labels with the samples. Additional localities are shown in Fig. 8. Concretions sometimes have a name, e.g., *Cucullaea*, *Gilbertina*, Lumachelle (= shell gravel), but without further information. The label information has been translated into English following the Danish words as closely as possible. This procedure will facilitate future comparative investigations on material from these canyons and hopefully also refer these layers to the formations and "members" given in earlier papers. All names in citations are in the original spelling.

To avoid needless repetition under "Material", all samples from a given main locality are in a single paragraph. Names of the main localities and first and second subdivisions of these are



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Fig. 3. Map of the main localities in Agatdalen which yielded the greater part of the fossils, from fig. 35 in Koch (1959).

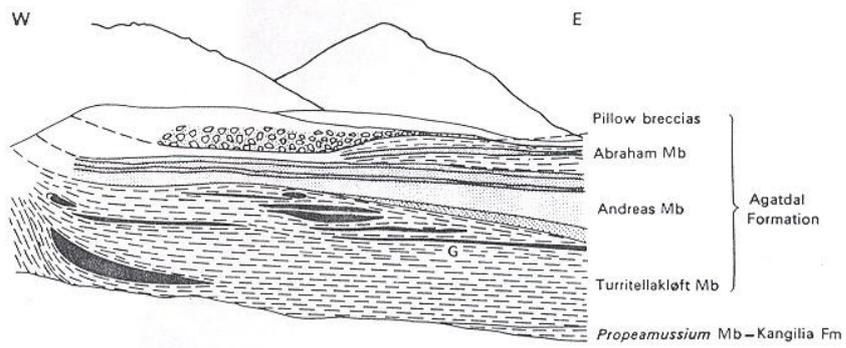


Fig. 4. Great Section, modified from fig. 312 in Escher & Watt (1976).

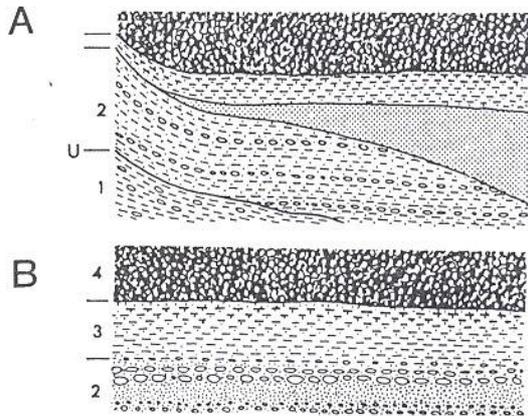


Fig. 5. Sections through the two localities: A. Turrzellakløft and B. Qaersutjægerdal. 1. Lower Danien, *Propeamussium* Member, 2. *Turrzellakløft* Member, 3. Andreas Member, 4. Pillow breccias, U: Unconformity. Modified from fig. 4 in Rosenkrantz (1970).

GEOLOGICAL SETTING

A summary of the geological history of the Cretaceous-Tertiary period in Northwest Greenland is given in Escher & Watt (1976). Fig. 1 gives a survey of the area, from their fig. 301. Dam (1992) gives a more recent model of the regional geological setting.

The regional stratigraphy has been described several times and illustrated by figures and photos in Koch (1959, 1963), Birkelund (1965), Hansen (1970), Rosenkrantz (1970) and Floris (1972). All these authors participated in the expeditions. From their papers we have extracted some information on the localities where the bivalve material was collected. The Cretaceous-Paleocene lithostratigraphy is shown in Fig. 6 (after Collins & Rasmussen 1992).

written in capitals, bold and italics, respectively; because of their location, a few localities (e.g., Agatdal/AGATDAL) may have more than one typeface, but no name refers to more than one site. See the maps (Figs 1-3) if in doubt. Different samples from a given site are separated by short dashes, different sites by long ones.

MATERIALS AND METHODS

The samples were provided with labels with apparently good documentation. The labels give both the collecting date and the locality, and were used to reconstruct the sections and layers shown

	NORTH COAST OF NUGSSUAQ	CENTRAL NUGSSUAQ
PALEOCENE	? AGATDAL FORMATION	AGATDAL FORMATION Abraham Member Andreas Member Turrzellakløft Member } ? Sonja Member
	KANGILIA FORMATION <i>Propeamussium</i> Member <i>Thyasira</i> Member Fossil Wood Member Conglomerate Member	KANGILIA FORMATION <i>Propeamussium</i> Member <i>Thyasira</i> Member
CRETACEOUS	Undifferentiated Cretaceous shales	Oyster-ammonite Conglomerate  Undifferentiated Cretaceous shales  ATANE FORMATION

Fig. 6. The Paleocene-Cretaceous lithostratigraphy of central Nuussuaq compared with the north coast of Nuussuaq. From fig. 2 in Collins & Rasmussen (1992).

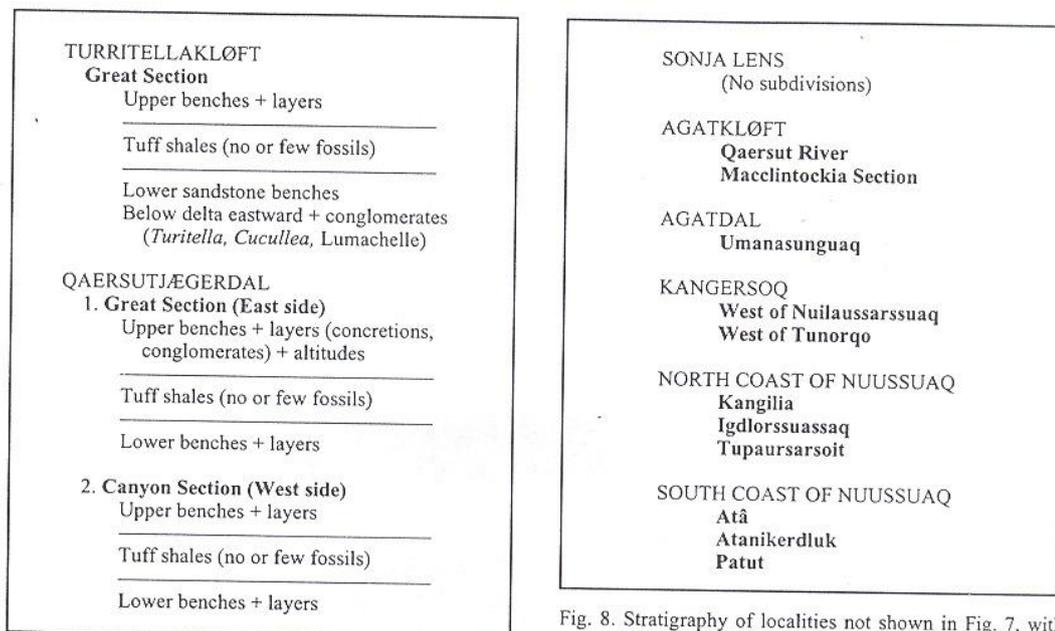


Fig. 7. Stratigraphy of the main localities in Turritellakløft and Qaersutjægerdal, based on label notes with the samples. "Altitudes" refers to localities in the Great Section (East side) of Qaersutjægerdal where this is the only more detailed information given, also referred to in earlier publications.

in Figs 7-8. Unfortunately the labels do not refer to the stratigraphic layers and "members". Later Rosenkrantz's helpers furnished the labels with a number, which also was written on small pieces of paper carefully glued to all the pieces of rocks and shells. This was unfortunate, because in several cases the labels were glued over important taxonomic characters, and the glue had sometimes penetrated the rock and made it difficult to distinguish the faint traces of, e.g., muscle scars and the pallial line.

We also received two of Rosenkrantz's notebooks that contain a few drawings and photos of selected specimens, which, however, are missing from the collection. A few species are represented only by these drawings or photos, which have also been included in the catalogue. The information and the numbers on labels are given together here. This is in accordance with the system in Kollmann & Peel (1983).

The classification follows that of Moore

Fig. 8. Stratigraphy of localities not shown in Fig. 7, with main subdivisions.

(1969). Species names are not introduced even though we are convinced that many of the species are new or that others are morphologically equivalent to modern species. We have used general publications, regional fauna lists, and also the large collections of Recent bivalves at the Zoological Museum, University of Copenhagen to identify the specimens and to establish relations to Recent faunas.

We measured the shells when it was possible and appropriate. Length (L) refers to the largest distance from the anterior to the posterior end, and height (H) refers to the distance from the umbo to the ventral edge. It was sometimes possible to measure the width (W), when the two valves were closed and undisturbed, or the depth of one valve, which is approximately half the width. For boring bivalves, the size is sometimes given as diameter (D). Unless otherwise specified, all measurements are in mm. Data on the condition of the shells (e.g., single, paired, bored, etc.) and samples (e.g., gravel, sand, coal, etc.) were noted.

Except as noted, all photographs were taken by G. Høpner Petersen and developed and printed by

photographer Geert Brovad, ZMUC. All graphs were made by GHP, and except as noted, all line drawings of shells were made by Annie Vedelsby with the aid of a drawing apparatus.

In addition to those mentioned above, the following abbreviations are used in the catalogue: GGU = Grønlands Geologiske Undersøgelser (Greenland's Geological Investigations, later changed to GEUS); MGUH = Geological Museum, University of Copenhagen; ZMUC = Zoological Museum, University of Copenhagen.

SYSTEMATIC PALEONTOLOGY:  
THE CATALOGUE

PALAEOTAXODONTA  
NUCULOIDA Dall, 1889  
Nuculidae Gray, 1824  
*Nucula* Lamarck, 1799  
*Nucula sensu stricto*, sp. 1  
Fig. 9.

Material:  
TURRITELLAKLØFT: Great Section: Lower sandstone bench: 1980-225, 1946 (1 complete specimen, the two valves pushed slightly apart: L = 12, H = 7.8).  
INTERIOR NUUSSUAQ: Block: 1980-220, 1939 (1 valve: L = 15.6; Fig. 9).

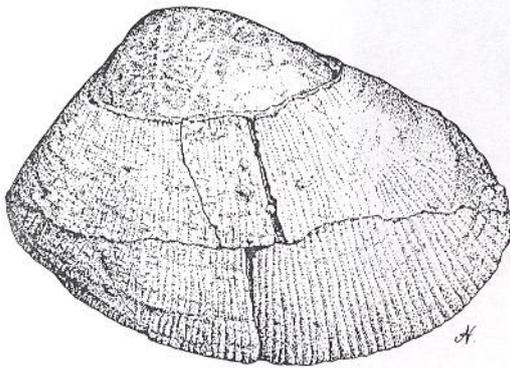


Fig. 9. MGUH 25.137. *Nucula sensu stricto*, sp. 1. One right valve: L = 15.6, H = 11.1, D = 5.5 mm. Turritellakløft, interior Nuussuaq, block, 1980-220, 1939.

*Nucula sensu stricto*, sp. 2  
Figs 10-11.

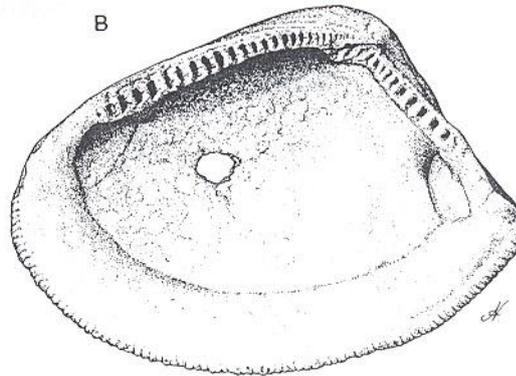
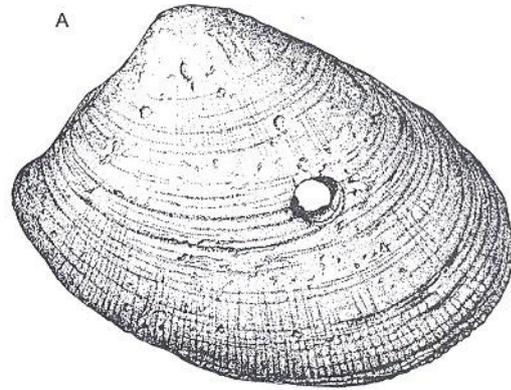


Fig. 10. MGUH 25.138. *Nucula sensu stricto*, sp. 2. One right valve, outer (A) and inner (B) views. L = 25.8, H = 19 mm. Inner ventral margin crenate, bored by naticid. Sonja Lens, 1980-223, 1958.

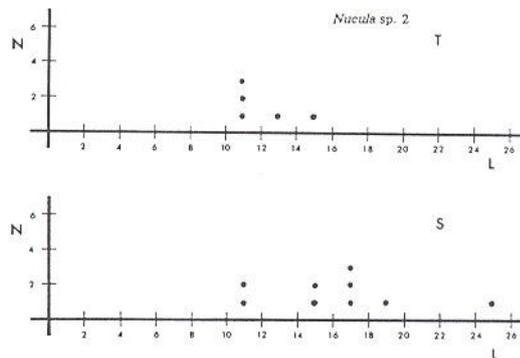


Fig. 11. *Nucula* sp. 2. Length distributions from: Turritellakløft (T, includes Interior Nuussuaq) and Sonja Lens (S). Dots = single valves.

**Material:**

**TURRITELLAKLØFT: Great Section: Lower sandstone bench:** 1980-118, 1946 (1 valve: L = 13, H = 10). - 1981-453, 1949 (1 right valve: L = 10, H = 9).

**INTERIOR NUUSSUAQ: Block:** 1980-220, 1939 (3 valves: L = 10.8, H = 8.8; L = 10.9, H = 9.6; L = 14.0, H = 10.3).

**SONJA LENS:** 1980-221, 1953 (1 right valve: L = 18, H = 14.5, bored by naticid). - 1980-222, 1956 (1 right valve: L = 17.8, H = 13.8, bored by naticid). - 1980-223, 1958 (Fig. 10). - 1980-224, 1948 (2 valves: L = ca. 14 [both specimens, 1 with naticid hole]); 1 right valve: L = 25.8, H = 19, naticid hole. - 1981-389, 1948 (4 fragments). - Sample without number (1 left valve: L = 16.5, H = 12.5; 2 right valves: L = 10.5, H = 8; L = 16, H = 13).

**Remarks**

Resembles the Recent *Nucula donaciformis* Schmidt, 1895, Indopacific; see Knudsen (1967: 247-248, fig. 3).

**Summary of the material**

Turritellakløft: 5 valves. Sonja Lens: 9 valves + 4 fragments, 5 with naticid holes. Fig. 11 gives the length distributions.

***Nucula?* sp. 3**

Figs 12-13.

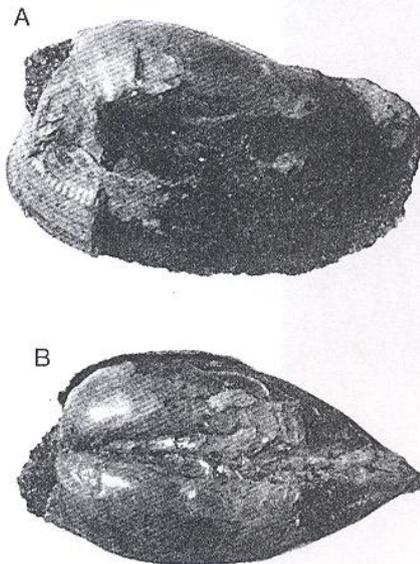


Fig. 12. MGUH 25.140. *Nucula?* sp. 3. One whole, closed specimen, stinkern with shell fragments. L = 17.9, H = 10.4 mm. Left side (A) and umbo (B) are shown. Turritellakløft, Great Section, lowermost sandstone bench, 1980-214, 1948.

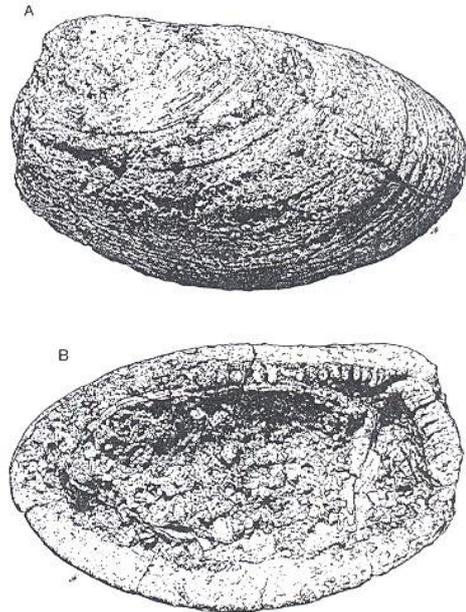


Fig. 13. MGUH 25.139. *Nucula?* sp. 3. One left valve, outer (A) and inner (B) views, taxodont hinge just visible. L = 14.4, H = 9.9 mm. Qaersutjægerdal, Great Section, altitude 495 m. No number, 1958.

**Material:**

**TURRITELLAKLØFT: Great Section: Lowermost sandstone bench:** 1980-214, 1948 (1 whole, closed specimen, stinkern with shell fragments: L = 17.0, H = 10.4; Fig. 12).

**QAERSUTJÆGERDAL: Great Section: Altitude 495 m:** no number, 1958 (1 valve, Fig. 13).

**Remarks**

This species resembles the figures in Moore (1969: N230) of species from the genera *Palaeonucula*, *Nuculoidea* and *Nuculoma*. However, these are only reported from periods earlier than the Cretaceous; see also Ostreacea.

***Nuculoma* Cossmann, 1907*****Nuculoma* sp. 1**

Figs 14-15.

**Material:**

**TURRITELLAKLØFT: Great Section: Lower sandstone bench:** 1980-219, 1948 (1 complete specimen: L = 17.5, H = 16.5; 1 right valve: L = 15).

**QAERSUTJÆGERDAL: Great Section: Concretion layer above tuff-shale series:** 1980-218, 1952 (1 right valve: L = 10.5, H = 8; 1 left valve: L = 14, H = 12). - Concretion

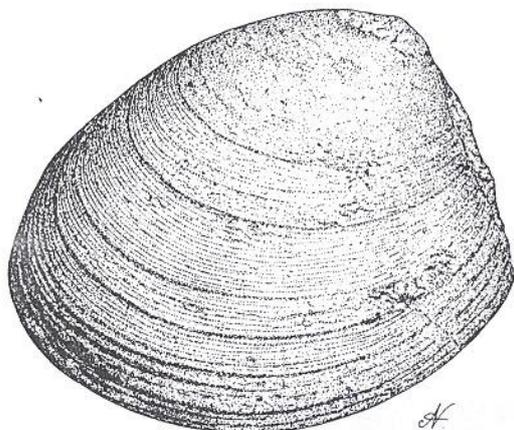


Fig. 14. MGUH 25.141. *Nuculoma* sp. 1. One left valve: L = 16, H = 14 mm, ventral inner margin sharp. Qaersutjægerdal, west side, 1980-291, 1953.

layer below tuff-shale series: 1980-215, 1958 (1 articulated, closed specimen: L = 14, H = 11; 1 right valve: L = 14.3, H = 12.5). - 1980-216, 1953 (12 complete, closed specimens: L = 9.5, 13.5, 13.6, 14.0, 14.0, 14.8, 15.2, 17.3; with naticid hole: L = 10.2, 13.6, 14.1, 16.4; 11 left valves: L = 11.5, 12.0, 12.1, 12.6, 12.7, 13.0, 13.1, 13.4, 14.1, 14.2, 14.5; 10 right valves: L = 9.0, 11.0, 12.9, 13.0, 13.1, 14.0, 14.8, 15.5, 15.6 [with naticid hole], 15.8). - 1980-217, 1956 (3 paired, closed specimens: L = 13.0, 14.9, 17.2; 1 single valve: L = 13.6; 3 valves with naticid holes: L = 15.0, 15.2, 16.9). - 1981-63, 1953 (1 valve: L = 8.5). - West side at second turn: 1980-208, 1951 (1 complete specimen: L = 14.5, H = 11.8). - West side: 1980-291, 1953 (3 valves: L = 11.9, 15.8, 16 [Fig. 14]).

*Summary of the material*

TURRITELLAKLØFT: 1 paired specimen + 1 valve. Qaersutjægerdal: 17 paired specimens, 4 with naticid hole. 32 valves, 4 with naticid hole. Fig. 15 gives the length distribution of specimens from the two localities.

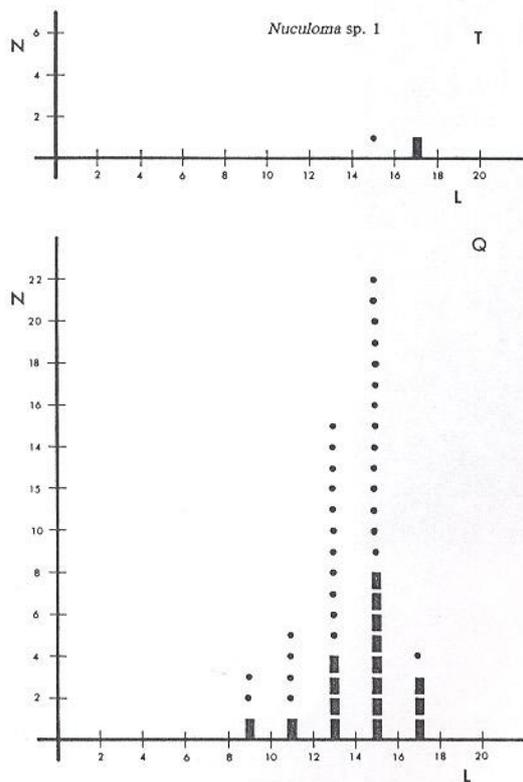


Fig. 15. *Nuculoma* sp. 1. Length distributions of specimens from Turritellakløft (T) (n = 2) and Qaersutjægerdal (Q) (n = 49). Dots = single valves, bars = paired valves.

*Nuculana* Link, 1807

*Nuculana* sp. 1

Figs 16-17.

Material:

TURRITELLAKLØFT: Great Section: Sandstone bench below tuff-shale series: 1980-123, 1956 (1 right valve: L = 9.0). - 1980-198, 1956 (1 complete, closed specimen: L = 12.3, H = 6.8; 1 valve: L = 8.5, H = 5.2). - 1980-206, 1948 (1 complete, closed specimen: L = 6.1; 1 single valve: L = ca. 8). 1980-211, 1948 (4 single valves: L = 6.5, 8.5, 8.8, 10.0. Rosenkrantz, in a note on the label, gave two preliminary names: "*Nuculana* aff. *occidente* (v. Koenen)" and "*Nuculana* aff. *mansfieldi* (Stanton)"). - 1981-197, 1964 (1 valve: L = 12.5; 2 moulds: L = 18.2, 18.5). - South side: Lumachelle: 1980-201, 1939 (1 complete, closed specimen: L = ca. 6, compressed).

SONJA LENS: 1980-195, 1953 (2 complete specimens: L = 8, 8; 12 single valves: L = 8-15). - 1980-197, 1953 (1 complete specimen: L = 7.8, H = 5). - 1980-212, 1948 (2 complete specimens and 49 single valves: L = 8-16). - 1981-324, 1953 (1 valve, L = 12). - 1981-396, 1953 (5 valves: L = 11-13, 1 bored by naticid; Fig. 16 is from this sample). - 1981-419, 1952 (ca. 29 fragments). - 1981-500, 1948 (1 left valve: L = 12.2). - 1981-502, 1951 (39 valves).

QAERSUTJÆGERDAL: Great Section: (layer not noted) 1980-202, 1951 (1 left valve: L = 11.2). - Upper concretion layer: 1980-203, 1952 (1 complete, closed specimen: L = ca. 14; 3 single valves: L = 8.8, ca. 15, ca. 17, 8.8). - 1980-204, 1952 (1 paired, closed specimen: L = ca. 12). - 1981-195, 1952 (1 complete, closed specimen: L = ca. 22). - Concretion layer below tuff-shale series: 1980-196, 1954 (3 complete, closed specimens: L = 12.3, ca. 17, 17.6; 3 single valves: L = 14.9, 15.5, 15.8). - 1980-205, 1953 (1 complete, closed specimen: L = 16.1; 3 single valves: L = ca. 9, ca. 11, 15.0). - 1980-210, 1953 (3 paired, closed specimens: L = ca. 16, 16.5 (displaced), ca. 20). - 1980-363, 1956 (1 left valve: L = 12, H = 8). - 1981-118, 1953 (1 mould: L = ca. 11).

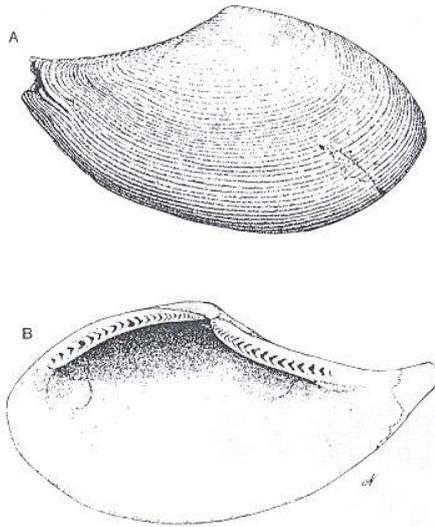


Fig. 16. MGUH 25.142. *Nuculana* sp. 1. One right valve, outer (A) and inner (B) views: L = 13 mm. Sonja Lens, 1981-396, 1953.

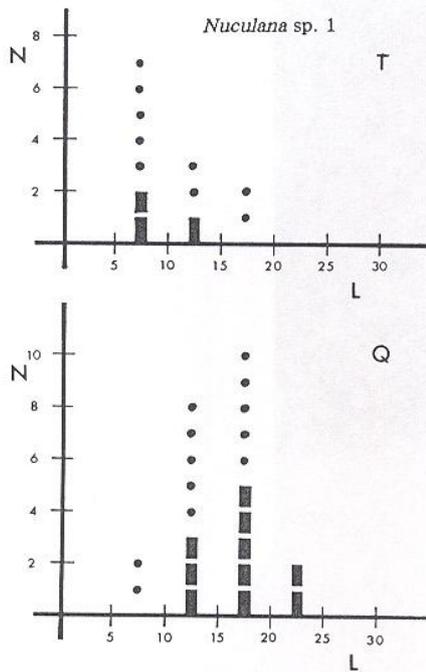


Fig. 17. *Nuculana* sp. 1. Length distributions for material from Turrnellakløft (T) (n = 12) and Qaersutjægerdal (Q) (n = 22). Dots = single valves, bars = paired valves.

*Summary of the material*

Turrnellakløft: 3 complete specimens + 10 valves. Sonja Lens: 5 complete + ca. 136 valves, 1 with naticid hole. The Sonja Lens specimens are ca. 8-16 mm long. Qaersutjægerdal: 10 paired specimens + 12 valves. Fig. 17 shows the length distribution for the Turrnellakløft and Qaersutjægerdal material.

*Tindaria* Bellardi, 1875

*Tindaria* sp. 1

Fig. 18.

Material:

SONJA LENS: 1981-95, 1952 (3 valves: L = 3.9, 4.1 (Fig. 18), 4.4; 2 valves with naticid hole: L = 4.1, 4.5). - 1981-395, 1953 (1 valve: L = 5).

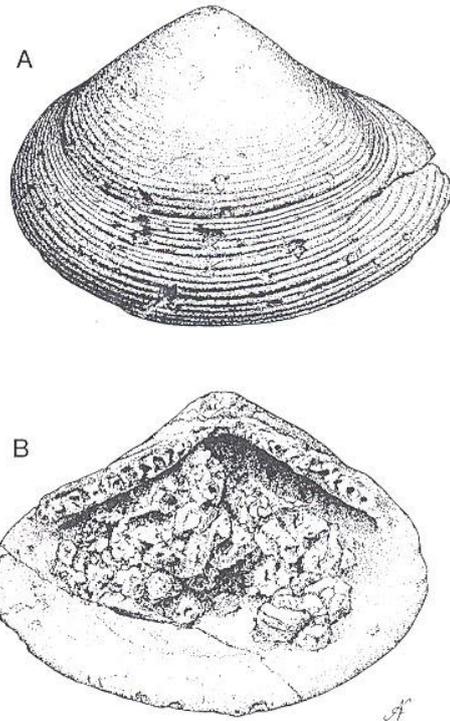


Fig. 18. MGUH 25.143. *Tindaria* sp. 1. One valve, outer (A) and inner (B) views: L = 4.1 mm. Sonja Lens, 1981-95, 1952.

*Tindaria* sp. 2

Fig. 19.

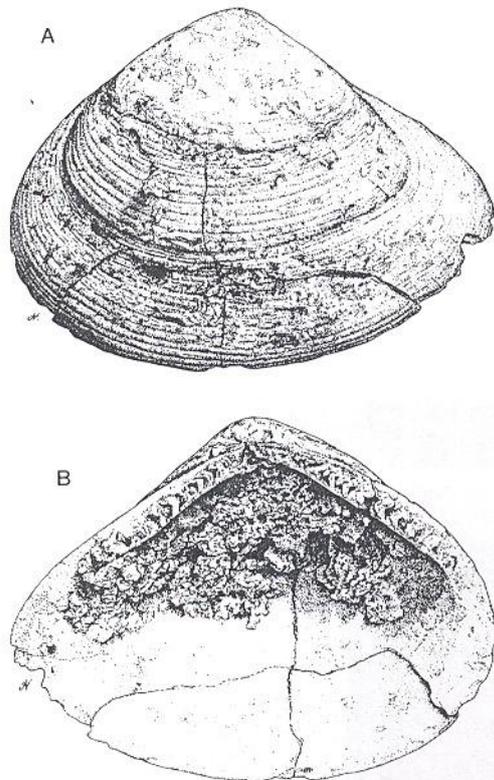


Fig. 19. MGUH 25.144. *Tindaria* sp. 2. One left valve, outer (A) and inner (B) views: L = 5.7 mm. Sonja Lens, 1981-502.

**Material:**

SONJA LENS: 1981-68, 1952 (1 valve: L = 3.0). - 1981-419, 1952 (3 valves: L = ca. 4, ca. 7, ca. 9). - 1981-502, 1952 (3 valves: L = ca. 4, ca. 5.5; Fig. 19). - Photo from Rosenkrantz's notes, 1958: L = 5.5, H = 4.0, identified by Rosenkrantz as "*Leda prisca* Deshayes".

**PTERIOMORPHIA**

**ARCOIDA**

**Arcidae Lamarck, 1809**

***Arca* Linné, 1758**

***Arca* sp. 1**

Fig. 20

**Material:**

SONJA LENS: 1981-411, 1952 (11 worn valves: L = 4.0, 5.8, 6.0, 6.9, 8.0, 8.1, 8.5, 9.0, 10.2, 10.5, 12.0). - 1981-324, 1953 (1 valve: L = 10.7, Fig. 20). - 1981-494, 1948 (5 valves: L = 5.1, 7.6, 11.2, 16.4, 27.4).

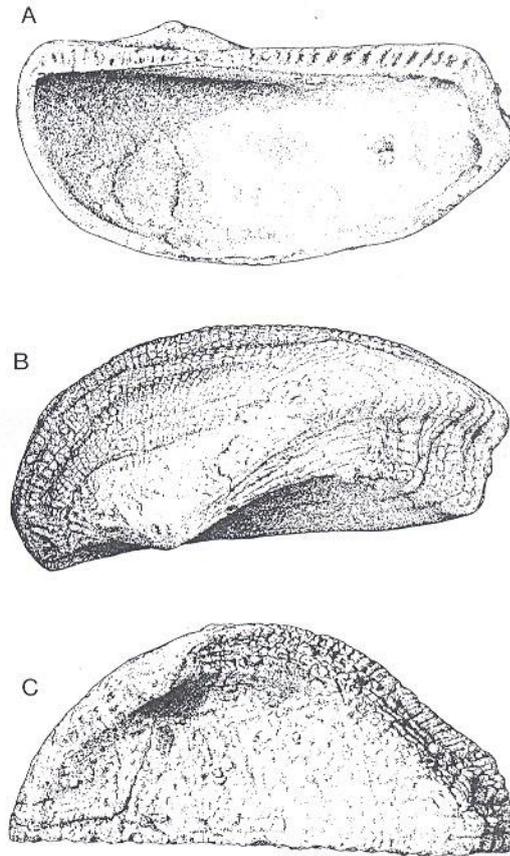


Fig. 20. MGUH 25.146. *Arca* sp. 1. One right valve showing inside (A), outside (B) and ligamental area (C); the latter is so large that the shell looks like a cap, with the umbo as the top. L = 10.7, H = 5.1, 1/2 W = 4.9 mm. Sonja Lens, 1981-384, 1953.

**Remarks**

Rosenkrantz, in a note, identified one of the valves as "*Arca biangula*, Lamarck acc. Cossmann & Pisaro 1904-06, pl. 35". We find that this species resembles *Arca termoumboniense* Grant & Gale, 1931 (Grant & Gale 1931: 142, pl. I, nr. 19). Pliocene, Los Angeles County.

**Summary of the material**

Sonja Lens: 17 valves.

***Arca* sp. 2**

Fig. 21.

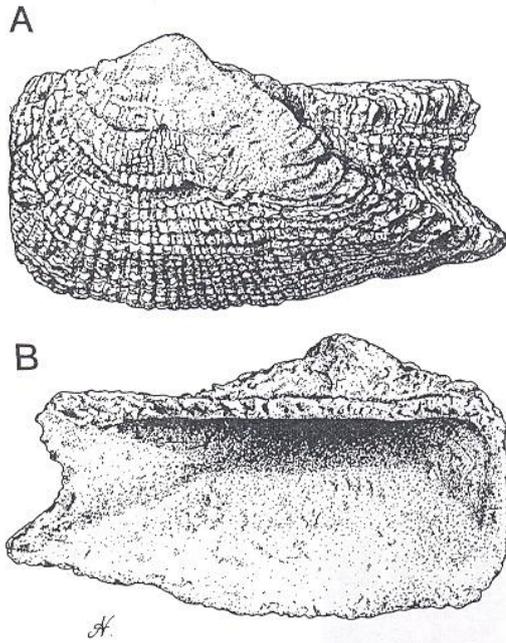


Fig. 21. MGUH 25.147. *Arca* sp. 2. One left valve in outer (A) and inner (B) views: L = 7 mm. Sonja Lens, 1981-424, 1953.

Material:  
SONJA LENS: 1981-424, 1953 (1 valve: L = 7, Fig. 21). - 1981-486, 1951 (1 valve: L = 6.4, and 4 fragments). - 1980-382, 1953 (1 valve: L = 10.4).

*Remarks*

Resembles figs 10, 11 (*Noetia (Eontia) incile* Say, 1824) and 12, 13 (*Noetia (Eontia) trigintinaria* Conrad, 1862) on plate 2 in Bird (1965). Resembles the Recent *Arca navicularis* Bruguière, 1789.

*Arca* sp. 3

Fig. 22.

Material:  
SONJA LENS: 1981-350, 1951 (1 left valve: L = 11, figured specimen only).

*Remarks*

Rather worn, but nevertheless clearly different from *Arca* sp. 1 and sp. 2.

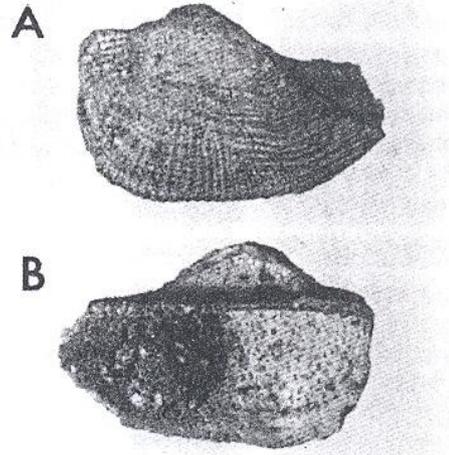


Fig. 22. MGUH 25.148. *Arca* sp. 3. One left valve in outer (A) and inner (B) views: L = 11 mm. Sonja Lens, 1981-350, 1951.

*Barbatia* Gray, 1842

*Barbatia* sp. 1

Fig. 23.

Material:  
SONJA LENS: 1980-379, 1953 (1 valve, Fig. 23). - 1981-416, 1952 (4 valves: L = 5-8). - Photograph from Rosenkrantz's notes, 1 valve.

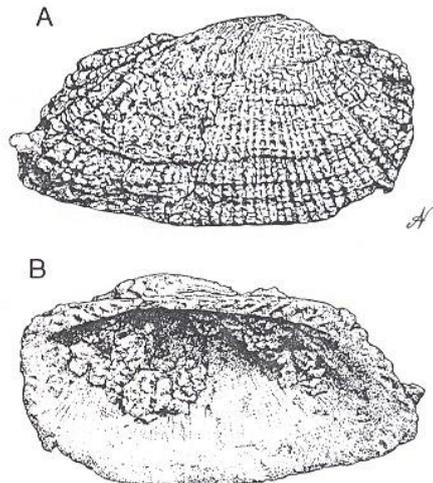


Fig. 23 MGUH 25.149. *Barbatia* sp. 1. One right valve in outer (A) and inner (B) views: L = 7.5 mm. Sonja Lens, 1980-379, 1953.

**Remarks**

Resembles *Barbatia polymorpha* Mayer, 1868 in Studencka (1986: pl. 2, fig. 1a, b). Miocene, Poland.

***Barbatia* sp. 2**

Fig. 24.

**Material:**

SONJA LENS: 1981-410, 1952 (2 small valves). - 1980-385, 1953 (1 fragment). - 1981-505, 1948 (1 valve: L = 7.2). - 1981-487, 1948 (1 fragment). - No number, 1953 (1 valve, Fig. 24).

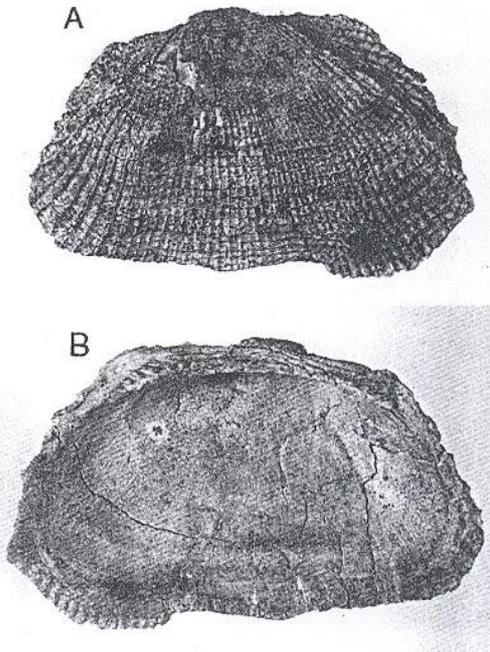


Fig. 24. MGUH 25.150. *Barbatia* sp. 2. One left valve in outer (A) and inner (B) views: L = 47.0, H = 28.1, 1/2 W = 6.1 mm. Sonja Lens, 1953.

**Remarks**

Identified by Rosenkrantz as *Cucullaearca*.

**Summary of the material**

Sonja Lens: 6 valves.

***Barbatia (Cucullaearca)* Gray, 1842*****Barbatia (Cucullaearca?)* sp. 3**

Fig. 25.

**Material:**

SONJA LENS: 1981-349, 1951 (1 fragment referred to *Cucullaearca* by Rosenkrantz). - 1980-368, 1956 (1 valve, Fig. 25).

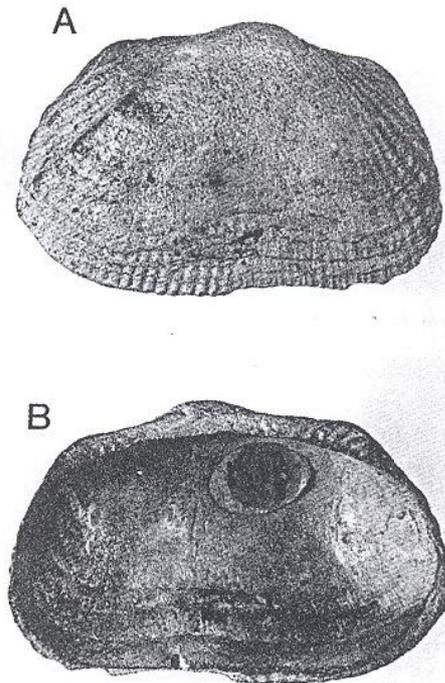


Fig. 25. MGUH 25.151. *Barbatia (Cucullaearca)* sp. 3. One right valve in outer (A) and inner (B) views: L = 37.5, H = 24.0, 1/2 W = 5.8 mm. The shell was worn before fossilization. Sonja Lens, 1980-368, 1956.

**Remarks**

Resembles *B. (C.) lincta* (Conrad, 1875) illustrated in Moore (1969: N252, fig. C3, 2a, b). Upper Cretaceous, North Carolina.

***Barbatia (Cucullaearca?)* sp. 4**

Figs 26-27.

**Material:**

SONJA LENS: 1981-488, 1951 (1 valve: L = 10.2, Fig. 26; 5 valves: L = 7.0, 7.1, 9.9, 16.0, 18.0). - Not numbered, 1956 (1 left valve: L = ca. 18, Fig. 27).

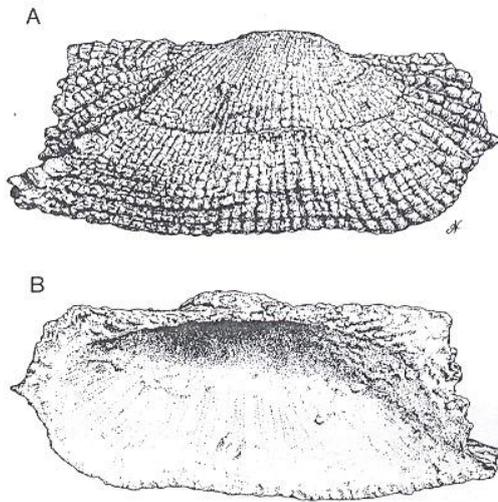


Fig. 26. MGUH 25.152. *Barbatia (Cucullaearca?)* sp. 4. One right valve in outer (A) and inner (B) views: L = 10.2 mm. Sonja Lens, 1981-488, 1951.

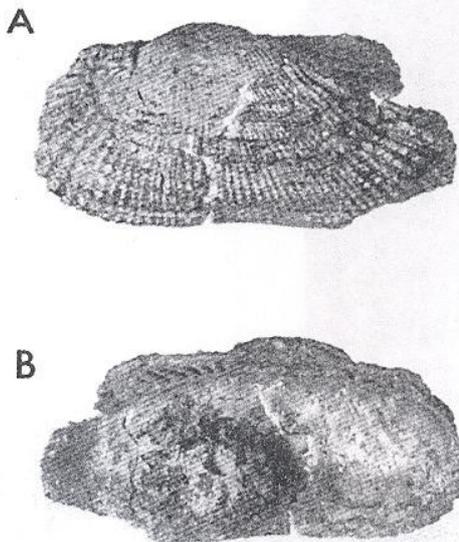


Fig. 27. MGUH 25.153. *Barbatia (Cucullaearca?)* sp. 4. One left valve in outer (A) and inner (B) views: L = ca. 18 mm. Sonja Lens, no number, 1956.

*Remarks*

The hinge corresponds to *Cucullaearca*, but the structure is different (Moore 1969: N253, fig. C3 2a, b).

*Summary of the material*

Sonja Lens: 7 valves.

*Barbatia (Acar?)* Gray, 1842

*Barbatia (Acar?)* sp. 5

Fig. 28.

*Material:*

SONJA LENS: 1981-399, 1953 (figured specimen only).

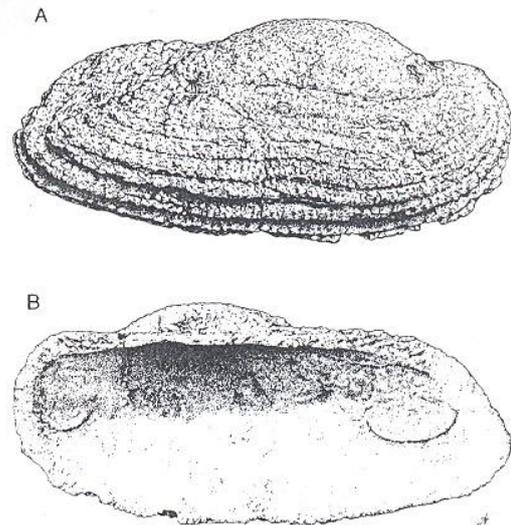


Fig. 28. MGUH 25.154. *Barbatia (Acar?)* sp. 5. One right valve in outer (A) and inner (B) views: L = 12.5 mm. Sonja Lens, 1981-399, 1953.

*Remarks*

The adductor scars are raised.

*Barbatia* sp. 6

Fig. 29.

*Material:*

SONJA LENS: 1958 (only Rosenkrantz's photograph, Fig. 29).

*Remarks*

Identified by Rosenkrantz as *Barbatia*.

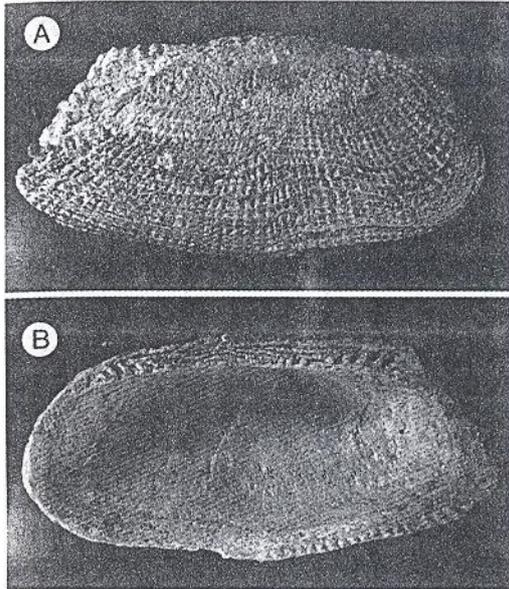


Fig. 29. MGUH 25.155. *Barbatia* sp. 6. One right valve in outer (A) and inner (B) views. Photo from Rosenkrantz's notes. Sonja Lens, 1958.

***Barbatia* sp. 7**

Fig. 30.

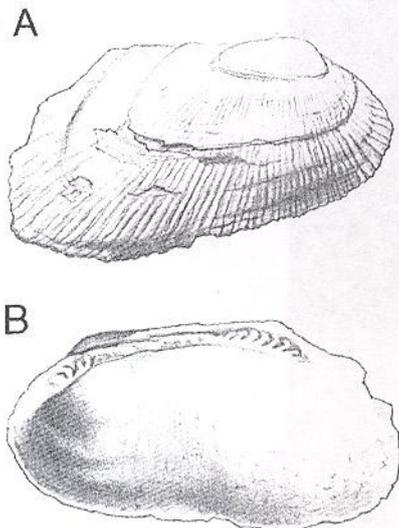


Fig. 30. MGUH 25.156. *Barbatia* sp. 7. One right valve in outer (A) and inner (B) views: L = 12.5, H = 6.9 mm. Sonja Lens, drawings from Rosenkrantz's notes.

Material:

SONJA LENS (figured specimen only: 1 right valve: L = 12.5, H = 6.9. Drawings from Rosenkrantz's notes).

*Remarks*

Identified by Rosenkrantz as *Barbatia*.

***Barbatia* sp. 8**

Fig. 31.

Material:

NUILAUSSARSSUAQ: Northwest corner: 1953 (figured specimen only).

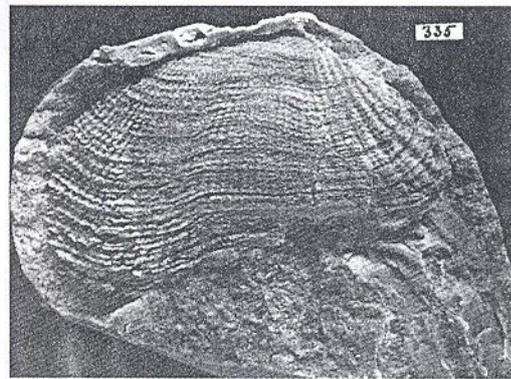


Fig. 31. MGUH 25.157. *Barbatia* sp. 8. One valve, outer view. Photo of a mould from Rosenkrantz's notes. Nuilaussarssuaq, northwest corner, 1953.

*Remarks*

Identified by Rosenkrantz as "*Arca (Barbatia) scabrosa* Nyst according to Cossman & Pissarro, pl. 35, fig. 7".

***Barbatia* sp. indet.**

Fig. 32.

Material:

NUILAUSSARSSUAQ: West side: 1981-279, 1953 (steinkern of a right valve: L = ca. 57). Figured specimen only.

*Remarks*

The imprints of hinge and outline come close to those of *Barbatia*.

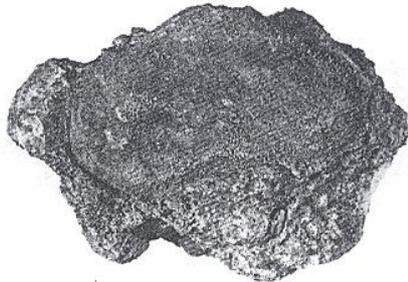


Fig. 32. MGUH 25.158. *Barbatia* sp. indet. Steinkern of right valve, ca. 57 mm long, Nuilaussarsuaq, west side, 1981-279, 1953.

*Anadara* Gray, 1847

*Anadara* sp. 1

Fig. 33.

Material:

SONJA LENS: 1081-442, 1951 (1 left valve: L = 4.2).  
Figured specimen only.

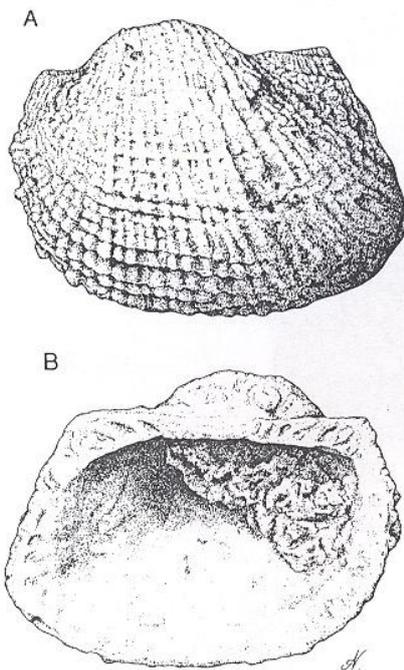


Fig. 33. MGUH 25.159. *Anadara* sp. 1. One left valve, outer (A) and inner (B) views: L = 4.2 mm. Sonja Lens, 1081-442, 1951.

*Remarks*

This resembles the Recent *Anadara brasiliiana* (Lamarck, 1819). Florida to Brazil.

*Anadara?* sp. indet.

Fig. 34.

Material:

QAERSUTJÆGERDAL: Canyon Section: 1980-439, 1956 (figured specimen and 2 steinkerns: L = 67, 75). All 3 steinkerns are from paired valves that are slightly displaced. – West side: 1981-329, 1943 (2 steinkerns of umbonal parts). – Macclintockia Section: Agatkløft: 1980-334, 1953 (3 steinkerns of left valves: L = 46, 55, 58, in layer of coarse gravel).



Fig. 34. MGUH 25.160. *Anadara?* sp. indet. Steinkern comprising pair of slightly displaced valves: L = 53 mm. Qaersutjægerdal, Canyon Section, 1980-439, 1956.

*Remarks*

The steinkerns are referred with reservation to *Anadara*.

*Summary of the material*

Qaersutjægerdal: 3 paired + 2 single valves.  
Agatkløft: 3 single valves.

Paralleodontidae Dall, 1898

*Nemodon* Conrad, 1869

*Nemodon* sp. 1

Fig. 35.

Material:

SONJA LENS: 1981-408, 1953 (figured specimen and 1 other left valve: L = 14).

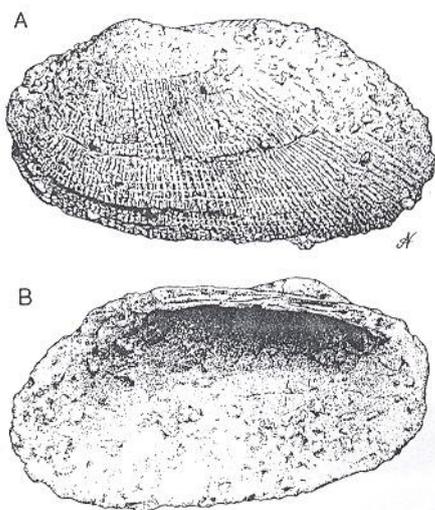


Fig. 35. MGUH 25.161. *Nemodon* sp. 1. One left valve, outer (A) and inner (B) views: L = 9.5 mm. Sonja Lens, 1981-408, 1953.

*Remarks*

Resembles *Nemodon eufalensis* (Gabb, 1860) figured in Moore (1969: N258, fig. C7, 6a, b). Upper Cretaceous, North America.

*Nemodon* sp. 2

Fig. 36.

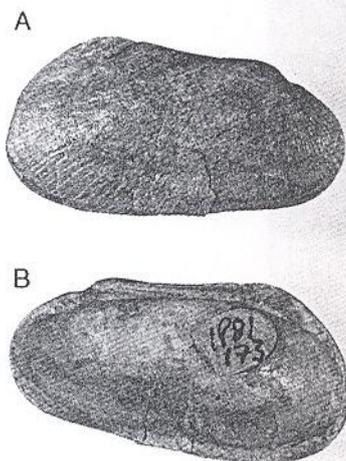


Fig. 36. MGUH 25.162. *Nemodon* sp. 2. One right valve, outer (A) and inner (B) views: L = 32.5, H = 17.3, D = 4.6 mm, worn before fossilization. Sonja Lens, 1981-173, 1953.

*Material:*

SONJA LENS: 1981-173, 1953 (specimen shown in Fig. 36 and 1 right valve: L = ca. 7). Photo (not shown) from Rosenkrantz's notes (1 valve: L = ca. 20).

*Remarks*

Identified by Rosenkrantz as *Cucullaearca* sp.

*Nemodon* sp. 3

Fig. 37.

*Material:*

SONJA LENS: figured specimen.

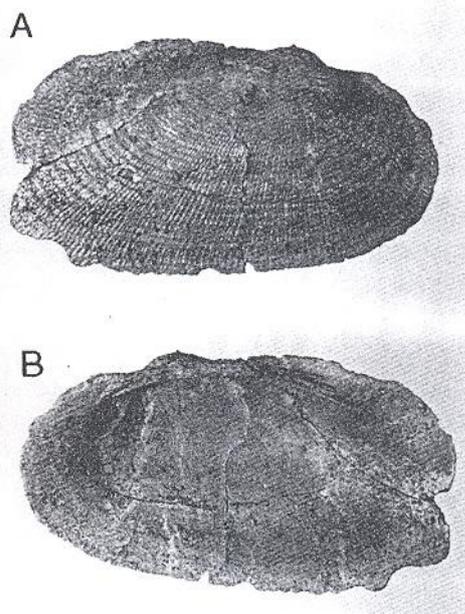


Fig. 37. MGUH 25.164. *Nemodon* sp. 3. One right valve, outer (A) and inner (B) views: L = 32 mm. Sonja Lens, 1981-489, 1948.

*Remarks*

Identified by Rosenkrantz as "*Arca* (*Cucullaria*) *heterodonta* Deshayes".

*Nemodon* sp. 4

Fig. 38.

*Material:*

Only drawings and information from Rosenkrantz's notes are available. SONJA LENS: 1958. Several shells. Rosenkrantz gives the following measurements: L = 8.8, H = 5.0; L = 12.2, H = 7.6; L = 17.0, H = 9.7

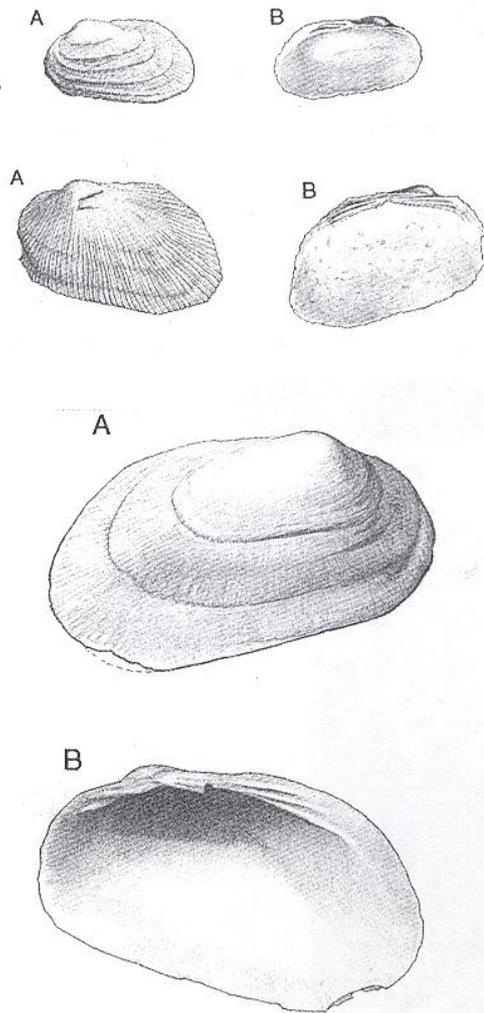


Fig. 38. MGUH 25.165. *Nemodon* sp. 4. Three valves in outer (A) and inner (B) views. Drawings from Rosenkrantz's notes. Sonja Lens, 1958.

*Remarks*

Identified by Rosenkrantz as *Nemodon*.

*Summary of the material*

Sonja Lens: ca. 8 shells.

*Nemodon* sp. 5

Fig. 39.

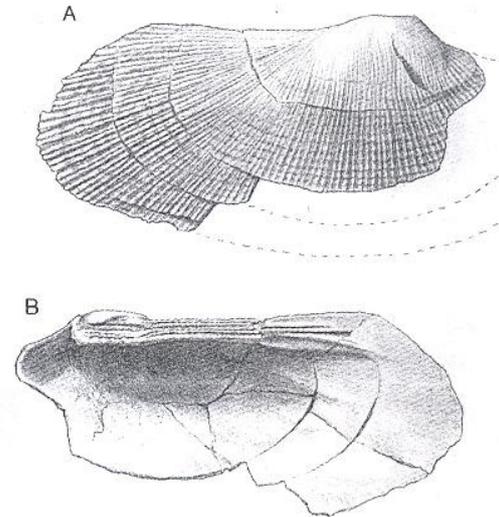


Fig. 39. MGUH 25.166. *Nemodon* sp. 5. Broken right valve in outer (A) and inner (B) views: L = 26.5, H = 14.1 mm. Drawings from Rosenkrantz's notes. Sonja Lens, 1958.

*Material:*

SONJA LENS: 1958 (1 broken valve: L = 26.5, H = 14.1). Only the drawings from Rosenkrantz's notes exist.

*Remarks*

Identified by Rosenkrantz as *Nemodon*.

*Nemodon* sp. 6

Fig. 40.

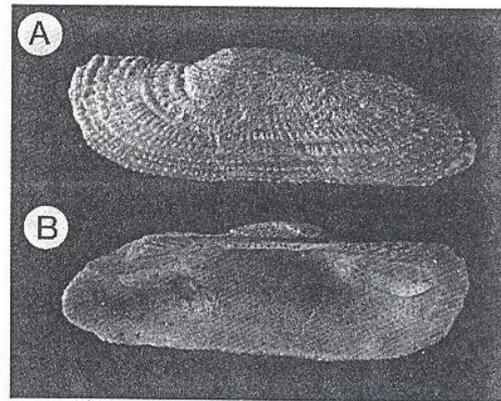


Fig. 40. MGUH 25.167. *Nemodon* sp. 6. One left valve, outer (A) and inner (B) views. Photo from Rosenkrantz's notes. Sonja Lens, 1956.

Material:  
SONJA LENS: 1956. Only the figured specimen is known.

**Cucullaeidae Stewart, 1930**  
***Cucullaea* Lamarck, 1801**  
***Cucullaea* sp. 1**

Figs 41-42.

Material:  
TURRITELLAKLØFT: Great Section: *Lower sandstone*

*bench*: no number, 1948 (Fig. 41, identified by Rosenkrantz as *Cucullaea*).

SONJA LENS: 1981-414, 1951 (1 valve: L = 7.6, Fig. 42; 4 valves: L = 6, 14, 18, 21). - 1981-399 1953 (1 valve: L = 5.5). - 1981-400, 1952 (1 valve: L = 8.0 and fragments of 2 valves: estimated L = 22, 23).

QAERSUTJÆGERDAL: *Concretion layer below tuff-shale series*: 1981-157, 1958 (1 valve: L = ca. 20).

*Summary of the material*

Turritellakløft: 1 valve. Sonja Lens: 9 valves. Qaersutjægerdal: 1 valve.

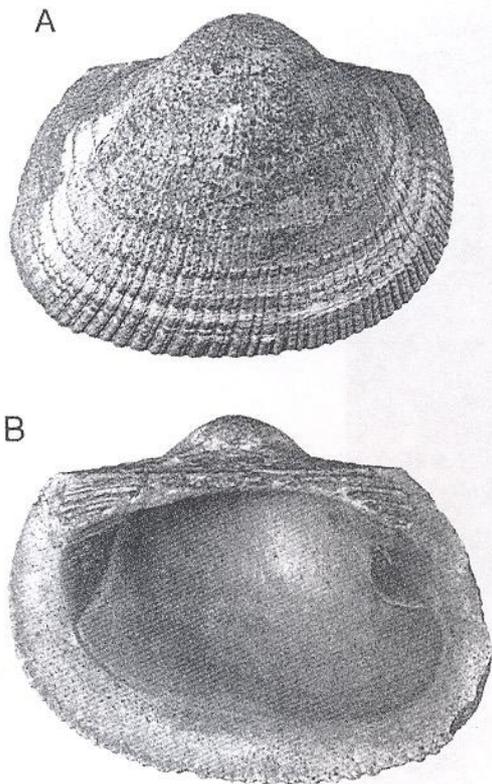


Fig. 41. MGUH 25.168. *Cucullaea* sp. 1. One right valve, outer (A) and inner (B) views: L = 64.6, H = 51.8, 1/2 W = 21.3 mm. Turritellakløft, Great Section, lower sandstone bench, no number, 1948.

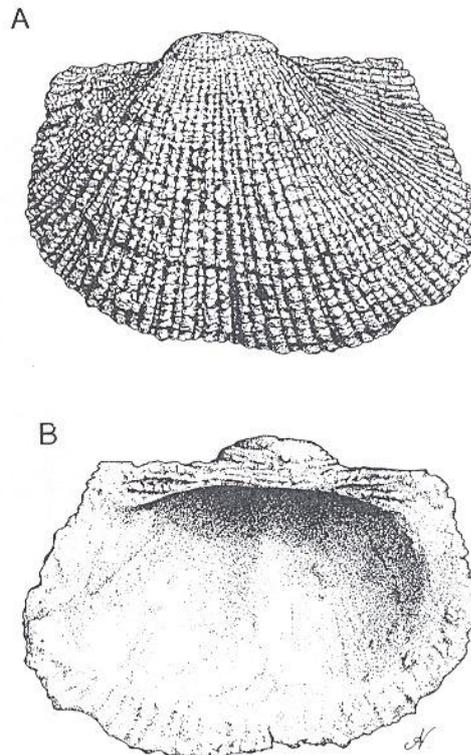


Fig. 42. MGUH 25.169. *Cucullaea* sp. 1. One left valve, outer (A) and inner (B) views: L = 7.6 mm. Sonja Lens, 1981-414, 1951.

*Cucullaea* sp. 2

Fig. 43.

## Material:

TURRITELLAKLØFT: Concretion layer at base of delta layer: GGU 4708, 1948 (figured specimen and 1 left valve: L = 87.2, H = 69, 1/2 W = 40.2).

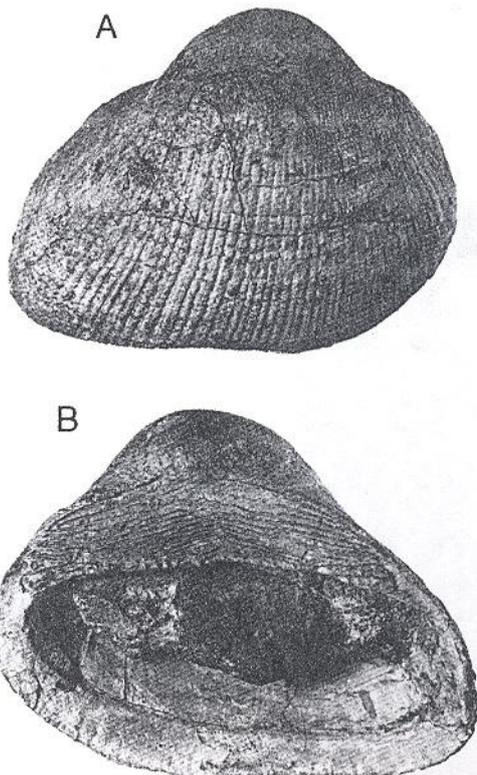


Fig. 43. MGUH 25.170. *Cucullaea* sp. 2. One right valve, outer (A) and inner (B) views: L = 92.6, H = 72.1, 1/2 W = 42.0 mm. Turritellakløft, concretion layer at base of delta layer, GGU 4708, 1948.

*Remarks*

Identified by Rosenkrantz as "*Cucullaea (Latiarca)*".

*Cucullaea* sp. 3

Fig. 44.

## Material:

QAERSUTJÆGERDAL: Concretion layer below tuff-shale series: figured specimen, identified by Rosenkrantz as *Cucullaea*.

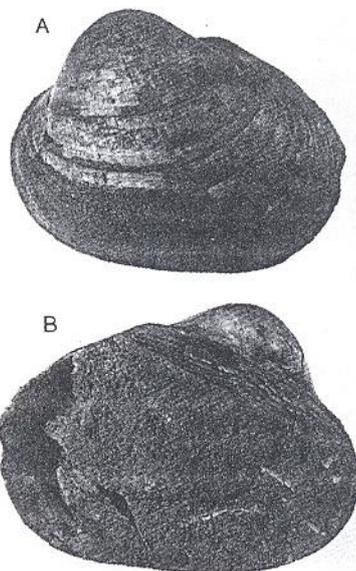


Fig. 44. MGUH 25.171. *Cucullaea* sp. 3. One left valve, outer (A) and inner (B) views: L = 102.0, H = ca. 90, 1/2 W = 41.5 mm. Qaersutjægerdal, concretion layer below tuff-shale series. No number, 1953.

*Cucullaea* sp. 4

Fig. 45.

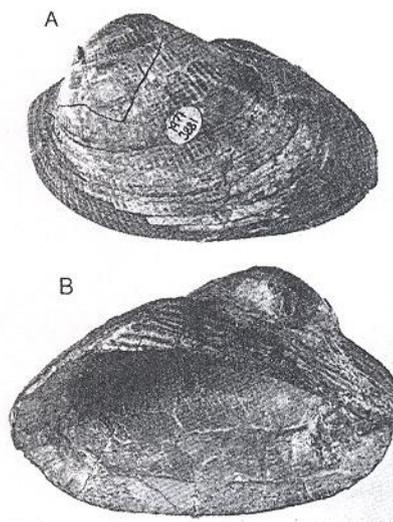


Fig. 45. MGUH 25.172. *Cucullaea* sp. 4. One left valve, outer (A) and inner (B) views; approximate measures: L = 86.3, H = ca. 57, 1/2 W = ca. 39 mm). Turritellakløft, Great Section. 1977-3881, 1958.

Material:  
TURRITELLAKLØFT: Great Section: 1977-3881, 1958 (1 left valve; approximate measures: L = 86.3, H = ca. 57, 1/2 W = ca. 39). Figured specimen only.

*Cucullaea* sp. 5

Figs 46-47.

Material:  
TURRITELLAKLØFT: *Cucullaea* concretion, eastward below delta: 1977-3849, 1946 (1 valve, L = 65.6, Fig. 46. Identified by Rosenkrantz as "*Cucullaea (Latiarca)*").

QAERSUTJÆGERDAL: Concretion layer below tuff-shale series: GGU no. 8166, 1956 (1 specimen with two paired valves partly opened and displaced: L = 99.5, H = 84). - GGU no. 11848, 1954 (1 specimen with two paired valves partly open and displaced. The specimen is also distorted by compaction: L = 97.1, Fig. 47). - 1977-3862, 1953 (1 left valve: L = ca. 100).

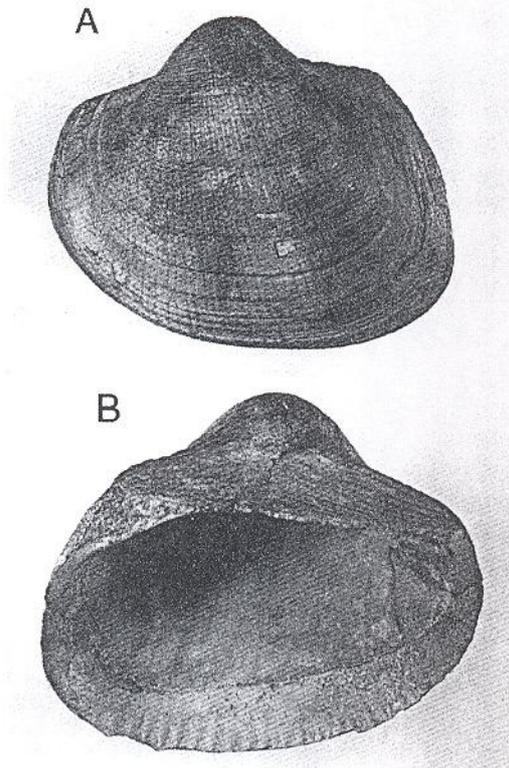


Fig. 46. MGUH 25.173. *Cucullaea* sp. 5. One left valve, outer (A) and inner (B) views: L = 65.6, H = 53, 1/2 W = 29.4 mm. Turritellakløft, *Cucullaea* concretion, eastward below delta. 1977-3849, 1946.

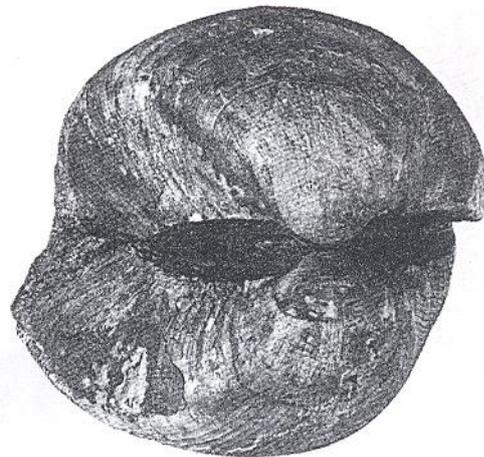


Fig. 47. MGUH 25.174. *Cucullaea* sp. 5. One specimen with the two paired valves partly open and displaced. The specimen is also distorted by compaction: L = 97.1 mm. Qaersutjægerdal, concretion layer below tuff-shale series. GGU 11848, 1954.

*Cucullaea* sp. 6

Not figured.

Material:  
TURRITELLAKLØFT: 1977-3870, 1939 (1 specimen with closed valves, but deformed by compaction. Estimated length ca. 100. Identified by Rosenkrantz as *Cucullaea*).

*Cucullaea* ("*Latiarca*") cf. *solenensis* Stanton?  
Not figured.

Material:  
This species is only represented by a preliminary sketch in Rosenkrantz's notes, and identified by him as the said species from the Cannonball Formation (Danian) of the north-central U.S. It is a reconstruction of a valve: L = 45, H = 39; there is also 1 fragment of a larger specimen. Collected in 1946 at "Kangilia, Ryg B, conglomerate, 688 m altitude". We have not seen the original material.

Remarks

The *Cucullaea* material indicates a faunistic relationship between the Kangilia Formation and the Agatdal Formation. The two partly open, whole specimens of *Cucullaea* sp. 5 indicate that part of the Qaersutjægerdal sediment was flushed gently before the valves were imbedded and fossilized.

## Noetiidae Stewart, 1930

*Striarca* Conrad, 1862*Striarca* sp. 1

Figs 48-49.

## Material:

SONJA LENS: 1980-378, 1953 (1 valve: L = 8.9 and 1 valve: L = 13.0, Fig. 48). - 1981-428, 1953 (5 valves: L = 7.6, 8.6, 8.9, 9.9, 10.5, Fig. 49).

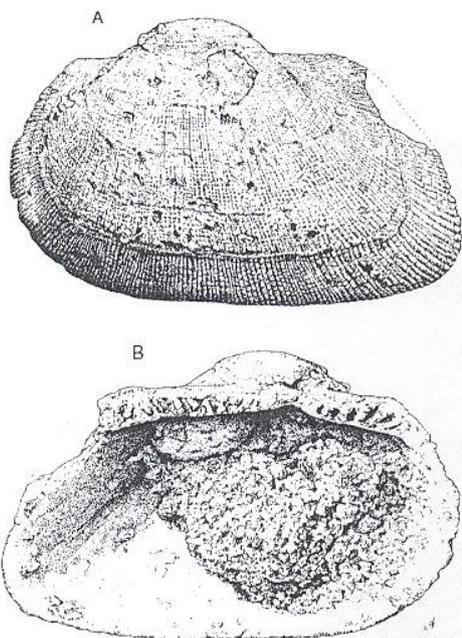


Fig. 48. MGUH 25.175. *Striarca* sp. 1. One left valve, outer (A) and inner (B) views: L = 13.0 mm. Sonja Lens, 1980-378, 1953.

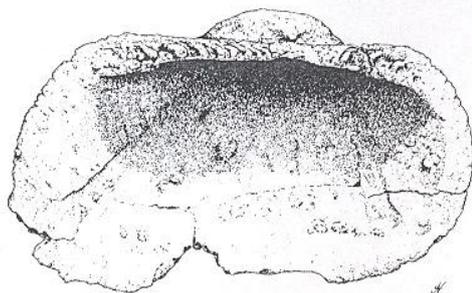


Fig. 49. MGUH 25.176. *Striarca* sp. 1. One left valve, inner view: L = 10.5 mm. Sonja Lens, 1981-428, 1953.

*Arcopsis* Koenen, 1885*Arcopsis* sp. 1

Fig. 50.

## Material:

TURRITELLAKLØFT: Great Section: Lower sandstone bench: 1980-104, 1948. - 1980-121, 1956. - 1980-373, 1949. - 1981-130, 1948. - 1981-369, 1946. - 1981-378, 1959. - 1981-397, 1953. - 1981-456, 1948. - 1981-466, 1948. - 1981-445, 1951. - 1981-459, 1948. - 1981-469, 1948. - 1981-473, 1951. - 1981-482, 1953.

SONJA LENS: 1980-109, 1951. - 1981-386, 1953. - 1981-511, 1948. - The photographs of the figured specimen are from Rosenkrantz's notes.

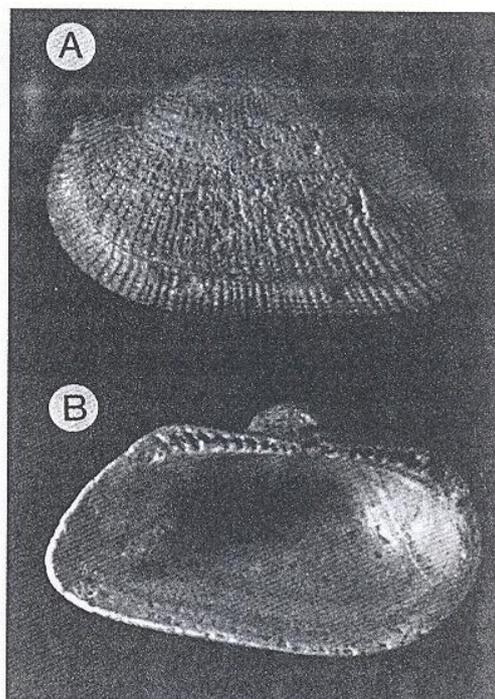


Fig. 50. MGUH 25.177. *Arcopsis* sp. 1. One left valve, outer (A) and inner (B) views. Photos from Rosenkrantz's notes. Sonja Lens.

*Remarks*

The material is difficult to identify, count and measure. It comes from two localities: 1. Turritellakløft, where the shells are imbedded in hard conglomerate, and some are in their life positions, and 2. Sonja Lens, where the shells lie in loose material and look as if they have been

transported and worn. The largest specimens are about 15 mm long. The shells fit the description and figure in Reinhardt (1935) and Bird (1965, plate 1, figs 7, 8). Two of the specimens were identified by Rosenkrantz as *Arcopsis*.

*Summary of the material*

Turritellakløft: ca. 30 valves + 1 whole specimen.  
Sonja Lens: ca. 25 valves.

**Glycymerididae Newton, 1922**

*Glycymeris* Da Costa, 1778

*Glycymeris* sp. or spp.

The material of *Glycymeris* is rather large, but not well preserved. It seems possible to distinguish between three forms, but it is not possible to tell whether they are variations, different populations or species.

***Glycymeris* form 1**

Figs 51-54.

**Material:**

TURRITELLAKLØFT: **Great Section:** (layer not noted) 1980-89, 1968 (2 valves: L = 53.2, H = 50.6; L = 57.0, H = 56.0). - *Lower sandstone bench:* 1980-103, 1953 (1 worn valve: L = ca. 11). - 1981-231, 1946 (1 valve: L = 11.8, H = 12.0). - 1981-232, 1948 (2 valves in sand and shells: L = 14.0, H = 8.5; L = ca. 15, H = ca. 9.9). - 1981-266, 1946 (1 valve: L = 14.5 H = 13.2). - 1981-288, 1948 (1 valve in coarse sand with shells: L = 39.2, H = 38.9). - 1981-289, 1956 (1 valve: L = ca. 10). - 1981-290, 1946 (1 whole specimen with closed valves: L = 56.2, H = 55.0). - 1981-291, 1949 (1 valve: L = ca. 9). - 1981-364, 1946 (1 worn valve: L = ca. 5). - 1981-451, 1948 (1 worn valve: L = ca. 17). - 1981-465, 1946 (1 worn valve: L = ca. 4). - 1981-470, 1948 (1 valve: L = ca. 11). - No number, 1946 (2 valves, L = 59.7, 62.6, identified by Rosenkrantz as *Glycymeris*). - *Turritella conglomerate, eastward below delta:* 1981-262, 1949 (4 worn valves imbedded in gravel and rolled stones: L = 47.2, H = 46.9; L = 57.5, H = 58.0; L = 60.7, H = 61.5; L = ca. 60). - 1981-263, 1948 (4 valves: L = 25.1, 40.5, 57.0, 64.5; note that *Glycymeris* forms 2 and 3 are from this sample). - 1981-265, 1949 (1 left valve in conglomerate of gravel and rolled stones: L = ca. 62.8, H = 66.6). - 1981-281, 1949 (4 valves in gravel and rolled stones: L = ca. 59, 55, 43, 33). - 1981-282, 1949 (2 worn valves: L = ca. 48; L = 53, H = 52.5). - 1981-283, 1949 (2 valves: L = ca. 22, H = ca. 21; L = ca. 33). - 1981-284, 1949 (1 valve imbedded in rolled stones: L = ca. 59, Fig. 52). - 1981-285, 1949 (1 worn, broken valve: L = ?, H = ca. 68). - 1981-286 (1 valve: L = ca. 9). - *Cucullaea layer:* 1981-267, 1946 (1 whole closed specimen: L = 48.1, H = 48.1; 7 worn valves: L = 39.3, L = 43.2; L = 45.2, H = 44.1; L = 49.0, H = 47.2; L = 53.6, H = 52.8; L = 55, H = 53; L = 66.0, H = 61.7

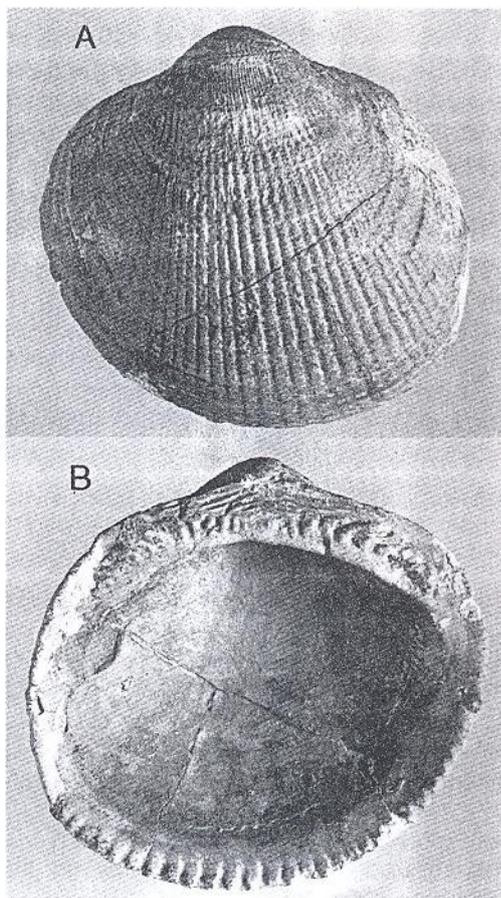


Fig. 51. MGUH 25.178. *Glycymeris* form 1. One left valve, outer (A) and inner (B) views. L = 59.0, H = 55, 1/2 W = 20.5 mm. The muscle scars are visible. Turritellakløft, Great Section, loose block in the riverbed, 1981-287, 1949.

+ fragments or steinkerns of 9 valves from 34 to 57 mm). - 1981-295, 1948 (3 valves: L = ca. 28, H = ca. 27; L = 53.8, H = 54.4; L = 58.3, H = 55.4). - 1981-296, 1946 (2 valves: L = 28.2, H = 27.0; L = 39.4, H = 36.4). - *Loose block in riverbed:* 1981-287, 1949 (1 left valve: L = 59.0, H = 55, D = 20.5, Fig. 51). - *South side:* (layer not noted) 1981-293, 1946 (1 valve: L = 59.2, H = 59.0). - *Lumachelle:* 1981-254, 1939 (1 valve: L = ca. 7).

SONJA LENS: 1981-272, 1958 (fragments of big specimen). - 1981-380, 1948 (5 valves: L = 6.8, 6.9, 9.0, 9.8, 10.6). - 1981-412, 1952 (1 valve: L = 8.4). - 1981-444, 1951 (2 valves: L = 8.0, 8.5). - 1989-491, 1953 (2 valves: L = 4.5, 6.5, Fig. 53).

QAERSUTJÆGERDAL: **Great Section: Upper concretion layer:** 1981-230, 1951 (1 whole, closed, somewhat distorted, specimen: L = ca. 51, H = ca. 50). - 1981-268, 1952

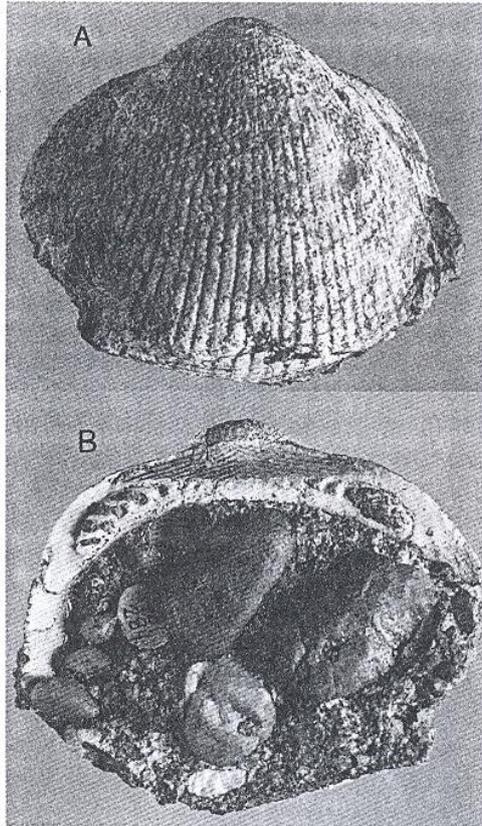


Fig. 52. MGUH 25.180. *Glycymeris* form 1. One valve, outer (A) and inner (B) views. L = ca. 59 mm, with rolled stones. Turritellakløft, Great Section, *Turritella* conglomerate, eastward below delta. 1981-284, 1949.

(2 valves: L = 42.1, H = 39.5; L = 42.6, H = 39.5). - 1981-270, 1952 (1 closed, paired, displaced 1 mm, specimen: L = 37.0, H = 36.5). - 1981-300, 1954 (2 whole, closed specimens: L = 25, H = 22; L = 56, H = 52.3; 1 whole specimen, valves gaping ca. 20 degrees: L = 59, H = 53; 2 valves: L = 38, H = 37; L = ?, H = 43). - *Conglomerate below tuff-shale series*: 1981-116, 1948 (1 valve: L = 31.6, H = 29.1). - 1981-249, 1954 (fragment of valve: L = ca. 50). - 1981-271, 1953 (1 whole, closed, distorted specimen: L = ca. 18.3, H = ca. 17.4). - 1981-297, 1953 (2 valves: L = 9.0, H = 7.9; L = 19.8, H = 18.6; 2 valves with naticid holes: L = 19.0, H = 17.2; L = 19.2, H = 18.0). - 1981-298, 1956 (3 whole, closed, distorted specimens: L = 35.2, H = 33.4; L = 37.3, H = 36.3; L = 51.0, H = 50.5 1 whole specimen, gaping ca. 20 degrees: L = ca. 25; 3 valves: L = 34; L = 43, H = 38; L = 49, H = 48). - 1981-299, 1953 (1 whole closed, distorted specimen: L = 28.5, H = ca. 29).

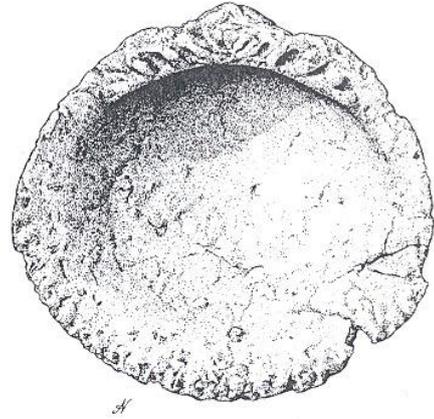


Fig. 53. MGUH 25.179. *Glycymeris* form 1. One valve: L = 4.5, H = 4.5 mm. Sonja Lens, 1981-491, 1953.

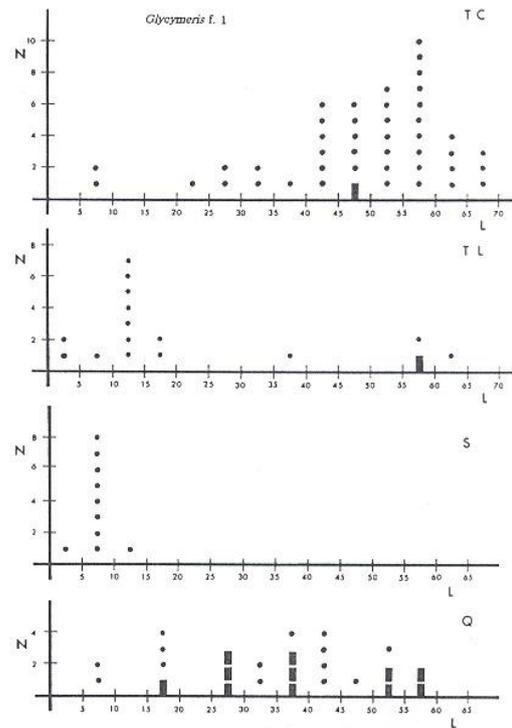


Fig. 54. *Glycymeris* form 1. Length distributions of material from: Turritellakløft, conglomerates (TC) (n = 44); Turritellakløft, lower sandstone bench (TL) (n = 16); Sonja Lens (S) (n = 10); Qaersutjægerdal (Q) (n = 25). Dots = single valves, bars = paired valves.

*Remarks*

This form is close to Recent *G. americana* (De France, 1829), Florida to Brazil, see Abbott (1986), or to Recent *G. maculata* (Broderip, 1832), see Olsson (1961: 106, fig 2, C). California to Peru. It is rather circular and the two hinge lines meet at an angle of ca. 110 degrees.

*Summary of the material*

Turritellakløft: 2 whole specimens + 60 valves. The shells are imbedded in very coarse gravel. Sonja Lens: 11 valves. The valves are worn and look as if they have been transported roughly. Qaersutjægerdal: 11 whole specimens + 13 valves, 2 with naticid holes. The samples are imbedded in sand. The length distributions are shown in Fig. 54. The material from Sonja Lens and from Turritellakløft, lower sandstone bench, is dominated by small, single valves, while larger valves dominate the material from Turritellakløft conglomerate.

*Glycymeris form 2*

Figs 55-56.

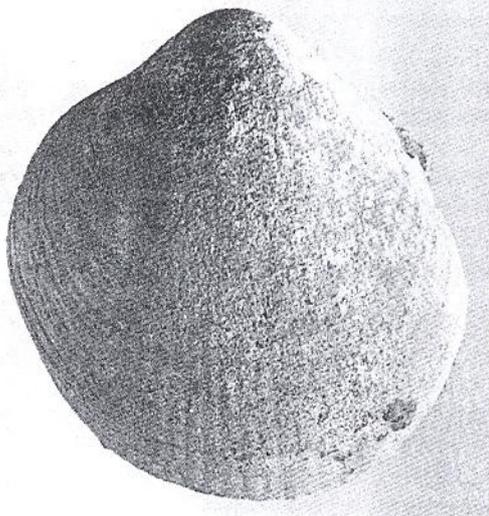


Fig. 55. MGUH 25.181. *Glycymeris* form 2. One right valve: L = 54.9, H = 55.2 mm. Turritellakløft, Great Section, *Turritella* conglomerate, eastward below delta, 1981-263, 1948.

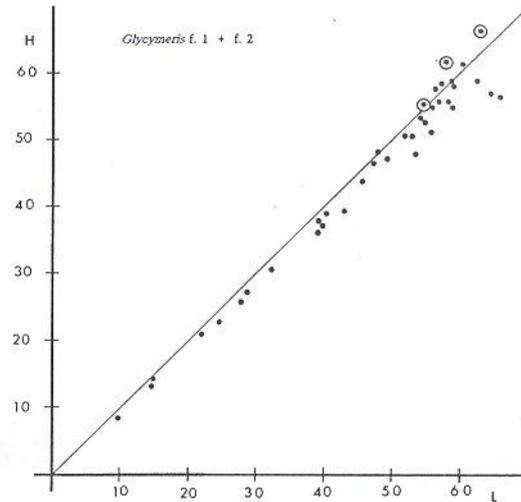


Fig. 56. Length-height relation of *Glycymeris* form 1 (dots) and form 2 (dots in a circle) from Turritellakløft.

*Material:*

TURRITELLAKLØFT: Great Section: *Turritella conglomerate*, eastward below delta: 1981-263, 1948 (figured specimen). - 1981-281, 1949 (1 valve: L = 58.0, H = 62.1).

*Remarks*

This form has a rather high shell, the two hinge lines meeting at an angle of ca. 90 degrees. The shell surface seems to be more smooth with less prominent radial ribs than in the other two forms. This form is close to *G. ovata* (Broderip, 1832) (Olsson 1961). Fig. 56 gives the length-height relations for forms 1 and 2.

*Glycymeris form 3*

Fig. 57.

*Material:*

TURRITELLAKLØFT: Great Section: *Turritella conglomerate*, eastward below delta: 1981-263, 1948 (1 valve: L = 29.8, H = 26.4). Figured specimen only.

*Remarks*

This form is almost circular, with a straight hinge that gives the shell two "shoulders".

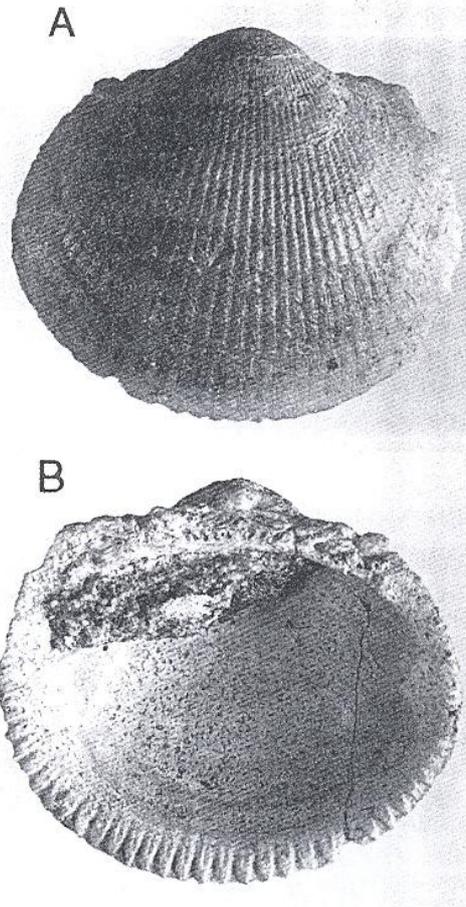


Fig. 57. MGUH 25.182. *Glycymeris* form 3. One right valve, outer (A) and inner (B) views. L = 29.8, H = 26.4 mm. Turrnellakløft, Great Section, *Turrnell* conglomerate, eastward below delta. 1981-263, 1948.

#### MYTILOIDA Férussac, 1822

##### *Mytilidae* Rafinesque, 1815

##### *Mytilid* sp. 1

Fig. 58.

##### Material:

TURRITELLAKLØFT: South side: 1980-472, 1946 (figured specimen).

QAERSUTJÆGERDAL: Great Section: Below tuff-shale series: 1980-476, 1953 (1 right valve imbedded in concretion, only partly visible, estimated length ca. 23. Remnants of the shell present).

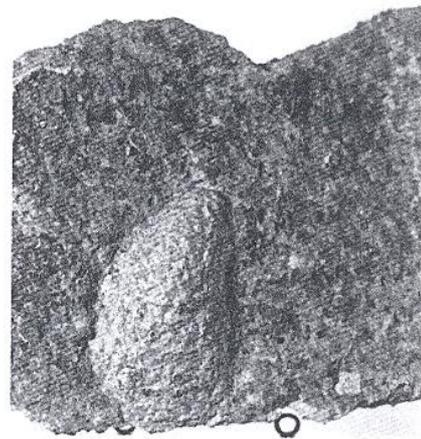


Fig. 58. MGUH 25.183. *Mytilid* sp. 1. One steinkern: L = ca. 16 mm. Turrnellakløft, south side. 1980-472, 1946 e.

#### *Brachidontes* Swainson, 1840

##### *Brachidontes* sp. 1

Fig. 59.

##### Material:

SONJA LENS: 1980-470, 1957 (1 left valve: L = ca. 5).

QAERSUTJÆGERDAL: Great Section: Upper concretion layer: 1980-469, 1952 (1 paired specimen: L = ca. 15, only partly visible in a block of sand and shells). - Layer below tuff-shale series: 1980-485, 1953 (figured specimen).

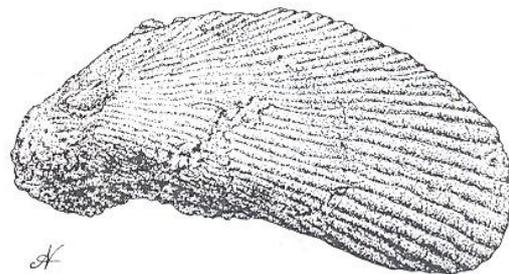


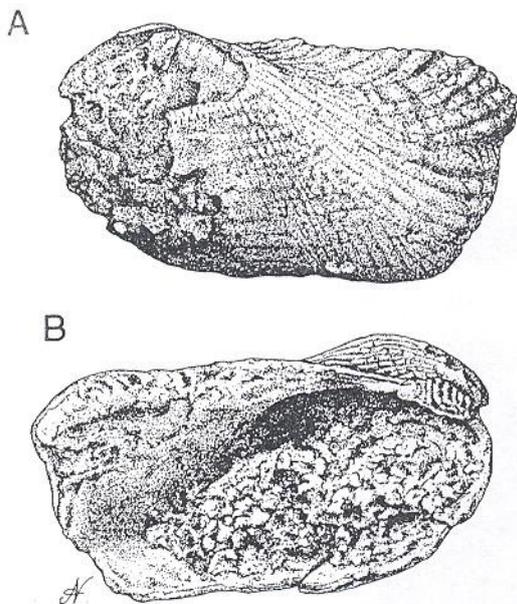
Fig. 59. MGUH 25.184. *Brachidontes* sp. 1. One left valve: L = 15, H = 6.5 mm. Qaersutjægerdal, Great Section, concretion layer below tuff-shale series, 1980-485, 1953.

***Brachidontes* sp. 2**

Fig. 60.

## Material:

SONJA LENS: 1981-501, 1952 (figured specimen + 1 valve: L = 6.3).

Fig. 60. MGUH 25.185. *Brachidontes* sp. 2. One left valve, outer (A) and inner (B) views. L = 6 mm. Sonja Lens, 1981-501, 1952.*Remarks*Identified by K. W. Ockelmann. Rosenkrantz identified it tentatively as "*Modiola?*" and "*Modiolaria?*"***Brachidontes* sp. 3**

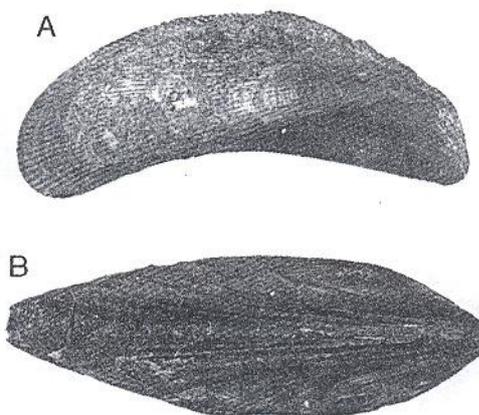
Figs 61-62.

## Material:

TURRITELLAKLØFT: Great Section: Lowermost sandstone bench: 1980-474, 1948 (steinkern, 1 right valve: L = ca. 48). - Interior Nuussuaq: 1980-480, 1939 (steinkern, 1 right valve: L = ca. 33, identified by Rosenkrantz as "*Modiola elegans* Sowerby").

QAERSUTJÆGERDAL: Great Section: Upper concretion layer: 1980-479, 1952 (2 valves: L = ca. 37, in sediment of sand, wood and shells, Fig. 62). - 1980-486, 1952 (5 right valves in sand, coal and shells: L = 15, 16, 21, 30, 30). - 1980-487, 1952 (1 complete, closed specimen: L = 23.5, and 2 left

valves: L = ca. 28, 37). - Concretion layer below tuff-shale series: 1980-481, 1954 (1 complete, closed specimen: L = 26.8 and 1 right valve: L = 28.2). - 1980-484, 1956 (1 complete, closed specimen: L = 39.0, H = 13.0, W = 14, Fig. 61). - 1980-571, 1953 (2 complete, closed specimens: L = ca. 29, 30; 2 right valves: L = ca. 21, 25; 2 left valves: L = 21, ca. 34; and 5 fragments). - 1981-475, 1956 (1 right valve: L = ca. 21). - West side: 1980-483, 1953 (1 right valve: L = ca. 15 + 1 left valve: L = ca. 10).

Fig. 61. MGUH 25.186. *Brachidontes* sp. 3. One complete, closed specimen: L = 39.0, H = 13.0, W = 14 mm. Seen from right side (A) and ventral (B) side. Qaersutjægerdal, Great Section, concretion layer below tuff-shale series, 1980-484, 1956.Fig. 62. MGUH 25.187. *Brachidontes* sp. 3. Two valves: L = ca. 37 mm. Qaersutjægerdal, Great Section, upper concretion layer. 1980-479, 1952.*Remarks*

Identified by K. W. Ockelmann.

*Summary of the material*

Turritellakløft: 2 valves. Qaersutjægerdal: 6 whole specimens + 17 valves.

*Lithophaga* Rüding, 1798*Lithophaga* sp. 1

Fig. 63.

## Material:

TURRITELLAKLØFT: Great Section: *Cucullaea conglomerate*: 1981-165, 1949 (1 whole specimen: L = 20.0, D = 7.0; 4 specimens with paired valves). - Eastward below delta: 1981-168, 1949 (1 whole specimen, see Fig. 63, and also pieces of original shells in their tubes in a fine clay matrix, probably Kangilia Formation. Also remnants of *Diplothyra*. Part of the tubes are filled with coarser sand).

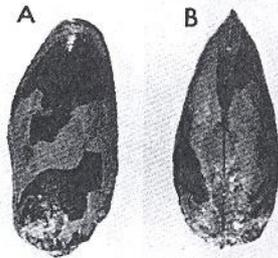


Fig. 63. MGUH 25.188. *Lithophaga* sp. 1. One whole specimen, seen from left (A) and dorsal (B) side. L = 15.4, H = 6.8, W = 6.8 mm (H = W = Diameter). Turritellakløft, Great Section, eastward below delta, 1981-168, 1949.

*Remarks*

The valves are smooth. Note that for boring bivalves, height = width = diameter. Close to modern *Lithophaga antillarum* Orbigny, 1842 (Florida to Brazil), and *L. nigra* Orbigny, 1842.

*Gregariella* Monterosato, 1883*Gregariella* sp. 1

Figs 64-65.

## Material:

TURRITELLAKLØFT: Conglomerate: Eastward below delta: 1981-169, 1949 (2 whole specimens, Fig. 64; also several pieces in position in the clay, Fig. 65. The specimens sit in tubes filled with a little coarser material, which is surrounded by a fine wall).

*Remarks*

Identified by K. W. Ockelmann. This species has radiating ribs. See also *Diplothyra*.

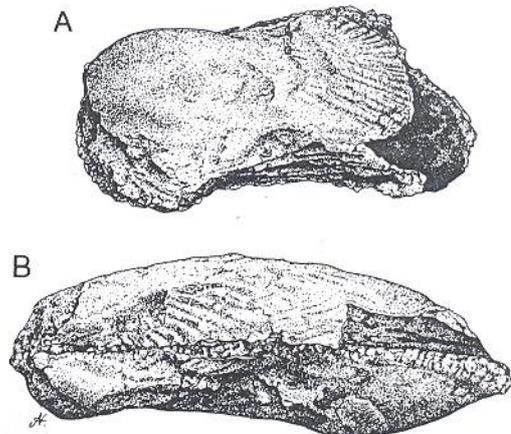


Fig. 64. MGUH 25.189. *Gregariella* sp. 1. Two complete specimens: L = 6.5 mm (A), 8.5 mm (B). Turritellakløft, Great Section, conglomerate, eastward below delta, 1981-169, 1949.

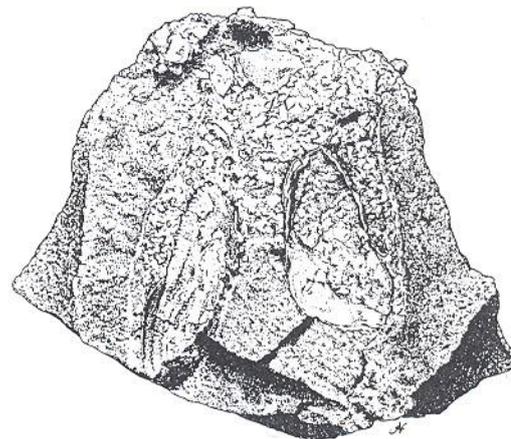


Fig. 65. MGUH 25.190. *Gregariella* sp. 1. Tube with remnants of shell. The tube is filled with a slightly coarser material than the surrounding hardened black clay, and is delimited by a fine wall. The piece is ca. 14 x 18 mm.

*Modiolus* Lamarck, 1799*Modiolus* sp. 1

Fig. 66.

## Material:

SONJA LENS: 1981-427, 1951 (1 left valve: L = ca. 6).  
QAERSUTJÆGERDAL: Great Section: Upper concretion layer: 1980-477, 1953 (1 valve: ca. 6 mm, steinkern). - 1980-478, 1953 (1 left valve: L = 13.2, H = 5.1). - 1981-55,

1952 (2 right valves: L = 6.5, 7.5). - 1981-57, 1952 (1 steinkern: L = ca. 20). - 1981-60, 1952 (1 valve: L = 9.6, Fig. 66). - *Below tuff-shale series*: 1981-56, 1953 (steinkern of left valve: L = 13.7).

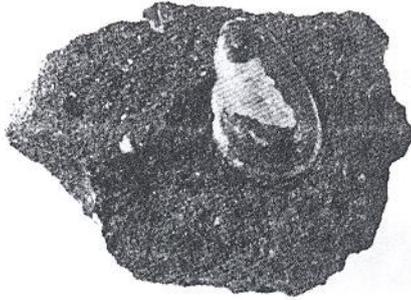


Fig. 66. MGUH 25.191. *Modiolus* sp. 1. One right valve: L = 9.6 mm, Qaersutjægerdal, Great Section, upper concretion layer, 1981-60, 1952.

#### *Modiolus* sp. 2

Fig. 67.

Material:

KANGERSÔQ WEST OF TUNORGO: 1981-61, 1952 (2 complete, closed specimens as steinkerns, compressed: L = 72, H = 25; L = 92, H = 34, Fig. 67).

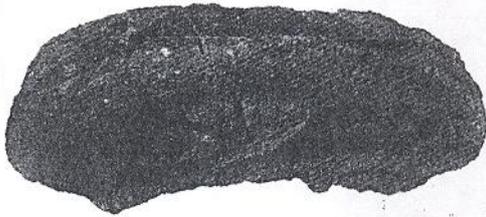


Fig. 67. MGUH 25.192. *Modiolus* sp. 2. Steinkern of complete specimen: L = 92, H = 34 mm. Kangersôq, 1981-61, 1952.

#### PTERIOIDA Newell, 1965

Pteriidae Gray, 1847

*Pteria* Scopoli, 1777

*Pteria* sp. 1

Fig. 68.

Material:

TURRITELLAKLØFT: **Great Section: Lower sandstone bench**: 1981-202, 1946 (block with several *Pteria* shells + other shells). - 1981-483, 1953 (pieces of *Pteria*). - **Lumachelle**: 1981-319, 1946 (block with many shells including at least 4 *Pteria*, ca. 10 mm; one is shown in Fig. 68). - **Turritella conglomerate, eastward below delta**: 1980-319, 1949 (1 fragment). - **South side**: 1981-318, 1946 (block with 2 types of sediment: 1. fine sediment with many small shells, and 2. coarser sand with a group of larger shells, mostly *Pteria*, ca. 30).

AGATKLØFT: **Great Section**: 1981-323, 1950 (block with many shells including 1 *Pteria*, ca. 30 mm).

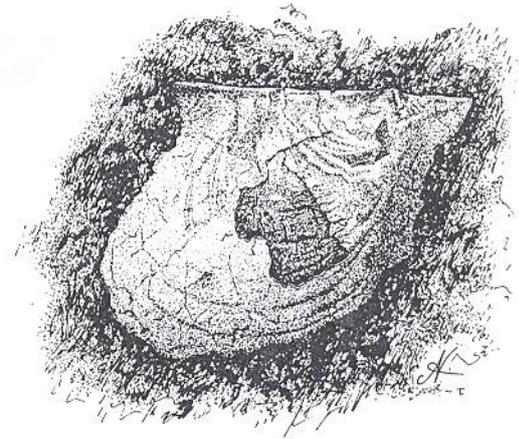


Fig. 68. MGUH 25.193. *Pteria* sp. 1. One right valve: L = ca. 9 mm. Turritellakløft, Great Section, lumachelle. 1981-319, 1946.

#### Summary of the material

Turritellakløft: ca. 46 valves. Agatkløft: ca. 1 valve.

#### *Pteria* sp. 2

Figs 69-70.

Material:

QAERSUTJÆGERDAL: **Great Section: Upper concretion layer**: 1981-244, 1952 (sediment with coal and shells, including some *Pteria*; one is shown in Fig. 69). - 1981-245, 1952 (block with coal and shells, including ca. 3 *Pteria*). - 1981-246, 1952 (small pieces of concretion where 4 *Pteria* are visible). - 1981-313, 1951 (block split along a flat aggregation of shells, all *Pteria*). - 1981-314, 1952 (block with coal and shells, including 5 valves of *Pteria*, ca. 8 mm). - 1981-315, 1952 (block with at least 2 *Pteria*, ca. 10 and 25 mm). - 1981-316, 1952 (block split through an assemblage of 5-8 *Pteria* specimens, shown in Fig. 70). - **Concretion layer below tuff-shale series**: 1981-248, 1953 (pieces of 3 *Pteria*).

- West side: 1981-275, 1953 (block with 2 specimens). - 1981-317, 1951 (block with 1 *Pteria*: L = ca. 30).

AGATKLØFT: Third canyon south of Umánaussán-guaq: Altitude 530 m: 1981-253, 1953 (1 valve). - 1981-256, 1956 (loose block split and with at least 5 *Pteria* along the split plane).

Material:

SONJA LENS: 1980-226, 1958 (figured specimen). - 1981-383, 1948 (piece of 1 *Pteria*). - 1981-413, 1951 (fragments of ca. 10 *Pteria*). - 1981-507, 1948 (piece of 1 *Pteria*). - 1981-509, 1952 (pieces of ca. 10 *Pteria*).

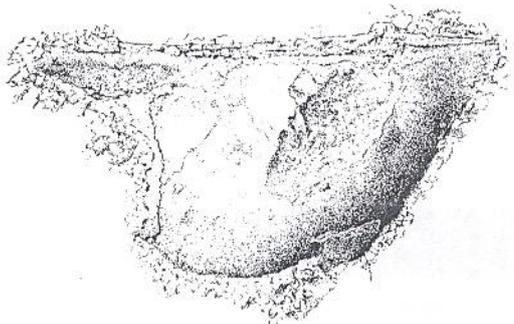


Fig. 69. MGUH 25.194. *Pteria* sp. 2. One right valve: L = 9, H = 4.5 mm. Qaersutjægerdal, Great Section, upper concretion layer. 1981-244, 1952.

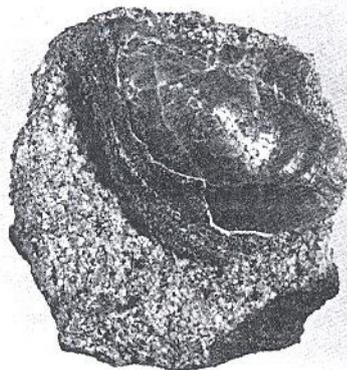


Fig. 71. MGUH 25.196. *Pteria* sp. 3. One valve: L = 17 mm. Sonja Lens, 1980-226, 1958.



Fig. 70. MGUH 25.195. Aggregation of *Pteria* sp. 2. The block is ca. 50 mm. Qaersutjægerdal, Great Section, upper concretion layer. 1981-316, 1952.

#### Summary of the material

Qaersutjægerdal: ca. 40 valves. Agatkløft: ca. 6 valves.

#### *Pteria* sp. 3

Fig. 71.

#### Summary of the material

Sonja Lens: ca. 20 valves.

#### Remarks to the *Pteria* spp.

It is with some hesitation that we split this material into 3 species. However, even when we only have fragments, they can hardly be treated as coming from one species. The material of *Pteria* sp. 1 from Turritellakløft may originate not only from the Agatdal Formation but also from other sources. The material of *Pteria* sp. 2 from Qaersutjægerdal is mainly found in blocks made up of concretions of sand, coal, shells, and with several *Pteria* aggregated. Recent *Pteria* are attached close together to, for example, a hydroid or a coral (e.g., Fig. 72). The material of *Pteria* sp. 2 may originate from such aggregations, which could have been nuclei for the blocks. Hence they have only had a short and gentle transport and belong to the Agatdal fauna. *Pteria* sp. 3 from Sonja Lens is also from the Agatdal fauna, but is different from *Pteria* sp. 2. It is difficult to measure *Pteria*, and the lengths given are estimates.

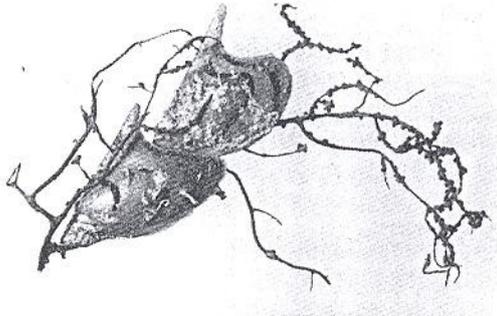


Fig. 72. ZMUC BIV-399. Recent material of *Pteria* from Ambon, Indonesia (ca. 4°S, 128°E).

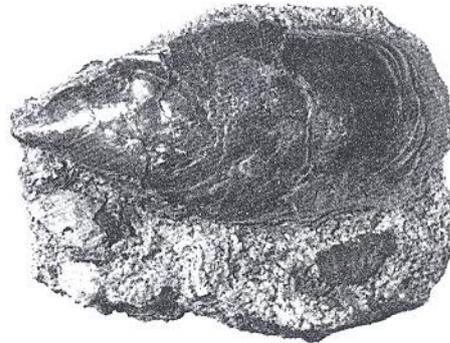


Fig. 74. MGUH 25.198. *Isognomon* sp. 1. One left valve: L = 33, H = 16 mm. Sonja Lens, 1980-473, 1958.

### Isognomonidae Woodring, 1929

#### *Isognomon* Lightfoot, 1786

##### *Isognomon* sp. 1

Figs 73-74.

#### Material:

TURRITELLAKLØFT: Great Section: *Turritella conglomerate*, eastward below delta: 1981-320, 1949 (conglomerate of gravel, coal and shells, including 2 *Isognomon* sp. 1).

SONJA LENS: 1980-226, 1958 (1 valve). - 1980-227, 1958 (Fig. 73). - 1980-317, 1953 (1 right valve: L = ca. 30). - 1980-388, 1952 (piece of valve: L = ca. 50). - 1980-473, 1958 (1 left valve: L = ca. 33, Fig. 74). - 1981-325, 1956 (piece of shell: L = ca. 50). - Two shells represented by drawings in Rosenkrantz's notes only.

AGATDAL: South of Umánarssánguaq: Altitude 550 m: 1981-312, 1953 (piece of valve: L = ca. 60).

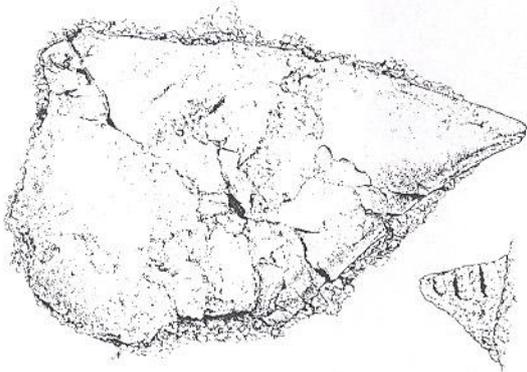


Fig. 73. MGUH 25.197. *Isognomon* sp. 1. One right valve: L = 28.5 mm. Visible part of hinge shown at lower right. Sonja Lens, 1980-227, 1958.

#### Remarks

The material is generally well preserved, with the nacreous layer intact, but it is difficult to see the inside. Recent *Isognomon* generally live in shallow water attached to mangrove roots or stones.

### Pectinidae Rafinesque, 1815

#### *Propeamussium* De Gregorio, 1884

##### *Propeamussium pfaffi* (Ravn, 1918)

Fig. 75.

#### Material:

NORTH COAST OF NUUSSUAQ: GGU 17964, 1957, loose block, Kangilia (1 valve: L = 7.1, H = 7.5). - GGU, 1961, Igdlorssuaussaag (figured specimen and 3 shells).

AGATDALEN: GGU 8163, 1956 "The plain above the Jeep camp" (1 shell). - GGU 37167, 1953, loose block from the riverbed, Nuilaussarsuaq, Tunorgo (1 shell: L = ca. 9).

SOUTH COAST OF NUUSSUAQ: Original, 1707, 1874, Pfaff leg., Atâ (1 mould), H = ca. 15 (Ravn 1918, plate VII, fig. 7). - GGU 5391, 1948, concretion, Atâ (1 shell: L = 15.0, H = 19.6).

#### Remarks

We have compared our material with the original material from Ravn (1918) and with the published figures. Several genus names have been used, e.g., *Pecten*, *Amussium*, *Variamussium* and *Propeamussium*. We use the latest of these, but have no opinion on the generic relationships. This small, delicate species resembles the Recent *Cy-*

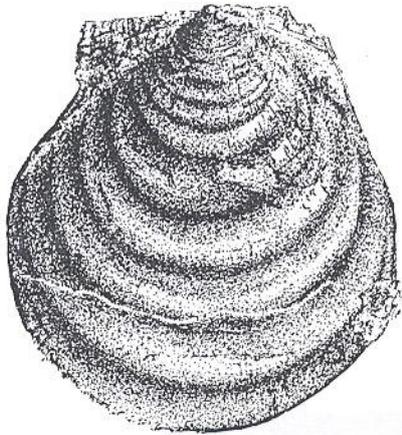


Fig. 75. MGUH 25.200. *Propeamussium pfaffi* (Ravn, 1918). One valve: L = 10.1, H = 10.5 mm. Igdlorssuausaq, GGU 1961.

*clopecten hadalis* Knudsen, 1970, which is a deep-sea species (see Knudsen 1970: pl. 8, fig. 2).

***Propeamussium striatissimum* (Ravn, 1918)**

Fig. 76

**Material:**

The material consists of small, delicate valves ca. 8-10 mm long, and comes from two different collections:

1. *The old material important for nomenclature.* *Pecten ignoratus* Ravn, 1918, identified by de Loriol as *P. ataensis* de Loriol, 1883, later changed by Ravn to *P. ignoratus* Ravn (1918) valve from "Kook angnertunek, Niakornat". - 1872, 530, K. J. V. Steenstrup leg., det. Ravn as "*Pecten (Amussium) ignoratus* Ravn." 1 valve from "Kordlortok". - Original, 1709, 1909, *Pecten striatissimus* Ravn, also labelled as: left valve of *P. ignoratus* Ravn, Atâ (1 valve). - Original, 1713, 1909, Atâ (2 valves). - Original, 1714, 1909, Atâ (1 valve).

2. *Material collected after 1938.*

*North coast localities:*

TUNORSSUAQ: **Danienkløft:** GGU 20124, 1957 (shell assemblage with, e.g., *Dentalium*, *Cylichna?*, prosobranchs, *Nucula*). - GGU 20175, 1957 (3 samples of concretions with several shells). - GGU without number, 1957 (2 samples with several shells). - Nuussuaq Expeditions, 1938 (1 valve).

KANGILIA: GGU without number, 1963, altitude 780 m (2 valves). - Nuussuaq Expeditions, 1939 (3 samples, altitudes: 600 m, 710 m and 730 m, with 3 valves and other molluscs).

ØSTRE KONGLOMERATKLØFT: Nuussuaq Expeditions, 1939 (4 samples with 5 valves and other molluscs; Fig. 76 is from this material).

VESTRE KONGLOMERATKLØFT: GGU 2637, 1949 (1 valve + other molluscs).

TUAPAUSSAT: **Near the shore:** GGU 1952 (1 valve in red sediment).

*Localities in the interior of Nûssuaq:*

AGATDALEN: **West side:** A little south of *Umánarsánguaq*, altitude 540 m: GGU 11828, 1954 (1 valve).

TURRITELLAKLØFT: **New Section: South side:** GGU 76569, 1964 (1 valve, identified by Rosenkrantz).

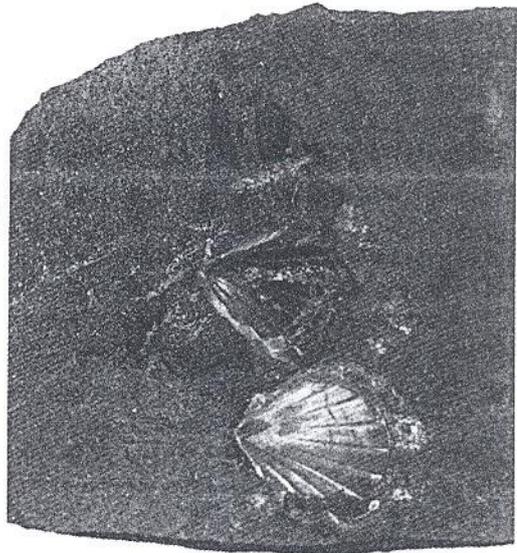


Fig. 76. MGUH 25.201. *Propeamussium striatissimum* (Ravn, 1918). One valve: L = 11.2 mm. Østre konglomeratkløft, Nuussuaq Exp. 1939.

**Remarks**

Part of the material had already been given label names, probably by Rosenkrantz, and the name used was *P. ignoratum* Ravn. According to the old labels, several scientists have noted that *P. striatissimum* is used for the outside of the shell, and *P. ignoratum* is used for the inside of the shell. This is also supported by our observations. Rosenkrantz (1970: 430) states that "*Pecten (Chlamys?) striatissimus* Ravn are left valves of *Propeamussium ignoratum* (Ravn)". In Ravn (1918), *striatissimus* is the first-mentioned name. According to the rules of Zoological Nomenclature the name of the species should be "*striatissimus*" Ravn, 1918. Actually Rosenkrantz had used *P. striatissimum* as the correct name in his notes. **The termination is herein corrected.**

*Propeamussium striatissimum* (= *ignoratum*) resembles the present deep-sea species *Amussium sewelli* Knudsen, 1967 (Knudsen 1967: pl. 9, fig. 2).

**"Pecten" ataensis de Loreol, 1883 emend. Ravn, 1918**

Not figured.

**Material:**

Original, 1708, Atâ (1 valve). We consider it appropriate to keep this as a species different from *Pecten striatissimum*.

***Pecten (Syncynoclonema) sp. Ravn, 1918***

Not figured.

**Material:**

SOUTH COAST, PATOOT (= Patut) a: Original 1710. This is a cast of a valve, and it cannot be included in any of the above species. It has been referred to Senonian age by Ravn (1918, plate VII, fig. 10).

**Remarks on the Pectinidae**

When we finished arranging the material received from the Geological Museum into groups, we noticed that the Pectinidae were missing. Dr. Walter Kegel Christensen searched the collections and sent the above samples. They are apparently all from the Kangilia Formation and most likely from the "*Propeamussium*" member. These pectinid species are small and delicate, and seem to be related to modern deep-sea species. They occur in concretions of black chalk and often together with other shells that indicate deep water environments, e.g., *Cylichna* and *Dentalium*. Furthermore, the Kangilia Formation is mainly found close to the shores both north and south of Nuussuaq. This is also why this was the first formation to be studied by early geologists, who at that time only had access to the shores. Later expeditions also found the Kangilia Formation mainly near the shores, but it also occurs in the interior of Nuussuaq below the Agatdal Formation. Rosenkrantz (1970: 436) lists the fossils from the Agatdal Formation, Central Nuussuaq, and writes: "*Pecten* sp. anterior ear, the only remains of pectinids found." Hence the lack or rareness of Pectinidae in the Agatdal fauna seems to be real. It relates the fauna to the present Panama-Pacific shallow water fauna, where Olsson (1961: 29) noted the rareness of pectinids in that fauna.

**Anomiidae Rafinesque, 1815**

***Anomia* Linné, 1758**

***Anomia* sp. 1**

Figs 77-81.

**Material:**

TURRITELLAKLØFT: **Great Section: Lower sandstone bench:** 1981-346, 1946 (1 shell: L = ca. 12). - 1981-376, 1946 (1 valve: L = ca. 18). - 1981-455, 1949 (1 shell: L = ca. 10). - *Cucullaea conglomerate, eastward below delta:* 1981-345, 1949 (1 shell: L = 13). - **South side:** 1981-337, 1946 (block of coarse gravel with 1 animal partly visible).

SONJA LENS: 1980-380, 1953 (2 shells). - 1980-428, 1958 (1 shell: L = 13.0, Fig. 80). - 1981-423, 1951 (several shells in good condition). - 1981-496, 1948 (ca. 12 shells). -

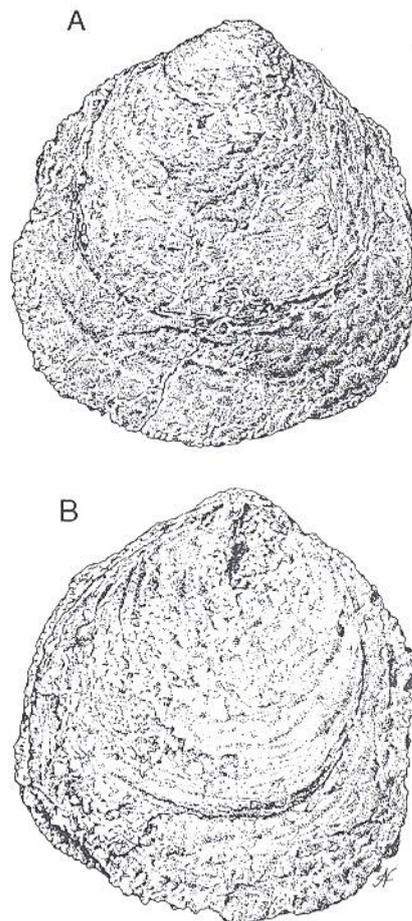


Fig. 77. MGUH 25.202. *Anomia* sp. 1. One complete specimen, seen from left (A) and right (B) sides: L = 14, H = 15.5 mm. Sonja Lens, 1981-403, 1952.

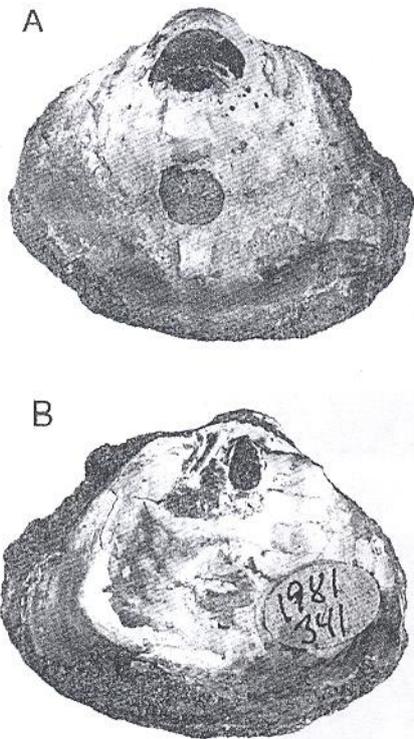


Fig. 78. MGUH 25.203. *Anomia* sp. 1. One whole specimen seen from left (A) and right (B) sides: L = 31.5, H = 26.6 mm. Qaersutjægerdal, Great Section, upper concretion layer, 1981-341, 1953.



Fig. 79. MGUH 25.204. Aggregation of *Anomia* sp. 1 on a big *Turritella*. The block is ca. 75 mm across. Qaersutjægerdal, Great Section, concretion layer above tuff-shale series. 1981-343, 1952.

1981-258, 1953 (1 shell). - 1981-383, 1948 (1 shell). - 1981-403, 1952 (1 whole specimen, Fig. 77; 1 shell). - 1981-420, 1952 (several shells). - 1981-422, 1951 (1 shell). - Without number, Aug. 1956 (1 shell).

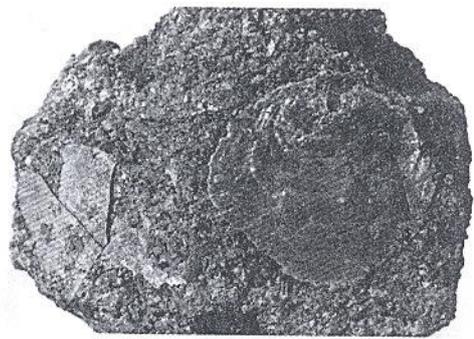


Fig. 80. MGUH 25.205. *Anomia* sp. 1. One valve with mother of pearl: L = H = 13.0 mm. Sonja Lens, 1980-428, 1958

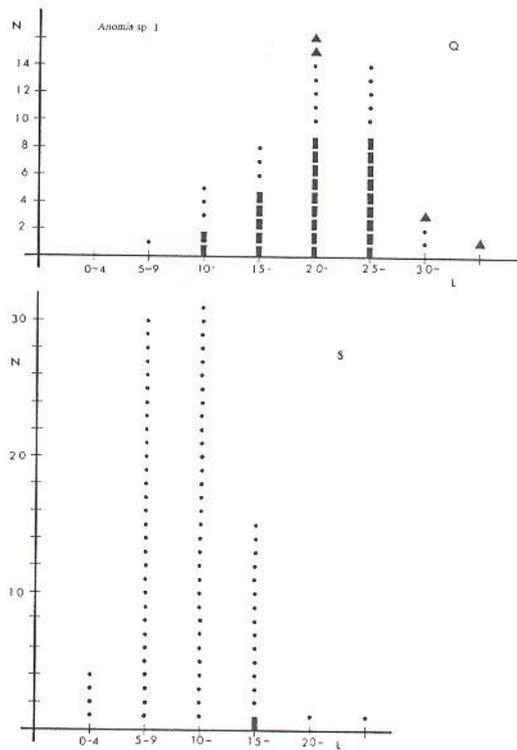


Fig. 81. *Anomia* sp. 1. Length distribution of specimens from Sonja Lens (S) (n = 82), Qaersutjægerdal (Q) (n = 44) and Agatkloft (n = 4). Dots = single valves; triangles = single valves from Agatdal, bars = paired valves.

QAERSUTJÆGERDAL: **Great Section: Concretion layer above tuff-shale series:** 1980-92, 1953 (1 shell). - 1981-339, 1952 (1 articulated specimen: L = 26.2 and 1 shell adhered to a big *Turritella*). - 1981-340, 1952 (2 fragments). - 1981-341, 1952 (2 complete specimens: L = 25; L = 31.5, Fig. 78). - 1981-342, 1952 (2 fragments in gravel with other shells). - 1981-343, 1952 (4 valves on *Turritella*, Fig. 79). - 1981-344, 1951 (2 valves: L = ca. 24, 28). - 1981-357, 1952 (aggregation of 6-8 specimens attached to a large *Turritella* + 1 articulated specimen). - 1981-358, 1952 (aggregation of 6-8 specimens on *Turritella*). - **Concretion layer below tuff-shale series:** 1981-151, 1953 (1 shell). - 1981-338, 1953 (3 specimens, 15-25 mm long). - **Canyon Section: Concretion layer below tuff-shale series:** 1981-477, 1956 (3 shells).

AGATDAL: **East side: *Turritella* conglomerate:** 1981-441, 1948 (1 shell). - **Third canyon south of Umánarságuaq: Altitude 530 m:** 1981-348 (4 valves: L = 20-30).

#### Remarks

The *Anomia* from Qaersutjægerdal seem to have been fossilized in their natural positions without having been transported. Many adhere to large *Turritella* in lumps that may have been nuclei for concretions. Fig. 81 shows the size distributions of the specimens from Qaersutjægerdal, Sonja Lens and Agatdal. The Sonja Lens material is dominated by the smaller valves.

#### Summary of the material

Turritellakløft: ca. 5 valves. Sonja Lens: 1 whole specimen + ca. 20 valves. Qaersutjægerdal: ca. 20 whole specimens + 18 valves. Agatdal: 4 valves.

#### Gryphaeidae Vyalov, 1936 *Gryphaeostrea* Conrad, 1865 *Gryphaeostrea* sp. 1

Fig. 82.

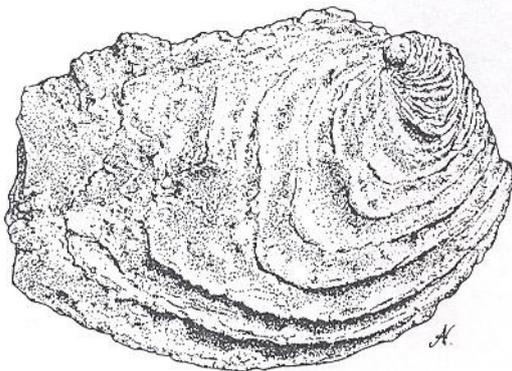


Fig. 82. MGUH 25.206. *Gryphaeostrea* sp. 1. One valve: L = 6 mm. Sonja Lens, 1980-113, 1953.

#### Material:

SONJA LENS: 1980-113, 1953 (figured specimen and 3 small valves).

#### Remarks

Corresponds to a figure in Stenzel (1971: N 1124, fig. J 98).

#### Ostreidae Rafinesque, 1815

#### *Crassostrea* Sacco, 1897

#### *Crassostrea* sp. 1

Fig. 83.

#### Material:

TURRITELLAKLØFT: **Great Section: *Cucullaea* conglomerate, eastward below delta:** No number, 1949 (figured specimen. Identified by Rosenkrantz as *Ostrea*).

SONJA LENS: One shell, L = ca. 30, is represented by photographs in Rosenkrantz's notes.

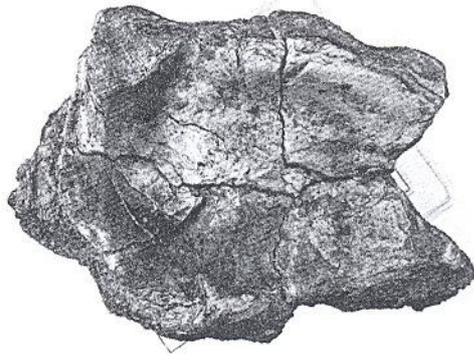


Fig. 83. MGUH 25.207. *Crassostrea* sp. 1. One fragment: L = ca. 80 mm. Turritellakløft, 1949.

#### Remarks on the oysters

This group is rare in this material. The *Gryphaeostrea* just survived the Cretaceous period (Stenzel 1971). Hence they may be a contamination from Cretaceous layers nearby. Birkelund (1965: 18) mentions that the "oyster-ammonite" conglomerate contains Danian oysters, which might include the present *Crassostrea* from the *Cucullaea* conglomerate. Olsson (1961: 30) notes that in the present Panama-Pacific fauna, the oysters are unimportant, and as there are other similarities with this fauna, the rareness of oysters and pectinids might be a real feature of the Agatdal material.

**HETERODONTA****VENEROIDA Adams & Adams, 1856****Lucinacea Fleming, 1828***General remarks on the Lucinacea*

The shells referred to this group belong among others to the difficult group: "small, whitish, roundish shells." Only a few can be seen from the inside, and they are mostly imbedded in hard sediment. However, the species were identified from the few shells where hinges, muscle scars, etc. are present, and the sorting of the larger part of the material was done by comparison with these shells.

**Lucinidae Fleming, 1828*****Lucina* Bruguière, 1797*****Lucina* sp. 1**

Figs 84-86.

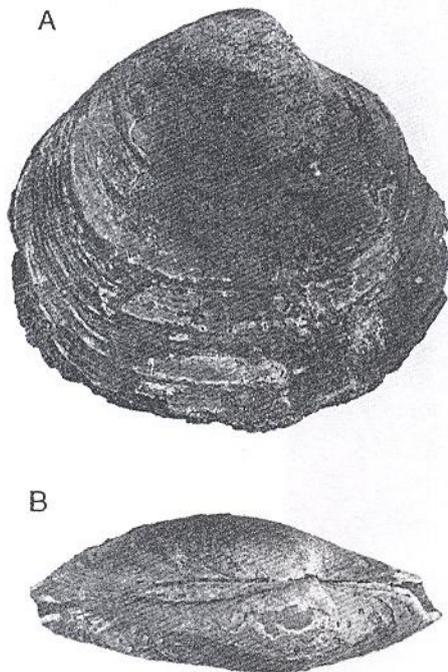


Fig. 84. MGUH 25.208. *Lucina* sp. 1. One whole specimen: L = 35.5, H = 34.0 mm. The right side (A) and umbo (B) are shown. The valves were dislocated after death. Qaersutjægerdal, Great Section, upper concretion layer, 1980-468, 1952.

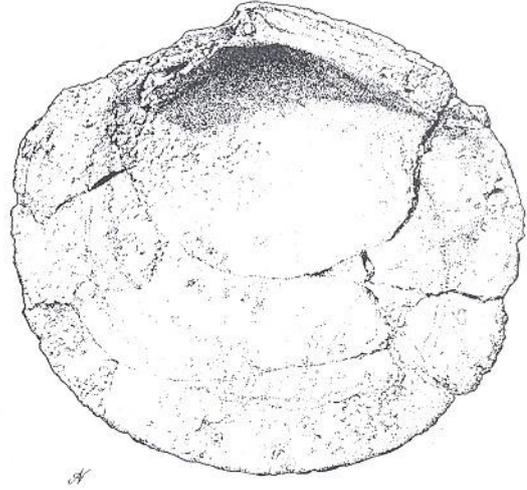


Fig. 85. MGUG 25.209. *Lucina* sp. 1. One right valve: L = 21, H = 20 mm. Sonja Lens, 1980-299, 1956.

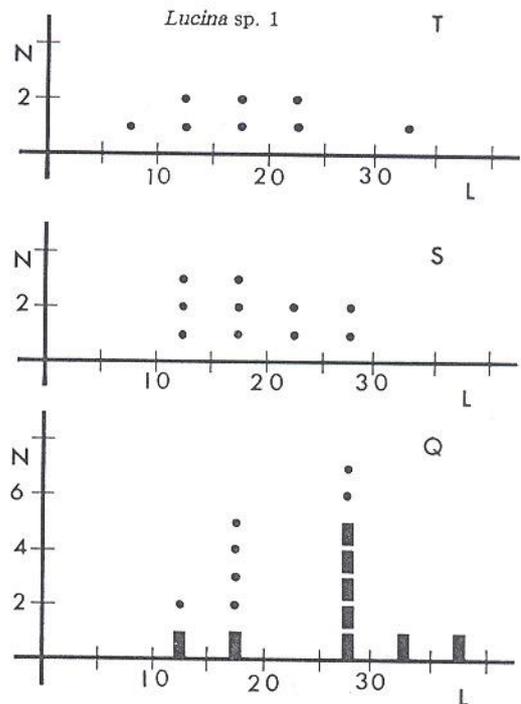


Fig. 86. *Lucina* sp. 1. Length distributions of material from: Turritellakløft (T) (n = 8), Sonja Lens (S) (n = 10), Qaersutjægerdal (Q) (n = 16). Dots = single valves, bars = paired valves.

## Material:

TURRITELLAKLØFT: Great Section: *Turritella conglomerate, eastward below delta*: 1980-188, 1949 (2 right valves: L = 17, H = 16; L = 17.5, H = 17). - Lower sandstone bench: 1981-64, 1946 (1 left valve: L = 23, H = 21; 3 right valves: L = ca. 12.5, H = 12; L = 14, H = 12.5; L = 20, H = 18). - 1981-134, 1949 (1 right valve: L = 33). - 1981-461, 1946 (1 valve: L = 7, H = 6).

SONJA LENS: 1980-288, 1951 (1 right valve: L = 13.5, H = 12.5). - 1980-295, 1948 (2 left valves: L = 13, H = 12; L = 14.0, H = 12.8). - 1980-296, 1953 (1 left valve: L = 15, H = 14.3; and pieces from 3 different valves). - 1980-299, 1956 (2 right valves: L = 17, H = 16; L = 21, H = 20, drawing, Fig. 85; 1 left valve: L = 19.5, H = 19). - 1981-138, 1948 (1 left valve: L = 28, H = 26). - 1977-3746, 1958 (1 right valve: L = 22, H = 20; 1 left valve: L = 28, H = 26).

QAERSUTJÆGERDAL: Great Section: (layer not noted) 1980-186, 1953 (1 whole specimen: L = 13.2; 1 right valve: L = ca. 17). - 1980-187, 1953 (1 right valve: L = 16.8, H = 15.0; 2 left valves: L = 17.7, H = 16.8; L = 19.2, H = 16.7). - 1981-252, 1961 (1 whole specimen, closed, purchased in Niaqor-nat: L = 30, H = 29). - 1981-474, 1951 (1 whole specimen, the two valves half open: L = 15, H = 14). - Upper concretion layer: 1980-468, 1952 (1 whole specimen, closed, undisturbed: L = 35.5, H = 34.0, photo, Fig. 84). - 1981-114, 1953 (3 whole specimens, closed: L = ca. 27, H = 25.2; L = 27.2, H = 25.1. Steinkern: L = ca. 26; 1 left valve: L = ca. 25; 1 right valve: L = ca. 26).

AGATKLØFT: 1980-290, 1948 (2 complete specimens, crushed by geological forces, silicified: ca. 25 to 30 mm long). - 1981-137, 1948 (1 rather destroyed valve: ca. 12 mm long). - 1981-347, 1957 (1 valve partly visible in hard sediment).

## Remarks

This species resembles the Recent *Lucina pectinata* (Gmelin, 1791), Florida to Brazil (Abbott & Dance 1986: 320) and *Ctena mexicana* (Dall, 1901) (Olsson 1961: 218, pl. 29, fig. 5).

## Summary of the material

Turritellakløft: 8 valves. Sonja Lens: 13 valves. Qaersutjægerdal: 7 whole specimens + 6 valves. Agatkløft: 2 paired + 2 single valves.

The length distributions of the material from the 3 main localities are shown in a histogram (Fig. 86). A preliminary plot of the length-height relation showed no differences between the localities.

*Lucina* sp. 2

Fig. 87.

## Material:

SONJA LENS: 1958. Photo from Rosenkrantz's notes, 1 left valve, identified by Rosenkrantz as "*Phacoides*", *Lucina*.

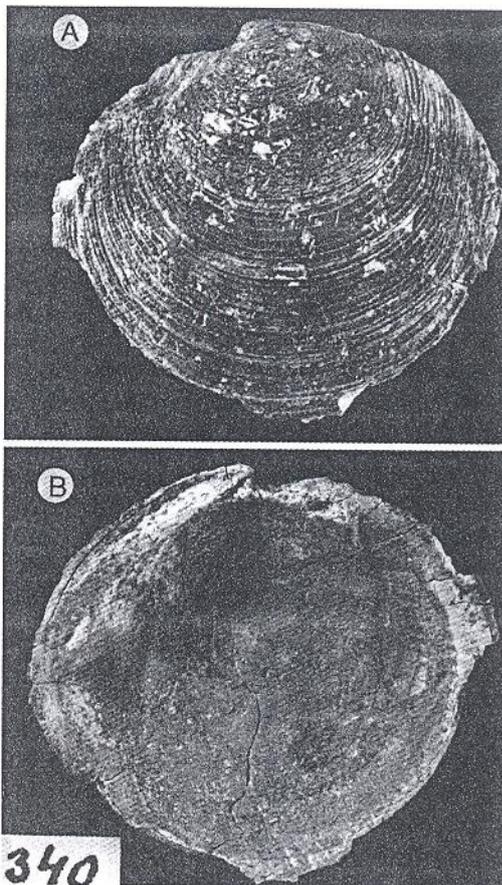


Fig. 87. MGUH 25.210. *Lucina* sp. 2. Photo from Rosenkrantz's notes, 1 left valve showing outside (A) and inside (B). Sonja Lens, 1958.

*Lucina occidentalis* Morton?

Fig. 88.

## Material:

Collected 30 July 1909 near Ekorgfat (= Ikorfat). One shell in black fine clay: L = 7.9. Identified by J. Ravn.

## Remarks

The name is recorded as Reeve, 1850. However, the material does not permit a closer examination. According to Rosenkrantz (1970: 430) it may be a *Myrtea* (Fig. 88).



Fig. 88. MGUH 25.211. *Lucina occidentalis*? One shell: L = 7.9 mm. Collected 30 Jul 1909 near Ekorgfat (= Ikorfat). Identified by J. Ravn.

*Loripes* Poli, 1791  
*Loripes* sp. 1  
Fig. 89.

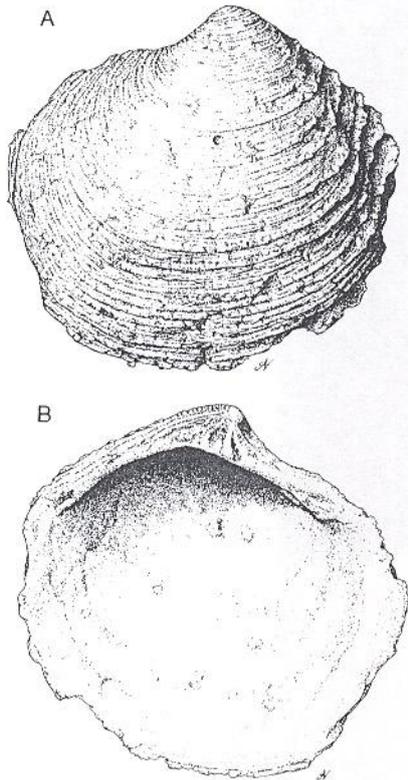


Fig. 89. MGUH 25.212. *Loripes* sp. 1. One left valve in outer (A) and inner (B) views: L = 4.3 mm. Sonja Lens, 1980-288, 1951.

Material:  
SONJA LENS: 1981-514, 1953 (1 left valve: L = 4.0). 1980-288, 1951 (1 left valve: 4.3 mm, Fig. 89).

*Lucinoma* Dall, 1901  
*Lucinoma* sp. 1  
Figs 90-91.

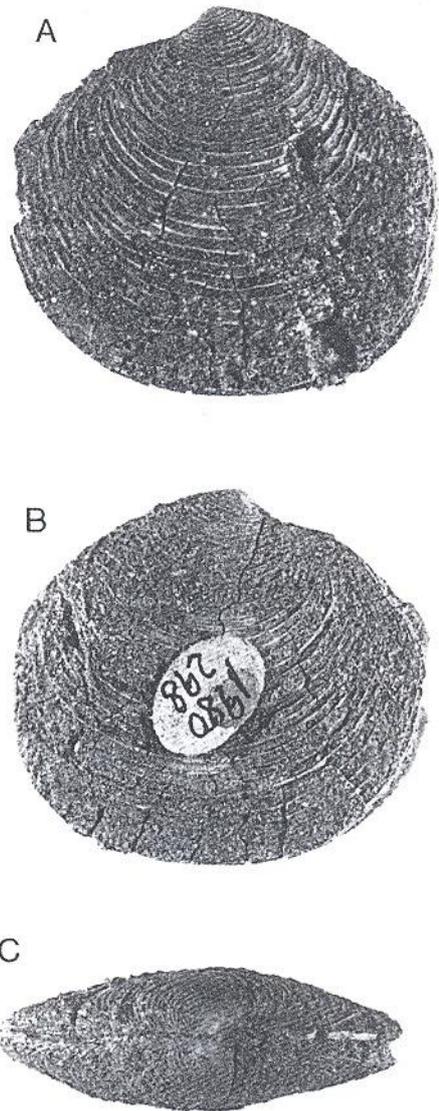


Fig. 90. MGUH 25.213. *Lucinoma* sp. 1. One whole specimen: L = 28.5, H = 26.0 mm. Left side (A), right side (B), and umbo (C) are shown. Qaersutjægerdal, 1980-298, 1953.

**Material:**

QAERSUTJÆGERDAL: **Great Section:** (layer not noted) 1980-293, 1953 (1 right valve: L = ca. 14; 1 right valve: L = ca. 7; 1 left valve: L = 6.5; piece of a left valve: L = ca. 22). - 1980-302, 1951 (1 whole specimen, valves dislocated just after death and later pressed by geological forces: L = 26, H = 24). - **Upper concretion layer:** 1980-304, 1952 (1 whole animal, pressed by geological forces: L = 11, H = 9.5). - **Concretion layer below tuff-shale series:** 1980-298, 1953 (1 whole specimen: L = 28.5, H = 26.0, Fig. 90) + 1 left valve with naticid hole: L = 27, H = 26). - 1980-299, 1954 (1 left valve: L = 9.5, H = 8.5).

SONJA LENS: (1 valve: L = 24). Photo from Rosenkrantz's notes (Fig. 91). Only this sample.

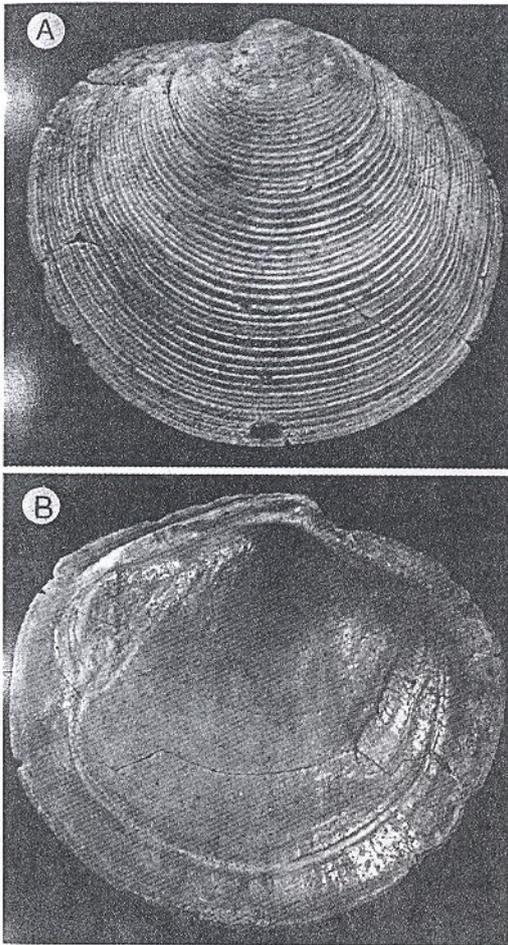


Fig. 91. MGUH 25.214. *Lucinoma* sp. 1. One left valve: L = 24 mm, showing left valve, outside (A), and inside (B). Photo from Rosenkrantz's notes. Sonja Lens, August 1958.

**Remarks**

The shells have been referred to this species because the lateral teeth are poorly developed and the surface is sculptured with prominent concentric rings.

**Summary of the material**

Sonja Lens: 1 valve. Qaersutjægerdal: 3 whole specimens + 6 valves, 1 with naticid hole.

***Lucinoma* sp. 2**

Figs 92-94.

**Material:**

TURRITELLAKLØFT: **Lower sandstone bench:** 1980-300, 1946 (1 left valve in coarse sediment with shell fragments: L = 15.5, H = 13.5). - 1981-479, 1956 (1 left valve: L = 6.7, H = 5.5). - **Great Section: *Turritella conglomerate, eastward below delta:*** 1980-289, 1949 (1 left valve in coarse sediment: L = ca. 28).

SONJA LENS: 1980-228, 1956 (fragment of left valve, but with nice hinge, Fig. 92). - 1980 229, 1956 (1 right valve: L = 25, H = 23.5). - 1980-230, 1956 (1 right valve: L = 21.5, H = 20.5, drawing in Fig. 93). - 1980-301, 1952 (1 right valve: L = 10, H = 9). - 1977/3746, 8/1958 (1 whole specimen, compressed: L = 36.5, H = 31; 1 whole specimen: L = ca. 15; 1 right valve: L = 28, H = 25.6).

QAERSUTJÆGERDAL: **Great Section: *Upper concretion layer:*** 1980-192, 1952 (3 whole specimens: L = 15, H = 14.5 (closed, dislocated and pressed); L = 19.2, H = 17.0 (closed); L = 19.6, H = 17.7 (closed); 2 right valves: L = 15.2, H = 14.6; L = 18.1, H = 16.0; 1 left valve: L = ca. 18). - 1981-437, 1952 (hard sediment with several valves). - 1980-461, 1952 (1 whole specimen, pressed: L = 39, H = 37). - 1980-467, 1951 (1 whole specimen, dislocated just after death, mainly steinkern: L = ca. 26). - **Concretion layer below tuff-shale series:** 1980-293, 1953 (2 whole specimens: L = 17.5, H = 16 (closed, displaced); L = 21.5, H = 19.5 (closed, undisturbed); 1 left valve: L = 11.8, H = 10.8). - 1980-294, 1953 (1 whole specimen, closed, undisturbed: L = 24, H = 22,

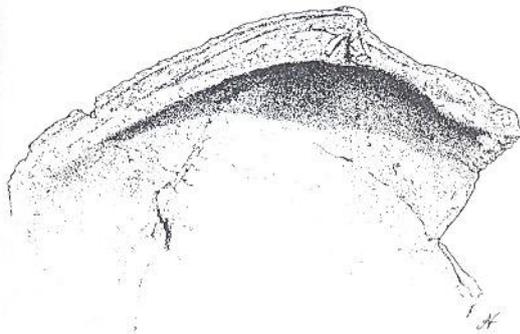


Fig. 92. MGUH 25.215. *Lucinoma* sp. 2. Piece of left valve, but with nice hinge. Sonja Lens, 1980-228, 1956.

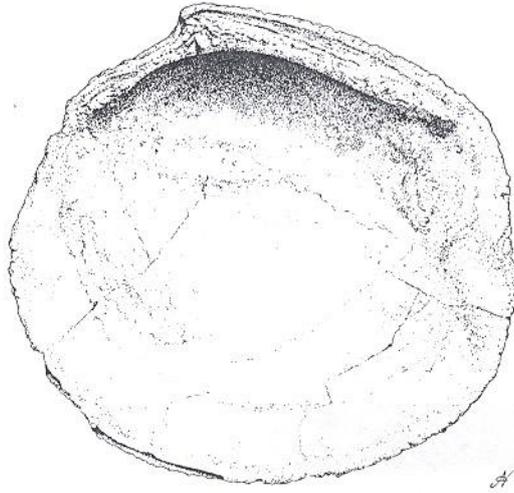


Fig. 93. MGUH 25.216. *Lucinoma* sp. 2. Inside of 1 right valve: L = 21.5, H = 20.5 mm. Sonja Lens, 1980-230, 1956.

photo, Fig. 94). - 1981-160, 1958 (1 whole specimen, closed, undisturbed: L = 28, H = 25; 1 left valve: L = 28, H = 26). - **West side:** 1980-466, 1953 (1 whole specimen, closed, undisturbed: L = ca. 24).

*Remarks*

The surface of the shells is rather smooth, with weakly developed concentric rings. A preliminary plot between length and height showed no differences between the three populations.

*Summary of the material*

Turritellakløft: 3 valves. Sonja Lens: 2 paired + 4 single valves. Qaersutjægerdal: 11 paired + ca. 10 single valves.

**Thyasiridae Dall, 1901**

*Thyasira* Leach in Lamarck, 1818

*Thyasira* sp. 1

Fig. 95.

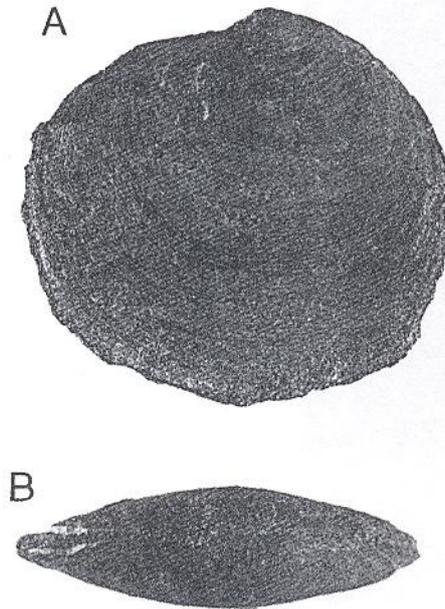


Fig. 94. MGUH 25.217. *Lucinoma* sp. 2. One whole specimen: L = 24, H = 22 mm, seen from left side (A) and umbo (B). Qaersutjægerdal, Great Section, below tuff-shale series, 1980-294, 1953.

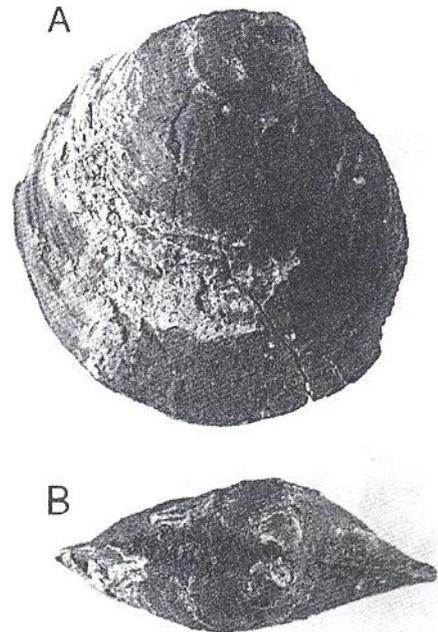


Fig. 95. MGUH 25.218. *Thyasira* sp. 1. One whole specimen, closed, undisturbed, seen from right side (A) and umbo (B): L = 25.0, H = 26.5 mm. Qaersutjægerdal, Great Section, concretion layer below tuff-shale series, 1980-462, 1954.

11.1, 12.6, 16.0). - 1981-499, 1948 (1 left valve: L = 15, H = 14; 1 right valve: L = 16.5, H = 16). - 1981-506, 1948 (1 right valve: L = 13).

QAERSUTJÆGERDAL: Great Section: (layer not noted) 1980-128, 1951 (1 whole specimen with naticid hole: L = 14, H = 13). - 1980-130, 1957 (1 whole specimen, closed, dislocated 2, L = 18, H = 15.5, photo, Fig. 98; 1 whole specimen, closed, undisturbed, with naticid hole: L = 16, H = 14; 2 whole specimens, closed, undisturbed: L = 9.5, H = 8; L = 11.5, H = 10; 1 left valve: L = 17, H = 15). - Concretion layer above tuff-shale series: 1980-183, 1953 (1 whole specimen, closed, undisturbed: L = 18, H = 17.5; 7 valves: L = 15.3, 16.0, 16.1, 16.5, 17.4, 19.4). - 1980-189, 1952 (1 left valve: L = 10, H = 9). - 1980-191, 1952 (2 whole specimens, closed, undis-

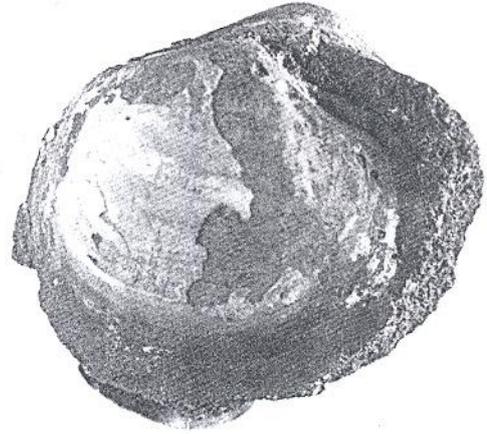


Fig. 98. MGUH 25.222. *Diplodonta* sp. 1. One whole specimen, valves dislocated after death of animal: L = 18, H = 15.5 mm. Qaersutjægerdal, Great Section. 1980-130, 1957.

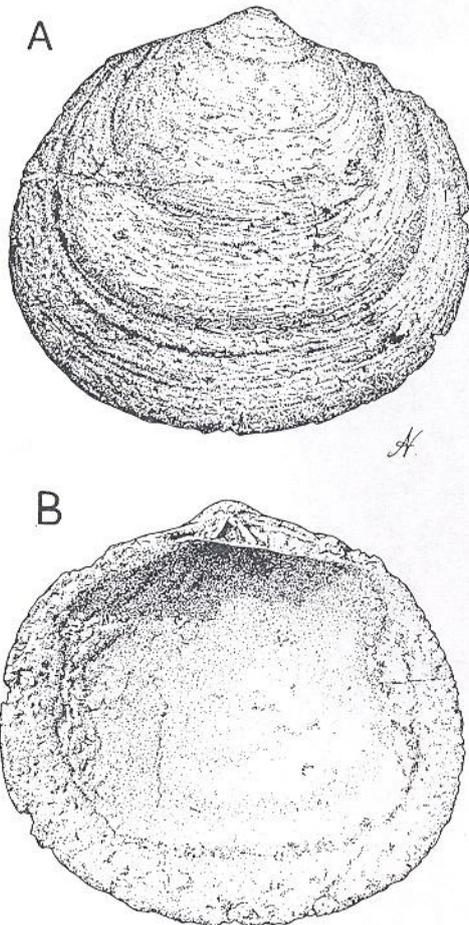


Fig. 97. MGUH 25.221. *Diplodonta* sp. 1. One right valve, outside (A) and inside (B): L = 11.8, H = 11.0 mm. Sonja Lens, 1977-3746, 1958.

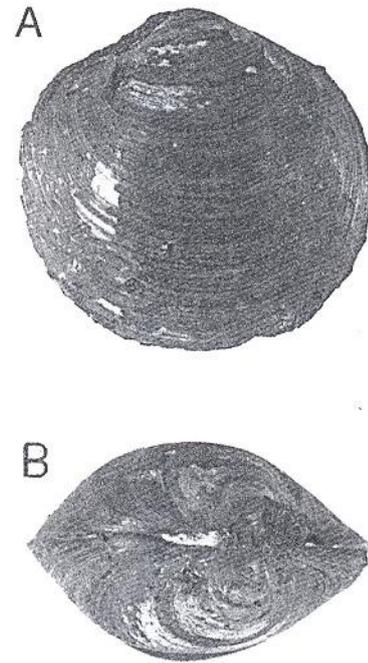


Fig. 99. MGUH 25.223. *Diplodonta* sp. 1. One whole specimen: L = 18.5, H = 17.5 mm, left side (A) and umbo (B). Qaersutjægerdal, Great Section, concretion layer below tuff-shale series. 1980-186, 1953.

11.1, 12.6, 16.0). - 1981-499, 1948 (1 left valve: L = 15, H = 14; 1 right valve: L = 16.5, H = 16). - 1981-506, 1948 (1 right valve: L = 13).

QAERSUTJÆGERDAL: Great Section: (layer not noted) 1980-128, 1951 (1 whole specimen with naticid hole: L = 14, H = 13). - 1980-130, 1957 (1 whole specimen, closed, dislocated 2, L = 18, H = 15.5, photo, Fig. 98; 1 whole specimen, closed, undisturbed, with naticid hole: L = 16, H = 14; 2 whole specimens, closed, undisturbed: L = 9.5, H = 8; L = 11.5, H = 10; 1 left valve: L = 17, H = 15). - Concretion layer above tuff-shale series: 1980-183, 1953 (1 whole specimen, closed, undisturbed: L = 18, H = 17.5; 7 valves: L = 15.3, 16.0, 16.1, 16.5, 17.4, 19.4). - 1980-189, 1952 (1 left valve: L = 10, H = 9). - 1980-191, 1952 (2 whole specimens, closed, undis-



Fig. 98. MGUH 25.222. *Diplodonta* sp. 1. One whole specimen, valves dislocated after death of animal: L = 18, H = 15.5 mm. Qaersutjægerdal, Great Section. 1980-130, 1957.

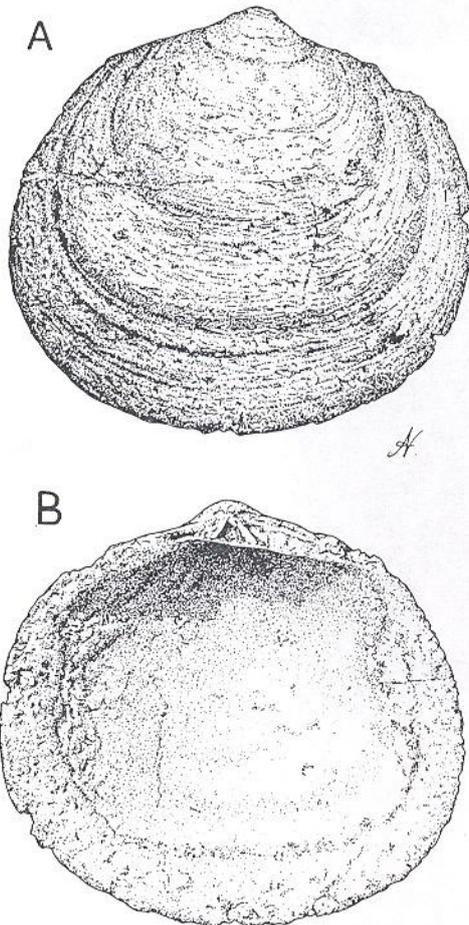


Fig. 97. MGUH 25.221. *Diplodonta* sp. 1. One right valve, outside (A) and inside (B): L = 11.8, H = 11.0 mm. Sonja Lens, 1977-3746, 1958.

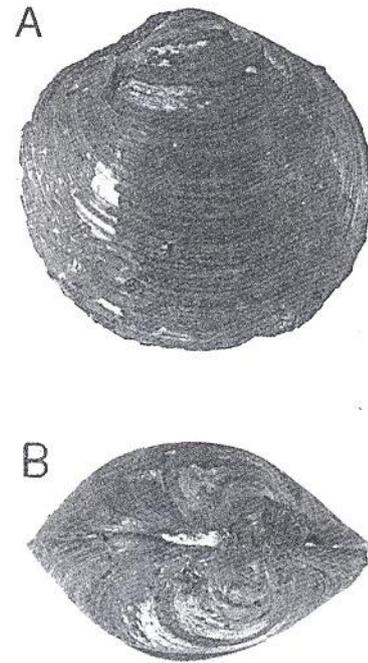


Fig. 99. MGUH 25.223. *Diplodonta* sp. 1. One whole specimen: L = 18.5, H = 17.5 mm, left side (A) and umbo (B). Qaersutjægerdal, Great Section, concretion layer below tuff-shale series. 1980-186, 1953.

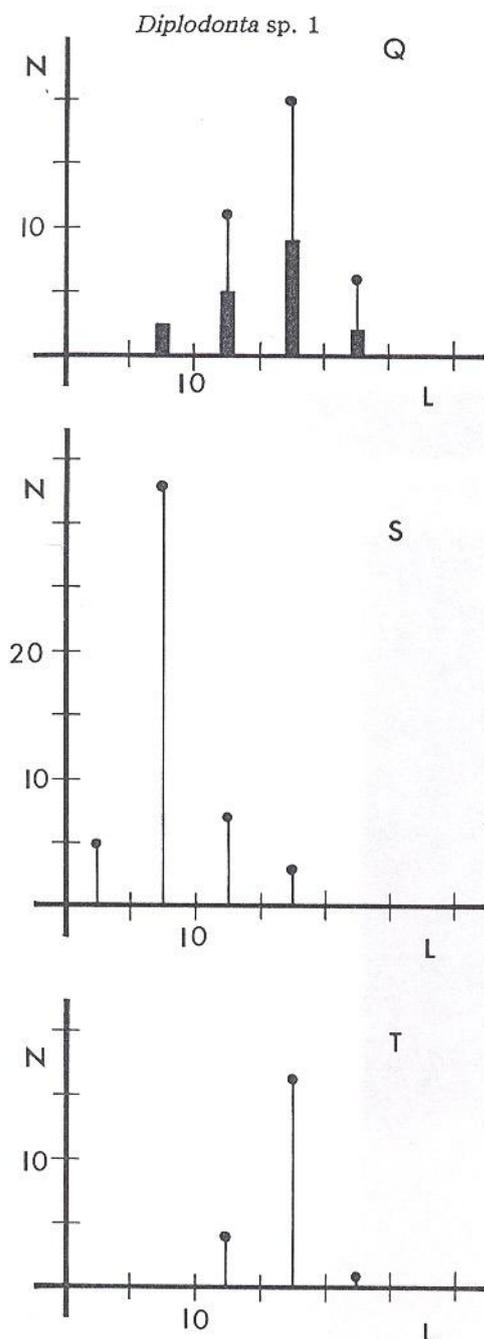


Fig. 100. *Diplodonta* sp. 1. Length distribution for material from Turrnellakløft (T) (n = 21); Sonja Lens (S) (n = 61); Qaersutjægerdal (Q) (n = 16). Lines with dots = single valves, bars = paired valves.

turbed: L = 15.4, 16.7; 2 whole specimens, closed, undisturbed, with naticid holes: L = 14.6, 17.3; 2 whole animals where the two valves were disconnected just after their death: L = 10.5, 20.1; 3 left valves: L = 13.2 (with naticid hole), 15.0, 18.0). - *Concretion layer below tuff-shale series*: 1980-186, 1953 (1 whole specimen, closed, undisturbed, with naticid hole: L = 18.5, H = 17.5, photo in Fig. 99; 1 whole specimen, closed, undisturbed: L = 12.5, H = 11.5; 1 right valve: L = 14, H = 13.8; 1 right valve: L = ca. 12). - 1980-187, 1953 (6 valves: L = 10.7, 14.0, 14.1 (with naticid hole), 17.3, 20.2, 21.0). - 1980-193, 1953 (1 whole animal, closed, displaced 1 mm, the right valve can just be seen: L = 18). - 1981-63, 1953 (1 whole specimen, slightly open and displaced, L = 9.3, H = 7.9). - 1981-109, 1958 (1 whole animal with naticid hole: L = 16, H = 14.5). - 1981-117, 1953 (1 right valve compressed by geological forces: L = 20, H = 19). - *Canyon Section*: *Concretion layer below tuff-shale series*: 1980-182, 1956 (1 whole specimen, closed, undisturbed, with naticid hole: L = 22, H = 19; 1 right valve: L = 19.5, H = 18). - 1980-443, 1956 (1 left valve with naticid hole: L = ca. 21).

#### Remarks

The material from Turrnellakløft and Qaersutjægerdal is generally imbedded in hard sediment and only the outside is visible. The material from Sonja Lens has given enough good specimens to refer the shells to *Diplodonta* sp. 1. They were a preferred prey for the naticids. Further, it shows that the sediment in which *Diplodonta* lived had not been flushed through, or flushed only to a minor degree, because so many of the bored specimens are in closed and intact positions. A few of the paired shells show a little dislocation. Fig. 100 shows the length distribution for the 3 main localities.

#### Summary of the material

Turrnellakløft: 21 valves, 1 with naticid hole. Sonja Lens: 61 valves, 5 with naticid holes. Qaersutjægerdal: 16 whole specimens, 8 with naticid holes + 23 valves, 2 with naticid holes.

#### Carditidae Fleming, 1828

##### *Cardiocardita* Anton, 1839

##### *Cardiocardita* sp. 1

Figs 101-103.

#### Material:

TURRITELLAKLØFT: *Great Section*: *Loose block in the riverbed*: 1981-446, 1945 (1 valve: L = ca. 12, H = ca. 11).

SONJA LENS: 1980-126, 1953 (1 right valve: L = ca. 7). - 1980-381, 1953 (1 right valve: L = 10, H = 8.5). - 1981-257, 1956 (1 left valve: L = 26.1, H = 22.3, photo, Fig. 101). - 1981-384, 1953 (3 valves: L = 6.1, H = 5.3; L = 8.2, H = 7.7; L = 8.7, H = 8.0). - 1981-393, 1953 (1 right valve, bored by

naticid: L=4.2, H=3.8; fragments of 2 small valves). - 1981-406, 1948 (1 valve: L=5.1, drawing, Fig. 102; fragments and valves from ca. 20 animals). - 1981-503, 1957 (valves and fragments from about 12 animals. The following measurements could be taken: L=3.9, H=3.5; L=4.8, H=4.2; L=4.9, H=4.1; L=4.9, H=4.4; L=7.9, H=7.2; L=8.2, H=7.8. - 1981-512, 1948 (1 left valve: L=13.7, H=12.0; 4 worn valves: L=6.2, H=5.1; L=5.2, H=4.6; L=3.9, H=3.8; L=3.9, H=3.2; and pieces of shells). - 1981-512, 1948 (5 valves: L=3.8, H=3.2; L=3.9, H=3.8; L=5.2, H=4.6; L=6.2, H=5.1; L=13.7, H=12.0). - Photo from Rosenkrantz's notes of a ca. 24 mm long shell, material not seen by us.

AGATDALEN: *Qaersutjæger River's tributary: Loose block: 1981-260, 1948 (1 valve: L = ca. 17).*

*Remarks*

The shells are close to Recent *Cardita ajar* Brugière, 1792. West Africa.

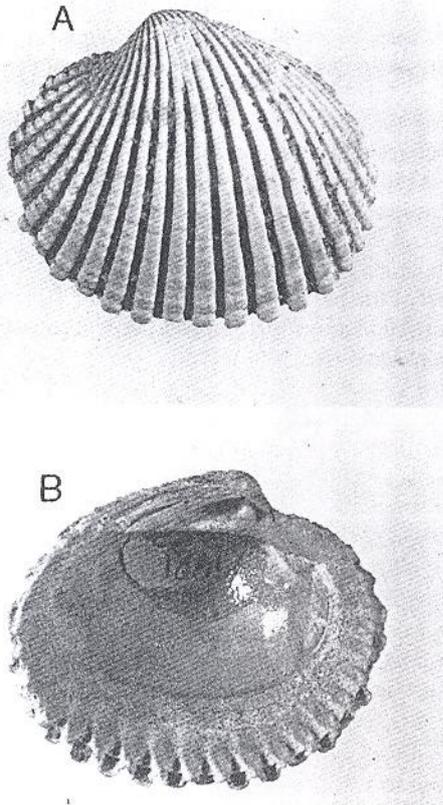


Fig. 101. MGUH 25.224. *Cardiocardita* sp. 1. One left valve, outer (A) and inner (B) views: L = 26.1, H = 22.3 mm. Sonja Lens, 1981-257, 1956.

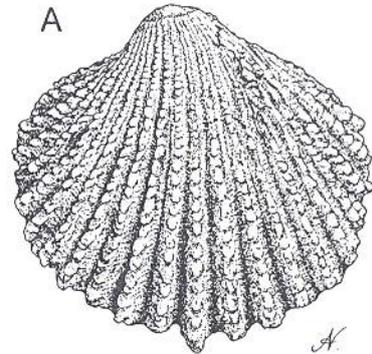


Fig. 102. MGUH 25.225. *Cardiocardita* sp. 1. One left valve, outer (A) and inner (B) views: L = 5.1 mm. Sonja Lens, 1981-406, 1948.

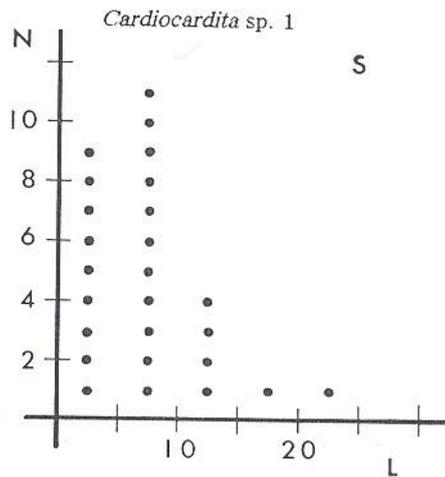


Fig. 103. *Cardiocardita* sp. 1. Length distribution for Sonja Lens (S) material including loose blocks (n = 26). Dots = single valves.

*Summary of material*

Turritelakløft: 1 valve. Sonja Lens: ca. 45 valves, 1 with naticid hole. Agatkløft: 1 valve. Fig. 103 gives the length distribution for Sonja Lens material including the loose blocks.

*Venericor* Stewart, 1930*Venericor* sp. 1

Figs 104-105.

## Material:

TURRITELLAKLØFT: **Great Section: Lower sandstone bench:** 1980-102, 1953 (2 valves both ca. 5 mm long). - 1980-122, 1956 (1 valve: L = ca. 4.5). - 1980-325, 1948 (steinkern of a ca. 75 mm long valve). - 1981-363, 1946 (1 left valve: L = ca. 8.5, H: ca. 7; 1 right valve: L = ca. 11, H = ca. 11; 1 valve: L = ca. 6.5; 1 valve: ca. 4. All valves are very worn and imbedded in sand-gravel with shells). - *Turritella conglomerate:* 1981-326, 1949 (1 right valve: L = 53.3, H: 50.2. Also casts in gypsum and silicone rubber. Identified by Rosenkrantz as *Venericor*). - *Conglomerate at bottom of delta layer:* 1981-327, 1948 (1 right valve: L = 29.3, H = 26.2; 1

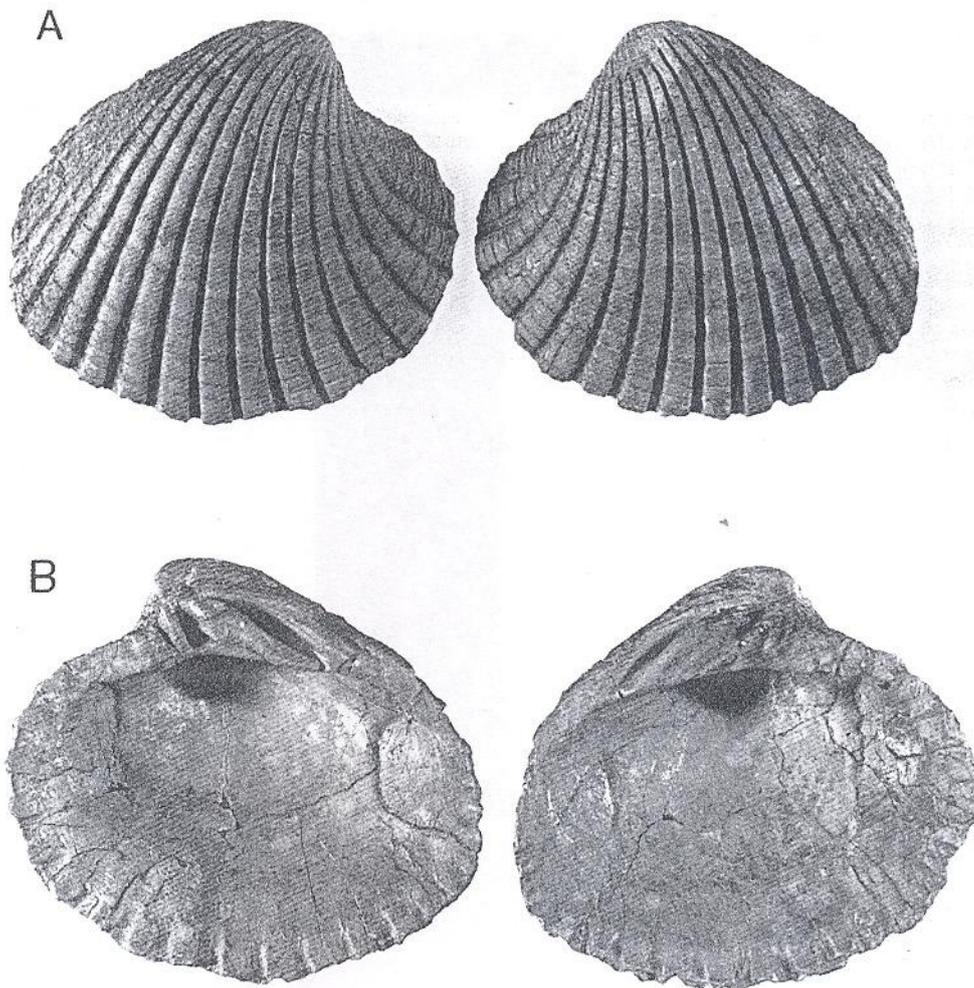


Fig. 104. MGUH 25.226. *Venericor* sp. 1. One whole specimen: L = 73.5, H = 68.0 mm. Both valves, outside (A) and inside (B). Qaersutjægerdal, Great Section, concretion layer below tuff-shale series. 1981-259, 1953.

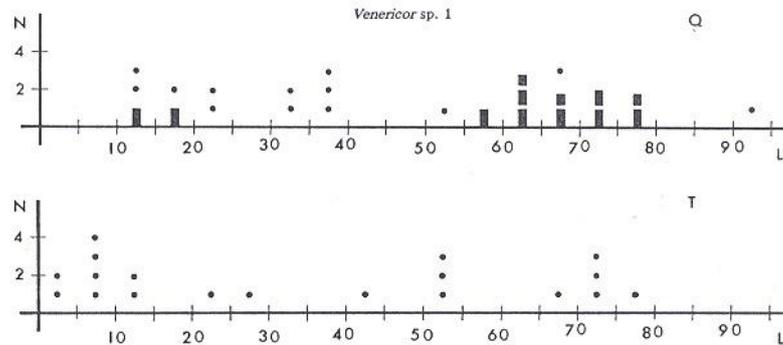


Fig. 105. *Venericor* sp. 1. Length distributions showing two size groups both at Turritlekløft (T) (n = 19) and at Qaersutjægerdal (Q) (n = 25). Dots = single valves, bars = paired valves.

right valve: L = ca. 22, H = 20.0). – **Interior Nuussuaq: Altitude 560 m:** 1980-430, 1939 (1 piece of hinge of an estimated 80 mm long specimen, silicified and crushed by compaction; 1 piece of hinge from an estimated 50-mm-long specimen). – 1981-236, 1939 (2 pieces of silicified broken shells of big animals, estimated length 70 mm. Rosenkrantz's note on the label: "Situated between *Venericardia* (*Venericor*) *nanaplata* Gardner & Bowles, and *V. (V.) medioplata* Gardner & Bowles"). – 1981-242, 1939 (1 piece from an estimated 50 mm long animal). – 1981-331, 1946 (1 piece with hinge of a ca. 80 mm long specimen. Identified by Rosenkrantz as "*Venericardia* (*Venericor*)"). – 1981-332, 1939 (1 piece with hinge of a ca. 40 mm long shell; 1 right valve: L = 11.1, H = 9.9).

**QAERSUTJÆGERDAL: Great Section: Upper concretion layer:** 1981-237, 1952 (cast of right valve imprint in sandstone concretion: L = ca. 34, H = ca. 33). – 1981-250, 1952 (1 whole specimen, almost closed, displaced 4 mm, compressed by geological forces: L = ca. 56, H = ca. 57; 1 whole specimen, gaping 180 degrees, coherent valves: L = estimated 60, H = estimated 60). – 1981-273, 1952 (1 left valve, imprint in brown sandstone with shells, and cast of imprint: L = ca. 37, H = ca. 35). – 1981-328, 1952 (1 right valve: L = 22, H = 21). – 1981-335, 1951 (1 whole specimen, ca. 60 mm long, the two valves gaping 180 degrees; casts of pieces of 2 larger valves, estimated L = ca. 70). – GGU 36849, 1952 (1 whole specimen, the 2 valves gaping 180 degrees: L = 66.0, H = 69.3). – **Concretion layer below tuff-shale series:** 1981-247, 1954 (1 left valve: L = 32.7, H = 30.0, identified by Rosenkrantz as *Venericardia*). – 1981-251, 1953 (1 right valve: L = 52.4, H = 47.0). – 1981-259, 1953 (1 whole specimen, L = 73.5, H = 68.0, photo, Fig. 104; piece from ca. 70 mm long valve; 1 right valve in sandstone with shells: L = ca. 18, H = ca. 17). – 1981-333, 1954 (1 whole specimen, tightly closed, undisturbed: L = 73, H = 73). – GGU 36286, 1951 (1 right valve: L = 67.2, H = 61.6, identified by Rosenkrantz as "*Venericardia* (*Venericor*)"). – GGU 8572, 1958 (1 whole specimen, the 2 valves gaping 180 degrees, coherent: L = 66, H = 65, identified by Rosenkrantz as *Venericor*). – GGU no number, 1952 (1 left valve: L = ca. 36, H = ca. 35). – **Cucullaea layer, below tuff-shale:** 1981-261, 1956 (1 whole specimen, almost closed, displaced ca. 2 mm: L = 76, H = 78,

identified by Rosenkrantz as *Venericor*). – **Canyon Section: Sandstone base:** GGU 8160, 1956 (1 whole specimen, the 2 valves gaping ca. 10 degrees and displaced ca. 2 mm: L = ca. 75. Identified by Rosenkrantz as "*Venericor* n. sp."). – **West side at second turn:** 1981-243, 1951 (1 whole specimen, steinkern, closed, displaced 2 mm: L = ca. 15, H = ca. 14; 1 whole specimen, steinkern, gaping ca. 40 degrees, disconnected: L = ca. 13; 1 left valve: L = ca. 14, identified by Rosenkrantz as "*Venericardia* (*Venericor*?)"). – **West side:** 1981-276, 1953 (cast in reddish conglomerate of imprint of 1 whole specimen, valves gaping 180 degrees, dislocated ca. 5 mm, estimated length 60 mm). – 1981-336, 1953 (1 imprint of left valve: L = ca. 35, H = 33).

**AGATKLØFT: East side: Turritlekløft:** 1981-229, 1948 (cast of right shell in coarse conglomerate: L = ca. 72, H = ca. 71). – 1981-334, 1948 (1 hinge piece from estimated 90-mm-long shell, identified by Rosenkrantz as *Venericor*). – **Just off tributary of Qaersut River:** 1981-254, 1948 (1 right valve: L = ca. 10, H = ca. 10; 1 left valve: L = ca. 22, H = ca. 22). – 1981-260, 1948 (piece of umbo, estimated length of animal = 70 mm, identified by Rosenkrantz as *Venericor*).

**NORTH SHORE OF NUUSSUAQ:** 1981-233: Tupaur-sarsoit, imprints in red sandstone, leg. Giesecke, identified by Rosenkrantz as "*Venericardia aposmithii* Gardner & Bowles from Lower Wilcox". – 1981-234: Tupaur-sarsoit, imprint in red sandstone, leg. Giesecke, identified by Rosenkrantz as "*Venericardia cf. aposmithii* from Eocæn, Lower Wilcox". – Photo of cast from Kangilia, Ryg B, Danien conglomerate, 8 Aug 1946, identified by Rosenkrantz as *Venericardia*.

#### Remarks

Part of the material was identified by Rosenkrantz, who used the names *Venericor* and *Venericardia* rather liberally. We agree that it is difficult to decide between these two names, not to mention the specific names. Many of the animals are only represented by pieces or by casts from the cavities left by the shell in the rather coarse

conglomerate. There is a tendency for the larger shells to be grouped into two forms: one where the length is less than the height, and one where the length is greater than the height.

*Summary of the material*

Turritellakløft: 19 valves. Qaersutjægerdal: 12 whole specimens + 13 valves. Agatkløft: 5 valves. Kangilia: 3 valves. Fig. 105 shows the length distributions with two size groups both at Turritellakløft and at Qaersutjægerdal.

**Astartidae D'Orbigny, 1844**

*Astarte* Sowerby, 1816

*Astarte* sp. 1

Figs 106-107.

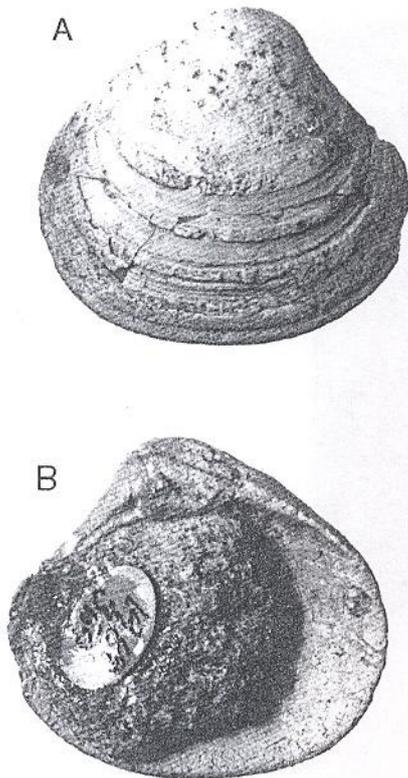


Fig. 106. MGUH 25.227. *Astarte* sp. 1. One right valve: L = 26.0, H = 23.5 mm. A. Outer view, surface corroded, exposing concentric lines. B. Inner view, showing hinge. Turritellakløft, Great Section, *Turritella conglomerate*. 1980-369, 1948.

**Material:**

**TURRITELLAKLØFT: Great Section: Lower sandstone bench:** 1980-124, 1956 (2 valves in sediment with shell and plant remnants: L = ca. 11, H = 10.5; L = 13, H = 12). - 1980-370, 1956 (2 valves in sediment, only the outside is visible. Both are bored by naticid: L = 11.5, H = 11; L = 12, H = 11.5). - 1980-371, 1946 (1 whole specimen: L = 12, H = 11, photo, Fig. 107). - 1981-372, 1946 (3 valves: L = 4.0, 5.2, 6.1). - *Turritella conglomerate*: 1980-369, 1948 (1 left valve: L = 26.0, H = 23.5, photo, Fig. 106).

**KANGERSØQ: West of Nuillaussarsuaq:** 1980-331, 1952 (steinkern of 1 right valve: L = 30, H = ca. 27).

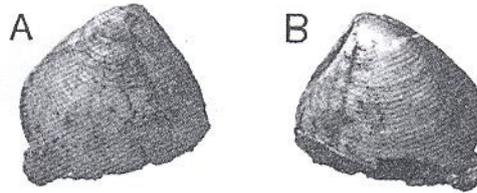


Fig. 107. MGUH 25.228. *Astarte* sp. 1. One whole specimen, seen from right (A) and left (B) sides, and showing rather smooth surface: L = 12, H = 11 mm. Turritellakløft, Great Section, lower sandstone bench. 1980-371, 1946.

*Summary of the material*

Turritellakløft: 1 whole specimen + 8 valves, 2 with naticid holes. Kangersôq: 1 valve.

*Astarte* sp. 2

Fig. 108.

**Material:**

**SONJA LENS:** 1958: 1 left valve: L = ca. 4. The shell has pronounced concentric ribs. It is only represented by the photos in Fig. 108 from Rosenkrantz's notes. It was identified by Rosenkrantz as *Astarte*. Original not seen by us.

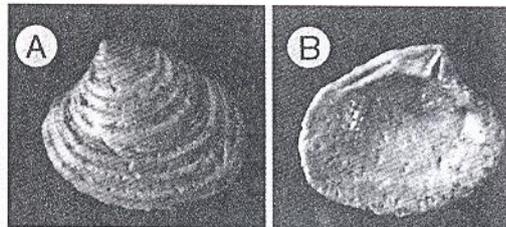


Fig. 108. MGUH 25.229. *Astarte* sp. 2. One left valve, in outer (A) and inner (B) views. L = ca. 4 mm. Sonja lens, 1958. Photo from Rosenkrantz's notes.

***Astarte* sp. 3**

Fig. 109.

## Material:

TURRITELLAKLØFT: Great Section: Layer I: 1961 (1 left valve: L = ca. 6.5, H = ca. 6.0). It is only represented by the drawings from Rosenkrantz's notes shown in Fig. 109. Rosenkrantz had tentatively identified this shell as: "*Eriphyla*?" and "close to *Astarte trigonula* van Koenen, Ravn pl. I, fig. 516". Original not seen by us.

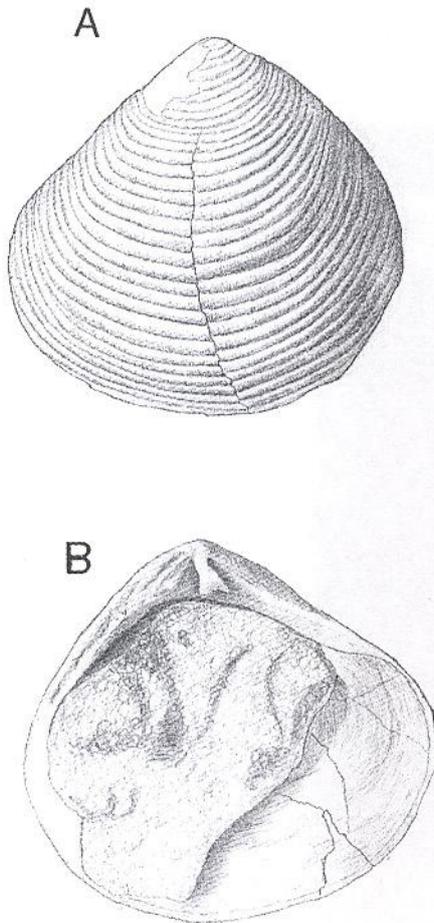


Fig. 109. MGUH 25.230. *Astarte* sp. 3. One left valve, outer (A) and inner (B) views. L = ca. 6.5, H = 16.0 mm. Turritellakløft, 1961, Great Section, layer I. Drawings from Rosenkrantz's notes.

***Astarte* sp. 4**

Fig. 110.

## Material:

TURRITELLAKLØFT: Great Section: Eastward below delta: 1981-58, 1949 (1 valve: L = 20.5, H = 16.0.)

QAERSUTJÆGERDAL: Great Section: (layer not noted) 1980-449, 1951 (1 valve: L = 13, photo, Fig. 110). - Concretion layer below tuff-shale series: 1980-465, 1953 (1 valve, steinkern, in hard rock of sand with shells: L = ca. 20).



Fig. 110. MGUH 25.231. *Astarte* sp. 4. One valve: L = 13 mm. Qaersutjægerdal, Great Section, 1980-449, 1951.

**Remarks for all 4 *Astarte* species**

Specimens of *Astarte* are not abundant or well preserved. The hinges are usually hidden in the rock.

**Crassatellidae Férussac, 1822*****Crassatella* Lamarck, 1799*****Crassatella* sp. 1**

Figs 111-115.

## Material:

TURRITELLAKLØFT: Great Section: Lower sandstone bench: 1981-177, 1948 (1 left valve: L = 61.0, H = 36.4). - 1981-178, 1948 (1 left valve: L = 34.3, H = 20.5). - 1981-179, 1946 (4 left + 5 right valves with the following dimensions: L = 10.5, H = 6.9 (drawing Fig. 114); L = 12.7, H = 9.1; L = 13.1, H = 9.0; L = 14.6, H = 9.2; L = 14.9, H = 9.7; L = 17.6, H = 11.5; L = 18.0, H = 10.6; L = 18.6, H = 11.4; L = 19.1, H = 11.0). - 1981-183, 1949 (1 left valve: L = 8.0). - 1981-200, 1948 (1 left valve: L = 11.2, H = 8.5). - 1981-201, 1948 (1 right valve: L = ca. 16, H = ca. 10; 1 right valve: L = 6.9, H = 5.0). - 1981-484, 1953 (1 valve: L = 3.6). - *Cucullaea conglomerate*, eastward below delta: 1891-180, 1949 (1 right valve: L = 76.6, H = 46.2). - 1981-182, 1949 (1 right valve: L = 52, H = 33.5, Fig. 112). - *Cucullaea conglomerate*: 1981-176, 1949 (1 left valve: L = 60.4, H = 40.3, photo and drawing, Fig. 113). - 1981-181, 1949 (1 left valve: L = 46.4, H = 32.0). - South side opposite Great Section: 1981-184, 1939 (front half of a shell pair, tightly closed and undisturbed, but deformed and silicified: L = estimated 80). - 1981-215, 1948 (1 valve: L = 23.0, H = 13.5).

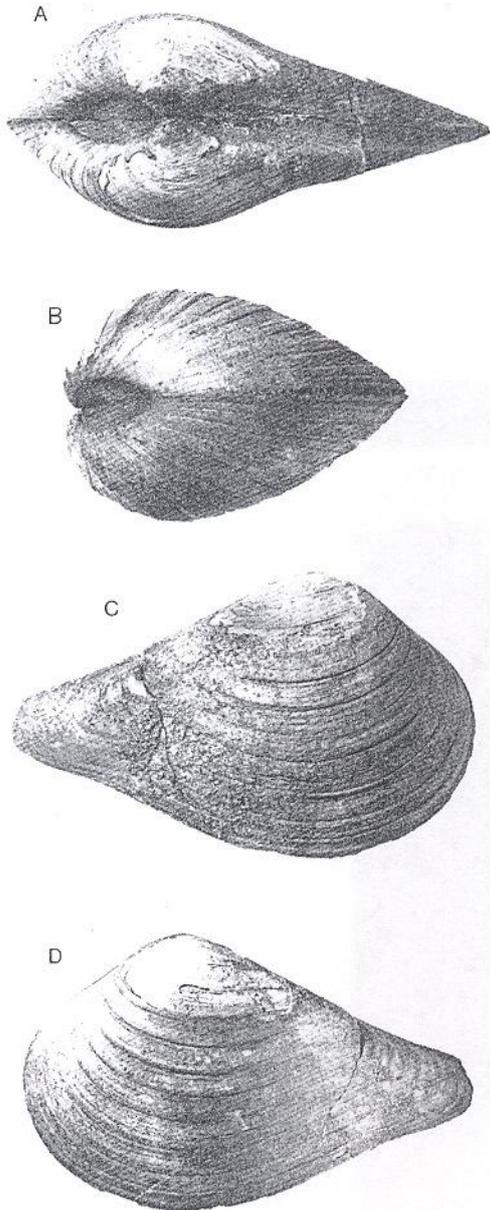


Fig. 111. MGUH 25.232. *Crassatella* sp. 1. One whole specimen: L = 69.0, H = 43.4 mm. The figure shows umbo (A), front (B) and right (C) and left (D) sides. Identified by Rosenkrantz as "*Crassatella (Bathytornys)* n. sp." Qaersut-jægerdal, concretion layer below tuff-shale series, 1981-192, 1956.

INTERIOR NUUSSUAQ: *Altitude 560 m*: 1981-185, 1939 (2 whole specimens, closed, undisturbed, but deformed: L = ca. 71, ca. 27). - *Altitude 525 m*: 1981-186, 1939 (1 valve, steinkern: L = 37.5, H = 26.2).

QAERSUTJÆGERDAL: *Great Section: Concretion layer below tuff-shale series*: 1981-108, 1958 (1 whole specimen, closed, undisturbed: L = 11.1, H = 7.7; 1 right valve: L = 15.4, H = 10.3). - 1981-110, 1958 (1 whole specimen, closed, undisturbed: L = 25.7, H = 15.4). - 1981-187, 1958 (1 whole specimen, closed, undisturbed: L = 71.4, H = 46.0; 1 right valve: L = 27.2, H = 16.7; 1 left valve: L = 15.3, H = 10.4). - 1981-188, 1953 (1 whole specimen, closed, undisturbed: L = ca. 22, H = 13.0; 1 left valve: L = 21.7, H = 13.5; 1 left valve, deformed by pressure: L = 7.3, H = 4.6; 1 right valve: L = 6.5, H = 5.5; 1 right valve, piece only). - 1981-189, 1953 (3 whole specimens, closed, undisturbed: L = 11.9, H = 7.6; L = 13.4, H = 9.6; L = 15.6, H = 10.9; 2 left valves: L = 7.8, H = 5.5; L = 15.4, H = 9.2; 1 right valve: L = 10.2, H = 7.1; 1 right valve, estimated length ca. 21 mm). - 1981-190, 1954 (1 whole specimen, closed, undisturbed: L = 19.0, H = 12.0; 1 right valve: L = 24.0, H = 15.0; 1 right valve, posterior part missing: L = ca. 26, H = 15.2; 1 left valve: L = ca. 21, H = 12.3; 1 left valve: L = 21.8, H = 13.8). - 1981-191, 1956 (1 whole specimen, slightly open, undisturbed, silicified: L = 71.1, H = 43.0; 1 whole specimen, closed, undisturbed, posterior part missing: L = ca. 73, H = 44.1; 1 right valve: L = 38.2, H = 24.0; 1 right valve: L = 73.2, H = 45.8. Imbedded

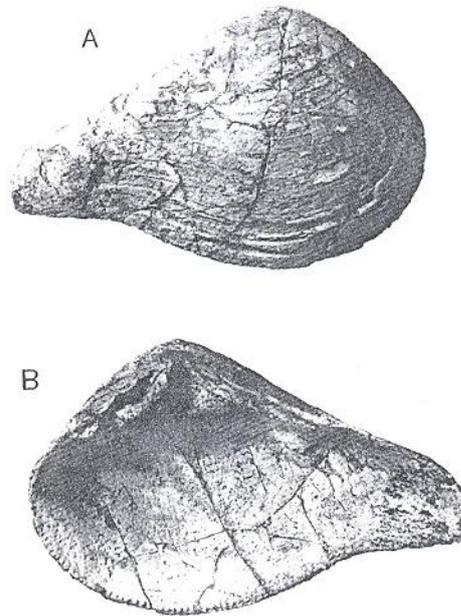


Fig. 112. MGUH 25.233. *Crassatella* sp. 1. One right valve, outside (A) and inside (B): L = 52.0, H = 33.5 mm. Turritellakløft, Great Section, *Cucullaea* conglomerate, 1981-182, 1949.

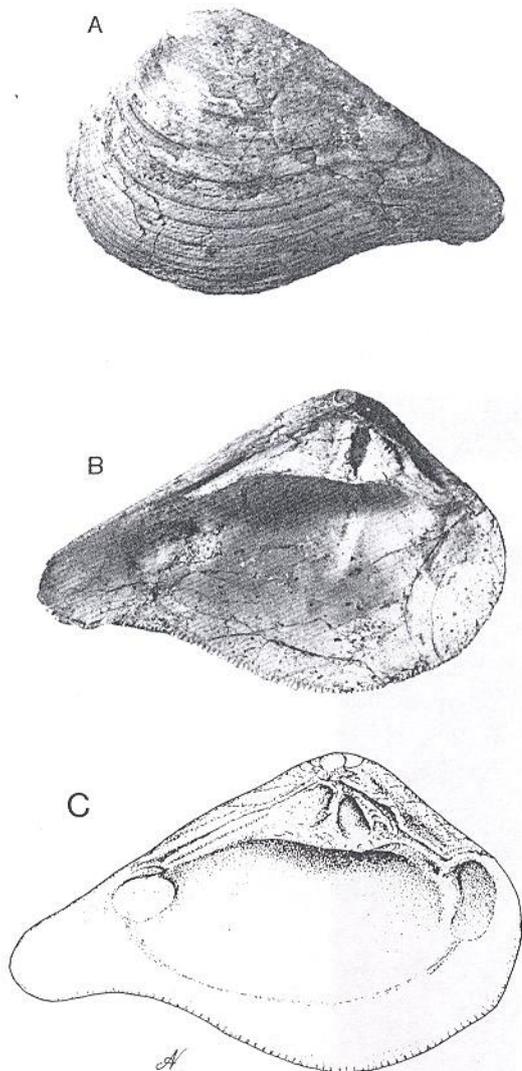


Fig. 113. MGUH 25.234. *Crassatella* sp. 1. One left valve; the photo shows the outside (A) and inside (B), and the drawing (C) gives the muscle scars and the pallial line: L = 60.4, H = 40.3 mm. Turritellakløft, Great Section, *Cucullaea* conglomerate, 1981-176, 1949.

in the sediment in the inside of this valve is a small *Crassatella*, ca. 10 mm long). - 1981-192, 1956 (3 whole specimens, tightly closed, undisturbed, identified by Rosenkrantz as "*Crassatella* (*Bathytornus*) n. sp.": L = 69.0, H = 43.4, Fig. 111; L = 76.3, H = 45.7; L = ca. 75, H = 46.9). - 1981-193, 1954 (3 whole specimens, closed, undisturbed: L = ca. 30, H

= 18.5; L = ca. 43, H = 25.1; L = ca. 44, H = 24.1; 10 valves with the following measurements: L = ?, H = 11.8. L = ?, H = 13.0; L = ?, H = 16.4; L = 8.9, H = 7.4; L = 12.9, H = 7.0; L = 14.0, H = 7.5; L = 15.4, H = 9.9; L = 19.6, H = 14.0; L = 21.8, H = 13.3; L = 22.6, H = 15.0). - *Upper concretion layer*: 1981-194, 1952 (1 whole specimen, closed, undisturbed, posterior part missing: L = ca. 33, H = 38.0; 1 left valve: L = 76.9, H = 49.8; 1 left valve, posterior part missing: L = ca. 33, H = 18.9; 1 right valve: L = 66.5, H = 42.4). - 1981-196, 1951 (1 right valve: L = 33.0, H = 19.3). - 1981-204, 1952 (2 whole specimens, closed, undisturbed: L = 9.9, H = 7.2; L = 18.4, H = 11.5; 3 left valves: ; L = 10.5, H = 7.6; L = 13.2, H = 9.0; L = 26.0, H = 16.0). - 1981-208, 1952 (anterior part of left valve, silicified, estimated length: ca. 75). - 1981-209, 1952 (2 left valves in sandstone: L = ca. 26, 36.4). - GGU number: 35 260, 1953 (3 whole specimens, closed, undisturbed, identified by Rosenkrantz as *Crassatella*: L = ca. 71, H = 45.5; L = ca. 80, H = 49.5; L = ca. 80, H = 52).

AGATKLØFT: East side: 1981-175, 1948 (1 right valve: L = ca. 17, H = 10.2; 1 left valve: L = 12.9, H = 8.1). - 1981-203, 1948 (1 right valve in hard sandstone together with other shells: L = ca. 31, H = 19.2).

#### Remarks

The species is close to Recent *Eucrassatella gibbosa*, Sowerby 1832 (see Olsson 1961: 179, pl. 25, fig. 1). California to Peru.

There seems to be both a short and a long form, perhaps because the older and bigger animals seem to develop a long posterior end. The material consists mainly of large forms, many of which are well preserved, but some have been crushed by geological forces. Some shells are silicified. Growth rings are generally easy to see. The posterior end is sometimes missing, and the lengths have then been estimated from the rela-

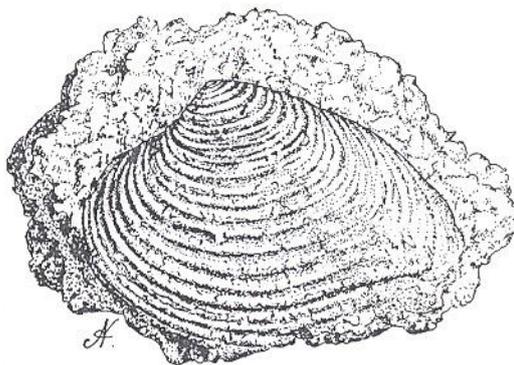


Fig. 114. MGUH 25.235. *Crassatella* sp. 1. One left valve: L = 10.5, H = 6.9 mm. Probably juvenile form. Turritellakløft, Great Section, lowermost sandstone bench, 1981-179, 1946.

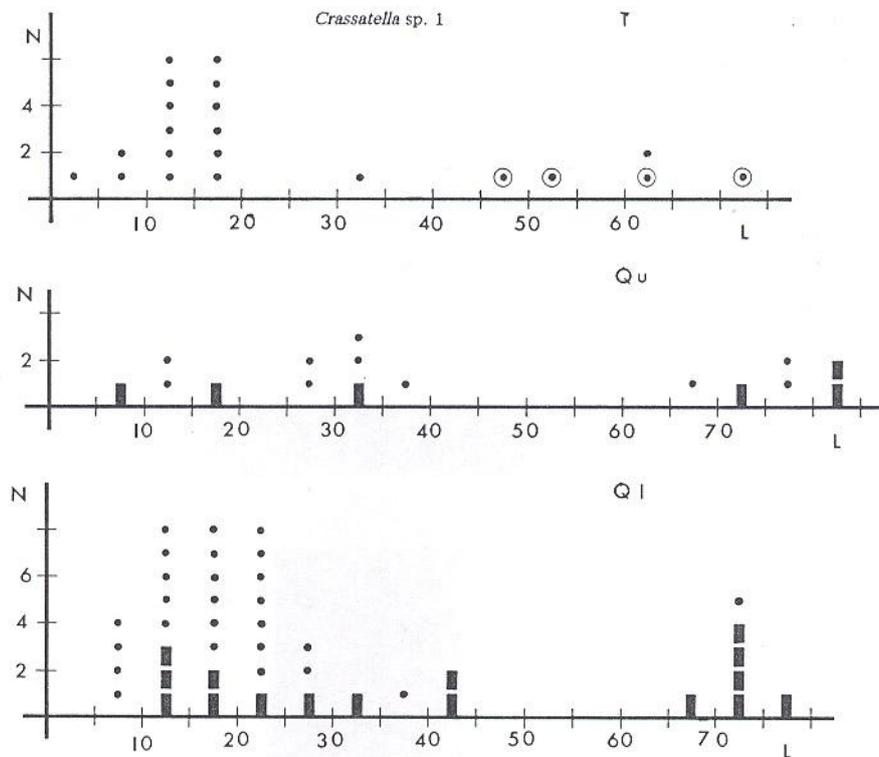


Fig. 115. *Crassatella* sp. 1. Length distributions from: Turrnellakløft, lower sandstone layer (n = 17, dots) + Turrnellakløft, conglomerate (n = 4, circles with dots); Qaersutjægerdal, upper sandstone layer (Qu) (n = 16); Qaersutjægerdal, lower sandstone layer (Ql) (n = 41). Dots = single valves, bars = paired valves.

tion between length and height from whole specimens.

#### Summary of the material

Turrnellakløft: 3 whole specimens + 22 valves.  
Qaersutjægerdal: 22 whole specimens + 36 valves. Agatkjøft: 3 valves. Fig. 115 gives the length distribution of the material from layers at Turrnellakløft and Qaersutjægerdal. They all indicate two size groups.

### CARDIACEA

#### Cardiidae Lamarck, 1809

##### *Microcardium* Thiele, 1934

##### *Microcardium* sp. 1

Figs 116-117.

#### Material:

**TURRITELLAKLØFT: Great Section:** (layer not noted) 1981-294, 1953 (1 valve: L = ca. 5). - *Altitude 628 m:* 1980-308, 1946 (1 left valve: L = 12.5, H = 11.6). - *Lower sandstone bench:* 1980-105, 1953 (1 left valve: L = 13.0, H = 11.3; 1 left valve: L = 7.1). - 1980-120, 1956 (1 valve: L = ca. 7). - 1980-125, 1956 (1 valve: L = ca. 11). - 1980-306, 1946 (1 valve: L = 12.3, H = 11.3). - 1980-307, 1948 (2 valves: L = 10.8, H = 10.0; L = 14.2, H = 13.4). - 1980-310, 1948 (2 valves: L = ca. 9; ca. 10). - 1980-311, 1948 (1 right valve: L = ca. 11; 1 left valve: L = 13.0, H = 12.3; 1 left valve: L = ca. 13). - 1980-312, 1948 (1 valve: L = ca. 13). - 1980-316, 1946 (32 valves: L in mm: 6, 6.4, 6.6, 7, 7.0, 7.2, 7.4, 7.5, 7.8, 7.8, 7.9, 8, 8, 8.3, 8.3, 8.5, 8.7, 8.7, 9, 9.9, 10, 10, 10, 11.2, 11.3, 11.6 (Fig 116), 12, 12, 12, 13.6). - 1981-367, 1946 (4 valves: L = ca. 9, ca. 9, ca. 13, ca. 14). - *Cucullaea conglomerate, eastward below delta:* 1981-127, 1949 (1 valve: L = 10.5). - **South side:** *Lumachelle I:* 1980-309, 1939 (2 valves: L = ca. 7, 8.2). - 1981-292, 1948 (1 valve: L = ca. 12).  
**SONJA LENS:** 1980-117, 1953 (1 valve in hard sediment: L = ca. 13). - 1981-497, 1948 (2 valves: L = 6.0, 6.9).

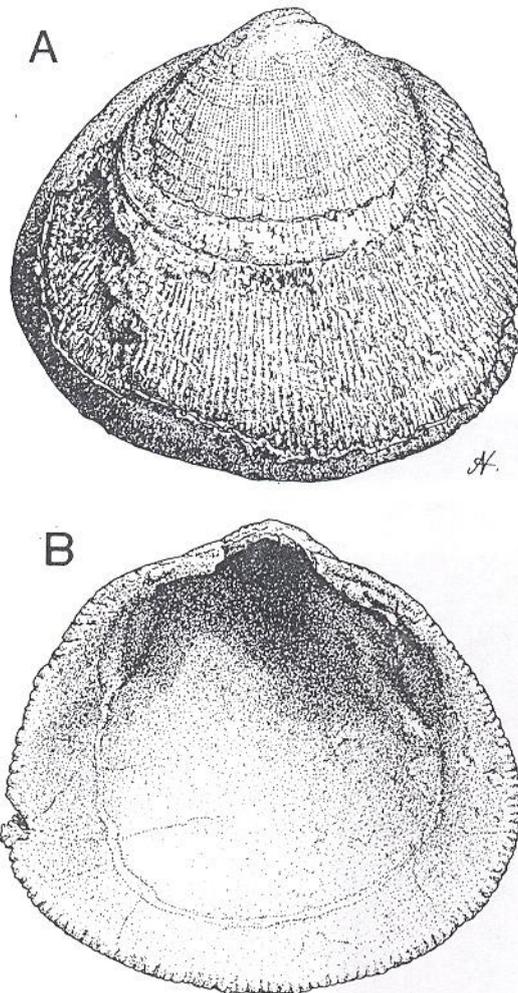


Fig. 116. MGUH 25.236. *Microcardium* sp. 1. One right valve, outside (A) and inside (B): L = 11.6 mm. Turritellakløft, Great Section, lower sandstone bench. 1980-316, 1946.

#### Remarks

The shells are very fragile and are imbedded in hard, coarse sandstone, which makes it almost impossible to study the inside. They are worn, and seem to have been washed up into this sediment together with other shells. They resemble *M. panamaensis* (Dall, 1908); see Olsson (1961: 254, pl. 39, fig. 4). Panama.

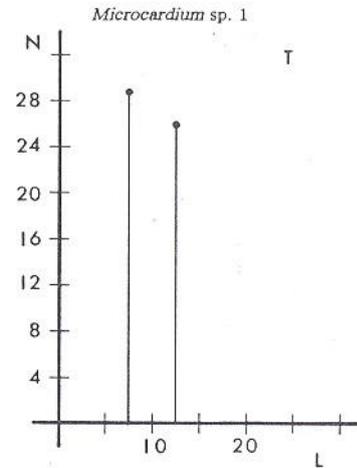


Fig. 117. *Microcardium* sp. 1. Size distribution of specimens from Turritellakløft (T) (n = 56). Lines with dots = single valves.

#### Summary of the material

Turritellakløft: 53 valves. Sonja Lens: 3 valves. Fig. 117 shows the size distribution of the measured specimens of *Microcardium* sp. 1 from Turritellakløft.

#### *Parvicardium* Monterosato, 1884

##### *Parvicardium* sp. 1

Fig. 118.

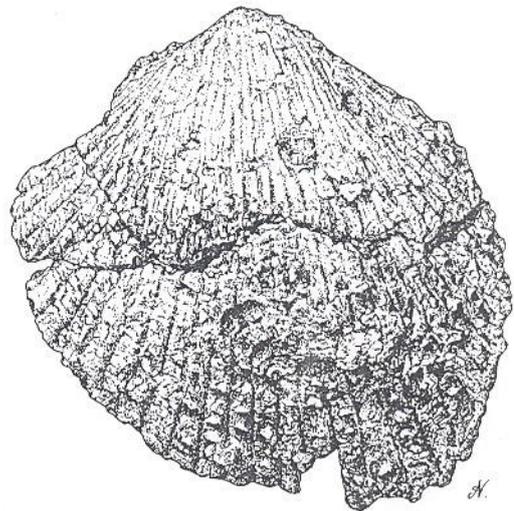


Fig. 118. MGUH 25.237. *Parvicardium* sp. 1. One left valve: L = 3 mm, H = 3 mm. Sonja Lens: 1981-68, 1952.

## Material:

SONJA LENS: 1981-418, 1952 (fragments). - 1981-68, 1952 (2 valves: L = ca. 3, ca. 3; figured specimen).

**Mastridae Lamarck, 1809*****Mastra* Linné, 1767*****Mastra* sp. 1**

Fig. 119.

## Material:

TURRITELLAKLØFT: **Great Section: Lower sandstone bench:** 1980-436, 1946 (1 whole animal, steinkern, closed, undisturbed: L = ca. 45). - **South side:** 1981-447, 1946 (1 valve in hard rock of coarse sediment: L = ca. 26).

SONJA LENS: 1981-430, 1953 (1 valve: L = ca. 6).

QAERSUTJÆGERDAL: **Great Section: Upper concretion layer:** 1980-349, 1952 (1 complete specimen in hard sandstone, valves displaced ca. 10 mm: L = ca. 28). - **Concretion layer below tuff-shale series:** 1981-155, 1958 (1 valve: L = ca. 44). - **Altitude 495 m:** 1980-232, 1958 (1 valve, steinkern in hard sandstone: L = ca. 28).

AGATKLØFT: **East side:** 1980-429, 1948 (1 valve, steinkern in hard rock of coarse gravel: L = ca. 34, Fig. 119).

KANGERSÔQ: **South side: West of Nuilaussarssuaq:** 1980-329, 1952 (1 valve, steinkern in hard rock of coarse gravel with shells: L = ca. 28).

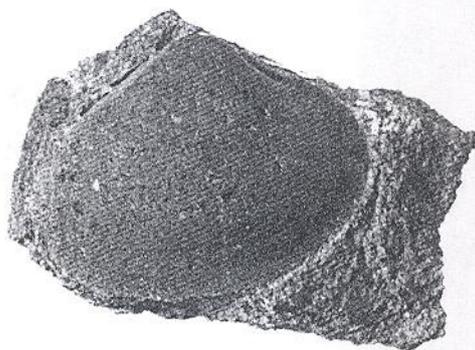


Fig. 119. MGUH 25.238. *Mastra* sp. 1. One valve, steinkern in hard rock: L = ca. 34 mm. Agatkløft, east side: 1980-429, 1948.

**Remarks**

The specimens are identified from their external morphology only, often from steinkerns or prints. Hinges, mantle lines and muscle scars are not visible on the steinkerns. The specimens are found in hard rock of fine sand to coarse gravel and almost without remnants of the shells. This includes the Kangersôq area. It all indicates high-

energy environments. Modern *Mastridae* often occur in sand and gravel in high-energy environments.

**Summary of the material**

Turritellakløft: 1 whole specimen + 1 valve. Sonja Lens: 1 valve. Qaersutjægerdal: 1 whole specimen + 2 valves. Agatkløft: 1 valve. Kangersôq: 1 valve.

**Tellinidae De Blainville, 1814*****Tellina* Linné, 1758*****Tellina* sp. 1**

Figs 120-121.

## Material:

TURRITELLAKLØFT: (layer not stated) 1981-134, 1949 (1 valve in sand with shells: L = 14.4). - **Great Section: Layers 1 & 2:** 1980-106, 1953 (1 valve in sand with shells: L = 12.3). - **Lower sandstone bench:** 1980-451, 1946 (1 valve in sand with shells: L = 19.9). - **Lowest sandstone bench I:** 1980-452, 1948 (1 valve in sand with shells: L = 16.9).

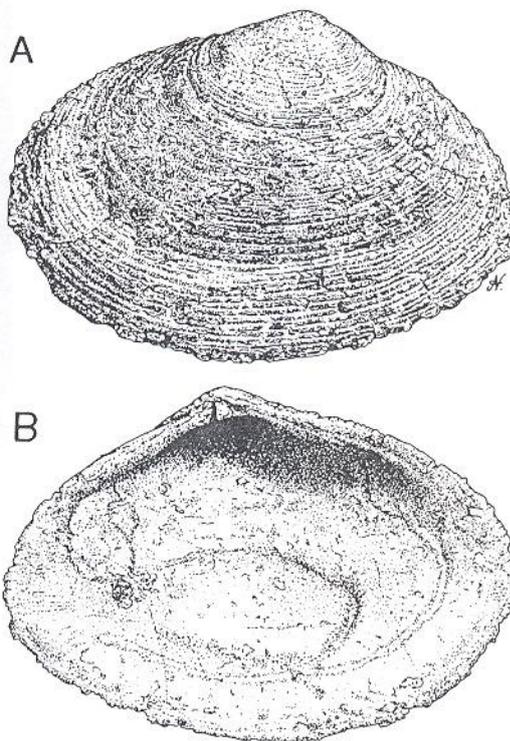


Fig. 120. MGUH 25.239. *Tellina* sp. 1. Left valve, outside (A) and inside (B): L = 13.1 mm. Sonja Lens: 1980-384, 1953.

INTERIOR NUUSSUAQ: *Altitude 525 m*: 1980-453, 1939 (1 valve in coarse sand: L = 21.2).

SONJA LENS: 1980-450, 1951 (8 valves: L = ca. 5, ca. 7, ca. 9, ca. 10, 14.3, ca. 15, 15.1, 16.5) - 1981-398, 1951 (7 valves: L = 4.1, 4.1, 4.2, 4.5, 5.0, 8.4 (with naticid hole), 12.0). - 1980-374 (6 valves: L = 11.4 (with naticid hole), 12.8, 12.9, 13.5, 14.9, 17.0; fragments of 4 valves, 1 with naticid hole). - 1980-384, 1953 (1 valve: L = 13.1, drawing, Fig. 120). - 1980-442, 1948 (16 valves: L = 4.1, 4.5, 5.0, 7.8, 8.6, 8.6, ca. 9, 9.0, 9.8, 11.6, ca. 12, 12.2, 12.2, 15.5, 16.0, 17.5, + fragments of 4 valves, 1 with naticid hole). - 1981-409, 1952 (47 valves: L = 3.4, 3.4, 3.5, 3.5, 3.8, 3.9, 3.9, 4.0, 4.1, 4.1, 4.1, 4.2, 4.2, 4.2, 4.3, 4.4, 4.5, 4.5, 4.5, 4.6, 4.8, 4.9, 5.0, 5.0, 5.2, 5.4, 5.5, 5.6, 6.1, 7.0, 9.9, 10.7, 10.8, ca. 11, ca. 12, 16.5, ca. 17, 17.0; with naticid holes: L = 3.6, 3.7, 3.9, 4.2, 4.6, 4.7, 5.1, 5.2, 5.5). - 1981-324, 1951 (1 valve with naticid hole, L = 14.0). - 1981-432, 1953 (2 valves: L = 13.0, 19.8).

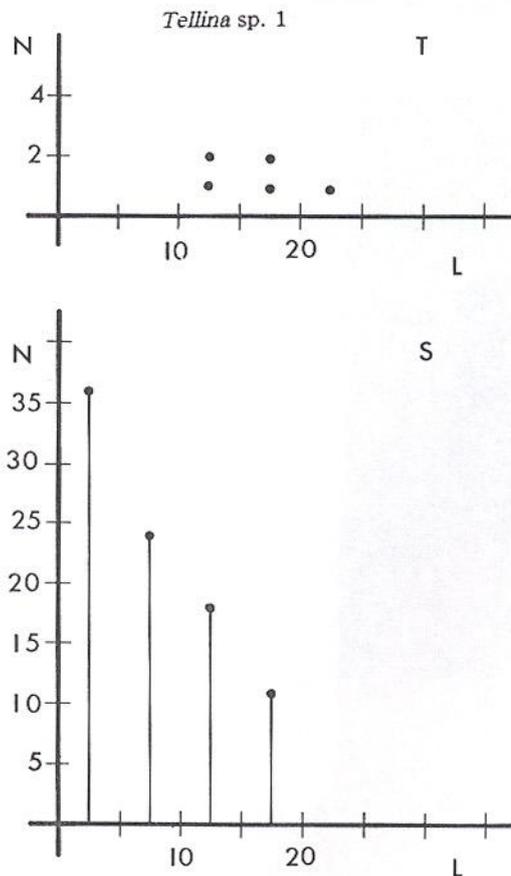


Fig. 121. *Tellina* sp. 1. Length distribution of specimens from Turrítellakløft (T, includes Interior Nuussuaq) (n = 5) and Sonja Lens (S) (n = 89). Dots and lines with dots: single valves.

#### Remarks

This species resembles Recent *Tellina donacina* Linné, 1758. Mediterranean.

#### Summary of the material

Turrítellakløft: 5 single valves. Sonja Lens: 89 valves + fragments, 5 with naticid holes. The size distributions are given on Fig. 121. *Tellina* sp. 1 is only found as single valves, but the "producer habitat" might be a shallow-water locality near the Sonja Lens, where so many small valves are accumulated.

#### *Tellina* sp. 2

Figs 122-124.

#### Material:

QAERSUTJÆGERDAL: Great Section: (layer not noted) 1980-343, 1951 (2 whole specimens, steinkerns with remnants of shells: L = ca. 30, closed; L = ca. 41, closed, compressed a little). - 1980-346, 1951 (1 whole specimen, steinkern with remnants of shell: L = ca. 39, closed, compressed a little). - *Upper concretion layer*: 1980-342, 1952 (2 whole animals, steinkerns with remnants of shells: L = 38.0, closed valves, displaced 4 mm; L = 47.5, closed, undisturbed). - 1980-347, 1952 (2 whole animals, steinkerns with shell fragments: L = ca. 30, closed, displaced ca. 3 mm; L = 34.2 closed, undisturbed). - 1981-274, 1952 (1 whole animal, steinkern with shell pieces in its molded hole. In hard reddish sandstone, sand with shell: L = ca. 54, photo, Fig. 123). - *Layer below tuff-shale series*: 1980-348, 1953 (1 whole specimen, steinkern with shell, undisturbed: L = ca. 40; 1 valve: L = ca. 47). - 1980-350, 1954 (2 whole animals, steinkerns, closed, undisturbed: L = ca. 40, ca. 58, photo, Fig. 122. -



Fig. 122. MGUH 25.240. *Tellina* sp. 2. One whole specimen, closed valves, steinkern, mantle line and muscle scars visible. L = ca. 40 mm. Qaersutjægerdal, Great Section, layer below tuff-shale series. 1980-350, 1954.

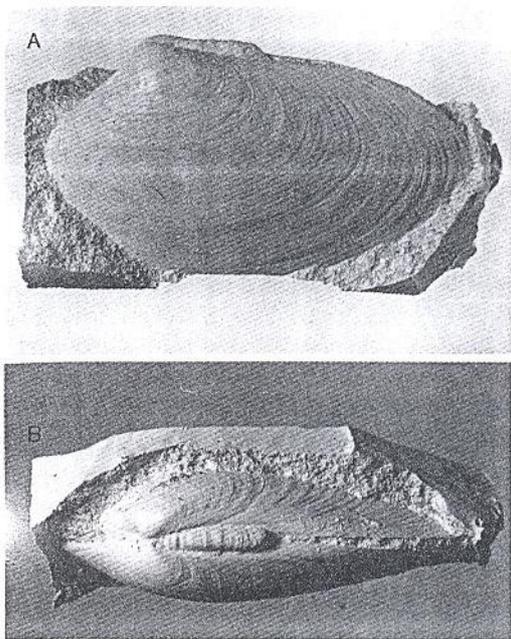


Fig. 123. MGUH 25.241. *Tellina* sp. 2. Gypsum cast of cavity formed by whole specimen with closed valves, seen from left side (A) and umbo (B). L = ca. 54 mm, ligament visible. Qaersutjægerdal, Great Section, upper concretion layer. 1981-274, 1952.

1980-351, 1953 (2 whole animals, steinkerns in hard reddish sandstone: L = ca. 38, closed, crushed a little; L = ca. 42, closed, displaced ca. 4 mm). - Canyon Section: Concretion layer above tuff-shale series: 1890-364, 1956 (2 whole animals, steinkerns: L = 33.0, closed, displaced 2 mm; L = 38.0, closed, undisturbed).

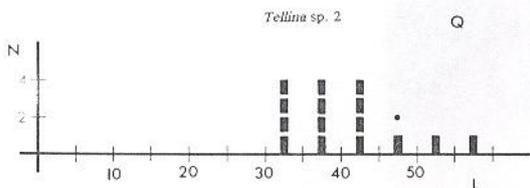


Fig. 124. Length distribution of *Tellina* sp. 2 from Qaersutjægerdal (Q) (n = 16). Dots = single valves, bars = paired valves.

*Summary of the material*

The species is only found at Qaersutjægerdal: 15 paired and 1 single valves. The size distribution is given in Fig. 124.

*Macoma* Leach, 1819

*Macoma* sp. 1

Figs 125-129.

Material:

TURRJTELLAKLØFT: Great Section: Lowermost sandstone bench I: 1980-458, 1948 (1 valve: L = 16.2). - 1981-460, 1948 (1 valve: L = ca. 12).

INTERIOR NUUSSUAQ: All samples from hard rock of coarse sediment: Altitude 560 m: 1980-96, 1939 (2 valves, very worn: L = ca. 22, ca. 21.5). - Altitude 525 m: 1980-447, 1939 (1 valve, steinkern with remnants of the shell: L = ca. 25). - 1980-448, 1939 (1 valve: L = ca. 22).

SONJA LENS: 1980-231, 1956 (1 right valve, with naticid hole: L = ca. 21, photo, Fig. 127). - 1980-424, (1 left valve: L

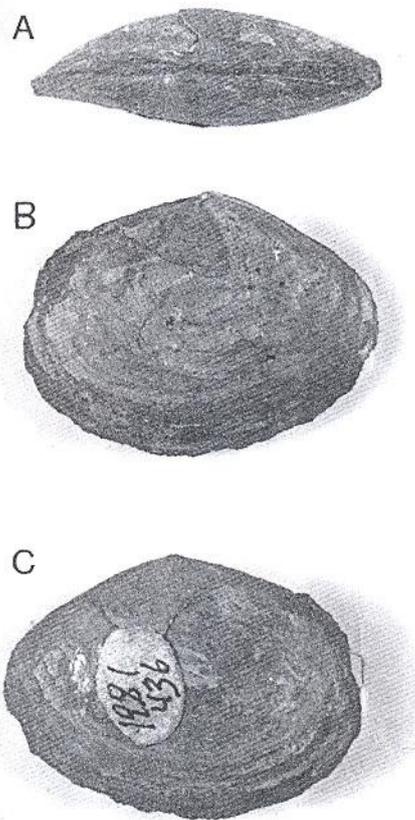


Fig. 125. MGUH 25.242. *Macoma* sp. 1. One whole specimen, with closed valves, steinkern; L = 25.7 mm. A. Dorsal view with bent posterior end. B. Left valve, pallial line faintly visible, steinkern with color changes not associated with pallial line. C. Right valve, label covering mantle line sinus. Qaersutjægerdal, Canyon Section, concretion layer below tuff-shale series: 1981-436, 1956.

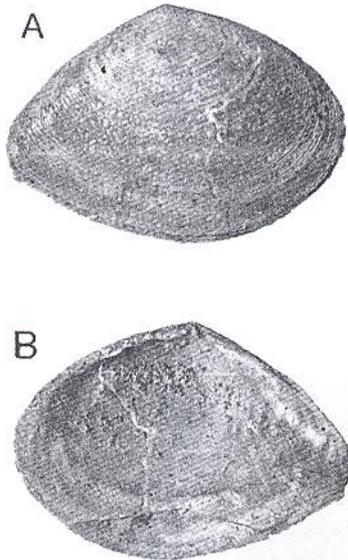


Fig. 126. MGUH 25.243. *Macoma* sp. 1. One right valve, outer (A) and inner (B) views. L = 22.5 mm. Sonja Lens: 1980-450, 1951.

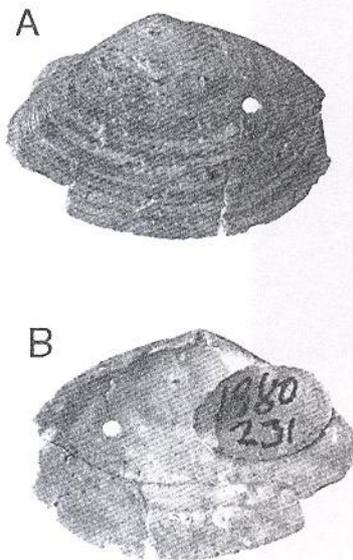


Fig. 127. MGUH 25.244. *Macoma* sp. 1. One right valve with naticid hole, outer (A) and inner (B) views. L = ca. 21 mm. Sonja Lens: 1980-231, 1956.

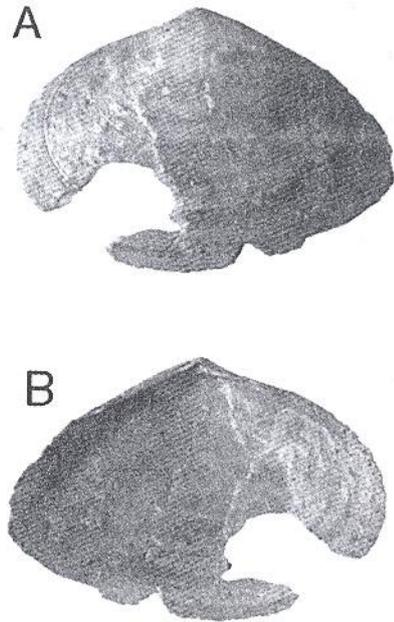
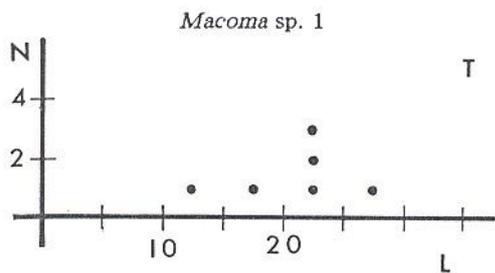


Fig. 128. MGUH 25.245. *Macoma* sp. 1. One left valve, outer (A) and inner (B) views. L = 19.9 mm. Sonja Lens: 1980-424, 1956.

= 19.9, photo, Fig. 128). - 1980-450, 1951 (2 whole specimens, valves closed, displaced 2 mm: L = ca. 20, 23.1; 8 valves: L = 5.2, 5.3, 5.9, 6.2, 10.5, 19.9, 22.5 [photo, Fig. 126], 24.1; + 4 fragments). - 1980-454, 1948 (1 valve: L = 25.6). - 1981-381, 1948 (2 valves: L = ca. 14, ca. 15). - 1981-421, 1953 (2 valves: L = ca. 12, ca. 13). - 1981-510, 1948 (2 valves: L = 17.2, ca. 22).

QAERSUTJÆGERDAL: **Great Section:** (layer not noted) 1980-459, 1951 (1 whole specimen, closed, undisturbed: L = 16.9). - **Altitude 495 m:** 1980-232, 1958 (2 valves: L = 22.8, 23.1 [naticid hole]). - **Upper concretion layer:** 1980-455, 1952 (2 valves: L = 22.1, 22.2). - 1980-457, 1952 (4 valves: L = 15.5, 17.7, 21.8, 21.3 [naticid hole], 21.8). - 1980-460, 1952 (1 valve: L = 18.9). - **Concretion layer below tuff-shale series:** 1980-393, 1954 (1 whole specimen, closed, undisturbed: L = 20.4). - 1980-441, 1953 (2 whole specimens, closed, undisturbed: L = 19.6 [naticid hole], 23.9 [slightly crushed]; 7 valves: L = 19.2, 19.9, ca. 21, ca. 21, 21.5 [naticid hole], 21.7, ca. 23). - 1980-456, 1953 (1 whole specimen, closed, undisturbed, crushed: L = 19.2; 1 valve: L = 21.6). - 1981-107, 1958 (1 valve: L = 23.4). - 1981-111, 1958 (1 valve: L = 23.8). - 1981-159, 1958 (1 valve: L = ca. 24). - **Canyon Section: Concretion layer below tuff-shale series:** 1980-110, 1956 (1 whole specimen, closed, undisturbed: L = 23.2). - 1981-436, 1956 (1 whole, closed, undisturbed specimen: L = 25.7, photo, Fig. 125).

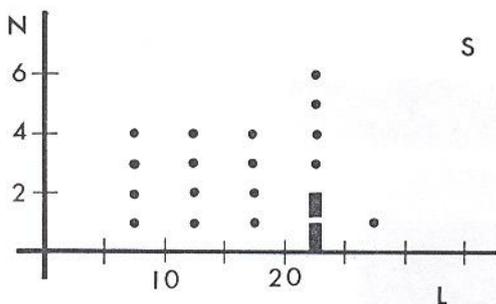


*Remarks*

This species resembles Recent *Macoma nasuta* Conrad, 1837. Alaska to California.

*Summary of the material*

Turrítellakløft: 6 single valves, no naticid holes. Sonja Lens: 2 paired and 17 single valves + fragments, 1 with naticid hole. Qaersutjægerdal: 7 paired and 20 single valves, 4 with naticid hole. The size distributions are given on Fig. 129. The smaller single valves are found at Sonja Lens.



**Donacidae Fleming, 1828**

*Donax* Linné, 1758

*Donax* sp. 1

Fig. 130.

*Material:*

AGATKLØFT: Great Section: 1981-174, 1951 (1 valve in hard rock of gravel with worn shells: L = 30.4, photo, Fig. 130).

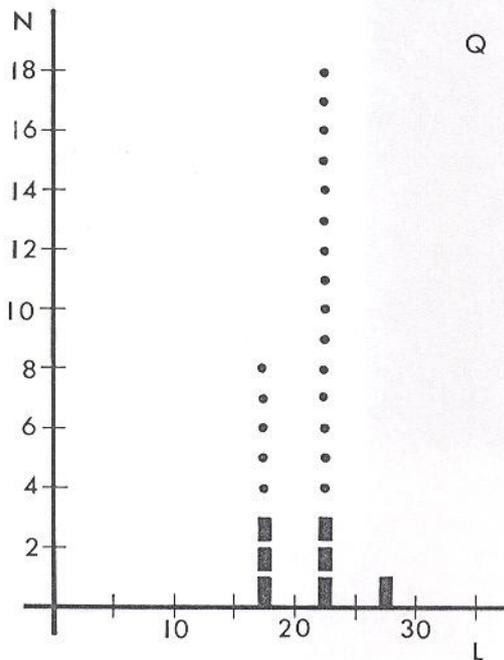


Fig. 129. *Macoma* sp. 1. Length distribution of specimens from Turrítellakløft (T, includes Interior Nuussuaq) (n = 6), Sonja Lens (S) (n = 19) and Qaersutjægerdal (Q) (n = 27). Dots = single valves, bars = paired valves.



Fig. 130. MGUH 25.246. *Donax* sp. 1. One right valve: L = 30.4 mm. Agatkløft, Great Section: 1981-174, 1951.

*Remarks*

The shape and the serrated edge are the only characters that have identified this valve as a *Donax*. Modern Donacidae prefer rough, shallow surf habitats.

**Psammobiidae Fleming, 1828*****Gari* Schumacher, 1817*****Gari* sp. I**

Figs 131-134.

**Material:**

**TURRITELLA KLØFT: South side: Sandstone of coarse sand:** 1980-404, 1946 (1 valve: L = ca. 24). - 1980-405, 1946 (1 valve: L = ca. 46).

**SONJA LENS:** 1980-234, 1956 (1 whole specimen, the 2 valves closed, displaced ca. 2 mm: L = ca. 45). - 1980-384, 1953 (1 valve: L = ca. 29).

**QAERSUTJÆGERDAL: Great Section: (layer not noted)** 1980-409, 1951 (2 valves: L = ca. 38, ca. 40). - 1981-80, 1951 (1 valve: L = 17.3). - *Altitude 495 m:* No number, 1959 (1 whole specimen, closed, undisturbed: L = ca. 25; 2 valves: L = 33, 38.5). - No number, 1958 (1 valve: L = ca. 25). - *Upper concretion layer:* 1980-392, 1952 (1 valve: L = ca. 47). 1980-408, 1958 (4 whole animals: L = 31, gaping 100 degrees; L = 35, closed, undisturbed; L = 39, closed, undisturbed; L = 44 connected, but displaced; 3 valves: L = 32, 37, 43). - 1980-415, 1952 (1 whole specimen, valves closed, but displaced: L = ca. 37; 1 valve: L = ca. 37). - 1980-418, 1952 (1 whole specimen, valves gaping 180 degrees: L = 35.6, photo, Fig. 132). - 1980-422, 1952 (1 whole specimen, valves gaping 180 degrees: L = ca. 37.2). - 1980-423 (1 whole specimen, valves closed but displaced: L = ca. 23; 3 valves: L = ca. 23, 38.2, ca. 40). - *Concretion layer above tuff-shale series:* - 1980-394,



Fig. 132. MGUH 25.248. *Gari* sp. I. One specimen with paired valves: L = 35.6 mm, valves gaping ca. 180 degrees, showing that animal was flushed gently out of sediment after its death, but before ligament had lost its elasticity. A rough environment would easily push the valves apart. Qaersutjægerdal, Great Section, upper concretion layer: 1980-418, 1952.

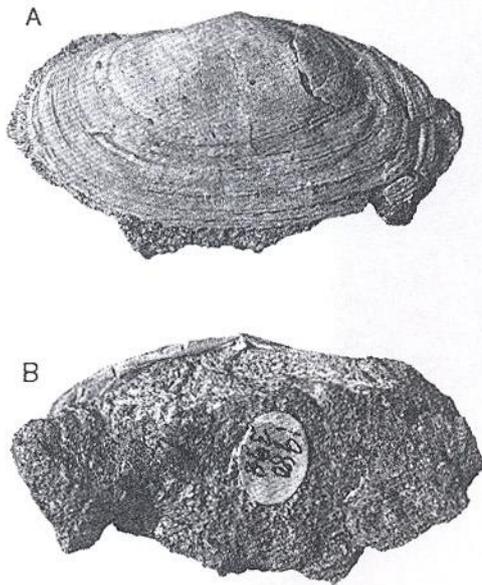


Fig. 131. MGUH 25.247. *Gari* sp. I. One right valve, outside (A) and inside (B) with visible hinge: L = 40.0 mm. Qaersutjægerdal, Great Section, concretion layer below tuff-shale series: 1980-398, 1956.

1953 (1 whole specimen, valves gaping ca. 45 degrees: L = ca. 32; 2 valves: L = ca. 17, ca. 32). - 1980-396, 1953 (3 whole animals: L = ca. 23, gaping ca. 50 degrees; L = ca. 40, closed, undisturbed; L = ca. 51, closed, displaced; 2 valves: L = ca. 19, ca. 25). - *Concretion layer below tuff-shale series, sand with shells and wood:* 1980-398, 1956 (2 valves: L = 40.0, Fig. 131; L = 40.1). - 1980-403, 1953 (1 whole specimen, valves displaced: L = 28.8). - 1980-411, 1953 (2 whole specimens, closed, undisturbed: L = 31.6, ca. 41). - 1980-414, 1953 (1 whole specimen, valves closed and crushed: L = 40.5). - 1980-417, 1954 (1 valve: L = ca. 38.0). - 1980-420, 1953 (1 whole specimen, valves gaping ca. 5 degrees, slightly displaced: L = ca. 41; 1 valve: L = ca. 29). - 1981-124, 1958 (2 whole specimens: L = 39.0, closed, undisturbed; L = 41.2, valves closed but displaced; 1 valve: L = 37.0). - 1981-309, 1951 (1 whole specimen, valves gaping 180 degrees, displaced ca. 13 mm, L = 41). - **West side:** 1981-302, 1953 (1 whole specimen, steinkern, closed: L = 40.2). - 1980-397, 1951 (1 valve: L = ca. 27.9). - 1980-416, 1951 (1 whole specimen, closed, displaced ca. 2 mm: L = 40.5). - 1980-419, 1951 (1 whole specimen, valves gaping ca. 150 degrees: L = ca. 50). - 1980-421, 1953 (2 whole specimens: L = 34.7, valves closed, photo, Fig. 133; ca. 39, valves closed but displaced). - 1981-106, 1951 (1 valve: L = ca. 16). - 1981-307, 1951 (1 valve: L = 32.0). - No number, 1953 (1 whole specimen, valves gaping ca. 120 degrees: L = ca. 30). - **"The Triangle":** 1981-399, 1951 (1 whole specimen, closed, compressed: L = ca. 29).

**AGATKLØFT: Great Section:** 1980-402, 1951 (1 whole specimen, closed, undisturbed: L = ca. 31).

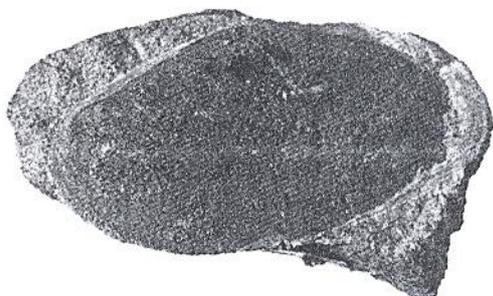


Fig. 133. MGUH 25.249. *Gari* sp. 1. One specimen with coherent valves, paired valves closed but displaced ca. 2 mm against each other after the animal's death and caused by movements in the unconsolidated sediment; L = 34.7 mm. Qaersutjægerdal, west side: 1980-421, 1953.

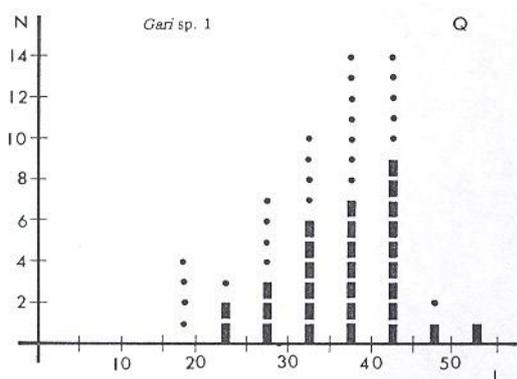


Fig. 134. *Gari* sp. 1. Length distribution for specimens from Qaersutjægerdal (Q) (n = 55). Dots = single valves, bars = paired valves.

*Remarks*

Similar to several species in the genera *Sanguinolaria* and *Hiatula*.

*Summary of the material*

Turritellakløft: 2 valves. Sonja Lens: 1 whole specimen and 1 valve. Qaersutjægerdal: 29 paired and 26 single valves. Agatkløft: 1 valve. The size distribution for the Qaersutjægerdal material is given in Fig. 134.

**Semelidae Stoliczka, 1870**

***Semele* Schumacher, 1817**

***Semele* sp. 1**

Fig. 135.

**Material:**

QAERSUTJÆGERDAL: Great Section: 1980-464, 1951 (1 whole specimen, valves closed and undisturbed: L = 32.6, photo, Fig. 135).



Fig. 135. MGUH 25.250. *Semele* sp. 1. One whole specimen: L = 32.6 mm, seen from left (A) and right (B) sides and the umbo (C). Qaersutjægerdal, Great Section: 1980-464, 1951.

**Solecurtidae D'Orbigny, 1846*****Solecurtus* De Blainville, 1824*****Solecurtus* sp. 1**

Fig. 136.

**Material:**

SONJA LENS: 1981-171, 1953 (1 valve in hard sand: L = ca. 75, photo, Fig. 156).

Fig. 136. MGUH 25.251. *Solecurtus* sp. 1. One valve in hard sand: L = ca. 75 mm. Sonja Lens: 1981-171, 1953.**Remarks**

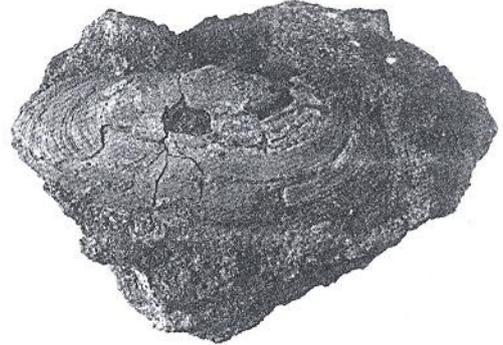
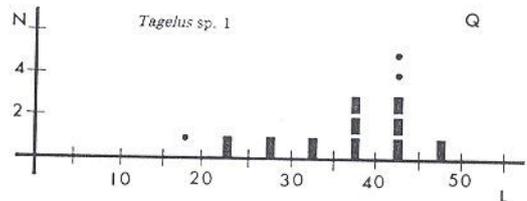
The specimen is very close to Recent *Solecurtus strigillatus* Linné, 1758. Mediterranean to West Africa.

***Tagelus* Gray, 1847*****Tagelus* sp. 1**

Figs 137-138.

**Material:**

QAERSUTJÆGERDAL: **Great Section:** (layer not noted) 1981-304, 1951 (1 whole animal, closed, imprint: L = ca. 30). - *Altitude 495 m:* No number, 1958 (1 whole specimen, closed, undisturbed, steinkern: L = ca. 39). - *Concretion layer above tuff-shale series:* 1980-396 (1 whole specimen in hard sandstone, sand with shells, closed: L = ca. 41). - *Concretion layer below tuff-shale series:* 1980-320, 1953 (1 whole animal, closed, compressed: L = ca. 25). - 1980-395, 1953 (2 valves: L = 40.3, photo, Fig. 137, 42.5). - 1981-85, 1953 (1 whole animal, closed, undisturbed: L = ca. 37). - **West side at the second turn: *Turritella conglomerate:*** 1980-313, 1951 (1 whole animal, steinkern, closed: L = 20). - **West side:** 1981-90, 1953 (3 whole specimens, steinkerns, closed: L = ca. 35, displaced 1 mm, L = ca. 40, undisturbed, L = ca. 48, undisturbed). - 1981-120, 1953 (1 valve, steinkern: L = ca. 16). - **Canyon at *Turritella waterfall:*** In *Turritella* sandstone: 1980-427, 1956 (1 whole animal, steinkern: L = ca. 40).  
SONJA LENS: 1980-386, 1951 (fragments of 1 valve).

Fig. 137. MGUH 25.252. *Tagelus* sp. 1. One valve: L = 40.3 mm. Qaersutjægerdal, Great Section, layer below tuff-shale series: 1980-395, 1953.Fig. 138. *Tagelus* sp. 1. Length distribution of material from Qaersutjægerdal (Q) (n = 13). Dots = single valves, bars = paired valves.**Remarks**

This species resembles the Recent *T. californianus* (Conrad, 1837), California to West Mexico, and *T. bidentatus* (Spengler, 1794).

**Summary of the material**

Sonja Lens: fragments. Qaersutjægerdal: 10 paired and 3 single valves. The size distribution is given in Fig. 138.

**Arcticidae Newton, 1891*****Arctica* Schumacher, 1817*****Arctica* sp. 1**

Figs 139-143.

**Material:**

TURRITELLAKLØFT: **Great Section:** *Uppermost in section:* not numbered, 1956 (1 right valve: L = 63, H = 53, identified by Rosenkrantz in a note as *Cyprina*). - *Lower sandstone bench:* 1980-328, 1946 (2 left valves: L = 22.5, H

= 18; L = 37.5, H = 32. Both steinkerns in fine sediment, but with several pieces of original shell). - *Layers 1 & 2*: 1981-480, 1953 (1 right valve in coarse sediment with shells: L = 31, H = 27.5). - *Turritella conglomerate*: 1980-431, 1948 (fragment of right valve: L = ca. 40, Fig. 142). - *South side*: 1980-330, 1948 (1 left valve: L = 35, H = 28, Fig. 141). - 1980-339, 1946 (1 right valve: L = 28, H = 22.5; 2 valves (steinkerns): L = ca. 80, L = 85).

QAERSUTJÆGERDAL: *Great Section: Upper concretion layer*: 1980-322, 1954 (1 whole specimen with closed valves: L = 75, H = 65; 2 right valves: L = ca. 70, H = 67; L = 81, H = 70; 1 left valve: L = 72, H = 67). - 1980-326, 1952 (1 right valve: L = ca. 79, H = 67). - 1980-433, 1952 (fragments of 2 valves: L = ca. 85). - *Concretion layer below the tuff-shale series*: 1980-324, 1958 (1 right valve: L = 78.0, H = 62.2. Rosenkrantz's label note: "cfr. *Arctica ovata* Meek &

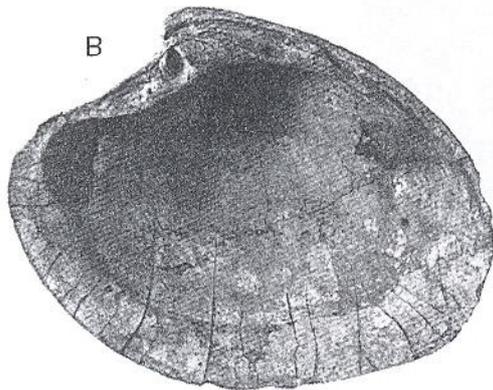
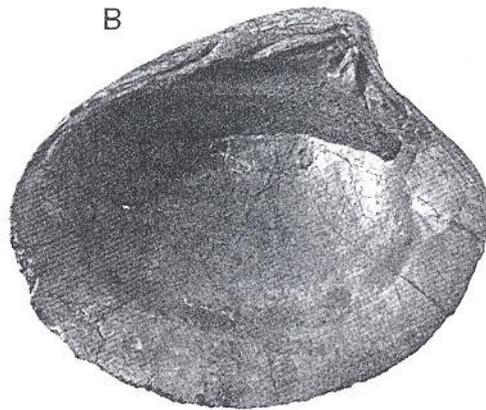
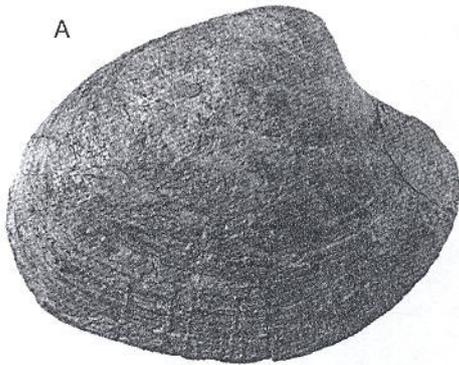
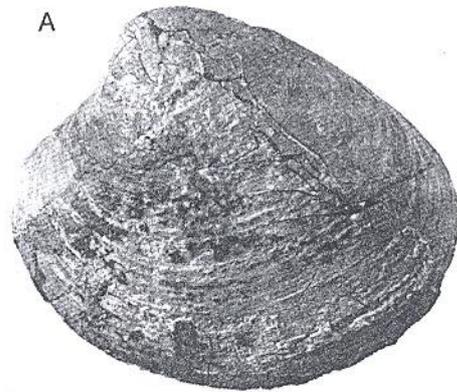


Fig. 139. MGUH 25.253. *Arctica* sp. 1. One right valve, outside (A) and inside (B), corroded surface: L = 78 mm. Qaersutjægerdal, Great Section, concretion layer below tuff-shale series: 1980-324, 1958.

Fig. 140. MGUH 25.254. *Arctica* sp. 1. One left valve, outside (A) and inside (B), surface crushed: L = 86.5 mm. Qaersutjægerdal, Canyon Section: 1980-434, 1956.

Hayden", photo, Fig. 139). - 1980-335, 1958 (1 left valve: L = 79, H = 68; 1 right valve: L = 76, H = 72, 2 fragments of large shells). - 1980-336, 1955 (1 left valve: L = 47, H = 42). - 1980-338, 1953 (3 whole, closed, undisturbed specimens: L = 17, H = 15; L = 32, H = 27; L = 35, H = 28; 1 left valve: L = 28, H = 23; 1 right valve: L = 22.5, H = 19). - 1980-437, 1954 (1 whole specimen, the 2 valves slightly displaced: L = ca. 41, H = ca. 32). - 1981-112, 1954 (1 right valve: L = ca. 21, H = 17.5. - 35251, 1953 (1 left valve: L = 70.5, H = 66, Rosenkrantz's label name: "*Cyprina*"). - *Canyon Section: Concretion layer below the tuff-shale series*: 1980-434, 1956 (1 whole specimen, the 2 valves slightly displaced: L = ca. 83,

H = ca. 78; 1 left valve: L = 86.5, H = 75.2, photo, Fig. 140). 1981-235, 1956 (1 whole specimen, the two valves half-open but not displaced, steinkern: L = ca. 70).

*Remarks*

Turritellakløft: The 9 valves are imbedded in conglomerate ranging from fine sand to coarse gravel and with shell fragments. Qaersutjægerdal material: The 7 paired and 15 single valves are imbedded in fine sand, and are more or less silicified.

Fig. 143 shows the length distribution of the material from Turritellakløft and Qaersutjægerdal. It indicates 2 size groups at both localities.

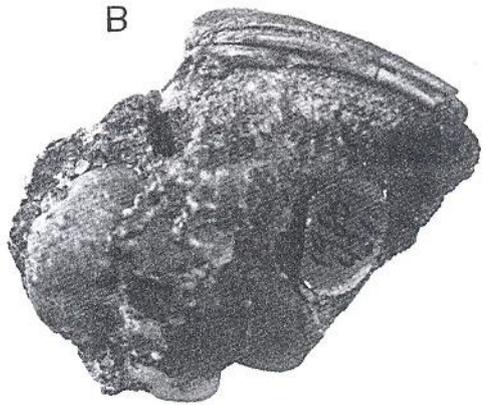
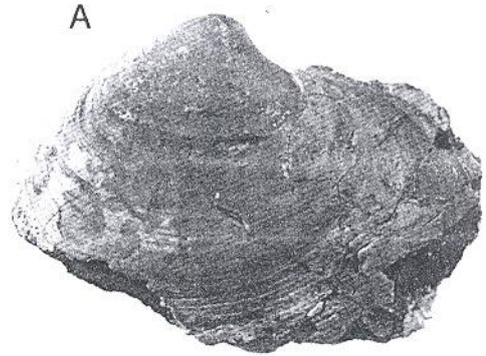


Fig. 142. MGUH 25.256 *Arctica* sp. 1. One right valve, fragment, outside (A) and inside (B): L = ca. 40 mm, nice surface and hinge. Turritellakløft, Great Section, *Turritella* conglomerate: 1980-431, 1948.

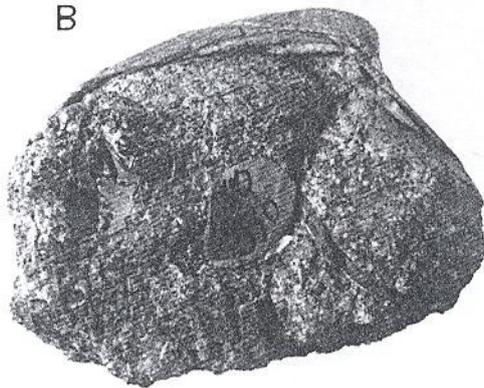


Fig. 141. MGUH 25.255. *Arctica* sp. 1. Left valve, outside (A) and inside (B), nice surface and hinge: L = 35 mm. Turritellakløft, south side: 1980-330, 1948.

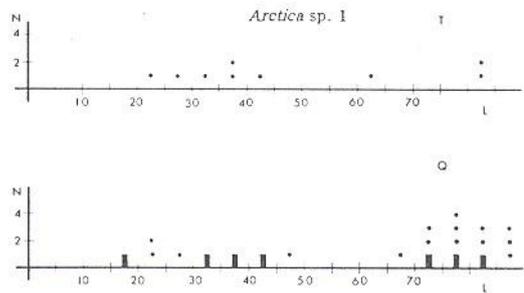


Fig. 143. *Arctica* sp. 1. Length distribution of material from Turritellakløft (T) (n = 9) and Qaersutjægerdal (Q) (n = 22), showing 2 size groups at both localities. Dots = single valves; bars = paired valves.

**Trapeziidae Lamy, 1920**  
***Coralliophaga* De Blainville, 1824**  
***Coralliophaga?* sp.1**  
 Figs 144-145.

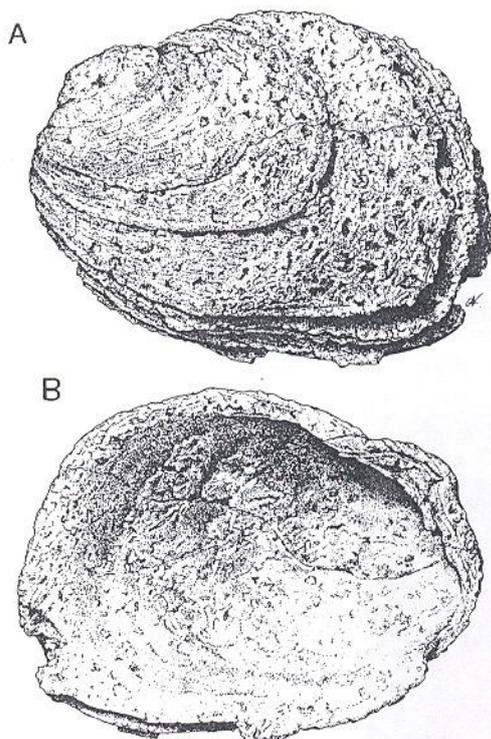


Fig. 144. MGUH 25.257. *Coralliophaga* sp. 1. One left valve, outside (A) and inside (B): L = ca. 8 mm. Sonja Lens: 1980-327, 1952.

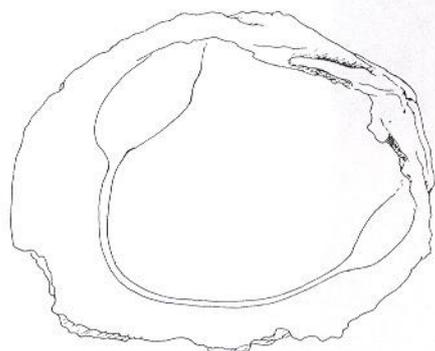


Fig. 145. MGUH 25.258. *Coralliophaga* sp. 1. Sketch of muscle scars and pallial line from a left valve: L = 7.0 mm. Sonja Lens: 1981-405, 1952.

Material:  
 SONJA LENS: 1980-327, 1952 (1 valve: L = ca. 8, H = ca. 6.5. Identified by Rosenkrantz as "*Veniella?*", drawing, Fig. 144). - 1981-405, 1952 (1 valve: L = 7.0, Fig. 145. Identified by Rosenkrantz as "*Veniella?*"). - 1981-485, 1951 (1 valve: L = ca. 7).

*Remarks*  
 The identification of these three small valves was difficult; they may also be close to *Irus*.

**Veneridae Rafinesque, 1815**

*General remarks on the material*  
 The shells referred to this family were mainly identified from the shape of the shells because they generally were imbedded in sediment that covered the inside of the shells. The best hinges, muscle scars and pallial lines are illustrated. The material is further sorted out into the genera listed below, but considering the large number of taxonomic units in this family, there may be more species than we have been able to detect.

***Circe* Schumacher, 1817**

***Circe* sp. 1**  
 Fig. 146.

Material:  
 SONJA LENS: 1981-513, 1953 (1 valve: L = 4.4, Fig. 146).

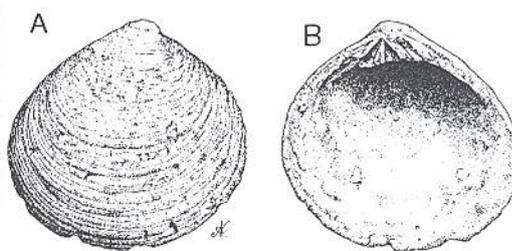


Fig. 146. MGUH 25.259. *Circe* sp. 1. One right valve: L = 4.4 mm, outside (A) and inside (B). Sonja Lens: 1981-513, 1953.

***Pitar* Römer, 1857**

***Pitar* sp. 1**  
 Figs 147-148.

Material:  
 TURRITELLAKLØFT: Great Section: Lower sandstone bench: 1981-70, 1946 (2 whole specimens, L = 10.8, 19.7; 6

left valves: L = 13.9, 14.5, 17.6, 18.1, 18.4, 21.8; 7 right valves: L = 13.5, 14.1, 16.0, 17.7, 18.2, 19.6, 19.8. The valves are imbedded in coarse sediment with shell fragments, incl. 1 *Microcardium*, 1 *Arca* and 1 *Anomia*. - 1981-131, 1946 (1 right valve: L = 18.0). - 1980-337, 1949 (1 right valve, steinkern: L = ca. 28). - 1981-354, 1948 (1 left valve: L = ca. 20, + 1 *Microcardium*: L = ca. 7, in same piece). - 1981-366, 1946 (1 right valve: L = 9.6). - 1981-371, 1948 (1 left valve: L = 22.4, in coarse conglomerate with shells, e.g., *Arca*?). - No number, 1953 (1 left valve: L = 7.6). - *Cucullaea conglomerate, eastward below delta*: 1981-361, ? (1 left valve: L = ca. 20, with naticid hole). - 1981-362, ? (1 right valve: L = 13.3). - *Loose block*: 1980-333, 1953 (1 right valve: L = ca. 31).

INTERIOR NUUSSUAQ: *Altitude 560 m*: 1981-353, 1939 (1 left valve: L = 5.7).

SONJA LENS: 1981-65, 1953 (4 valves: L = 12.8, with naticid hole, 11.2, 11.3, 15.3). - 1981-67, 1948 (3 whole specimens: L = 11.0, 12.2, 12.3, 11.0; 74 valves and fragments from specimens 5-15 mm long, 3 with naticid hole). - 1981-68, 1952 (2 whole specimens: L = 2.5 [closed], 6.8 [half open]); valves and fragments from ca. 50 specimens 5-10 mm long + 1 ca. 20 mm). - 1981-69, 1951 (7 whole specimens: L = ca. 9, ca. 10, 10.0, 10.3, 10.7, ca. 11, 11.0). 66 valves or fragments from specimens 3-14 mm long, 1 with naticid hole). - 1981-415, 1951 (17 worn and corroded valves in loose sediment: 10 valves: L = 3.0-4.9; 5 valves: L = 5-9.9; 2 valves: L = 10-12.9. One valve: L = 4.3, with naticid hole). - 1981-431, 153 (1 left valve: L = 11.5). - 1981-490, 1951 (51 valves or fragments from specimens 4-14 mm long, 2 with naticid hole. All more or less corroded before fossilization). - 1981-500, 1948 (3 valves: L = ca. 6, ca. 7, 10.8).

QAERSUTJÆGERDAL: **Great Section: Upper concretion layer**: 1980-332, 1952 (1 right valve: L = 41.5). - 1980-463, 1952 (1 whole specimen with closed valves: L = ca. 40). - 1981-356, 1957 (1 whole specimen, 2 valves are half-



Fig. 147. MGUH 25.260. *Pitar* sp. 1. One whole specimen: L = ca. 35 mm, the 2 valves closed but displaced apart ca. 2 mm. Qaersutjægerdal, Great Section, upper concretion layer: 1980-359, 1952.

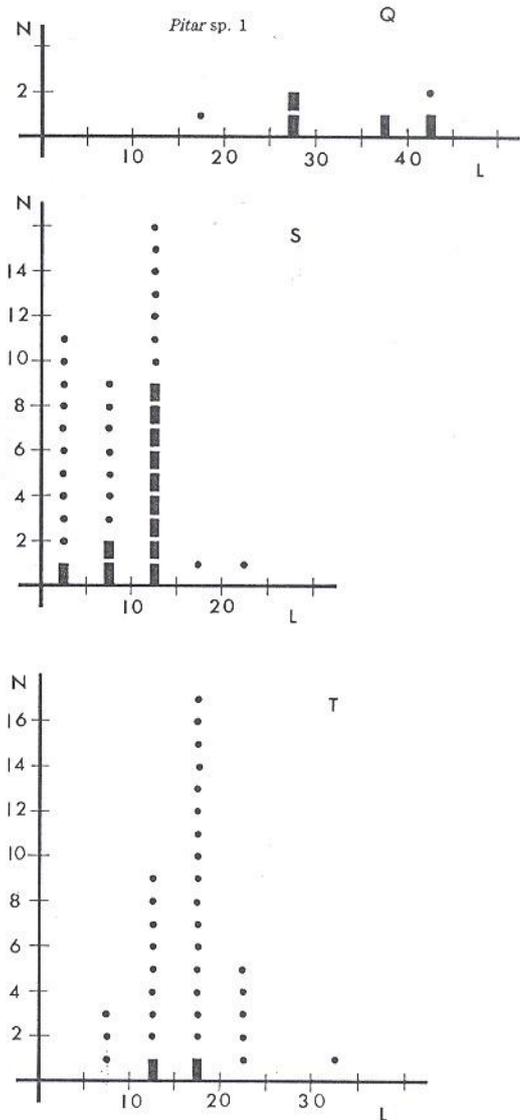


Fig. 148. *Pitar* sp. 1. Length distribution for the 3 main localities: Qaersutjægerdal (Q) (n = 6), Sonja Lens (S) (n = 38) and Turitellakløft (T, includes Interior Nuussuaq + Agatkløft) (n = 35). Dots = single valves, bars = paired valves.

opened and slightly displaced: L = 25.1). - 1980-359, 1952 (1 whole specimen, the 2 valves dislocated: L = ca. 35, photo, Fig. 147). - **Canyon Section: Concretion layer below tuff-shale series**: 1980-363, 1965 (1 valve: L = 15.2). - **West side at second turn**: 1980-344, 1951 (1 whole specimen, steinkern, valves closed, but displaced ca. 4 mm, L = 29.0).

AGATKLØFT: 1980-108, 1957 (1 valve: L = ca. 10. In coarse sediment with shells, including 1 *Thyasira?*). - 1981-66, 1948 (7 valves: L = ca. 15, ca. 15, ca. 17, ca. 17, 18.1, 19.9, ca. 20. Imbedded in coarse sediment with shells, including *Turritella* and a naticid.

#### Summary of the material

Turritellakløft: 2 whole specimens + 26 single valves. Sonja Lens: 12 whole specimens + 266 valves, 8 with naticid holes. Qaersutjægerdal: 4 whole specimens + 2 valves. Agatkløft: 8 valves. Fig. 148 shows the length distribution for the 3 main localities. Sonja Lens is the "producer" habitat for this species.

#### *Pitar* sp. 2

Fig. 149.

#### Material:

TURRITELLAKLØFT: Great Section: *Cucullaea conglomerate, eastward below delta*: No number, 1949 (3 valves: L = ca. 10, ca. 12, ca. 18, photo, Fig. 149).

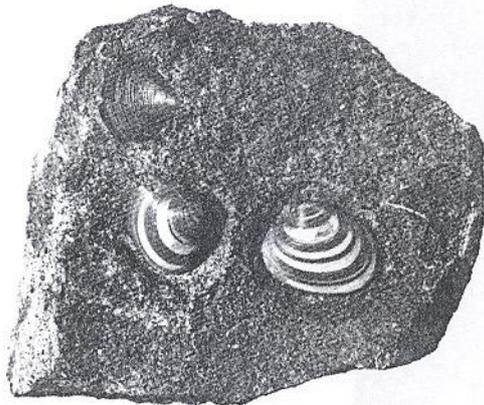


Fig. 149. MGUH 25.261. *Pitar* sp. 2. Three valves: L = ca. 10 (A), ca. 12 (B), ca. 18 mm (C). Turritellakløft, Great Section, *Cucullaea conglomerate*, below delta, eastward: 1949.

#### *Callista* Poli, 1791

#### *Callista* sp. 1

Figs 150-152.

#### Material:

TURRITELLAKLØFT: Great Section: *Lower sandstone bench*: 1980-356, 1946 (1 whole animal, the 2 valves displaced: L = ca. 35). - 1980-432, 1949 (1 right valve: L = 27.6).

- 1980-438, 1946 (1 right valve: L = 28.8). - *Eastward below delta*: 1980-323, 1949 (1 left valve: L = ca. 37). - 1980-366, 1949 (1 left valve: L = ca. 32).

SONJA LENS: 1980-115, 1951 (valves and fragments from 35 specimens: L = ca. 4-14). - 1980-367, 1952 (1 valve: L = 2.8; 15 valves: L = 3.0-3.9; 13 valves: L = 5.0-9.9; 1 valve, L = 11.1; 4 valves: L = 20.0-24.9; 4 valves: L = 25.0-29.9; 1 valve: L = ca. 34; 2 valves with naticid hole). - 1980-352, 1948 (32 valves and fragments from specimens ca. 6-28.5 mm long. 1 valve with naticid hole. Identified by Rosenkrantz as "cfr. *Meretrix (Callista) montiensis* Cossm."). - 1980-383, 1953 (1 fragment with umbo, estimated L = 14). - 1981-402, 1953 (1 valve: L = ca. 12). - 1981-417, 1953 (1 right valve: L = 19.3). - 1980-425, 1958 (1 left valve: L = 28.0). - 1977. 3796 (1 whole, closed specimen, L = 16.0; 12 valves: L = ca. 13, 15.3, 16.2, 17.1, 18.0, 19.2, 19.8, 19.9, 24.1, 25.0, 32.2, 40.4) - No number, 1956 (1 right valve: L = 47.0, photo, Fig. 150, identified by Rosenkrantz as "*Callista* cfr. *montiensis* Cossm."). - No number (4 valves: L = 17.0, 18.5, 21.6, ca. 31. Identified by Rosenkrantz as *Callista*). - No number (2 left valves: L = 20.6; 33.7, photo, Fig. 151).

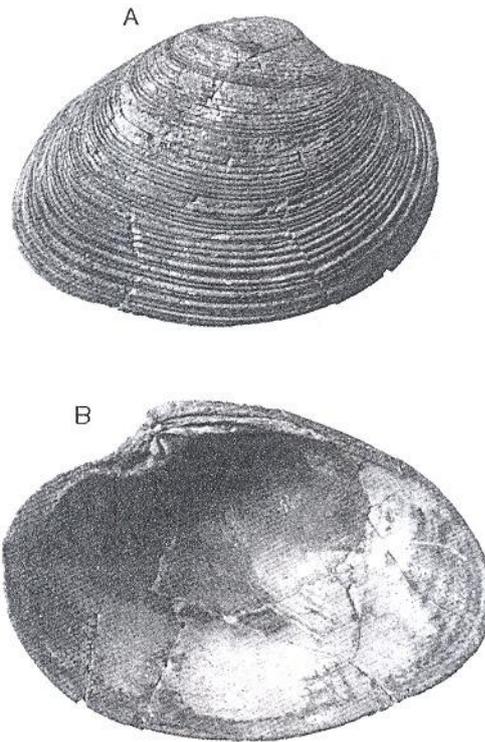


Fig. 150. MGUH 25.262. *Callista* sp. 1. One right valve, outside (A) and inside (B). L = 47.0 mm. Sonja Lens: no number, 1956.

QAERSUTJÆGERDAL: **Great Section:** (layer not noted) 1981-278, 1951 (1 whole specimen, valves closed but slightly displaced: L = 21.6). – **Upper concretion layer:** 1980-355, 1952 (1 whole specimen, steinkern, closed valves: L = 29.8). – 1980-358, 1953 (1 whole specimen, steinkern, closed valves, L = 30.6; 1 valve, imprint, L = 32). – 1980-362, 1952 (1 right valve, imprint, L = 32.0). – **From tuff-shale series:** 1981-59, 1953 (1 whole specimen with closed valves, squeezed by geological pressure: L = ca. 21). – **Conglomerate below tuff-shale series:** 1980-97, 1953 (1 left valve: L = 5.8; 1 left valve: L = 7.9, H = 7.0; 1 whole specimen, valves totally opened and slightly displaced: L = 9.9, H = 9.0; 1 whole specimen, the 2 valves slightly displaced: L = 11.1, H = 9.4. – 1980-107, 1956 (1 whole specimen with closed valves: L = 21.7, H = 15.5, W = 11.0). – 1980-345, 1953 (1 whole specimen with closed valves, L = ca. 38). – 1980-353, 1953 (1 whole specimen, steinkern, closed valves: L = 25.5; 1 whole specimen, steinkern, closed but slightly distorted valves: L = 26.3). – 1981-63, 1953 (4 valves: L = 10.0, 15.3, 18.6, 20.4). – 1981-163, 1958 (1 whole specimen with closed valves: L = 27.0). – **West side at second turn:** 1980-361, 1951 (1 whole specimen, the 2 valves 180 degrees apart, but joined at hinge:

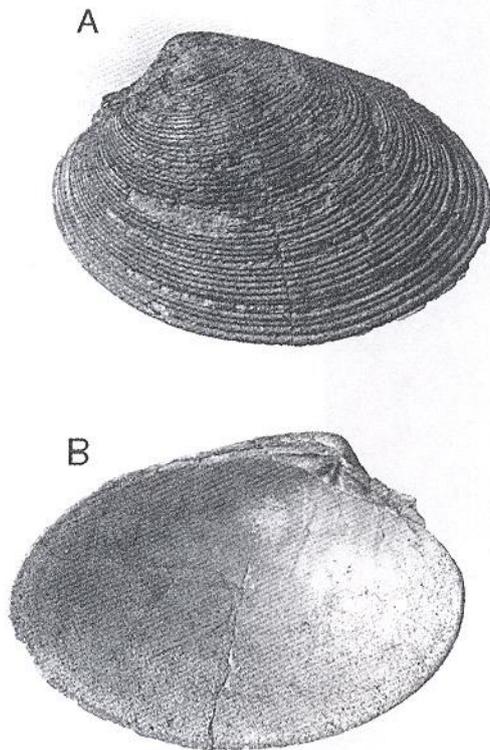


Fig. 151. MGUH 25.263. *Callista* sp. 1. One left valve, outside (A) and inside (B). L = 33.7 mm. Sonja Lens: no number, 1956.

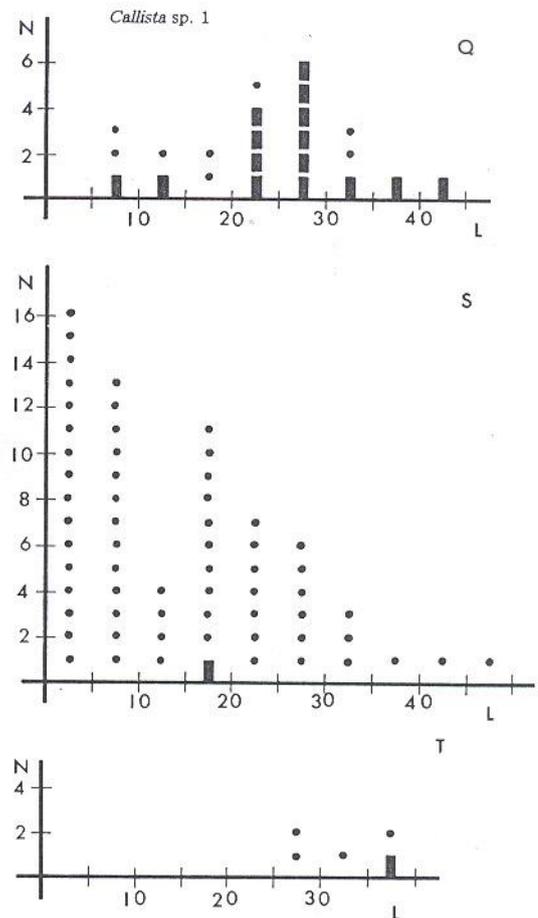


Fig. 152. *Callista* sp. 1. Length distribution of material from the 3 main localities: Qaersutjægerdal (Q) (n = 15 whole specimens + 8 valves), Sonja Lens (S) (n = 1 whole specimen + 62 valves), and Turritelakløft (T) (n = 1 whole specimen + 4 valves). Dots = single valves, bars = paired valves.

L = 22.5). – 1981-305, 1952 (1 whole specimen, the 2 valves ca. 100 degrees apart and slightly displaced: L = 44.5). – **West side:** 1980-357, 1953 (1 whole specimen, steinkern, valves are closed, but displaced ca. 2 mm: L = 25.9). – 1980-365, 1953 (1 whole specimen, steinkern, valves are closed but displaced ca. 1 mm: L = ca. 26).

**NUILAUSSARSSUAQ: West side:** 1981-310, 1953 (1 right valve, imprint: L = ca. 30).

#### Remarks

This species is close to Recent *Macrocallista squalida*, (Sowerby, 1835) (see Olsson 1961: 273, pl. 46, fig. 2). California to Peru.

*Summary of the material*

Turritellakløft: 1 whole specimen + 4 valves.  
 Sonja Lens: 1 whole specimen + 128 valves, 3  
 with naticid holes. Qaersutjægerdal: 15 whole  
 specimens + 8 valves. Fig. 152 shows the length  
 distribution of the material from the 3 main lo-  
 calities. Qaersutjægerdal is the main "producer"  
 habitat and Sonja Lens is the main "receiver"  
 habitat for these shells.

*Liochoncha* Mörch, 1853*Liochoncha?* sp. 1

Fig. 153.

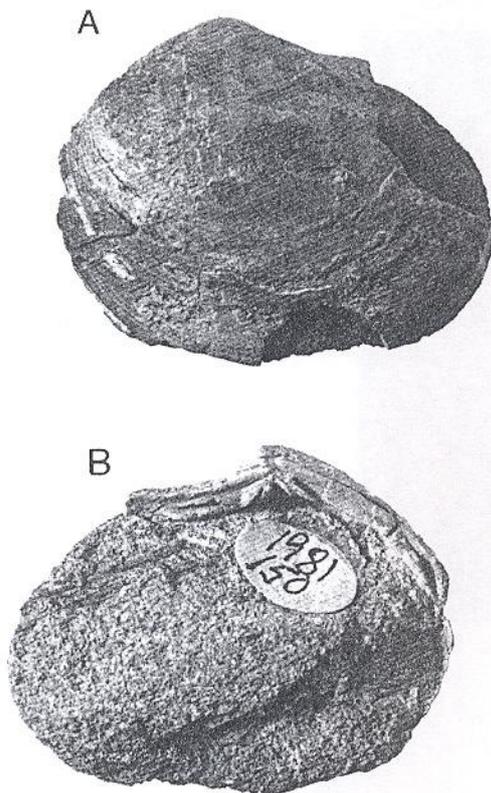


Fig. 153. MGUH 25.264. *Liochoncha?* sp. 1. One right valve: L = 31 mm, outside (A) and inside (B) with hinge. Qaersutjægerdal, Great Section, below tuff-shale series: 1981-150.

## Material:

QAERSUTJÆGERDAL: Great Section: *Below tuff-shale series*: 1981-150, 1954 (1 right valve: L = 31, Fig. 153).

*Dosinia* Scopoli, 1777*Dosinia* sp. 1

Figs 154-156.



Fig. 154. MGUH 25.265. *Dosinia* sp. 1. One whole specimen viewed from the right: L = 35 mm. Qaersutjægerdal, Great Section, upper concretion layer: 1981-123, 1952.



Fig. 155. MGUH 25.266. *Dosinia* sp. 1. One whole specimen, steinkern: L = 31.7 mm. The pallial line and muscle scars are visible. Qaersutjægerdal, west side: 1980-101, 1953.

## Material:

**TURRITELLAKLØFT: Great Section: Sandstone bench I:** 1980-305, 1956 (2 valves in coarse sediment with shells: L = ca. 10, ca. 15). – *Cucullaea conglomerate, below delta, eastward:* 1980-303, 1949 (1 valve, steinkern, in very coarse sediment: L = ca. 42).

**INTERIOR NUUSSUAQ:** 1980-292, 1939 (1 whole specimen, closed valves: L = 12.6; 2 valves: L = 18.5, ca. 25).

**QAERSUTJÆGERDAL: Great Section: (layer not noted)** 1980-88, 1968 (1 whole specimen, closed valves, steinkern: L = 36.4). – *Upper concretion layer:* 1981-123, 1952 (1 whole specimen, valves half opened and displaced: L = 24.6; 1 whole specimen with closed valves: L = 35, Fig. 154). – 1981-360, 1952 (1 whole specimen, valves displaced: L = ca. 25; 1 whole specimen with closed valves: L = ca. 33). – **West side at second turn:** 1980-94, 1951 (2 whole specimens with closed valves: L = 17.0, 17.8). – 1981-118, 1951 (1 whole specimen, closed valves, steinkern: L = 32.0). – **West side:** 1980-101, 1953 (1 valve: L = 21.5; 1 whole specimen, closed valves, steinkern: L = 31.7, Fig. 155).

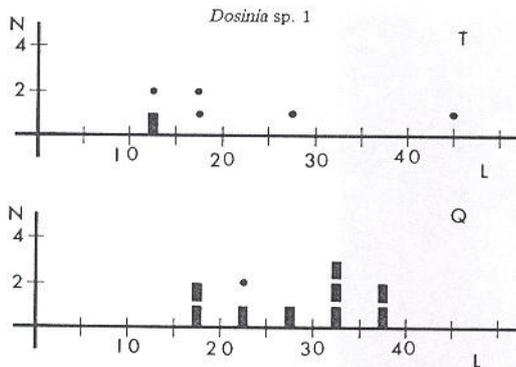


Fig. 156. *Dosinia* sp. 1. Length distribution of material from Turritellakløft (T, includes Interior Nuussuaq) (n = 6) and Qaersutjægerdal (Q) (n = 10). Dots = single valves, bars = whole specimens.

*Summary of the material*

Turritellakløft: 1 whole specimen + 5 valves.  
Qaersutjægerdal: 9 whole specimens + 1 valve.  
Fig. 156 gives the length distribution of the material from Turritellakløft and Qaersutjægerdal.

**Venerid? sp. 1**

Fig. 157.

## Material:

**TURRITELLAKLØFT: Great Section: Cucullaea conglomerate, eastward below delta:** 1981-129, no year (1 whole animal, closed, undisturbed valves: L = ca. 20, photo, Fig. 157).



Fig. 157. MGUH 25.267. Venerid? sp. 1. One whole specimen, closed, undisturbed valves: L = ca. 20 mm. Turritellakløft, Great Section, *Cucullaea conglomerate* below delta, eastward: 1981-129, no year.

**Venerid? sp. 2**

Fig. 158.

## Material:

**SONJA LENS:** 1981-498, 1948 (1 valve: L = 14.6, photo, Fig. 158).

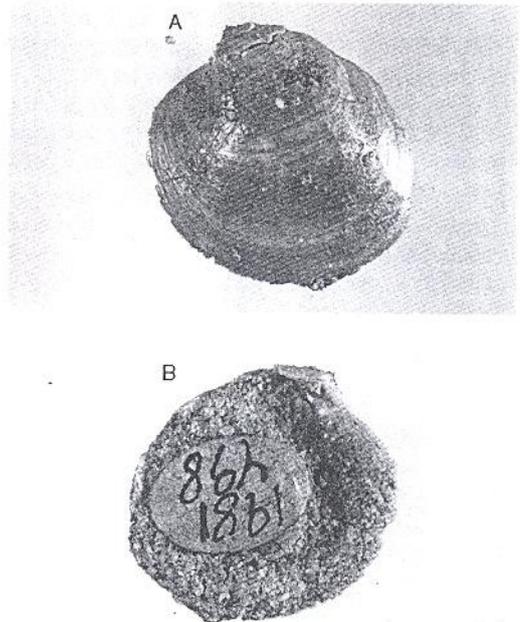


Fig. 158. MGUH 25.268. Venerid? sp. 2. One left valve: L = 14.6 mm, outside (A) and inside (B) with hinge. Sonja Lens: 1981-498, 1948.

**Venerid? sp. 3**

Fig. 159.

Material:

SONJA LENS: 1981-495, 1948 (2 whole specimens, valves closed, undisturbed: L = ca. 12; L = 10.8, photo, Fig. 159).



Fig. 159. MGUH 25.269. Venerid? sp. 3. One whole specimen, closed, undisturbed valves: L = 10.8 mm. Sonja Lens: 1981-495, 1948.

**Venerid? sp. 4**

Fig. 160.

Material:

QAERSUTJAEGERDAL: West side at second turn: *Turritella conglomerate*: 1981-115, 1951 (1 whole specimen, steinkern: L = ca. 20.3, photo Fig. 160).

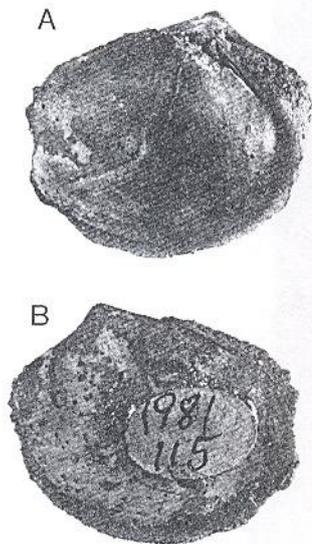


Fig. 160. MGUH 25.270. Venerid? sp. 4. One whole specimen, closed valves, steinkern: L = ca. 20.3 mm, seen from right (A) and left (B) sides; valves displaced ca. 2 mm apart, right side shows pallial line and muscle scars, left side partly concealed by label and glue. *Turritella conglomerate*: 1981-115, 1951.

**Venerid? sp. 5**

Fig. 161.

Material:

SONJA LENS: No number, 1958 (photo of fragment of valve: ca. 50 x 40, Fig. 161, from Rosenkrantz's notes, identified by him as "*Lutraria?*", material not seen).



Fig. 161. MGUH 25.271. Venerid? sp. 5, outside (A) and inside (B). Fragment, ca. 50 x 40 mm, photo from Rosenkrantz's notes. Sonja Lens: no number, 1958.

**Venerid? sp. 6**

Not figured because of specimen's poor condition.

Material:

TURRITELLAKLØFT: South side: (layer not noted) 1980-440, 1946 (7 valves represented by fragments, prints or steinkerns in very coarse material with other shells. Max length = ca. 63. Identified by Rosenkrantz as "*Dosiniopsis?*").

**Venerupis Lamarck, 1818****Venerupis? sp. 1**

Fig. 162.

## Material:

QAERSUTJÆGERDAL: Great Section: *Upper concretion layer*: 1981-277, 1954 (2 whole specimens, steinkern, valves closed, but slightly displaced: L = ca. 27, photo, Fig. 162; L = 26.6).

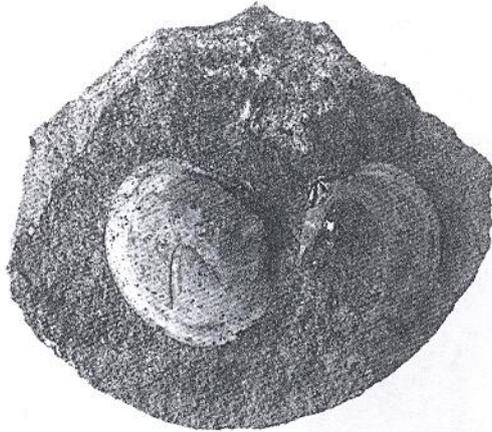


Fig. 162. MGUH 25.272. *Venerupis?* sp. 1. Two paired specimens, hinge, pallial line and muscle scars visible. L = ca. 27 mm. Qaersutjægerdal, Great Section, upper concretion layer: 1981-277, 1954.

**MYOIDA Stoliczka, 1870****Myidae Lamarck, 1809****Mya Linné, 1758****Mya? sp. 1**

Fig. 163.

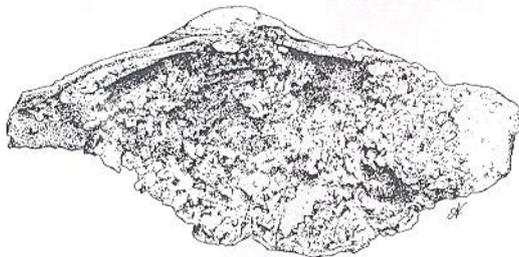


Fig. 163. MGUH 25.273. *Mya?* sp. 1. Fragment of umbonal part: L = ca. 18 mm. Sonja Lens: 1981-429, 1953.

## Material:

SONJA LENS: 1981-429, 1953 (fragment of umbonal part, see Fig. 163).

**Remarks**

This fragment is referred to *Mya?* based on the hinge structure.

**Corbulidae Lamarck, 1818****Corbula Bruguière, 1797****Corbula sp. 1**

Figs 164-168.

## Material:

TURRITELLAKLØFT: Great Section: *Loose block*: 1981-103, 1954 (1 valve: L = 11.7). - 2 *lowermost sandstone layers*: 1981-87, 1956 (1 whole specimen, closed valves: L = 6.9. 10 valves in hard rock of sand with shells, L = 8.0-8.9 (4), 9.0-9.9 (5), 10.0-10.9 (1), 1 with naticid hole). - 1981-91, 1946 (23 valves in hard rock of sand, gravel shells, L = 7.0-7.9 (1), 8.0-8.9 (8), 9.0-9.9 (9), 10.0-10.9 (4), 11.0-11.9 (1)). - 1981-93, 1948 (6 valves: L = 7.3, 8.9, 9.2, 9.2, 9.3, 10.6 (naticid hole)). - 1981-94, 1946 (33 valves in hard rock of coarse sand with shells, 8 with snout, 1 with naticid hole: L =

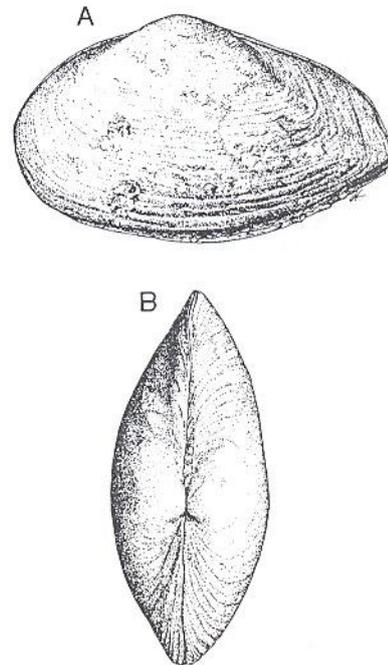


Fig. 164. MGUH 25.274. *Corbula* sp. 1. One whole specimen with closed valves, seen from left side (A) and from umbo (B): L = 6.9 mm. Qaersutjægerdal, west side, at second turn: 1981-104, 1951.

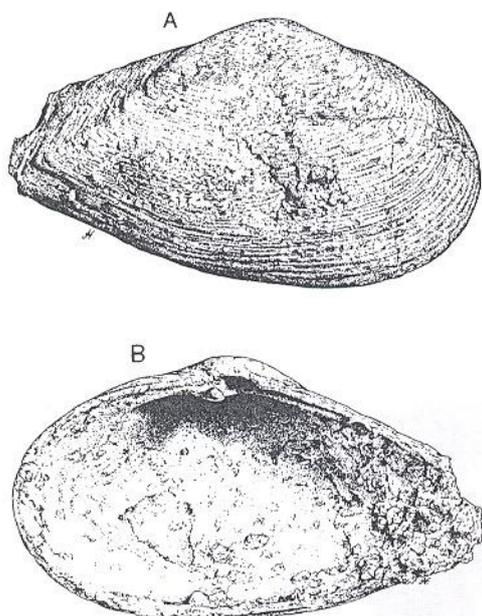


Fig. 165. MGUH 25.275. *Corbula* sp. 1. Outside (A) and inside (B) of one right valve: L = 10.8 mm. Sonja Lens: 1981-102, 1948.

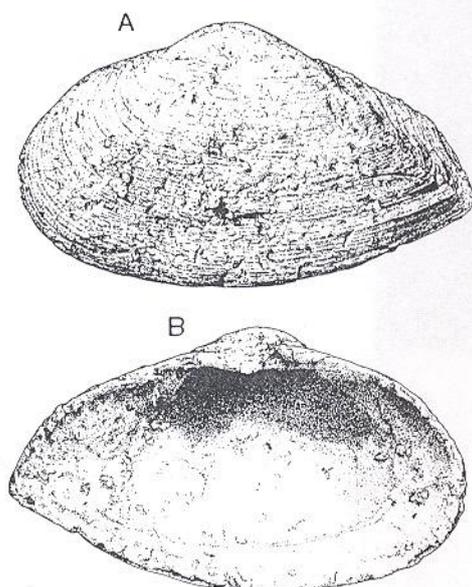


Fig. 166. MGUH 25.276. *Corbula* sp. 1. Outside (A) and inside (B) of one left valve: L = 9.0 mm. Pallial line and muscle scars just visible. Sonja Lens: 1981-102, 1948.

5.0-5.9 (1), 7.0-7.9 (2), 8.0-8.9 (11), 9.0-9.9 (13); 10.0-10.9 (5), 11.0-11.9 (1). See photo in Fig. 167). - 1981-99, 1948 (15 valves in hard rock of coarse sand with shells: L = 7.0-7.9 (3), 8.0-8.9 (3), 9.0-9.9 (7), 10.0-10.9 (2)). - 1981-101, 1948 (1 valve: L = 9.4). - 1981-123, 1956 (1 valve: L = 11.7). - 1981-166, 1946 (1 valve in hard rock of sand with shells: L = 16.0). - 1981-217, 1946 (2 valves in hard rock of coarse sand with shells: L = 10.1, 10.2). - 1981-351, 1948 (2 valves: L = 8.9, 9.3). - 1981-454, 1948 (2 valves in hard rock of sandy clay with many shells, estimated lengths = 6.0, 6.0). - 1981-481, 1953 (5 valves in hard rock, sand with shells, 1 with snout: L = 8.1, 8.2, 9.5, 9.9, 10.0).

INTERIOR NUUSSUAQ: 1981-89, 1939 (1 valve: L = 12.8).

SONJA LENS: 1980-377, 1953 (1 valve: L = 10.1). - 1981-95, 1952 (22 valves, L = 3.0-3.0 (1), 4.0-4.9 (1), 5.0-5.9 (2), 6.0-6.9 (6), 7.0-7.9 (8), 8.0-8.9 (3), 9.0-9.9 (1)). - 1981-96, 1953 (6 valves: L = 7.2, 8.4, 8.9, 9.1, 9.8, 10.5, 2 with naticid holes). - 1981-102, 1948 (6 valves: L = 7.2, ca. 8, 9.0, 9.0 (drawings, Figs 165, 166), 9.8, 10.8). - 1981-105, 1951 (7 valves: L = 4.8, 5.9, 6.5, 6.7, 7.8, 7.9, 8.3). - No number (16 valves: L = 5-10, 2 with naticid holes).

QAERSUTJÆGERDAL: Great Section: Upper concretion layer: 1981-98, 1952 (4 valves). - Concretion layer



Fig. 167. MGUH 25.277. *Corbula* sp. 1. Piece with valves from sample 1981-94, 1946, Turritelakloft, Great Section, lower sandstone bench. One right valve (A): L = 10.5 mm, and 1 right valve with naticid hole and posterior end with "snout" (B): L = 12.6 mm including "snout".

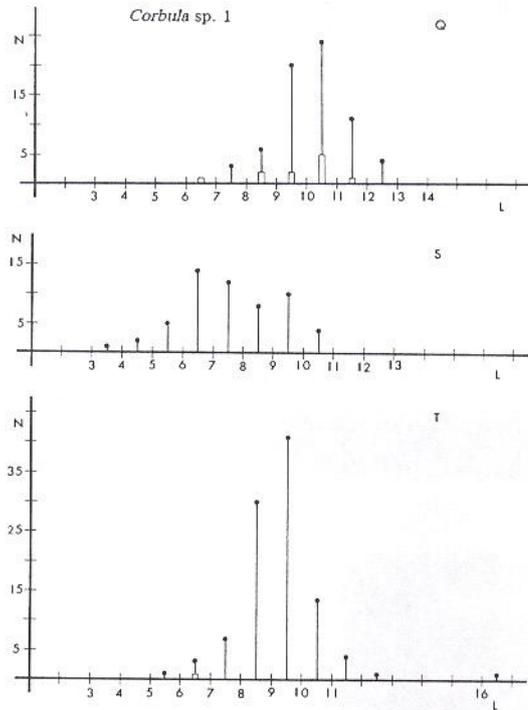


Fig. 168. *Corbula* sp. 1. Length distribution at the main localities: Qaersutjægerdal (Q) (n = 69), Sonja Lens (S) (n = 57) and Turritellakløft (T, includes Interior Nuussuaq) (n = 104). Lines with dots = single valves, open bars = paired valves.

below tuff-shale series: 1981-92, 1953 (6 whole animals in hard sand, valves closed but compacted: L = 8.9, 9.5, 10.1, 10.4, 10.8, 11.2. 28 valves, somewhat compressed: L = 7.0-7.9 (1), 8.0-8.9 (2), 9.0-9.9 (6), 10.0-10.9 (11), 11.0-11.9 (6), 12.0-12.9 (2)). 1981-97, 1954 (1 valve: L = 9.1). - 1981-100, 1953 (3 whole specimens, valves closed: L = 9.5, ca. 10, 10. 23 valves: L = 8.0-8.9 (1), 9.0-9.9 (11), 10.0-10.9 (6), 11.0-11.9 (4), 12.0-12.9 (1). Some of the valves are compressed). - 1981-158, 1958 (1 whole specimen, closed valves, compressed: L = 8.9; 1 valve: L = 10.0). - West side at second turn: 1981-104, 1951 (1 whole specimen: L = 6.9, drawing, Fig. 164; 1 valve: L = 7.1).

#### Remarks

This species resembles Recent *Caryocorbula nasuta* (Sowerby, 1833); see Olsson (1961: 429, pl. 75, fig. 3). Panama to Ecuador.

#### Summary of the material

Turritellakløft: 1 paired specimen and 103 single valves, 3 of which have naticid holes. Sonja Lens:

57 single valves, 7 of which have naticid holes. Qaersutjægerdal: 11 paired and 58 single valves, none with naticid holes. Fig. 168 shows the size distribution of *Corbula* sp. 1 at the main localities.

#### *Corbula* sp. 2

Fig. 169.

#### Material:

TURRITELLAKLØFT: Great Section: *Cucullaea conglomerate*, eastward below delta: 1980-200, 1949 (1 valve: L = 5, drawing, Fig. 169).

SONJA LENS: 1981-379, 1948 (1 valve with naticid hole: L = 4.9).

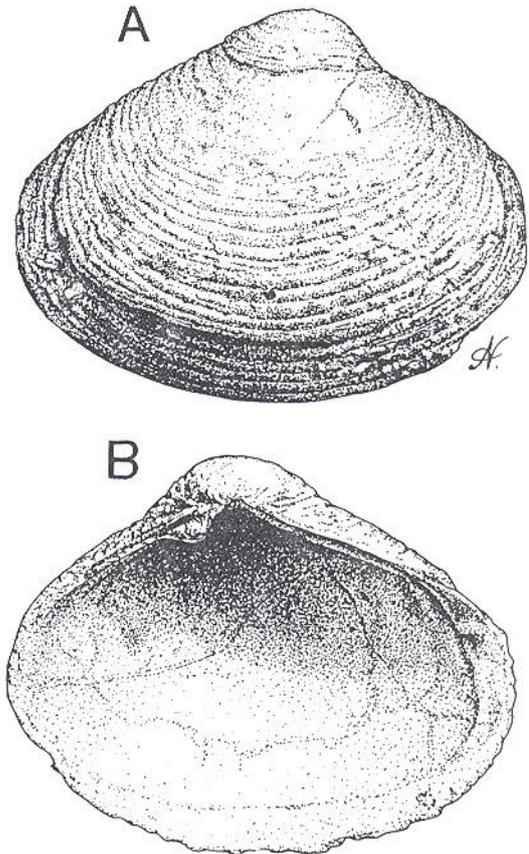


Fig. 169. MGUH 25,278. *Corbula* sp. 2. One right valve, outside (A) and inside (B): L = 5 mm. Turritellakløft, Great Section, *Cucullaea conglomerate*, below delta, eastward: 1980-200, 1949.

*Remarks*

Apparently this species originates from other layers than does *Corbula* sp. 1.

**Pholadidae Lamarck, 1809**

The size of these borers is given by the largest "diameter" (D) (height = width) of the animals and in some cases of the tubes. In this material are also found tubes of polychaetes and other tube-building animals.

***Martesia* Sowerby, 1824*****Martesia* sp. 1**

Figs 170-171, 173.

*Material:*

**TURRITELLAKLØFT: Great Section: Lower sandstone layer:** 1981-199, 1949 (piece of driftwood, ca. 20 x 5 mm bored by 10 *Martesia*: D = ca. 2). - 1981-227, 1956 (fragments of shells in tubes in petrified wood).

**INTERIOR OF NUUSSUAQ: Altitude 560 m:** 1981-224, 1939 (fragments of 3 specimens: D = ca. 11, + tubes in wood in conglomerate of sand with shells).

**SONJA LENS:** 1980-387, 1953 (1 valve in sand: D = ca. 8). - 1981-221, 1952 (3 valves: D = ca. 4, ca. 6, 11.2). - 1981-324, 1951 (2 valves: D = ca. 6 mm, ca. 10 mm). - No number, 1956 (fragments of wood imbedded in sandy sediment with shells, 2 whole specimens visible).

**QAERSUTJÆGERDAL: Great Section: Upper concretion layer:** 1980-435, 1954 (a piece of petrified wood, ca. 50 x 60 x 90 mm, penetrated by tubes (Fig. 170). 2 whole



Fig. 170. MGUH 25.279. Piece of petrified driftwood, c. 50 x 60 x 90 mm, bored by *Martesia*, Qaersutjægerdal, Great Section, upper concretion, layer: 1980-435, 1954 (see next sample).

specimens: D = 10.2, = 17, photo, Fig. 171). - 1981-205, 1952 (1 valve in wood and sand: D = ca. 12). - 1981-206, 1952 (piece of petrified wood with tubes of *Martesia* and *Teredo*). - 1981-207, 1952 (1 valve in wood: D = ca. 5). - *Concretion layer below tuff-shale series:* 1980-119, 1953 (1 valve: D = ca. 5.1). - 1981-161, 1958 (10 "bulbs", 5 hollows filled with sand, 5 with remnants of whole animals: D = 4.7, 5.5, 5.8, 6.0, 6.1). - 1981-210 (1 valve in wood and sediment: D = ca. 8). - 1981-211, 1953 (1 whole specimen: D = ca. 11). - 1981-228, 1953 (2 pieces of petrified wood penetrated by 3 different kinds of tubes, incl. *Martesia*).

**AGATDAL: West side: Altitude 510 m:** 1980-91, 1958 (petrified wood with ca. 20 conical holes perpendicular to surface. The holes are 8-10 mm long, each ending in a globule ca. 3 mm in diameter. Remnants of the shells are visible, photo, Fig. 173).

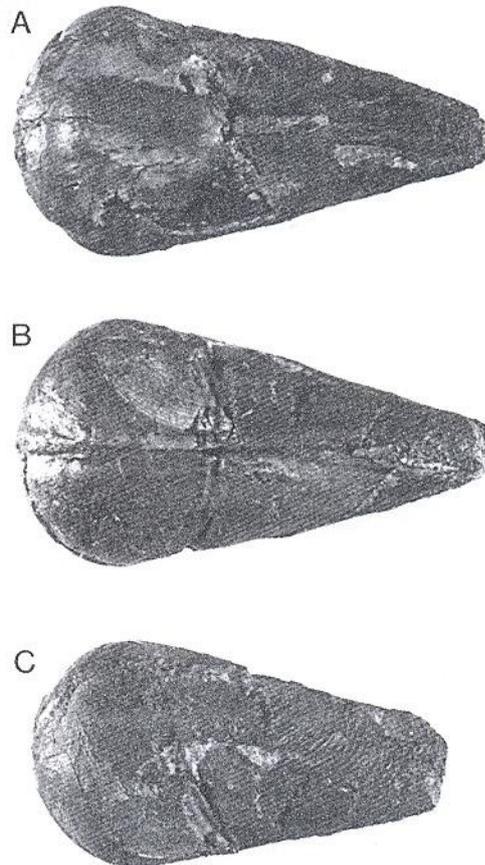


Fig. 171. MGUH 25.279. *Martesia* sp. 1. One specimen seen from 3 sides, D = 17 mm. A. Dorsal side, mesoplax and metaplax visible. B. Ventral side, umbonal-ventral sinus, hypoplax and remnants of callum visible. C. Left side. Qaersutjægerdal, Great Section, upper concretion layer: 1980-435, 1954.

*Martesia* sp. 2

Fig. 172.

Material:

SONJA LENS: No number, 1956 (2 valves, L = ca. 3.0, drawing, Fig. 172; L = ca. 5).

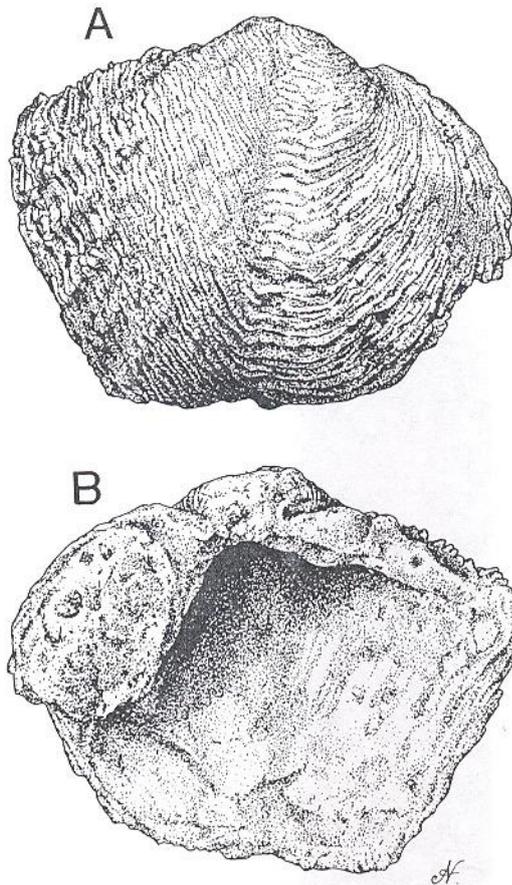


Fig. 172. MGUH 25.280. *Martesia* sp. 2. Right valve of young specimen with mesoplax clinging to inside, outer (A) and inner (B) views D = ca. 3 mm. Sonja Lens: 1956.

*Remarks on wood borers*

The specimens seen in the tubes are taken as whole, paired specimens, even if they are only partly visible.

Wood floats only a certain time, depending on the circumstances, and then sinks to the bottom. The sizes of the animals are an indication of how long time the wood has drifted. Wood with larger

animals is found at Qaersutjægerdal in the upper concretion layer, and hence such wood has drifted a longer time than pieces with smaller animals. Fig. 174 shows modern driftwood from Thailand.

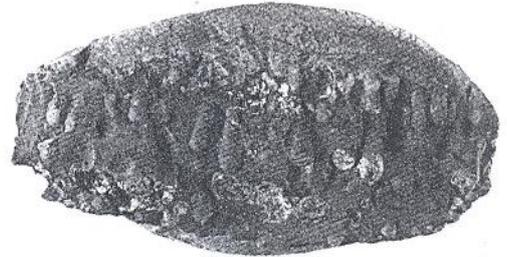


Fig. 173. MGUH 25.281. Fossil driftwood bored by ca. 20 *Martesia*; the bulb-shaped holes are 8-10 mm long and end in a globule ca. 3 mm in diameter. Also a few *Teredo*. Agatdal, west side, altitude 510 m: 1980-91, 1958.

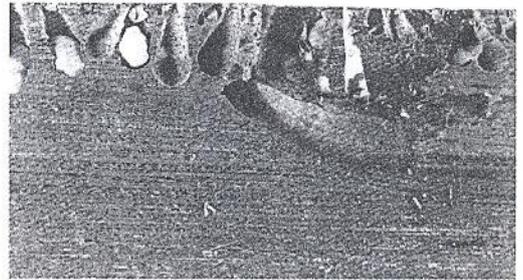


Fig. 174. ZMUC BIV-400. Modern driftwood bored by *Martesia* and *Teredo*; the piece is 64 mm long. Phuket, Thailand 1977.

*Diplothyra* Tryon, 1862*Diplothyra* sp. 1

Figs 175-180.

Material:

TURRITELLAKLØFT: Great Section: Lower sandstone layer: 1981-217, 1945 (1 valve in hard rock: D = ca. 10). - *Turritella conglomerate*, eastward below delta: 1981-218, 1948 (block of black clay bored by several species of borers, including *Diplothyra*. The "original" grey weathered Danian surface is preserved, Fig. 178). - 1981-219, 1949 (3 whole specimens in situ in block of black clay: D = ca. 10. Empty holes filled with coarser sediment). - 1981-225, 1949 (block of black clay with empty holes, some filled with coarser sediment). - *Cucullaea conglomerate*: 1981-165, 1949 (5 whole specimens, D = ca. 6.5, 7.0, 8.5, 9.2, 9.3. Also several pieces of rock of black fine sediment with imprints, fragments

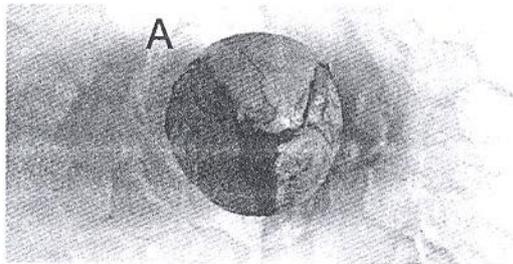


Fig. 175. MGUH 25.282. *Diplothyra* sp. 1. Material from Turrnellakloft, Great Section, *Cucullaea* conglomerate: 1981-322, 1949. A-E: One specimen, D = 10 mm, seen from 5 different angles. A. Frontal view, the 2 valves, mesoplax and pedal opening. B. Ventral view, the 2 valves and pedal opening. C. Dorsal view, the mesoplax covers the valves. D. Right valve. E. Left valve and part of mesoplax.

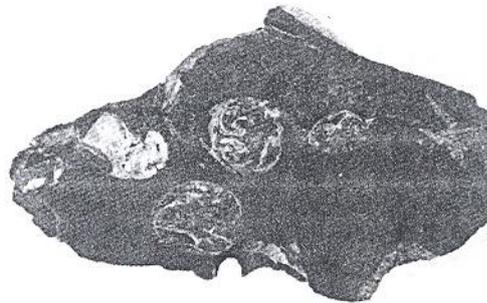


Fig. 176. MGUH 25.283. *Diplothyra* sp. 1. Piece of loose block, ca. 40 x 30 mm, from Turrnellakloft, Great Section: 1981-220, 1948. The cut goes through the apophyses of one *Diplothyra*: D = 8 mm.

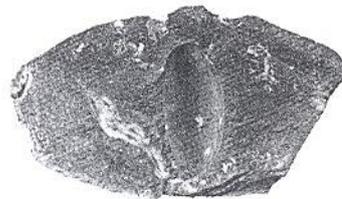


Fig. 177. MGUH 25.284. *Diplothyra* sp. 1. The photos show the two planes from a cut through a *Diplothyra* hole, L = 17, D = 8 mm, with the "original" opening to the "original" Paleocene surface of the rock, together with tubes of other borers. Turrnellakloft, Great Section, *Cucullaea* conglomerate: 1981-322, 1949.

and holes. - 1981-322, 1949 (4 whole specimens: D = 10.0, 10.0, 10.3, 12.4. Also pieces of the rock with holes. The rock consists of fine black sediment and a few shells that lived in this sediment, e.g., *Dentalium* sp., photos in Figs 175, 177, 180 are from this sample. - Loose blocks: 1981-212, 1953 (1 valve in hard rock, sand with shells: D = ca. 10). - 1981-220,

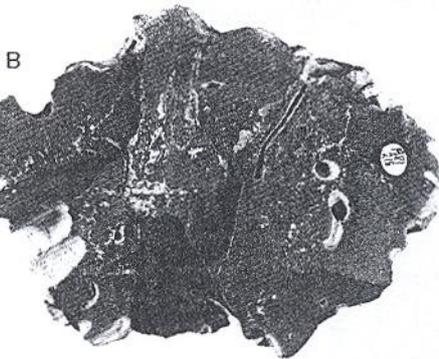


Fig. 178. MGUH 25.285. *Diplothyra* sp. 1. Block, 120 x 90 mm, from Turrnellakløft, Great Section, *Turritella* conglomerate eastward: 1981-218, 1949. A. "Original" Paleocene surface with holes from different boring organisms, mainly *Diplothyra*. B. Underside of same piece, which is a cut through the block.

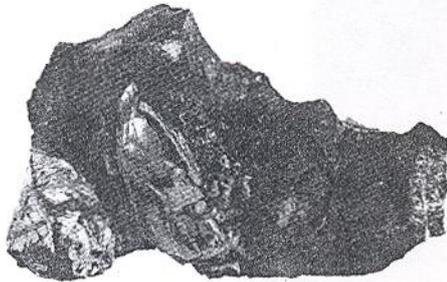


Fig. 179. MGUH 25.286. Piece of a loose block, ca. 30 x 17 mm, with the cut showing the 2 borers *Diplothyra* and *Gregariella*, both members of the Agatdal fauna. Turrnellakløft, Great Section: 1981-220, 1948.

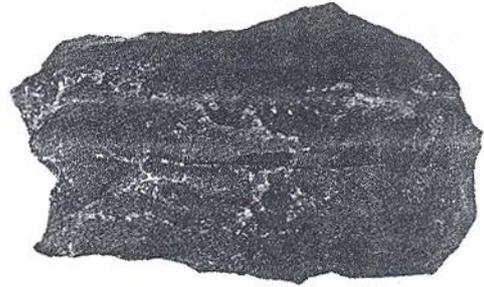


Fig. 180. MGUH 25.287. Piece, 40 x 25 mm, with a *Dentalium*, one of several species from the older Kangilia fauna deposited in black clay into which the Agatdal borers bored. Turrnellakløft, Great Section, *Cucullaea* conglomerate: 1981-322, 1949.

1948 (block in riverbed; block consists of black fine sand or clay with a few small shells. It has been bored by several specimens and also by other borers, e.g., *Gregariella* sp. 1, 5 whole loose specimens, D = 8.3, 9.0, 9.1, 9.2, 10.8. 7 specimens in rock: D = 8.2, 8.9, 9.1, 9.2, 9.6, 10.2, 10.3. Some shells have been pushed 1-2 mm apart, photos Figs 176 and 179).

#### Remarks

*Diplothyra* sp. is very close to the modern *Diplothyra curta* Sowerby, 1834; see Turner (1955: 121, pl. 72). Colorado River to Ecuador.

#### Summary of material

Turrnellakløft: 2 valves, ca. 24 whole specimens.

#### Teredinidae Rafinesque, 1815

##### *Teredo* Linné, 1758

##### *Teredo* sp. 1

Figs 181-182.

#### Material:

Pieces of petrified wood are often penetrated by densely packed cylindrical tubes, 4-5 mm in diameter. Remnants of boring bivalve can be seen, but not enough for a further identification.

TURRITELLAKLØFT: Great Section: Lower sandstone bench: 1981-198, 1964 (wood).

INTERIOR NUUSSUAQ: Altitude 560 m: 1981-321, 1939 (wood).

SONJA LENS: 1081-221, 1952 (a whole animal in a tube: D = ca. 2). - No number, 1958 (drawing of a pallet, Fig. 182, from Rosenkrantz's notes, material not seen).

QAERSUTJÆGERDAL: Great Section: 1981-211, 1953 (2 whole specimens: D = ca. 7, 7.0, Fig. 181). - 1981-222, 1952 (bored driftwood). - 1981-228, 1953 (bored driftwood).

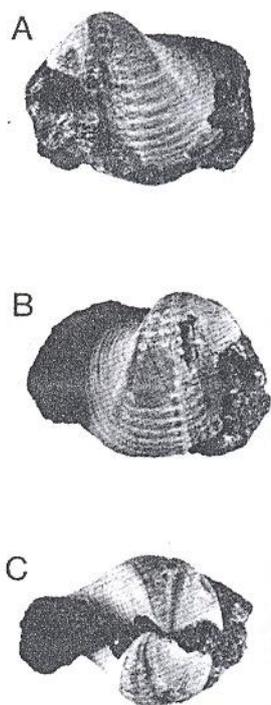


Fig. 181. MGUH 25.288. *Teredo* sp. 1. One paired specimen: D = ca. 7 mm. Qaersutjægerdal, Great Section, concretion layer below tuff-shale series: 1981-211, 1953. A. Left valve. B. Right valve. C. Dorsal view.

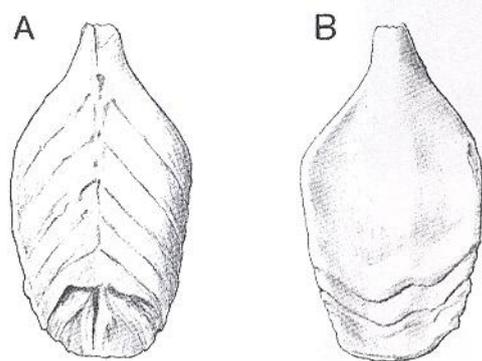


Fig. 182. MGUH 25.289. *Teredo* sp. 1. Drawing of pallet, 3.2 x 1.7 mm, from Rosenkrantz's notes. Sonja Lens 1958.

#### Remarks

Boring bivalves are found both in petrified wood and consolidated soft sediment. Furthermore, some shells and tubes are found separately. Some of the tubes belong to other animal groups. *Martesia* sp. 1 and *Teredo* sp. 1 bore in wood, and *Diplothyra* sp. 1 bores in soft rock. The pear-shaped tubes with small openings show that both the wood and the soft rock have preserved their "original" Paleocene surfaces.

Bored driftwood is found at many localities, but mainly at Qaersutjægerdal, where it probably sank. A modern example of bored driftwood from Thailand, shown in Fig. 174, is very similar to the piece shown in Fig. 173. The fossil wood has not been identified, but is contemporary with *Martesia* sp. 1, i.e., with the Agatdal fauna.

The "original" soft rock bored by *Diplothyra* sp. 1 is found in Turrstellakløft as loose blocks or in the so-called *Turrstellakløft* conglomerate and *Cucullaea* conglomerate, which now is very hard. *Gregariella* is found together with *Diplothyra*. The pieces of conglomerate consist of fine black sediment with a few shells and resemble the few samples we have from the Kangilia Formation, where the *Propeamussium* material is also found. This sediment appears to belong to the *Propeamussium* member of the Kangilia Formation (or to the Turrstellakløft member of the Agatdal Formation). If the information obtained from the bored rock can be substantiated, then the sequence may be explained as follows:

The *Propeamussium* member with black shale was deposited in deeper water, e.g., 200 to 900 meters. Later it was lifted to above sea level and was partly consolidated to a soft rock which constituted the shore and sea bottom for the ocean, where *Diplothyra*, *Gregariella* and other organisms bored in the rather soft rock. It was also exposed to a coarser sediment, which can be seen in some of the tubes. Later again it was raised to several hundred meters above sea level. Hence there are a considerable time gap and large tectonic events between the older Kangilia Formation and the younger Agatdal Formation, but they might both belong to the same ocean, if this ecosystem persisted long enough.

ANOMALODESMATA Dall, 1889  
 PHOLADOMYOIDA Newell, 1965  
 Pholadomyidae Gray, 1847  
*Pholadomya* Sowerby, 1823  
*Pholadomya* sp. 1

Fig. 183.

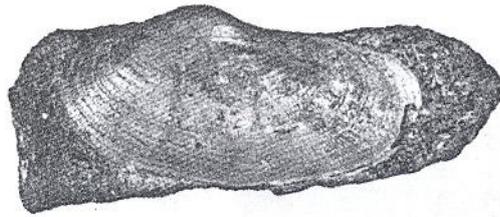


Fig. 183. MGUH 25.290. *Pholadomya* sp. 1. One left valve: L = ca. 19.5 mm. Qaersutjægerdal, Great Section, upper concretion layer: 1980-318, 1952.

Material:

QAERSUTJAEGERDAL: Great Section: Upper concretion layer: 1980-318, 1952 (1 valve: L = ca. 19.5, photo in Fig. 183).

*Pholadomya* sp. 2

Fig. 184.

Material:

SONJA LENS: No number, 1956 (photo from Rosenkrantz's notes, identified by him as *Pholadomya*, Fig. 184. Material not seen).

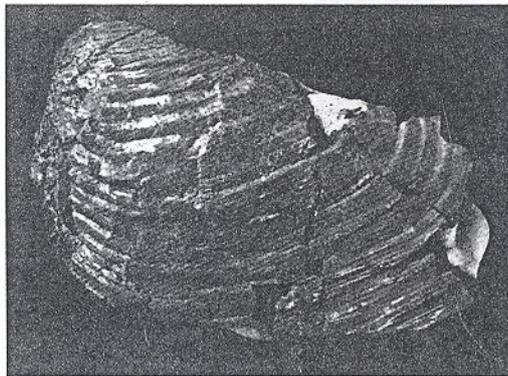


Fig. 184. MGUH 25.291. *Pholadomya* sp. 2. One left valve, incomplete. Sonja Lens: no number, 1956 (photo from Rosenkrantz's notes, identified by him as *Pholadomya*).

Lyonsiidae Fischer, 1887

*Lyonsia* Tuttun, 1822

*Lyonsia* sp. 1

Figs 185-186.

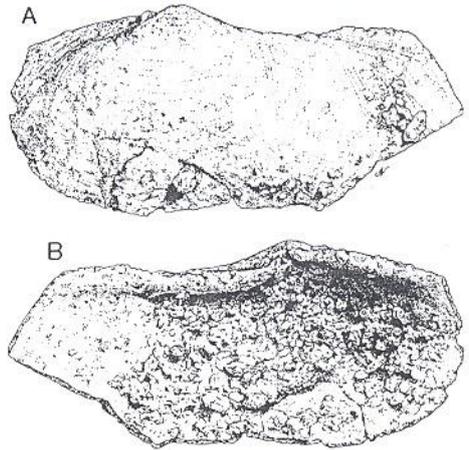


Fig. 185. MGUH 25.292. *Lyonsia* sp. 1. Fragment with hinge, outside (A) and inside (B). L = ca. 9.5 mm. Sonja Lens: 1980-376, 1953.

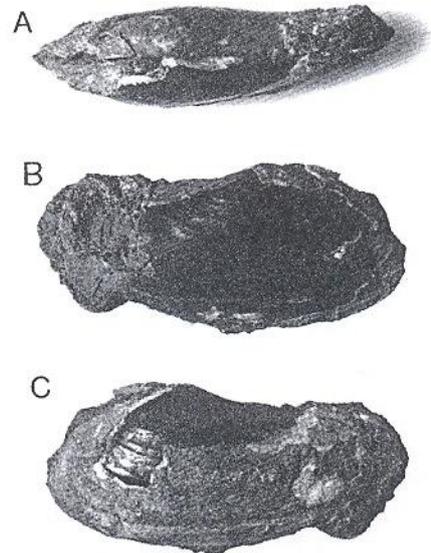


Fig. 186. MGUH 25.293. *Lyonsia* sp. 1. One whole specimen: L = ca. 26 mm, closed, undisturbed, surface with concentric and radial stripes, remnants of sand encrusted around posterior part. Qaersutjægerdal, Great Section, below tuff-shale series: 1981-119, 1954. A. Dorsal view. B. Right side. C. Left side.

## Material:

SONJA LENS: 1980-376, 1953 (fragment with hinge: L = ca. 9.5, drawing, Fig. 185).

QAERSUTJÆGERDAL: Great Section: *Below tuff-shale series*: 1981-119, 1954 (1 whole animal: L = ca. 26, photo, Fig. 186). – West side: 1980-315, 1953 (1 valve, mould in hard rock of sand and shells: L = ca. 17).

**Thraciidae Stoliczka, 1870*****Thracia* Sowerby, 1823*****Thracia* sp. 1**

Figs 187-188.

## Material:

TURRITELLAKLØFT: South side: 1981-447, 1946 (1 valve in reddish sandstone, coarse sand with shells: L = 14.6).

SONJA LENS: 1981-172, 1953 (1 valve in loose sandstone: L = 15.2).

QAERSUTJÆGERDAL: Great Section: (layer not noted) 1981-140, 1951 (2 valves in hard reddish sandstone, sand

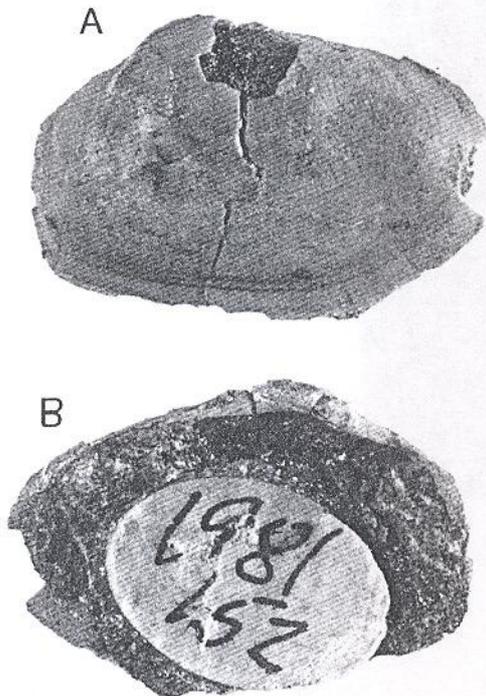


Fig. 187. MGUH 25.294. *Thracia* sp. 1. Left valve: L = 14.4 mm, outside (A) and inside (B). Qaersutjægerdal, Great Section, concretion layer below tuff-shale series. 1981-152, 1953.

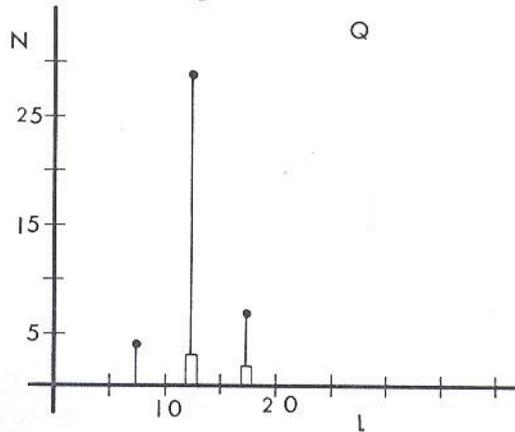
***Thracia* sp. 1**

Fig. 188. *Thracia* sp. 1. Length distribution of the Qaersutjægerdal (Q) material. Line with dot: single valves. Open bars: paired valves.

with shells: L = 10.3 (naticid hole), 14.8)). – *Upper concretion layer*: 1981-141, 1951 (1 valve in hard, reddish sandstone, sand with shells and leaves: L = 13.2). – 1981-142, 1952 (1 valve in hard sandstone, sand with shells and coal: L = 13.4). – 1981-143, 1952 (1 valve in hard sandstone: L = 9.8). – 1981-144, 1952 (1 valve in hard sandstone, sand with shells and wood: L = 7.9). – 1981-145, 1952 (1 whole animal, closed, undisturbed: L = 10.7; 10 valves in hard, reddish sandstone, sand with coal: L = 10.2, 10.3, 11.3, 12.3, 12.5, 13.4, 13.7, 14.0, 14.1, 15.9). – 1981-146, 1952 (1 whole specimen, closed, undisturbed: L = 15.7, 3 valves in hard reddish sandstone: L = 8.7, 13.0, 13.0). – 1981-147, 1953 (1 valve in dark coarse sand with shells: L = 15.5). – *Concretion layer below tuff-shale series*: 1981-148, 1953 (1 whole animal, closed, a little compressed: L = 15.4; 2 valves in hard reddish sandstone: L = 12.1, 12.6). – 1981-152, 1953 (2 whole animals, closed: L = 12.5, 14.0; 8 valves in dark, hard sandstone: L = 9.8, 12.6 (naticid hole), 12.9, 13.0, 13.5, 14.4 (photo, Fig. 187), 14.6, 16.0 – 1981-154, 1954 (3 valves: L = ca. 12, 13.3 (naticid hole), 14.1 (compressed)). – 1981-162, 1958 (1 valve in hard, dark sandstone: L = 17.0). – *Canyon Section: Concretion layer below tuff-shale series, paleocene*: 1981-476, 1956 (1 valve in hard reddish sandstone, sand with shells: L = ca. 16).

**Summary of the material**

Qaersutjægerdal: 5 paired specimens and 35 single valves, 3 with naticid holes. The size distribution of the Qaersutjægerdal material is given in Fig. 188.

***Thracia* sp. 2**

Figs 189-192.

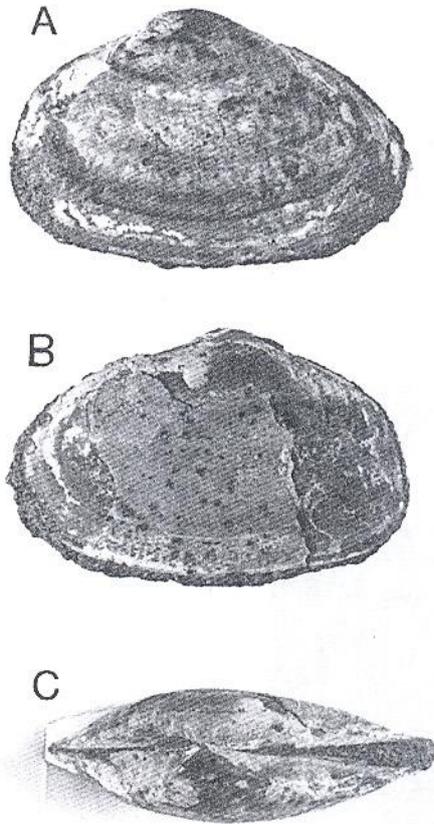


Fig. 189. MGUH 25.295. *Thracia* sp. 2. One whole, closed specimen, steinkern: L=24, H=15.7, W=8.1 mm, seen from left (A) and right (B) sides and umbo (C). Qaersutjægerdal, Great Section: 1981-73, 1951.



Fig. 190. MGUH 25.296. *Thracia* sp. 2. Left valve: L = 16.0 mm. Sonja Lens: 1981-404, 1952.

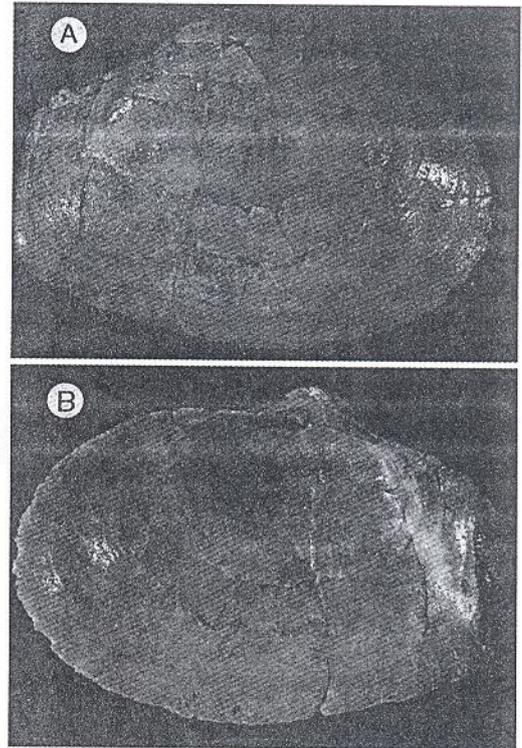


Fig. 191. MGUH 25.297. *Thracia* sp. 2. One left valve in outer (A) and inner (B) views. Sonja Lens: 1958. Photo from Rosenkrantz's notes.

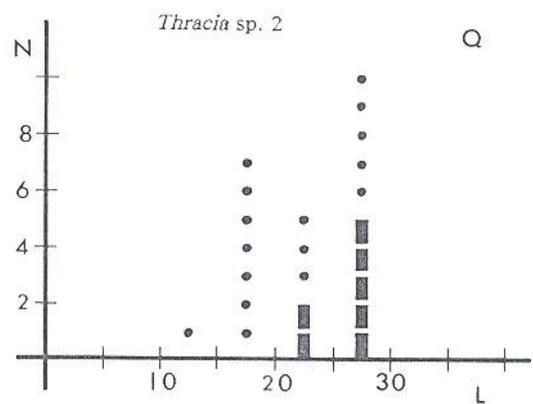


Fig. 192. *Thracia* sp. 2. Length distribution of the Qaersutjægerdal (Q) material (n = 23). Dots = single valves, bars = paired valves

## Material:

SONJA LENS: 1981-404, 1952 (1 valve in loose sand: L = 16.0, photo, Fig. 190). - No number, 1958 (1 valve: L = ca. 27, Fig. 191, photo from Rosenkrantz's notes, identified by him as "*Thracia* cfr. *prestwichi* Deshayes" and "*Thracia grignonensis* Deshayes". Material not seen).

QAERSUTJÆGERDAL: **Great Section:** (layer not noted) 1981-73, 1951 (1 complete specimen, closed: L = 24, H = 15.7, W = 8.1, photo, Fig. 189). - 1981-74, 1951 (1 valve, steinkern in hard rock of fine sand with shells: L = 18.3). - 1981-301, 1951 (3 valves, all imprints in hard red rock of fine sand with shells and wood: L = 13.6, ca. 21, 27.9). - **Upper concretion layer:** 1980-410, 1952 (1 valve in hard sandstone, fine sand with shells and wood: L = ca. 27). - 1980-444, 1951 (1 whole animal, closed, displaced ca. 1 mm: L = 28.5). - 1980-445, 1952 (1 valve in hard sandstone of fine sand with fragments of a big *Turritella*: L = ca. 18). 1981-71, 1952 (1 valve in hard sandstone with shells: L = 17.0). - 1981-76, 1952 (1 valve: L = ca. 18, naticid hole). - 1981-77, 1952 (1 valve in hard yellow sandstone, fine sand with shells: L = 16.8). - 1981-78, 1952 (1 valve, in hard sandstone, fine sand with shells and coal: L = 17.2). - 1981-82, 1952 (2 whole animals: L = 25.4, closed, undisturbed; L = 28.1, closed, compressed). - **Concretion layer below tuff-shale series:** 1981-72, 1953 (2 valves: L = ca. 19, 20.5). - 1981-75, 1953 (2 whole animals: L = 25.0, closed, displaced ca. 4 mm, 1 valve broken; L = 27.0, closed, undisturbed). - 1981-81, 1953 (1 whole animal, closed, displaced 2 mm, compressed: L = 25.7, 1 valve: L = ca. 26). - 1981-164, 1958 (1 valve, naticid hole: L = 26.4). - **West side:** 1980-446, 1951 (1 valve, naticid hole: L = 21.7). - 1981-79, 1953 (1 valve in hard rock, sand with shells and coal: L = 29.9).

**Summary of the material:** Sonja Lens: 2 valves. Qaersutjægerdal: 7 paired specimens and 16 valves, 2 with naticid holes. Fig. 192 gives the length distribution of the Qaersutjægerdal material.

**Cuspidariidae Dall, 1886*****Cuspidaria* Nardo, 1840*****Cuspidaria* sp. 1**

Fig. 193

## Material:

TURRITELLAKLØFT: **Great Section:** *Lumachelle in shale, westernmost in section:* 1980-426, 1956 (1 imprint in black shale with many small shells, indicating deep-water environment: L = 6.9, photo, Fig. 193).

**Verticordiidae Stoliczka, 1871*****Verticordia* Sowerby, 1844*****Verticordia* sp. 1**

Figs 194-196.



Fig. 193. MGUH 25.298. *Cuspidaria* sp. 1. Imprint of 1 shell in black shale with small shells: L = 6.9 mm. Turritellakløft, Great Section, lumachelle in shale, westernmost in the section: 1980-426, 1956.

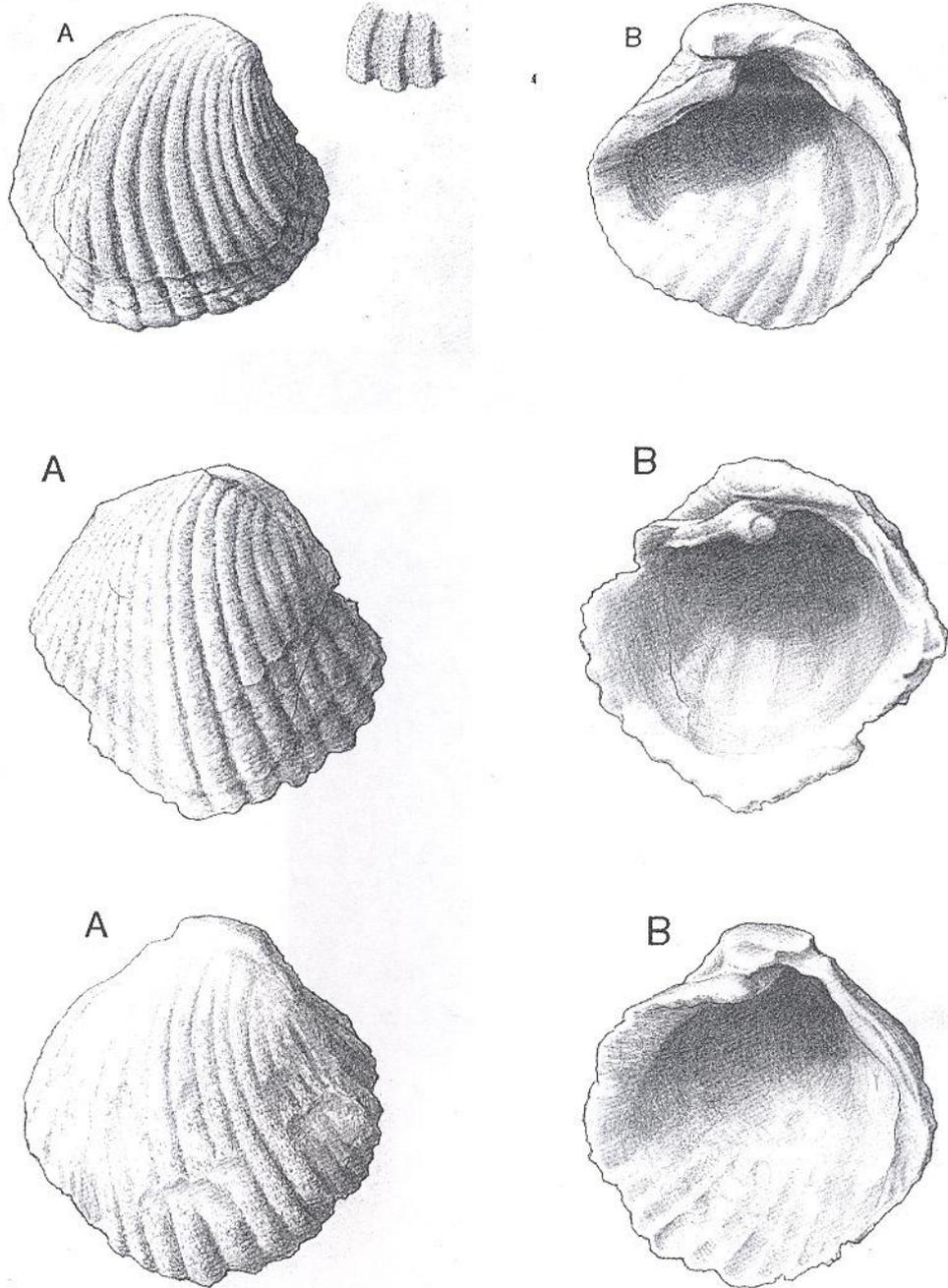
## Material:

SONJA LENS: No number, 1958 (drawings of 3 specimens from Rosenkrantz's notes, identified by him as "*Verticordia* aff. *granulosa* (Ravn)": L = 3.0, 3.0, 3.8. Material not seen).

## RESULTS

**Analysis of the fossil material**

The purpose of this paper is to estimate the environments in which the fossil bivalves lived. In order to do so information from the catalogue has been extracted and condensed into the following tables. The length distributions given in the catalogue are also considered. It must be remembered that the traces of the original marine environments have been mixed by the tectonic events, mudslides, landslides, etc. Also the incomplete



Figs 194-196. MGUH 25.299. *Verticordia* sp. 1. Three specimens: L = 3.8, 3.0, and 3.0 mm in outer (A) and inner (B) views. Drawings from Rosenkrantz's notes. Sonja Lens: 1958.

mapping, sampling, curating, etc. have caused some mixing. For instance, the locality "Sonja Lens" was first discovered by Sonja Jakobsen from some fossils that had fallen down the steep mountain side (Sonja Jakobsen pers. comm.).

Table 1 presents data on all the species and their occurrence at the six localities: *Turritellakløft*, Sonja Lens, Qaersutjægerdal, Agatkløft, Agatdal and Kangilia. For each locality the tables give the number of specimens with paired valves and the number of single valves. Altogether 2357 specimens comprising 115 species were treated. Of these, 17 species were prey for naticids and Table 1 gives in parentheses the number of valves bored by naticids. Kollmann & Peel (1983) list several boring gastropods.

Forty-seven species were found at *Turritellakløft*, represented by 66 paired and 482 single valves. The modern relatives of the paired species are generally known from wave-beaten or current-swept environments and include, e.g., the rock borers and the Glycymeridae (Thomas 1975). Single valves are generally worn. All the paired specimens except one (*Venerid?* sp. 1) are also represented by single valves. All the other valves except *Microcardium* sp. 1, *Tellina* sp. 1, *Venerid?* sp. 6, *Corbula* sp. 2, and *Cuspidaria* sp. 1 may originate from populations similar to those found in Qaersutjægerdal. The bivalves from *Turritellakløft* indicate a current-swept, exposed, rather shallow, rocky locality, 2-10 m deep, with slack water between the rocks.

Seventy species were found at *Sonja Lens*, represented by 27 paired and 1060 single valves. This locality has by far the largest ratio of single valves and also of single bored valves. The valves are generally the smallest and best preserved of the material examined. The modern relatives of the paired species are known from sandy shallow-water to tidal-zone localities. The fossils indicate a typical wash-up zone.

Forty-two species were found at *Qaersutjægerdal*, represented by 286 paired and 438 single valves. The large ratio of paired valves together with the concretions of species like *Pteria* and *Anomia*, whose modern relatives have an aggregational behaviour, indicates that the sediment was undisturbed or had only been slightly agitated. Hence *Qaersutjægerdal* represents a

sandy bottom around the wave base and could be the "producer" habitat for the majority of the single valves found at the two other localities.

*Agatkløft* includes different localities near the three mentioned above, but the information is not suitable for inclusion or comparison with the three sites above. Twelve species represented by 3 paired and 32 single valves were found.

*Agatdal* covers the few localities from the big valleys south of the four localities mentioned above. The five species, 22 paired and 8 single specimens, indicate similarities between the four northernmost localities in *Agatkjøft* and the southernmost localities in *Agatdal*.

*Kangilia* includes samples from both the north and south shores of Nuussuaq and also from the *Kangilia* Formation in the interior of Nuussuaq below the *Agatdal* Formation. The occurrence of *Cucullaea*, *Glycymeris*, *Venericor* sp. 1, *Crassatella* sp. 1 and *Thyasira* indicates a faunal relation between the older deep-water *Kangilia* Formation and the younger, shallow-water *Agatdal* Formation (Rosenkrantz 1970). However, the material we received may not be complete, as the groups *Cucullaea*, *Thyasira* and pectinids, which gave names to certain layers, are rare in this catalogue.

The materials from the first three main localities in Table 1 have, together with the descriptions and measurements given for each species, yielded information on paired valves, single valves and mortality due to naticid boring. Only bivalves digging in sand-mud mixtures are possible preys for naticids. Species of specimens where at least one valve indicates predation by naticids at any of the three localities are listed in Table 1 and summarized in Table 2. At *Turritellakløft* (2.5% of valves bored) and at *Sonja Lens* (4.6%) only single valves are bored, and their numbers are respectively ca. 22 and 42 times as large as the number of specimens with paired valves. This indicates a transport to high-energy environments from a more calm environment with naticids. At *Qaersutjægerdal* 11.3% of the paired and 8% of the single valves are bored and the number of single valves is about twice the number of paired ones. This indicates a "naticid" environment where the valves have not been washed out of the sediment.

Table 1. Fossil bivalves from West Greenland. List of all species and numbers of specimens. Specimens are listed according to the condition: paired valves and single valves. For each, the total number of specimens per sample is given first, followed by the number of these (if any) with naticid-bored holes given in parentheses. + = present, not possible to count specimens (only *Teredo*). P+S = total number of species based on paired + single valves.

Localities	Turritellakløft		Sonja Lens		Qaersutjægerdal		Agatkløft		Agatdal		Kangilia	
	Paired	Single	Paired	Single	Paired	Single	Paired	Single	Paired	Single	Paired	Single
<i>Nucula</i> sp. 1	1	1	.	.	.	.	.	.	.	.	.	.
<i>N.</i> sp. 2	.	5	.	13 (2)	.	.	.	.	.	.	.	.
<i>N.?</i> sp. 3	1	.	.	1	.	.	.	.	.	.	.	.
<i>Nuculoma</i> sp. 1	1	1	.	.	17 (4)	32 (4)	.	.	.	.	.	.
<i>Nuculana</i> sp. 1	3	10	5	136 (1)	10	12	.	.	.	.	.	.
<i>Tindaria</i> sp. 1	.	.	.	6 (2)	.	.	.	.	.	.	.	.
<i>T.</i> sp. 2	.	.	.	8	.	.	.	.	.	.	.	.
<i>Arca</i> sp. 1	.	.	.	17	.	.	.	.	.	.	.	.
<i>A.</i> sp. 2	.	.	.	3	.	.	.	.	.	.	.	.
<i>A.</i> sp. 3	.	.	.	1	.	.	.	.	.	.	.	.
<i>Barbatia</i> sp. 1	.	.	.	6	.	.	.	.	.	.	.	.
<i>B.</i> sp. 2	.	.	.	6	.	.	.	.	.	.	.	.
<i>B.</i> sp. 3	.	.	.	2	.	.	.	.	.	.	.	.
<i>B.</i> sp. 4	.	.	.	7	.	.	.	.	.	.	.	.
<i>B.</i> sp. 5	.	.	.	1	.	.	.	.	.	.	.	.
<i>B.</i> sp. 6	.	.	.	1	.	.	.	.	.	.	.	.
<i>B.</i> sp. 7	.	.	.	1	.	.	.	.	.	.	.	.
<i>B.</i> sp. 8	.	.	.	1	.	.	.	.	.	.	.	.
<i>B.</i> indet.	.	.	.	1	.	.	.	.	.	.	.	.
<i>Anadara</i> sp. 1	.	.	.	1	.	.	.	.	.	.	.	.
<i>A.</i> indet.	.	.	.	.	3	2	.	3	.	.	.	.
<i>Nemodon</i> sp. 1	.	.	.	2	.	.	.	.	.	.	.	.
<i>N.</i> sp. 2	.	.	.	2	.	.	.	.	.	.	.	.
<i>N.</i> sp. 3	.	.	.	1	.	.	.	.	.	.	.	.
<i>N.</i> sp. 4	.	.	.	8	.	.	.	.	.	.	.	.
<i>N.</i> sp. 5	.	.	.	1	.	.	.	.	.	.	.	.
<i>N.</i> sp. 6	.	.	.	1	.	.	.	.	.	.	.	.
<i>Cucullaea</i> sp. 1	.	1	.	9	.	1	.	.	.	.	.	.
<i>C.</i> sp. 2	.	2	.	.	.	.	.	.	.	.	.	.
<i>C.</i> sp. 3	.	.	.	.	.	1	.	.	.	.	.	.
<i>C.</i> sp. 4	.	1	.	.	.	.	.	.	.	.	.	.
<i>C.</i> sp. 5	.	1	.	.	2	1	.	.	.	.	.	.
<i>C.</i> sp. 6	1	.	.	.	.	.	.	.	.	.	.	.
<i>C. ("L.") solenensis</i>	.	.	.	.	.	.	.	.	.	.	.	2
<i>Striarca</i> sp. 1	.	.	.	7	.	.	.	.	.	.	.	.
<i>Arcopsis</i> sp. 1	1	30	.	25	.	.	.	.	.	.	.	.
<i>Glycymeris</i> form 1	2	60	.	11	11	13 (2)	.	.	.	.	.	.
<i>G.</i> form 2	.	2	.	.	.	.	.	.	.	.	.	.
<i>G.</i> form 3	.	1	.	.	.	.	.	.	.	.	.	.
<i>Mytilid</i> sp. 1	.	1	.	.	.	1	.	.	.	.	.	.
<i>Brachidontes</i> sp. 1	.	.	.	1	1	1	.	.	.	.	.	.
<i>B.</i> sp. 2	.	.	.	2	.	.	.	.	.	.	.	.
<i>B.</i> sp. 3	.	2	.	.	6	17	.	.	.	.	.	.
<i>Lithophaga</i> sp. 1	6	.	.	.	.	.	.	.	.	.	.	.
<i>Gregariella</i> sp. 1	2	.	.	.	.	.	.	.	.	.	.	.
<i>Modiolus</i> sp. 1	.	.	.	1	.	7	.	.	.	.	.	.
<i>M.</i> sp. 2	.	.	.	.	.	.	.	.	2	.	.	.
<i>Pteria</i> sp. 1	.	46	.	.	.	.	.	1	.	.	.	.
<i>P.</i> sp. 2	.	.	.	.	.	40	.	6	.	.	.	.
<i>P.</i> sp. 3	.	.	.	20	.	.	.	.	.	.	.	.
<i>Isognomon</i> sp. 1	.	2	.	8	.	.	.	1	.	.	.	.
<i>Propeamussium pfaffi</i>	.	.	.	.	.	.	.	.	.	.	.	8
<i>P. striatissimum</i>	.	.	.	.	.	.	.	1	.	.	.	22
" <i>Pecten</i> " <i>ataensis</i>	.	.	.	.	.	.	.	.	.	.	.	1
<i>P.</i> sp.?	.	.	.	.	.	.	.	.	.	.	.	1
<i>Anomia</i> sp. 1	.	5	1	20	20	18	.	.	5	.	.	.

Localities	Turritellakløft		Sonja Lens		Qaersutjægerdal		Agatkløft		Agatdal		Kangilia	
	Paired	Single	Paired	Single	Paired	Single	Paired	Single	Paired	Single	Paired	Single
<i>Gryphaedstrea</i> sp.1	.	.	.	4	.	.	.	.	.	.	.	.
<i>Crasostrea</i> sp. 1	.	1	.	1	.	.	.	.	.	.	.	.
<i>Lucina</i> sp. 1	.	8	.	13	7	6	2	2	.	.	.	.
<i>L.</i> sp. 2	.	.	.	1	.	.	.	.	.	.	.	.
<i>L. occidentalis</i>	.	.	.	.	.	.	.	.	.	.	.	1
<i>Loripes</i> sp. 1	.	.	.	2	.	.	.	.	.	.	.	.
<i>Lucinoma</i> sp. 1	.	.	.	1	3	6 (1)	.	.	.	.	.	.
<i>L.</i> sp. 2	.	3	2	4	11	10	.	.	.	.	.	.
<i>Thyasira</i> sp. 1	.	1	.	.	1	2	.	.	.	.	.	.
<i>T.</i> sp. 2	.	.	.	2	.	.	.	.	.	.	.	.
<i>Conchocele conradi</i>	.	.	.	.	.	.	.	.	.	.	2	.
<i>Diplodonta</i> sp. 1	.	21 (1)	.	61 (5)	16 (8)	23 (2)	.	.	.	.	.	.
<i>Cardiocardita</i> sp.1	.	1	.	45 (1)	.	.	.	.	1	.	.	.
<i>Venericor</i> sp. 1	.	19	.	.	12	13	.	5	.	.	.	3
<i>Astarte</i> sp. 1	1	5 (2)	.	.	.	.	.	.	1	.	.	.
<i>A.</i> sp. 2	.	.	.	1	.	.	.	.	.	.	.	.
<i>A.</i> sp. 3	.	.	.	1	.	.	.	.	.	.	.	.
<i>A.</i> sp. 4	.	1	.	.	.	2	.	.	.	.	.	.
<i>Crassatella</i> sp. 1	3	22	.	.	22	36	.	3	.	.	.	.
<i>Microcardium</i> sp.1	.	53	.	3	.	.	.	.	.	.	.	.
<i>Parvicardium</i> sp.1	.	.	.	3	.	.	.	.	.	.	.	.
<i>Mactra</i> sp. 1	1	1	.	1	1	2	.	1	.	1	.	.
<i>Tellina</i> sp. 1	.	5	.	90 (6)	.	.	.	.	.	.	.	.
<i>T.</i> sp. 2	.	.	.	.	15	1	.	.	.	.	.	.
<i>Macoma</i> sp. 1	.	6	2	17 (1)	7	20 (4)	.	.	.	.	.	.
<i>Donax</i> sp.1	.	.	.	.	.	.	.	1	.	.	.	.
<i>Gari</i> sp. 1	.	2	1	1	29	26	1	.	.	.	.	.
<i>Semele</i> sp. 1	.	.	.	.	1	.	.	.	.	.	.	.
<i>Solecurtus</i> sp. 1	.	.	.	1	.	.	.	.	.	.	.	.
<i>Tagelus</i> sp. 1	.	.	.	1	10	3	.	.	.	.	.	.
<i>Arctica</i> sp. 1	.	9	.	.	7	15	.	.	.	.	.	.
<i>Coralliophaga</i> sp.1	.	.	.	3	.	.	.	.	.	.	.	.
<i>Circe</i> sp. 1	.	.	.	1	.	.	.	.	.	.	.	.
<i>Pitar</i> sp. 1	2	26	12	266 (8)	4	2	.	8	.	.	.	.
<i>P.</i> sp. 2	.	3	.	.	.	.	.	.	.	.	.	.
<i>Callista</i> sp. 1	1	4	1	128 (3)	15	8	.	.	.	1	.	.
<i>Leioconcha</i> sp. 1	.	.	.	.	.	1	.	.	.	.	.	.
<i>Dosinia</i> sp. 1	1	5	.	.	9	1	.	.	.	.	.	.
<i>Venerid?</i> sp. 1	1	.	.	.	.	.	.	.	.	.	.	.
" sp. 2	.	.	.	1	.	.	.	.	.	.	.	.
" sp. 3	.	.	2	.	.	.	.	.	.	.	.	.
" sp. 4	.	.	.	.	1	.	.	.	.	.	.	.
" sp. 5	.	.	.	1	.	.	.	.	.	.	.	.
" sp. 6	.	7	.	.	.	.	.	.	.	.	.	.
<i>Venerupis</i> sp. 1	.	.	.	.	2	.	.	.	.	.	.	.
<i>Mya?</i> sp. 1	.	.	.	1	.	.	.	.	.	.	.	.
<i>Corbula</i> sp. 1	1	103 (3)	.	56 (7)	11	58	.	.	.	.	.	.
<i>C.</i> sp. 2	.	1	.	1 (1)	.	.	.	.	.	.	.	.
<i>Martesia</i> sp. 1	13	.	.	8	19	4	.	.	20	.	.	.
<i>M.</i> sp. 2	.	.	.	2	.	.	.	.	.	.	.	.
<i>Diplothyra</i> sp. 1	24	2	.	.	.	.	.	.	.	.	.	.
<i>Teredo</i> sp. 1	+	.	1	1	+	.	.	.	.	.	.	.
<i>Pholadomya</i> sp. 1	.	.	.	.	.	1	.	.	.	.	.	.
<i>P.</i> sp. 2	.	.	.	1	.	.	.	.	.	.	.	.
<i>Lyonsia</i> sp. 1	.	.	.	1	1	1	.	.	.	.	.	.
<i>Thracia</i> sp. 1	.	1	.	1	5	35 (3)	.	.	.	.	.	.
<i>T.</i> sp. 2	.	.	.	2	7	16 (2)	.	.	.	.	.	.
<i>Cuspidaria</i> sp. 1	.	1	.	.	.	.	.	.	.	.	.	.
<i>Verticordia</i> sp. 1	.	.	.	3	.	.	.	.	.	.	.	.
No. specimens	66	482	27	1060	286	438	3	32	22	8	2	38
No. species P+S		47		70		42		12		5		8

Table 2. Summary of the 17 species preyed upon by naticids from the three main localities in Table 1. No bored specimens were found at the other three localities.

Locality Valves	Turitellakløft		Sonja Lens		Qaersutjægerdal	
	Paired	Single	Paired	Single	Paired	Single
No. of prey species	7	12	4	25	11	11
No. of bored species	0	3	0	22	2	7
No. of possible preys	11	243	20	834	106	225
No. of bored valves	0	6	0	37	12	18
Percent of bored valves	0	2.5	0	4.6	11.3	8

Table 3. Analysis of the paired valves at the Great Sections in Turritellakløft and Qaersutjægerdal according to stratigraphic layers. The paired valves occur as tightly closed or more or less opened from just displaced to fully opened.

Sections Layer Condition	Turritellakløft				Qaersutjægerdal			
	Lower		Eastward+ Conglomerate		Upper		Lower	
	Closed	Open	Closed	Open	Closed	Open	Closed	Open
<i>Nucula</i> sp. 1	1	.	.	.	.	.	.	.
<i>N.</i> sp. 3	1	.	.	.	.	.	.	.
<i>Nuculoma</i> sp. 1	1	.	.	.	.	.	16	.
<i>Nuculana</i> sp. 1	2	.	1	.	3	.	7	.
<i>Cucullaea</i> sp. 5	.	.	.	.	.	2	.	.
<i>Arcopsis</i> sp. 1	1	.	.	.	.	.	.	.
<i>Glycymeris</i> form 1	.	1	.	1	4	1	5	1
<i>Brachidontes</i> sp. 1	.	.	.	.	1	.	.	.
<i>B.</i> sp. 1	.	.	.	.	1	.	.	.
<i>Lithophaga</i> sp. 1	.	.	6	.	.	.	.	.
<i>Gregariella</i> sp. 1	.	.	2	.	.	.	.	.
<i>Anomia</i> sp. 1	.	.	1	.	20	.	.	.
<i>Lucina</i> sp. 1	.	.	.	.	4	.	.	.
<i>Lucinoma</i> sp. 1	.	.	.	.	1	.	2	.
<i>L.</i> sp. 2	.	.	.	.	5	.	5	.
<i>Thyasira</i> sp. 1	.	.	.	.	.	.	1	.
<i>Diplodonta</i> sp. 1	.	.	.	.	5	2	5	.
<i>Venericor</i> sp. 1	.	.	.	.	1	3	3	1
<i>Astarte</i> sp. 1	1	.	.	.	.	.	.	.
<i>Crassatella</i> sp. 1	.	.	3	.	6	.	15	1
<i>Mactra</i> sp. 1	1	.	.	.	1	.	.	.
<i>Tellina</i> sp. 1	.	.	.	.	5	.	5	.
<i>Macoma</i> sp. 1	.	.	.	.	.	.	4	.
<i>Gari</i> sp. 1	.	.	.	.	7	5	7	1
<i>Tagelus</i> sp. 1	.	.	.	.	1	.	2	.
<i>Arctica</i> sp. 1	.	.	.	.	1	.	4	.
<i>Pitar</i> sp. 1	2	.	.	.	2	1	.	.
<i>Callista</i> sp. 1	1	.	.	.	2	.	6	1
<i>Dosinia</i> sp. 1	.	.	1	.	3	1	.	.
<i>Venerid</i> sp. 1	.	.	1	.	.	.	.	.
<i>Venerupis</i> sp. 1	.	.	.	.	2	.	.	.
<i>Corbula</i> sp. 1	1	.	.	.	.	.	10	.
<i>Diplothyra</i> sp. 1	.	.	24	.	.	.	.	.
<i>Lyonsia</i> sp. 1	.	.	.	.	.	.	1	.
<i>Thracia</i> sp. 1	.	.	.	.	2	.	.	.
<i>T.</i> sp. 2	.	.	.	.	3	.	3	.
No. of specimens	12	1	39	1	80	15	101	5
of which:								
Nuculanidae	5	.	1	.	3	.	23	.
Rock borers	.	.	32	.	.	.	.	.

Table 1 also lists the species represented by single valves, the majority by one or a few valves only. The large number of *Cardiocardita* sp. 1 and *Tellina* sp. 1 at Sonja Lens indicates a nearby shallow, possibly a tidal, wadden sea. The "Arcidae" and "Parallelodontidae", rather large, tropical, shallow-water to tidal-zone species, are represented by fine, small, juvenile, single valves in the Sonja Lens material, and by a few large, badly preserved shells from Agatdal, where postulated tidal flats might have been located. The large number of single valves of *Microcardium* sp. 1 at Turrillakløft cannot be interpreted due to insufficient knowledge of this species' life history.

Further analysis concerns species in single layers in the sections at Turrillakløft and Qaersutjægerdal. A fossil-poor tuff-shale series divides each of the two sections, but it is not clear how the tuff-shale series correlate. At Turrillakløft the layer above the tuff-shale series is poor in fossils, but the layer below and the layers "eastward below delta" and "conglomerates" contain many fossils. At Qaersutjægerdal, fossils are found both above and below the tuff-shale series. The 0.7 m x 7 m large Sonja Lens cannot be subdivided.

Table 3 gives a list of species where one or more specimens were found with paired valves, closed or open, in the single layers at Turrillakløft and Qaersutjægerdal. The species are divided rather crudely according to their mode of life: Nuculanidae, filter feeders and rock borers. The wood borers are not included in this analysis.

At Turrillakløft, five species of Nuculanidae

(all closed) are found at "the layer below tuff-shale", and only 1 in "eastward" + "conglomerates". The occurrence of filter feeders is spread without a recognizable trend. However, the rock borers are only found in "eastward" + "conglomerates", boring in the conglomerates made up by the Kangilia Formation.

At Qaersutjægerdal, all the Nuculanidae are closed, with 3 in the upper layer and 23 in the lower one. This indicates that the upper layer is from shallower depth with less detritus. There are 80 closed and 15 open burrowing filter feeders in the upper layer, and 101 closed and 5 open filter feeders in the lower layer. Thus, in the upper layer ca. 19% are open against only ca. 5% in the lower layer. These results also indicate that the layer above the tuff-shale is from a shallower depth, e.g., with more wave action, than the layer below.

## DISCUSSION

The palaeoenvironments of these Danian bivalves are estimated from a comparison with modern marine habitats. In order to explain the conclusions it has been necessary to give a short survey of the most important marine habitats. The modern distribution of the organisms and shells in these habitats depends both on physical parameters, the energy flows, the habitats and on the organisms' response to these conditions. The estimated habitats of the fossils are given in parentheses.

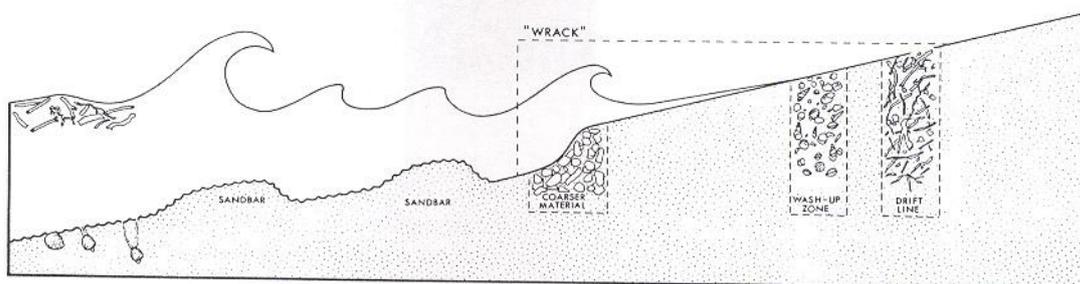


Fig. 197. Diagrammatic representation of the zones on a moderately exposed sediment shore, going from depths around the wave base to above High Water Mark. The burrowing bivalves and the drift material are indicated together with the zones where the materials are accumulated. "Wrack" indicates the area where wave action on the accumulated dead plants (seagrass, algae) can form "cliffs" in the wash-up mats of dead material.

### The modern marine habitats

**Deep water:** In calm water the bottom is dominated by clay, detritus, etc. and populated with species adapted to these conditions. Also, many remnants of dead pelagic specimens, including driftwood bored by wood borers, etc., settle in deep water. The bottom may be anoxic or poor in oxygen, depending on hydrographic conditions (= Kangilia Formation).

**Shallow water:** Features from a modern, exposed, sandy shore going from depths below wave base up to above the high water mark are given in Fig. 197.

Just below wave base, sandy sediments are common and inhabited by different types of burrowing and digging organisms. The bivalves will normally remain closed (= Qaersutjægerdal below tuff-shale layer).

Above wave base, the sediment will often be stirred up, and the ligaments of newly dead bivalves will open the shells (= Qaersutjægerdal above tuff-shale layer). The heavy particles are flushed out, transported away, and deposited elsewhere (= Turrillakløft below the tuff-shale layer).

Where strong currents and/or surf prevent sedimentation, epifauna and/or boring organisms populate the rocky bottom (= Turrillakløft, eastward + conglomerates).

The sandbars just off the shoreline are generally without dead organic remains, as these have been washed out (= Turrillakløft above tuff-shale layer).

The waves break as surf two or three times over offshore sandbars before the final small break when the waves roll up and die out on the shore, and where the transported contents will be sorted and accumulated in the following zones:

The final small-breaker zone, where rather coarse sediment and shells are accumulated at the steep front, where the swash and backwash zone starts.

The swash-and-backwash zone (Reineck & Singh 1980, fig. 478), where the remains are finally sorted and moved upwards (to the wash-up zone) or downwards (to the steep front at the small breaker zone), is without accumulation of dead remains. It is in more equatorial areas populated by several fast-digging species, e.g., *Donax*.

The wash-up zone is an accumulation of remains from benthic or epibenthic organisms that have been flushed out of the sediment farther out and transported upwards. Terrestrial and limnic material carried out by rivers can also be found here (= Sonja Lens).

The drift line is where floating items are accumulated, for instance, shells of floating molluscs, driftwood, etc. The drift line and the wash-up zone can be mixed and sorted again depending on changes in wave action (= Sonja Lens).

The beach is mostly dry and forms the transition to the dunes and other terrestrial habitats. The beach is normally rather barren, although older deposit lines from extreme high waters and storms do occur. Sometimes shells occur in huge masses in layers 10 to 20 cm thick, some hundred meters wide and several kilometers long, which may be fossilized in place (= part of Sonja Lens?).

Beach rocks can develop on some tropical-subtropical beaches and may produce a gentle and rapid fossilization (= Sonja Lens?).

### The modern distribution of the organisms and shells

The fate of the organisms and their dead remains depends not only on sorting, sedimentation and transportation of waves and currents, but also on their size, shape and life-form characteristics. The climatic conditions and biogeographic area also influence the species composition and the life forms. For instance, borers and deep-digging species are absent or rare in arctic waters, but common in tropical waters. Dead remains are produced by the living organisms in so-called "producer" habitats. They can be preserved in situ in the "producer" habitat, or they can be flushed out, sorted and accumulated in the "receiver" habitats, according to the following taxonomic characteristics.

#### *Bivalvia*

Dead specimens of surface-dwelling species and byssate species are easily transported from their "producer" habitat. Shallow-burrowing bivalves in unstabilized sediment are easily washed out and transported. Shallow burrowers in stabilized sediment and deep burrowers are preserved in life position with the two valves closed together. If

the bivalves are gently uncovered shortly after their death, the ligament can open the shells but still keep them together for a short period, until they may be covered again, and thus preserved with the paired valves in open, more or less connected positions. Slight movements of the sediment will separate the paired valves. Many shallow-burrowing bivalves are attacked in their position in the sediment by boring predatory snails (naticids). In undisturbed sediment the bored bivalves are left with closed valves (= Qaersutjægerdal). Single bored shells indicate agitated sediment (= *Turritella* Kløft + Sonja Lens).

Lighter and smaller shells from depths above wave base will be transported upwards through the wash-and-backwash zone and accumulated in the wash-up zone. Even very fragile shells can survive this transport intact (= Sonja Lens). The heavier shells will be transported downward and will, together with shells from deeper waters, be taken by currents and deposited in slack water. Such shells are often mechanically worn during transport (= *Turritellakløft* below tuff-shale).

#### Gastropoda

The majority of the gastropods belong to the epibenthic fauna that crawls on or just below the sediment surface. A few gastropods have a true sedentary life style, e.g., naticids, *Apporhais*, *Nassarius*, *Turritella* (see *Anomia* in the catalogue, and Kollmann & Peel 1983: 44). Thus, most gastropods are well exposed to water movements and transportation. Freshwater- and terrestrial snails can be washed out by rivers and end up in the wash-up zone. Kollmann & Peel (1983: 10) report land snails from Sonja Lens and Qaersutjægerdal. Furthermore, many dead gastropod shells are inhabited by hermit crabs that can transport them widely around and make them even more susceptible to wave action and transportation. Thus, gastropod shells are often found outside their habitat. Gastropods are more common and with more species in the tropical-subtropical wash-up zones (= Sonja Lens) than in the boreal to arctic wash-up zones.

#### Barnacles

Balanomorph cirripedes are very abundant in all

oceans except the Antarctic Ocean. Even though barnacle shells are produced in large quantities in shallow habitats, they are remarkably rare in the wash-up line, where mollusc shells are so common. Instead, barnacle shells are transported out to greater depths, where they constitute a major part of the so-called shell gravel, in which big and heavy mollusc shells are also found. Rosenkrantz (1970) mentioned valves of *Arcoscalpellum* from both the Kangilia and Agatdal Formations, and also a balanomorph cirripede from Sonja Lens. However barnacles do not occur in our material.

#### Vegetation

In the present material, remnants of plant material, often as bits of coal, are rather common, but they are difficult to identify. The wood borers are used to give a further clue to the environments.

#### The paleoenvironment of the Kangilia and Agatdal Formations

Fig. 198 (from Henderson et al. 1976, fig. 318) gives a columnar section through the Senonian-Danian sequence on the north coast of Nuussuaq at Kangilia that corresponds to the sections in the interior of Nuussuaq. The marine bivalves in this section indicate an uplift of a sea bottom from several hundred meters depth to several hundred meters above sea level.

The Kangilia Formation is a deep-water deposit consisting of calcareous black clay with deep-water species (e.g., *Propeamussium*, *Den-*

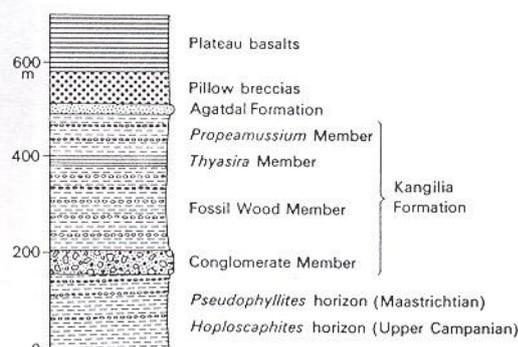


Fig. 198. Columnar section through the Senonian-Danian sequence at Kangilia. The fossil wood was bored by boring bivalves, then probably sank in deep water. After Henderson et al. (1976: 355, fig. 318).

*talium*) and sunken driftwood bored by wood borers. The depth could have been from 200 to 2000 meters. Rosenkrantz (1970: 419) mentions that the Kangilia Formation changes from a lower, older anoxic layer without fossils to an upper, younger fossiliferous layer. He explains this by calling on the development of increasingly strong currents. It could just as well be explained as the result of a rising sea bottom, producing shallower waters. Further, he divides the Kangilia Formation into a lower *Thyasira* member and an upper *Propeamussium* member according to the dominant bivalve in each layer. (Note: the material of *Thyasira* and *Propeamussium* received from layers other than those of the Agatdal Formation is small.) Modern *Thyasira* dig deeply and tolerate low oxygen, while *Propeamussium* are epibenthic. This also indicates an uplift. The Lower Danian Kangilia Formation is separated by a conglomerate layer from the Upper Cretaceous, where driftwood bored by bivalves is found in black clay (Rosenkrantz 1970), suggesting that this driftwood (not seen by us) sank in deep water. The Kangilia Formation was later lifted up to and above sea level, became consolidated, and formed the shores of the Agatdal Sea. The cliffs and boulders of the Kangilia Formation shores were bored by rock-boring organisms belonging to the fauna of the Agatdal Formation, see, for example, *Diplothyra*. The Kangilia Formation is thus older than the Agatdal Formation, but the few species found in both formations indicate that their faunas could have originated from the same ocean but from different depths.

The three main sections in the Agatdal Formation represent the following three different marine habitats:

*Turritellakløft* was an exposed current-swept locality. In some places the currents and/or surf kept part of the sea bottom clean, where the borers lived, and in other places they transported and deposited in slack water dead, worn valves together with pebbles and gravel. The depth is estimated to be from 5 to 20 m. The few species (e.g., *Glycymeris*) found with paired valves are related to modern species known to live in such a harsh environment.

*Sonja Lens* was a "wash-up" zone. The size distributions show that Sonja Lens received

smaller valves, such as *Callista*. The few specimens found with paired valves are from species related to modern shallow-water species (*Pitar*). Thus, Sonja Lens was a "receiver habitat" for small, dead shells transported from "producer habitats" resembling both the *Turritellakløft* and *Qaersutjægerdal* marine habitats and also from some unknown tidal flats that may have been located in the southern part of Agatdalen. Some 237 of the 254 gastropod species in Kollmann & Peel (1983) are found in Sonja Lens, generally as small, well preserved specimens, which also supports the concept that Sonja Lens is a "wash-up" zone, with a species composition similar to modern tropical "wash-up" zones. A piece of Sonja Lens was cut out intact for exhibiting at the Geological Museum. This piece, shown from three sides in Fig. 199, is a perfect cut through a "wash-up" zone. Fig. 200 shows another intact piece of Sonja Lens, with a bored *Tellina*. Hansen (1970: 19) obtained most of his material of Foraminifera from gastropod infillings collected in Sonja Lens. He crushed several hundred gastropods, preferably naticids, but otherwise worn specimens not identified to any taxon. He concluded that it is unlikely that more than 300 species of gastropods found in Sonja Lens should have been living together in the same environment. Hansen was apparently not familiar with modern wash-up zones.

*Qaersutjægerdal* was a sandy locality around or just above wave base. The material is dominated by paired specimens, either with closed valves or with valves opened by ligament elasticity. This indicates that the sediment was gently washed away, uncovering the recently dead specimens, which shortly after were covered again. The depth is estimated to be about 10 to 20 m. The shells from the layer above the tuff-shale series are from shallower depths than the shells from the layer below. *Qaersutjægerdal* is thought to represent the "producer" habitat for many of the single valves found in the two other sections.

The Agatdal Formation is overlain by pillow breccias and plateau basalt. Today the outcrops are 400 to 600 m above sea level.

#### The paleoclimate

The climate depends on several parameters,

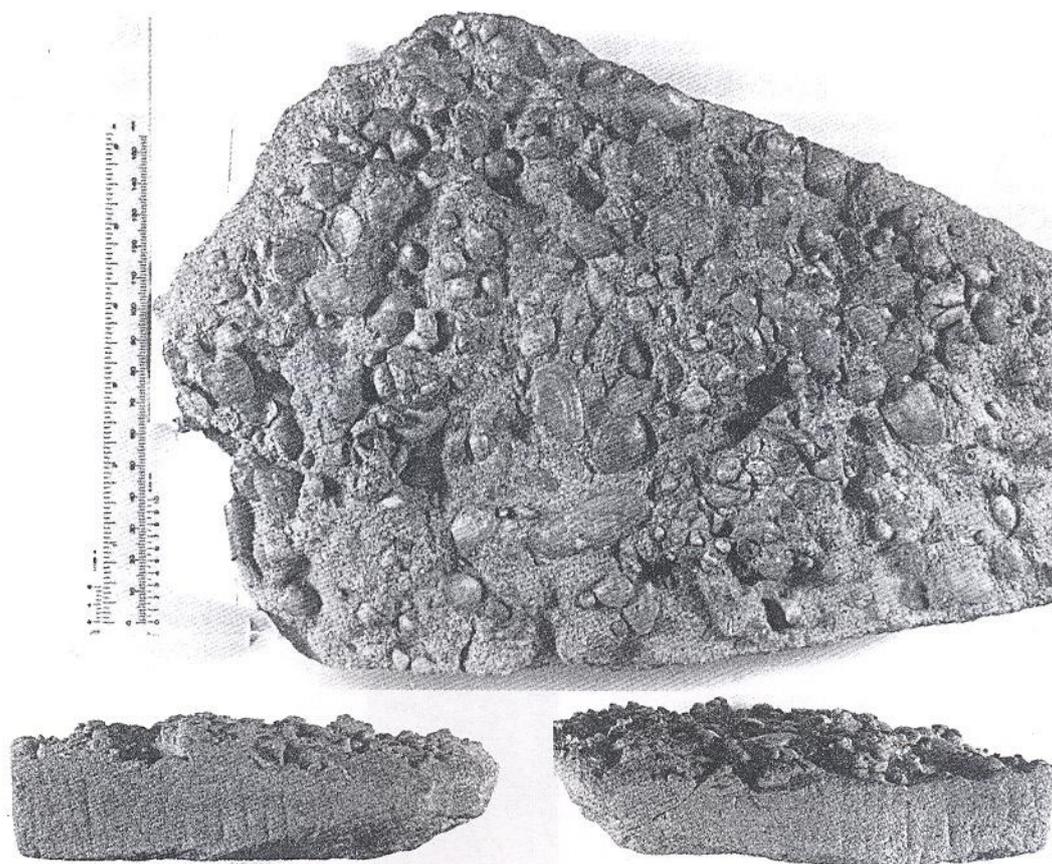


Fig. 199. MGUH 25.300. Block from Sonja Lens, seen from three sides, and showing a perfect cut through a wash-up layer with several single valves.

among which light regime and temperature are very important. The regular oscillations in light regime (polar day-polar night versus tropical day-night) are postulated to be the most important climatic parameters for the structure and function of ecosystems; see Petersen (1984a, b, 1985, 1986, 1989, 1990). The conclusion is that the development of ice sheets and evolution of arctic ecosystems in the late Tertiary are controlled by the gradual development of the polar light regime.

The paleoclimate can be estimated from comparisons with modern marine bivalve faunas regarding the following: 1. The distribution of re-

lated species in modern seas. 2. The life forms. 3. The biodiversity in modern seas. 4. The growth rings.

*Distribution of related species in modern seas*

The species composition of the bivalves in the Agatdal Formation is very similar to that of a modern tropical-subtropical fauna. In the latter 47 of the 51 species of Pteriomorpha most closely related to the fossil ones are restricted to the tropical-subtropical zones and 4 are deep-water species. The 43 species of Heterodonta are mainly tropical-subtropical but some enter the southern boreal zone, whereas the rock borers are

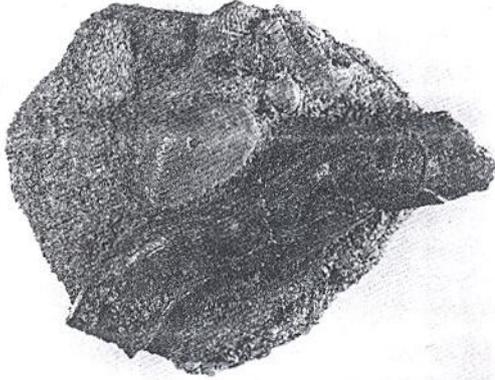


Fig. 200. MGUH 25.301. Piece from Sonja Lens with wash-up shells and debris.

exclusively tropical (see, e.g., Olsson 1961, Parker 1964, Nielsen 1976, Tantanasiwong 1979). A few of the Agatdal species are today represented by deep-water species or are extinct. In many cases it was tempting to identify the fossil species as modern species in today's Panama-Pacific, Indo-Pacific, Caribbean and Mediterranean faunas. However, the modern tropical faunas also encompass large groups that are absent in the fossil fauna. For instance, the superfamily Cardiacea occurs in modern faunas with several large-sized species (e.g., *Trachycardium* spp.), but is only present in the fossil fauna with the small *Microcardium* and *Parvicardium*. The same is true for the Solenacea and pectinids. The absence of these large species from the fossil fauna may indicate that they did not exist in Nuussuaq's Danian fauna, considering the abundance of many other, smaller species. A few fossil genera and species are related to modern northern species, e.g., *Astarte* spp., *Macoma* sp. 1 and some of the Paleotaxodonta and Anomalodesmata. This dominance of tropical-subtropical bivalves is comparable to the gastropod fauna, which consists of warm- to temperate-water species with a few cold-water forms. Kollmann & Peel (1983: 10) consider temperature to be the only important climatic parameter.

#### *Life forms*

The fossil bivalves include both epifauna and

infauna, which also occur in modern tropical and arctic oceans. However, the fossil fauna also has a considerable number of mainly tropical borers, such as *Lithophaga*, *Gregariella*, *Diplothyra*, *Martesia* and *Teredo*. True borers do not occur in arctic-subarctic waters. Thus, these life forms indicate a tropical to subtropical water mass.

#### *Biodiversity in modern seas*

Biodiversity is a commonly used but often misused concept, and has to be specified more precisely here. It is well known that the number of species is higher in the tropics than in the polar regions. However, it is not a general rule and it is necessary to select certain ecosystems and certain food levels for comparison, because in certain compartments of the ecosystems, in certain taxonomic groups, life cycles and life forms, the number of species is actually greater in the polar regions. Only the Arctic is considered here, because the Arctic and Antarctic are not comparable. Thus, biodiversity has to be specified according to energy-flow positions in order to be used as a climatic indicator. However, biodiversity is not only the number of species that share a common food resource and/or environment, but also how they share and compete. In boreal to arctic faunas one or a few species dominate, a situation that led to the "community" concepts, named after the dominating species. Large oscillations in food supply between surplus and starvation will favour certain species ("lebensformen"). This leads to dominating species, approaching monoculture, a better energy transfer, a levelling out of the oscillations and hence new speciation in the new food levels. The major controlling parameter in food supply is the light regime (day-night, polar day – polar night). This signal can be traced through the ecosystems, the speciations, the extinctions, etc. (Petersen 1984a, b, 1985, 1986, 1989, 1990).

Practically all bivalves function at the same food level, where they compete in the food pool that eventually accumulates at or near the bottom. Hence they are well suited as indicators of the food conditions, which reflect the light regimes.

Bivalves (and gastropods) show a high biodiversity in the Nuussuaq Paleocene fauna. However, since single valves may have been transported, only paired valves are considered and

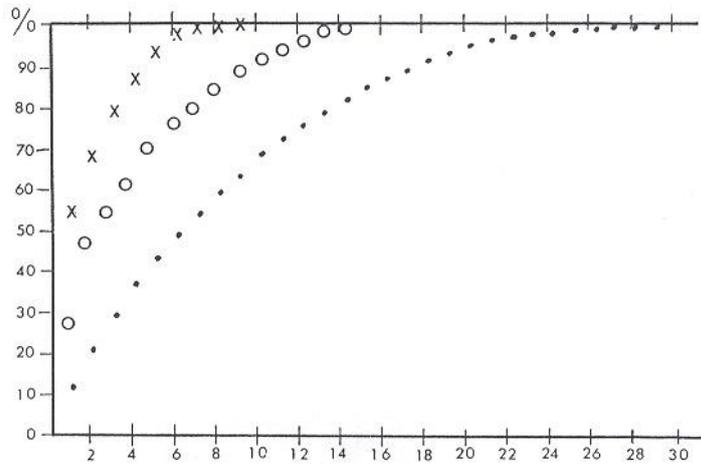


Fig. 201. Biodiversity in the eco-system level: "Bivalves in sand at wave base". X-axis gives ordered number of species. Y-axis gives accumulated, ordered relative number of specimens. Dots = Qaersutjægerdal, circles = North Sea, crosses = Disko Bay.

only those from Qaersutjægerdal, where they are found in the greatest numbers. Qaersutjægerdal represents a benthos from depths around the wave base, probably 10-30 m depth. A total of 238 specimens of burrowing paired filter-feeders from 29 species were found.

This material is compared with quantitative materials of modern bivalve faunas from sandy bottoms at depths around wave base from arctic and temperate seas, respectively (Petersen 1977, 1978). The arctic material originates from 4-40 m depth on a sandy bottom in Disko Bay, where 3429 specimens of 9 filter-feeding, burrowing species were found. The temperate material comes from a sandy bottom at 10-40 m in the North Sea, where 6036 specimens of 14 species were found. The Disko Bay fauna is a representative picture for the very large subarctic areas bordering the Arctic Ocean. The North Sea fauna does not have such a large range, but its biodiversity may be representative of boreal faunas.

Fig. 201 gives the accumulated percentage of the ordered occurrence of the species from the faunas. The fossil Qaersutjægerdal fauna shows a high biodiversity. The modern Disko Bay fauna shows a low biodiversity with a few dominating species, and the North Sea fauna an intermediate biodiversity.

The high biodiversity (= large number of species, no dominating species) found among the

Qaersutjægerdal bivalves indicates tropical light conditions.

Material from a modern tropical fauna that allows comparable calculations has not yet been found, but curves calculated on other quantitative materials in Parker (1964), Ursin (1960) and Sanders (1968) give similar results.

#### *Growth rings*

The growth rings on the fossils are often pronounced and are similar to the growth rings seen on comparable modern tropical-subtropical species. They should indicate the latitude where the specimens lived, if and when the day-and-night rings, the tide rings, the spring-tide rings, seasonality rings, spawning rings, etc. can be identified and counted. However, a study of the rings is postponed because of lack of comparable modern tropical material.

#### **The Nuussuaq fauna compared with the Ocean Point fauna**

A paper on the Danian Ocean Point fauna from northern Alaska (Marincovich 1993) gives fine photos of 25 Danian mollusc species, of which 21 are bivalves, including 15 new species. The Ocean Point bivalves are remarkably different from the Nuussuaq fauna, considering the similar geological age and the geographic positions, see map (Fig. 202). The habitat of the Ocean Point

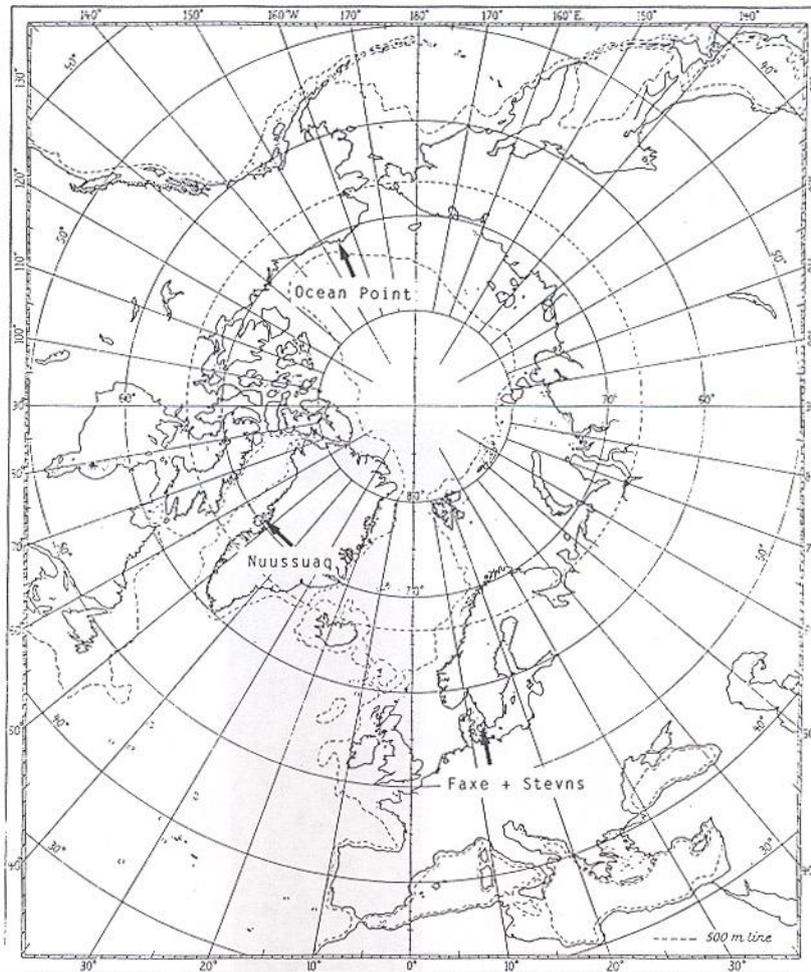


Fig. 202. Map with the positions of Nuussuaq, Ocean Point and the type localities for Danian: Faxe and Stevns.

bivalves was similar to that of Qaersutjægerdal, viz.: a sandy bottom around wave base.

#### Taxonomy

Only *Arctica ovata* (Meek & Hayden, 1857) listed by Marinovich (1993) might be the same species as our *Arctica* sp. 1. Furthermore, Marinovich (1993) has two species of Pectinidae and two species of Cardiidae, all four rather large species. These are absent in our material from the Agatdal Formation. The rest belong to genera that occur in our material, but they do not belong to the same species.

#### Climate

Marinovich (1993) uses several paleontological terms partly related to climatic conditions and distributions, e.g., paleogeographic affinities, lineage, biogeographic ties, association, origin, cool-temperate, northern, etc. These terms all relate the Ocean Point fauna to cool-temperate North Atlantic or North Pacific faunas. It is difficult to estimate paleolatitudes and paleohydrography based on these concepts.

#### Life forms

The Ocean Point fauna includes four species of

Paleotaxodonta, with 9 articulated specimens and 56 valves. The Pteriomorpha (generally epibenthic and byssate) include 7 species with 16 articulated specimens and 212 valves, and the burrowing Heterodonta include 10 species with 21 articulated specimens and 195 valves.

#### *Biodiversity in the Ocean Point bivalves*

In all groups the dominating species constitute more than 50% of the total number of specimens. Calculated in the same manner as the material from Qaersutjægerdal and the Recent Godhavn and North Sea material (see Fig. 201), the Ocean Point fauna resembles the subarctic Godhavn material. The Ocean Point fauna may indicate seasonally oscillating food conditions.

#### *Biogeography*

Marincovich (1993, figs 5 and 6) postulates a land bridge separating the Ocean Point fauna from the Nuussuaq fauna and a "seaway" to secure a mixing or a distribution of marine faunas. Experience from modern marine biogeography says that the "water walls" between two different water masses or eddies can be more efficient, steeper and longer-lasting barriers than the barriers of land bridges or continents. Thus, the two faunas could be shore faunas from the northwest? and southeast? shores respectively of an ocean with large currents and eddies.

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