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Upper Jurassic bivalves from Milne Land, East Greenland

by

Franz Theodor Fürsich

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Abstract

Eighty-six species of bivalves belonging to 49 genera are identified. Seventy-four species are described. Eleven of them are new: *Lopatinia callomoni, Modiolus elongatus, Aguilerella aldingeri, Camptonectes milnelandensis, Tancredia magna, ?Pronoella superjurensis, Isocyprina birkelundi, Hartwellia borealis, Goniomya bicarinata, Pleuromya triangularis,* and *Pleuromya zakharovi.* One new subspecies, *Limatula consobrina multicostata* is also described, and two new subgenera are erected: *Strimodiolus* and *Costicamptonectes.*

The autecology of each species is discussed and comprehensive faunal lists, which include the remaining benthic invertebrates, are given for each member.

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INTRODUCTION

The first descriptions of Upper Jurassic bivalves from East Greenland were by Madsen (1904) and Ravn (1911) who worked on material, chiefly from Jameson Land and North-East Greenland (Kuhn Ø, Hochstetter Forland), collected by the Danish Expedition in 1900. The first account of invertebrates from Milne Land, based on collections made during the 1926–1927 expedition, was by A. Rosenkrantz (1929) in Lauge Koch's 'Geology of East Greenland'. Additional material was collected by H. Aldinger in 1933 during the Three-Year-Expedition to East Greenland under the leadership of Lauge Koch. The material collected by Rosenkrantz and Aldinger was subsequently worked on by Spath (1935, 1936) who published the first detailed taxonomic descriptions of the Upper Jurassic invertebrate fauna from Milne Land. Previously, Parat & Drach (1933, 1934) had published faunal lists of the Upper Jurassic sequences. Spath's emphasis was on ammonites, and the remaining invertebrate groups (chiefly bivalves, gastropods and brachiopods) received only a cursory treatment. Further, mainly brief, descriptions of Upper Jurassic bivalves from East Greenland are found in Frebold (1933), Spath (1947) and Donovan (1953).

During the 1977 expedition of the Geological Survey of Greenland to East Greenland a small group of scientists concentrated on the Jurassic sequence in Milne Land. They worked on the ammonite succession (T. Birkelund and J. H. Callomon), the dinoflagellate stratigraphy (S. Piasecki), the depositional environments of the Upper Oxfordian Aldinger Elv Member (C. Heinberg) and the biofacies and palaeosynecology of the benthic invertebrate faunas (F. T. Fürsich). First results of the field work were published in Birkelund, Callomon & Fürsich (1978), Callomon & Birkelund (1980) and Piasecki (1980).

During the extensive collecting of the benthic faunas it became apparent that Spath's (1935, 1936) descriptions were an inadequate basis for a palaeoecological study as several new species were discovered and several of Spath's taxonomic conclusions were based on poorly preserved material and therefore led him to erroneous identifications. Therefore, a taxonomic study of the bivalves, the largest group of benthic invertebrates in Milne Land, was undertaken to provide a sound basis for the intended palaeosynecological and palaeobiogeographical study.

Studies on Jurassic bivalve faunas are severely hampered by the wealth of names in existence. Most faunas were described during the nineteenth century when the species concept differed markedly from that of modern taxonomy, population studies to establish the range of variation of a species being then largely unknown. In addition, the authors usually studied the bivalves of a small area and narrow

stratigraphic range, and insufficient comparison was made with faunas from the rest of the Jurassic, let alone the Upper Triassic or basal Cretaceous. A reliable documentation of a Jurassic bivalve fauna from one stratigraphic and geographic unit, such as the Upper Jurassic of Milne Land, would in fact necessitate a revision of a large part of the whole Jurassic bivalve fauna. Only in this way could the taxonomic confusion surrounding Jurassic bivalves be overcome. Such an undertaking is, of course, beyond the scope of the present paper and could, in fact, only be accomplished by a number of people tracing particular groups from the Upper Triassic into the Lower Cretaceous and dealing not only with the taxonomy, but also the ecology and evolution of these groups. (The work of Johnson, 1980, on Jurassic pectinids is an example of such a comprehensive study). This means that the present study can only be regarded as a contribution to the more complete understanding of the Jurassic Bivalvia.

Apart from classifying the bivalves, an attempt has been made to give a short account of the autecology of each species. This is based partly on observations of species in life position, and partly on inferences drawn from their morphology and from comparison with Recent relatives. In several cases, the presence of commensal organisms (usually as borers or encrusters) gave indications about mode of life.

JURASSIC SUCCESSION IN MILNE LAND

Jurassic sediments occur in Milne Land in the south-east corner of the island, from the Charcot Gletscher in the north to Lingularyggen and Kap Leslie in the south, and to Bays Fjelde in the east (fig. 1). They were first mentioned by Bay (1895) and subsequently by Rosenkrantz (1929). A detailed study of the stratigraphy, including mapping of the south-east corner of the island, was carried out by Aldinger (1935). A description of the rich invertebrate faunas by Spath (1935, 1936) followed. In 1961 Callomon published further details of the stratigraphy, and in 1971 Håkansson, Birkelund, Heinberg & Willumsen gave an account of new information gained during a geological mapping programme of the area.

Good sections of Kimmeridgian and Volgian sediments are found on the eastern slopes of Hartz Fjeld, and around Bays Fjelde and Kronen. In contrast, continuous sections in the Oxfordian Kosmocerasdal and Aldinger Elv Members are rare and commonly covered by scree. Fig. 1 gives the localities from which samples have been obtained (for details see appendix 2).

The Jurassic and lowermost Cretaceous of Milne Land is a clastic sequence, about 1200 m in thickness, which rests on a Caledonian crystalline basement (fig. 2). Transgression commenced in Bathonian times (Callomon & Birkelund, 1980) with the deposition of cross-bedded, coarse-grained arkoses and sandstones, in places gravelly; the so-called Charcot Bugt Formation. These near-shore, largely

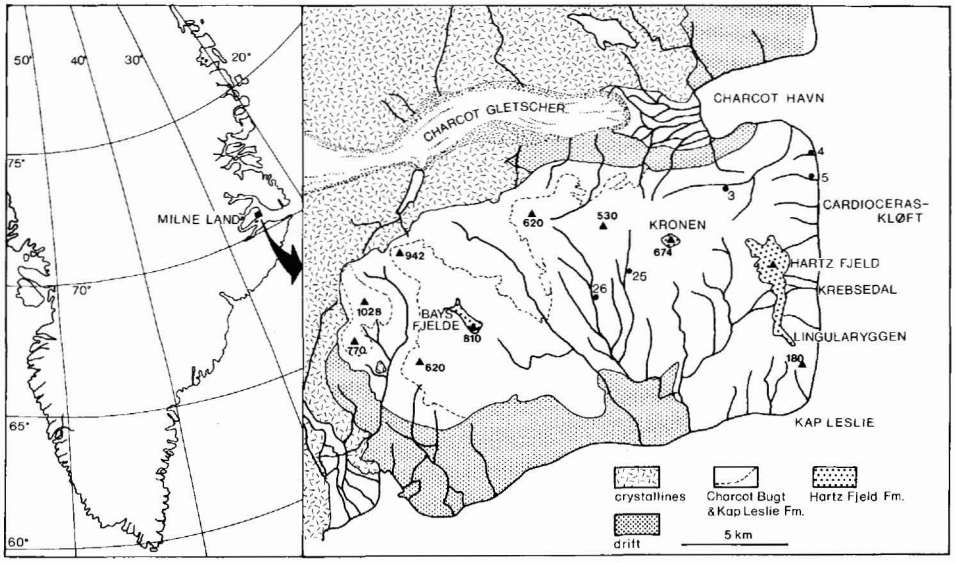

Fig. 1. Locality map, south-east Milne Land, East Greenland. Dots refer to localities listed in the appendix.

unfossiliferous, coarse-clastic units are followed by offshore fine-sandy silts and siltstones (Kosmocerasdal Member) which in turn are succeeded by the shallow-water sands and sandstones of the Aldinger Elv Member. Fine-grained sandstones and silts, partly glauconitic (Bays Elv Member) and silts and sandstones (Cardiocerasløft Member) reflect a return to a somewhat deeper environment, whilst the black, laminated silty shales of the succeeding Gråkløft Member are indicative of a quiet, largely anoxic environment. Again shallower conditions are evidenced by the highly bioturbated silts and fine-grained sandstones of the Krebsedal Member. Very favourable conditions for benthic faunal elements existed during the deposition of the glauconite-rich sands and sandstones of the Middle Volgian Pernaryggen Member, which is succeeded by the highly micaceous silts of the Astartedal Member.

The sediments of the Kap Leslie Formation, to which all the above members belong, are overlain by cross-bedded medium- to coarse-grained sands of the Hennigryggen Member which, from the evidence of its rich trace fossil assemblages, was laid down in a shallow marine, high energy environment. Scattered finds of ammonites show that, whilst the basal part of this member is still Middle Volgian, the top is Lower Cretaceous in age. The sedimentary sequence concludes with marginally marine shales and sandstones of the Hauterivian Pinnadal Member.

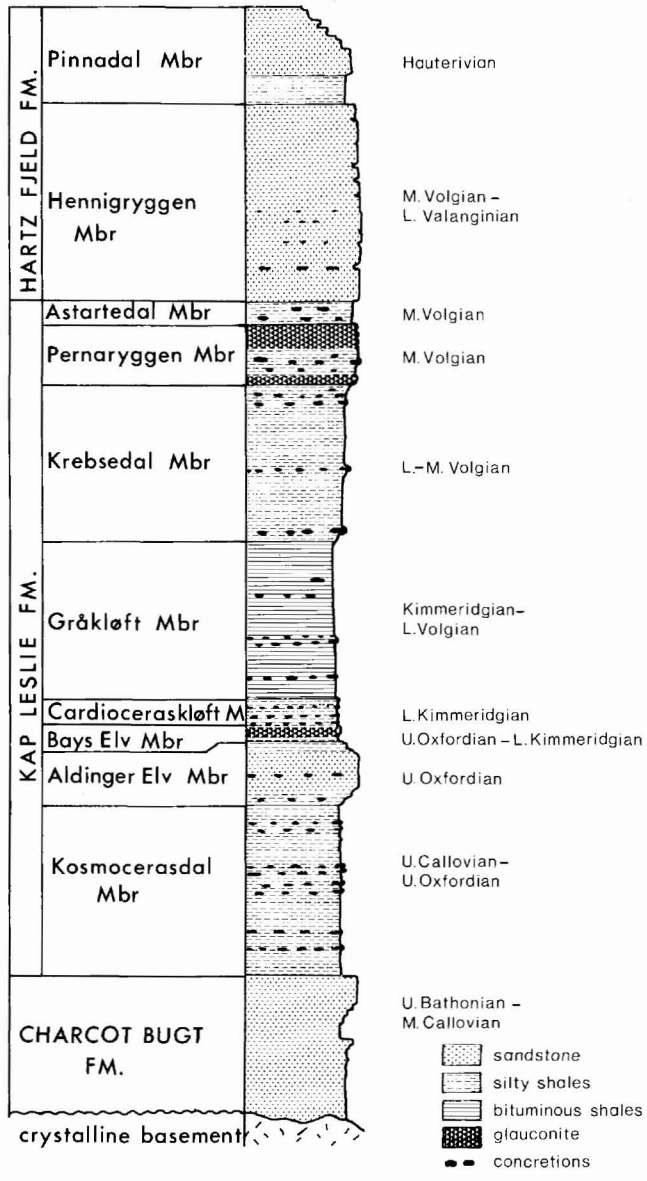

Fig. 2. Composite section of the Jurassic and Lower Cretaceous sequence. Hartz Fjeld area, south-east Milne Land. Thickness around 1100 m.

DISTRIBUTION OF BENTHIC FAUNAS

Benthic faunas are not evenly distributed throughout the succession, but are to a large extent concentrated at certain horizons, large parts of the sedimentary sequence in between being unfossiliferous. Faunal lists are given in tables 1–8 (Ap-

pendix 1). Within the Upper Jurasssic, the first horizons yielding a rich fauna are in sandstones of the Kosmocerasdal Member where *Grammatodon keyserlingii,* together with several other bivalve species and the polychaet *Ditrupa,* form shell beds a few centimetres in thickness. Within the Aldinger Elv Member, shell beds are widespread and dominated either by *Ditrupa,* the bivalves *Arctica syssollae* and *Lopatinia callomoni,* or by the pectinid *Camptonectes broenlundi.* Within the Bays Elv Member bivalves occur only rarely, but within the Cardioceraskløft Member occasional shell beds dominated by pectinids and *Pleuromya,* are found. The bituminous shales of the Gråkløft Member clearly were very unsuitable for colonisation by a rich benthic fauna. This is reflected by the occurrence of near-monotypic assemblages of *Buchia* and astartids. During the deposition of the Krebsedal Member conditions for the benthic fauna gradually became more favourable and towards the top diverse, bivalve-dominated assemblages occur. Common forms include *Grammatodon schourovskii, Pleuromya, Discomiltha lirata* and *Dentalium.* The most diverse faunas, however, are found in the Pernaryggen Member where shelly sandstones alternate with unfossiliferous silts. The largely autochthonous benthic faunas are dominated by bivalves and brachiopods; gastropods are less common. Characteristic faunal elements are *Grammatodon keyserlingii, Grammatodon schourovskii, Isognomon volaticum, Camptonectes morini, Buchia mosquensis, Astarte praeveneris, Isocyprina birkelundi, Thracia depressa,* and three species of *Pleuromya* (*P. uralensis, P. uniformis* and *P. triangularis*). Noteworthy is the occurrence of four species of *Hartwellia.* These rich faunas of the Pernaryggen Member formed the bulk of the material for the study. Within the Astartedal Member, benthic faunas occur in concretions at several horizons. The specimens are poorly preserved, and diversity is low. Typical forms are *Mesosaccella choroschowensis, Grammatodon schourovskii, Buchia mosquensis* and *Dentalium* sp.

The Hartz Fjeld Formation is unfossiliferous apart from a few horizons yielding poorly preserved *Entolium* and *Pleuromya,* and a shell bed near the base of the Formation (the so-called *Lingula* Bed) containing the inarticulate brachiopod *Lingula* and abundant bivalves. As it proved extremely difficult to extract specimens from the very hard sediment of the *Lingula* Bed, the fauna has only been discussed to a limited extent in the following account. Although supplemented by Spath's data, the faunal list given in table 8 is by no means comprehensive. Apart from *Lingula zeta, Eriphyla saemanni, Modiolus elongatus* and *Pleuromya uniformis* var. *peregrina* are characteristic faunal elements.

MATERIAL

Extensive collections of benthic faunas made during the 1977 expedition to East Greenland form the basis for this study. They were supplemented by material collected during earlier visits to Milne Land by T. Birkelund, J. H. Callomon, E. Håkansson, C. Heinberg and P. Willumsen. Spath's originals, depo-

sited in the Geological Museum of Copenhagen University, were also examined. The rest of Spath's material, originally collected by A. Rosenkrantz and H. Aldinger and at one time apparently stored at the British Museum of Natural History, London, seems to be lost.

Altogether, over 4000 bivalve specimens were collected, prepared and studied, whilst approximately another 10000 were simply identified in the field to provide basic data for a synecological analysis. The bulk of the material comes from the Aldinger Elv Member and Pernaryggen Member, where fossils are found concentrated in shell beds. Part of the material, mainly calcitic forms, is preserved with the shell; aragonitic faunal elements such as constitute a large proportion of the infauna were commonly found only as steinkerns. Frequently, such steinkerns (especially of species of *Pleuromya*) exhibit signs of compactional distortion rendering it very difficult to obtain quantitative morphological data. As all the bivalves are found in very hard sandstones, mechanical preparation using hammer and chisels was a prerequisite. In some cases it was possible to prepare the hinge using an air abrasive. Occasionally, the occurrence of moulds allowed casting of the hinge. This was accomplished by first sealing the rock with diluted shellac and then using silicone rubber. (A detailed account of casting techniques using silicone rubber has recently been given by Kelly & McLachlan, 1980).

Apart from a small reference collection which has been deposited with the Bayer. Staatssammlung für Paläontologie und historische Geologie München, the material is housed in Copenhagen, figured specimens (prefix MGUH) in the Geological Museum of Copenhagen University, the rest in the collections of the Geological Survey of Greenland.

TAXONOMY

Remarks. In the main, the synonymies only refer to the type specimens and list bibliographic references to material from Greenland. In a few cases, where a species has been discussed at greater length an attempt has been made to provide a more comprehensive synonymy list.

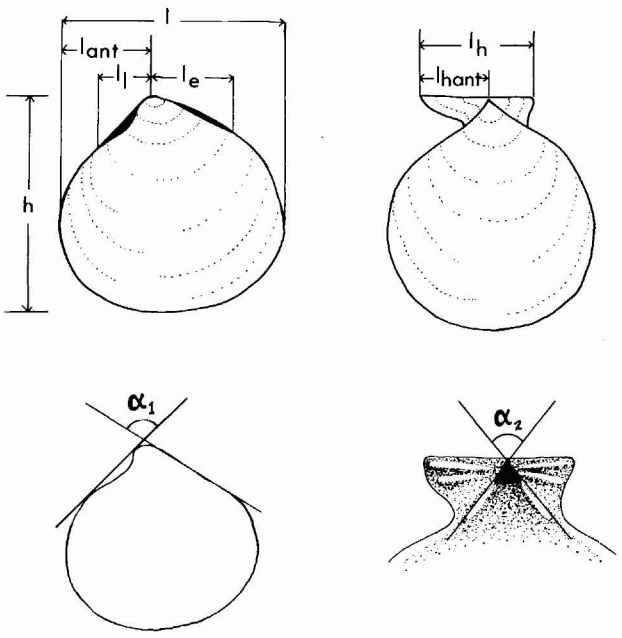

Fig. 3. Terminology used in the description of the species.

When giving measurements the following abbreviations have been used (see fig. 3):

l	= length	l_l	= length of lunule
h	= height	l_e	= length of escutcheon
d	= thickness	l_{ant}	= anterior length
h_{lig}	= height of ligament area	α_1	= umbonal angle (except pectinids)
l_h	= length of hinge line	α_2	= umbonal angle (pectinids)
l_{hant}	= length of anterior hinge line		

All measurements are given in centimetres.

Class Bivalvia Linné, 1758. Subclass Palaeotaxodonta Korobkov, 1954. Order Nuculoida Dall, 1889. Superfamily Nuculacea Gray, 1824. Family Nuculidae Gray, 1824.

Genus *Nuculoma* Cossmann, 1907.
Type species. Nucula castor d'Orbigny, 1849.

Nuculoma variabilis (J. de C. Sowerby, 1825)

Fig. 4E

*1825 *Nucula variabilis* sp. nov.; J. de C. Sowerby, p. 117, pl. 475, fig. 2.
1976 *Nuculoma variabilis* (Sowerby); Sanin, p. 22, fig. 18, pl. 1, figs 1–13, pl. 2, figs 1–10.

Material. 11 specimens from the Krebsedal Member at Krebsedal, the Pernaryggen Member at Hartz Fjeld, and the Astartedal Member at Hartz Fjeld and Lingularyggen (from GGU 235424–235425, 235485, 235552, 235566–235567).

Description. Shell small, rounded-triangular. Height about two-thirds of length, umbones prominent, strongly opisthogyrate; posterior portion of shell reduced, anterior much larger; anterior margin convex, forming blunt angle with ventral margin which is evenly convex; posterior margin forming yet another obtuse angle with ventral margin; posterodorsal margin slightly concave. Surface ornament of very fine commarginal ribs.

Remarks. Due to poor preservation nothing can be said about the hinge except that it is of the nuculid type. In shape, the specimens agree closely with Sowerby's figure of *Nucula variabilis* (1825, p. 117, pl. 475, fig. 2) and with the specimens described recently by Sanin (1976, p. 22, pl. 1, figs 1–13, pl. 2, figs 1–10) from the Lower Cretaceous of northern Siberia. According to Duff (1978, p. 22) the similar genus *Palaeonucula* possesses a smooth shell (in contrast to the commarginally ribbed shell of *Nuculoma*) and less strongly opisthogyrate and enrolled umbones.

Autecology. N. variabilis lived without doubt as a mobile infaunal deposit-feeder similar to Recent nuculids (see Yonge, 1939). Present-day *Nucula* ploughs through the sediment just below the depositional interface and feeds on organic detritus

which is collected with the help of palp proboscides. A similar mode of life may safely be assumed for its fossil relatives.

Superfamily Nuculanacea Adams & Adams, 1858. Family Malletiidae Adams & Adams, 1858.

Genus *Mesosaccella* Chavan, 1946.
Type species. Nucula foersteri Müller, 1847.

Mesosaccella choroschowensis (Borissjak, 1904)

Fig. 4 A–D

*1904 *Palaeoneilo choroschowensis* sp. nov.; Borissjak, p. 4, 32, pl. 2, fig. 11.

Material. 40 specimens from the Krebsedal Member at Hartz Fjeld, the Pernaryggen Member at Hartz Fjeld, Kronen and Bays Fjelde, and the Astartedal Member at Lingularyggen and Hartz Fjeld (from GGU 235418–235419, 235424–235425, 235432, 235465, 235476, 235479, 235485, 235491–235492, 235496–235498, 235500–235502, 235523, 235526–235527, 235566).

Description. Medium-sized, elongate-ovate shell; length usually twice the height; umbones small, orthogyrate, situated about one-fourth to one-third of shell length

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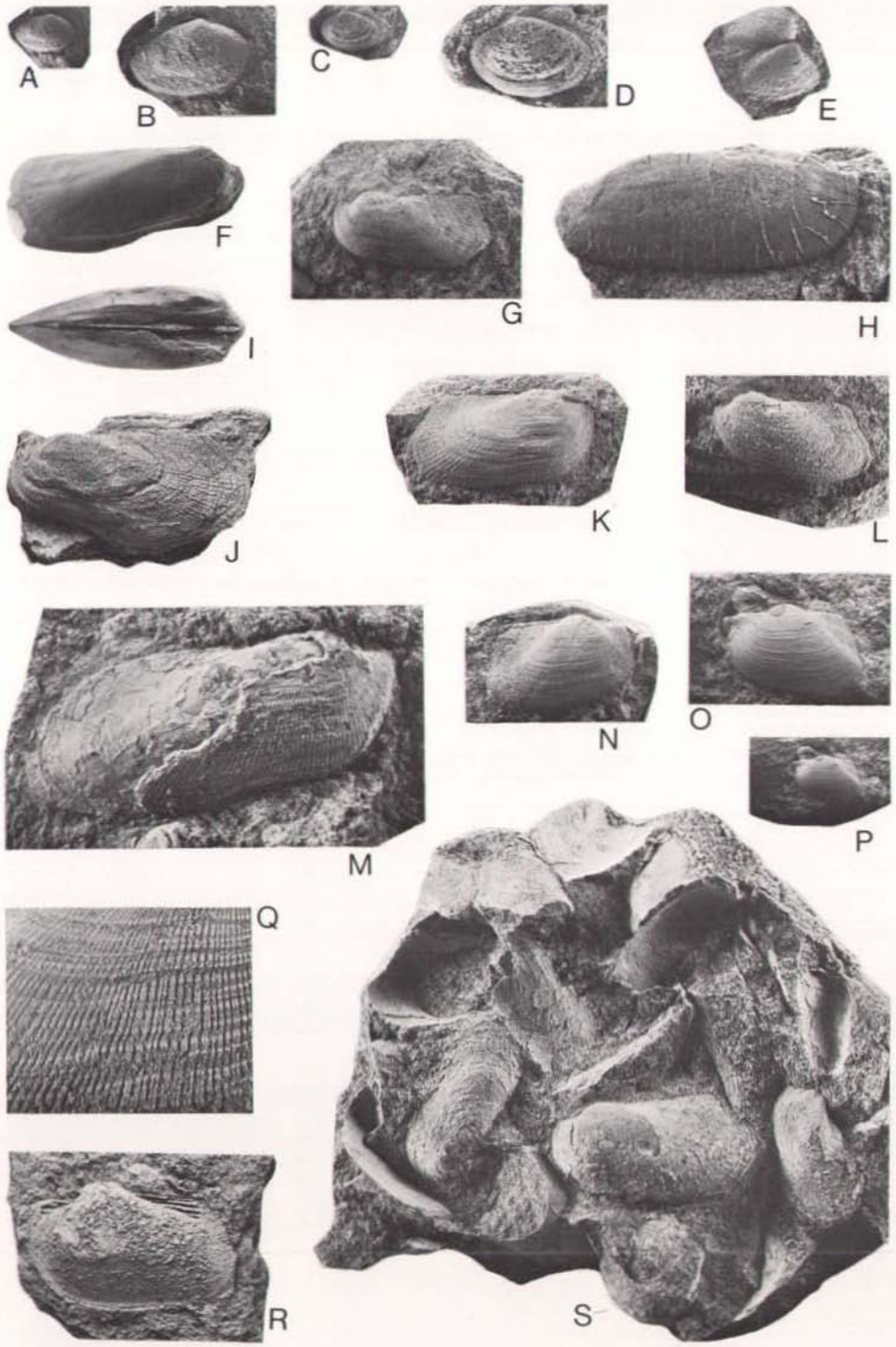
Fig. 4. *Mesosaccella choroschowensis* (Borissjak, 1904).
A, B. MGUH 15409 from GGU 235418; right valve; A, × 1; B, × 2. Pernaryggen Mb, Hartz Fjeld.
C, D. MGUH 15410 from GGU 235485; left valve; C, × 1; D, × 2. Astartedal Mb, Hartz Fjeld.

Nuculoma variabilis (J. de C. Sowerby, 1825).
E. MGUH 15411 from GGU 235566; left valve; × 1. Krebsedal Mb, Hartz Fjeld.

Grammatodon (Cosmetodon) keyserlingii (d'Orbigny, 1850).
F, I. MGUH 15412 from GGU 235529; steinkern, right (F) and dorsal (I) views; × 1. Pernaryggen Mb, Bays Fjelde.
G. MGUH 15413 from GGU 235535; left valve; × 1. Pernaryggen Mb, Hartz Fjeld.
J. MGUH 15414 from GGU 235563; left valve; × 1. Kosmocerasdal Mb, locality 4.
K. MGUH 15415 from GGU 235538; right valve; × 1. Pernaryggen Mb, Hartz Fjeld.
L. MGUH 15416 from GGU 235535; left valve; × 1. Pernaryggen Mb, Hartz Fjeld.
M. MGUH 15417 from GGU 235500; right valve; × 1. Pernaryggen Mb, Kronen.
Q. MGUH 15418 from GGU 235534; ornament of right valve; × 3. Pernaryggen Mb, Hartz Fjeld.
S. MGUH 15419 from GGU 235525; concretion; × 1. Pernaryggen Mb, Kronen.

Grammatodon (Grammatodon) schourovskii (Rouillier & Vosinsky, 1847).
N. MGUH 15420 from GGU 235569; right valve; × 1. Pernaryggen Mb, Hartz Fjeld.
O, P. MGUH 15421 from GGU 235577; left valve; O, × 2; P, × 1. Pernaryggen Mb, Hartz Fjeld.
R. MGUH 15422 from GGU 235539; internal cast of left valve; × 1. Pernaryggen Mb, Hartz Fjeld.

Solemya(?) sp.
H. MGUH 15423 from GGU 235476; internal cast of left valve; × 1. Astartedal Mb, Hartz Fjeld.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from the anterior. Anterior margin sharply rounded, anterodorsal margin with slight concavity in front of umbo; ventral margin evenly rounded, posterodorsal margin slightly convex, forming a blunt angle with posterior margin which is truncate. Shell surface covered with faint commarginal growth lines.

Hinge teeth chevron-shaped, points directed towards the umbo; hinge without resilifer, but teeth terminating just either side of umbo.

Remarks. Shape as well as hinge of the Milne Land specimens demonstrate that they belong to *Mesosaccella,* a genus which Duff (1978, p. 27) recently placed in the Malletiidae and not, as hitherto, in the Nuculanidae, because of a lack of a resilifer. The Greenland specimens closely resemble *Palaeoneilo amygdala* and *P. choroschowensis* (Borissjak, 1904, pl. 2, figs 8a–c, 11a–b), both of which probably represent morphological variants of the same species (*P. choroschowensis* has taxonomic priority). They differ from *M. morrisi* (Deshayes, 1853) and *M. dammariensis* (Buvignier, 1852) mainly in being less elongate.

Autecology. The presence of a small pallial sinus in *Mesosaccella* indicates that the individuals were siphonate. Duff (1978, p. 19) compared *Mesosaccella* with Recent species of *Yoldia* and suggested that it might have lived in a similar way: buried in the sediment with the anterior pointing downwards, and collecting food from within the sediment with the help of the palp proboscides (see Yonge, 1939).

Subclass Cryptodonta Neumayr, 1884. Order Solemyoida Dall, 1889. Superfamily Solemyacea Adams & Adams, 1857. Family Solemyidae Adams & Adams, 1857.

Genus *Solemya* Lamarck, 1818.
Type species. Solemya mediterranea Lamarck, 1818 (= *Tellina togata* Poli, 1795).

Solemya(?) sp.

Fig. 4 H

Material. 2 specimens from the Pernaryggen Member at Hartz Fjeld and Kronen (from GGU 234476, 235516).

Description. Very elongate, compressed shell; posterodorsal and ventral margins straight and parallel to each other; posterior rounded, anterior rounded-subacute. Umbones small, depressed, nearly level with hinge margin.

Remarks. The specimens are slightly squashed, smooth, internal casts not exhibiting the typical radial ornament of *Solemya.* Their shape, however, corresponds well to *Solemya* described from the Upper Jurassic (e.g. *Solemya togata* Trautschold, 1858, p. 550, pl. 4, fig. 3).

Autecology. Recent *Solemya velum* constructs a vertical U-shaped burrow with a deep extension (Stanley, 1970, p. 120) and lives as a suspension-feeder in the lowest portion of the U-tubes. It has also been observed swimming, but this is very unlikely to be the dominant mode of life. By analogy, Jurassic *Solemya* are also interpreted as mobile, deep burrowing, low-level suspension-feeders.

Subclass Pteriomorphia Beurlen, 1944. Order Arcoida Stoliczka, 1871. Superfamily Arcacea Lamarck, 1809. Family Parallelodontidae Dall, 1898. Subfamily Grammatodontinae Branson, 1942.

Genus *Grammatodon* Meek & Hayden, 1861.
Type species. Arca (Cucullaea) inornata Meek & Hayden, 1859.

Grammatodon (Grammatodon) schourovskii (Rouillier & Vosinsky, 1847)

Figs 4 N–P, R

*1847 *Cucullaea Schourovskii* sp. nov.; Rouillier & Vosinsky, p. 428.
1848 *Cucullaea Schourovskii* Rouillier & Vosinsky; Rouillier & Vosinsky, p. 287, pl. H, figs 39A, B.
1899 *Macrodon Schourovskii* Rouillier; Pompeckj, p. 67, pl. 1, fig. 17.
1905 *Macrodon Schourovskii* Rouillier; Borissjak, p. 12, pl. 2, figs 10–12.
1905 *Macrodon Schourovskii* Rouillier, var. a; Borissjak, p. 12, pl. 2, fig. 13.
1905 *Macrodon Schourovskii* Rouillier, var. b; Borissjak, p. 13, pl. 2, fig. 14.
v.1936 *Parallelodon schourovskii* (Rouillier); Spath, p. 113, pl. 43, figs 2a–e, pl. 49, figs 4a–b, 5.
1955 *Parallelodon schourovskii* (Rouillier & Vosinski); Gerasimov, p. 49, pl. 1, figs 17–18.
1978 *Grammatodon schourovskii* (Rouillier); Zakharov & Schurygin, p. 110, pl. 2, figs 4–5.

Material. 161 specimens from the Pernaryggen Member at Hartz Fjeld (from GGU 235416, 235418–235420, 235423–235425, 235432, 235440–235441, 235447, 235465, 235476, 235485, 235536–235539, 235543, 235547, 235567, 235569, 235575, 235577), Bays Fjelde (235522–235524), and Kronen (235491–235494, 235496–235497, 235499, 235505–235508, 235510), the Cardiocerasknøft Member at Cardiocerasknøft (235544, 235578), and the Krebsedal Member at Hartz Fjeld (235479).

Description. Strongly inflated, short shell, trapezoidal in outline; umbones rounded, prominent, situated about one-third to two-fifths of shell length from the anterior; anterior margin straight dorsally, curving backwards to meet the ventral margin which is straight to slightly convex; posterior margin obliquely truncated; rounded carina running from umbo to posteroventral margin.

Shell relatively thick, ornament consisting of very fine growth lines. Ligament area broad, hinge line straight, nearly as long as length of shell, hinge with up to 9 short anterior teeth and 4 short to long posterior teeth.

Remarks. This species is very common in the Pernaryggen Member, sometimes forming near-monotypic assemblages. There is a certain variation with regard to

degree of inflation and length/height ratio (fig. 5) which renders Borissjak's *Macrodon Schourovskii* var. a and b part of a continuous range. The fine radial ornament present on Spath's pl. 43, fig. 2b has not been found on any other specimen and seems not to be typical.

Autecology. Like other members of the Parallelodontidae, *G. schourovskii* most likely lived byssate, although no byssal gape is observable. Judging from the short, highly inflated shell, it lived on the substrate and not endobysally. Trophic group: low level suspension-feeder.

Subgenus *Cosmetodon* Branson, 1942.
Type species. Arca keyserlingii d'Orbigny, 1850.

Grammatodon (Cosmetodon) keyserlingii (d'Orbigny, 1850)

Figs 4 F–G, I–M, Q, S

*1850 *Arca Keyserlingii* d'Orb.; d'Orbigny, p. 369, No. 357.
1933 *Macrodon keyserlingi* d'Orb.; Frebold, p. 25, pl. 2, fig. 21.
1933 *Macrodon* cf. *M. keyserlingi* d'Orb.; Frebold, p. 21, pl. 2, figs 14–16.
v.1935 *Parallelodon keyserlingi* (d'Orbigny); Spath, p. 58, pl. 15, fig. 7.
v.1936 *Parallelodon* sp. nov.? aff. *P. keyserlingi* (d'Orbigny); Spath, p. 112, pl. 43, fig. 3, pl. 44, fig. 6, pl. 45, fig. 2, pl. 49, fig. 3.

Material. 198 specimens from the Pernaryggen Member at Kronen (from GGU 235492, 235494, 235498, 235500–235508, 235517, 235525), Hartz Fjeld (235417, 235420–235423, 235428, 235430, 235443–235444, 235448, 235471, 235534–235535, 235538–235539, 235547, 235577) and Bays Fjelde (235522, 235524, 235526, 235529), 8 specimens from the Aldinger Elv Member (235453–235456, 235460, 235555–235556), and 14 specimens from the Kosmocerasdal Member at locality 4 (235563–235564).

Description. Medium- to large-sized *Grammatodon* (some specimens over 6.5 cm in length), elongate, trapezoidal, moderately inflated; length between 1.7 times and twice the height; umbones broad, depressed, situated between one-fifth and one-eight of shell length from the anterior. Anterior short; anterior margin either straight and forming a right angle with hinge line or else slightly convex; anteroventral margin well rounded; ventral margin sinuous, with slight to conspicuous sulcus in the anterior half and sloping downwards towards the posterior. Posteroventral margin well rounded, posterior margin obliquely truncated, straight, sometimes slightly concave dorsally. Broad, well rounded carina running from the umbones to the posteroventral margin, preceded anteriorly by broad, shallow sulcus. A faint gape is present between both valves at the ventral margin in the region of the sulcus. Internal features not observable. Shell ornament consisting of radial riblets, crossed by less conspicuous growth lines.

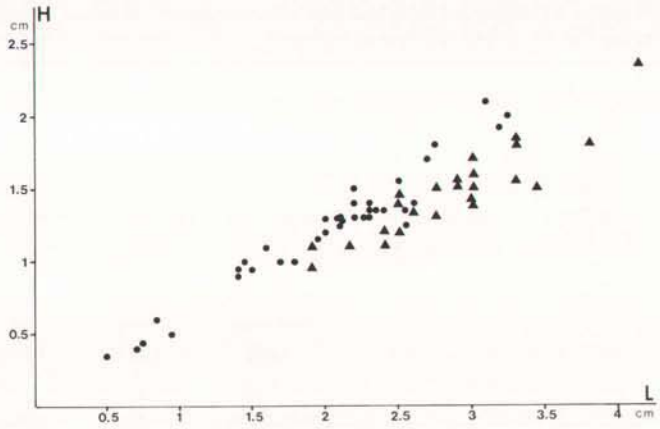

Fig. 5. Lenght/height ratio of *Grammatodon (G.) schourovskii* (dots) and *Grammatodon (C.) keyserlingii* (triangles) from the Pernaryggen Member.

Remarks. G. keyserlingii is a highly variable species. Size, position of umbones, length/height ratio (fig. 5), shape of anterior and posterior margins, degree of downward curvature of ventral margin all vary considerably even within one population. This must be the reason why a large number of names exists for what seems to be just one variable species. A detailed discussion of the synonymy of this species is beyond the scope of the present paper, but there can be little doubt that *G. lutugini* (Borissjak, 1905) and possibly also *G. productum* (Rouillier & Vosinski, 1847) and *G. menandellensis* (de Loriol, 1867) belong in the synonymy of *G. keyserlingii* which seems to have a range at least from the Callovian to the uppermost Jurassic.

Autecology. The existence of a narrow byssal gape in the ventral margin of *G. keyserlingii* indicates that the species was byssate. Judging from its modified shape and the expanded posterior, it most likely lived semi-infaunally, in the way envisaged by Stanley (1972, fig. 15 c), for Palaeozoic species of *Parallelodon.* Trophic group: low level suspension-feeder.

Family Cucullaeidae Stewart, 1930.

Genus *Lopatinia* Schmidt, 1872.
Type species. Pectunculus petschorae Keyserling, 1846.

Lopatinia (Lopatinia) callomoni sp. nov.

Fig. 6 E, G

Holotype. MGUH 15430 from GGU 235573 from the Aldinger Elv Member, valley north of Cardioceraskløft.

Material. 42 specimens from the Aldinger Elv Member at locality 3 and valley north of Cardioceraskløft (from GGU 235554–235555, 235573).

Derivatio nominis. After J. H. Callomon.

Diagnosis. Elongate-ovate *Lopatinia* with rounded posterior carina and obliquely truncated posterior; umbones situated two-fifths of shell length from the anterior. Surface covered with fine radial costellae and conspicuous, well spaced commarginal growth lines.

Description. Thick, elongate-ovate shell; umbones rounded, not very prominent, slightly protruding beyond the dorsal margins, situated about two-fifths of shell length from the anterior; dorsal margin convex, posterior obliquely truncated, ventral margin gently convex, anterior margin well rounded; with obtuse ridge running from the umbones to the posteroventral margins. Cardinal area with well developed amphidetic duplivincular ligament with several chevron-shaped grooves; hinge line curved, with several (usually between 10 and 14) small, transverse teeth in the middle, flanked on each side by about 4 pseudolaterals which run nearly parallel to posterior margin. The middle series of teeth is gradational with the marginal laterals. Shell surface covered with numerous fine radial costellae which are crossed by conspicuous wider spaced commarginal growth lines.

Remarks. This species abounds at some horizons in the Aldinger Elv Member, where it forms, together with *Arctica syssollae* and *Praebuchia kirghisensis,* the majority of the fauna.

In shape, *L. callomoni* is intermediate between *Idonearca* and *Lopatinia.* Its dentition, however, clearly shows that it belongs to the latter genus. There are no other species of *Lopatinia* with which it can be confused; both *L. petschorae* and *L. jenisseae* from the Lower Cretaceous of northern Russia are more equilateral, and both lack the umbonal ridge and the obliquely truncated posterior.

Autecology. L. callomoni does not exhibit a byssal sinus; the ovoid shape and very moderate inflation favour an infaunal mode of life with the truncated posterior situated more or less at the sediment-water interface. An identical mode of life has been suggested by Stanley (1972) for Mesozoic *Cucullaea* species.

Order Mytiloida Férussac, 1822. Superfamily Mytilacea Rafinesque, 1815. Family Mytilidae Rafinesque, 1815. Subfamily Crenellinae Adams & Adams, 1857.

Genus *Musculus* Röding, 1798.
Type species. Mytilus discors Linné, 1767.

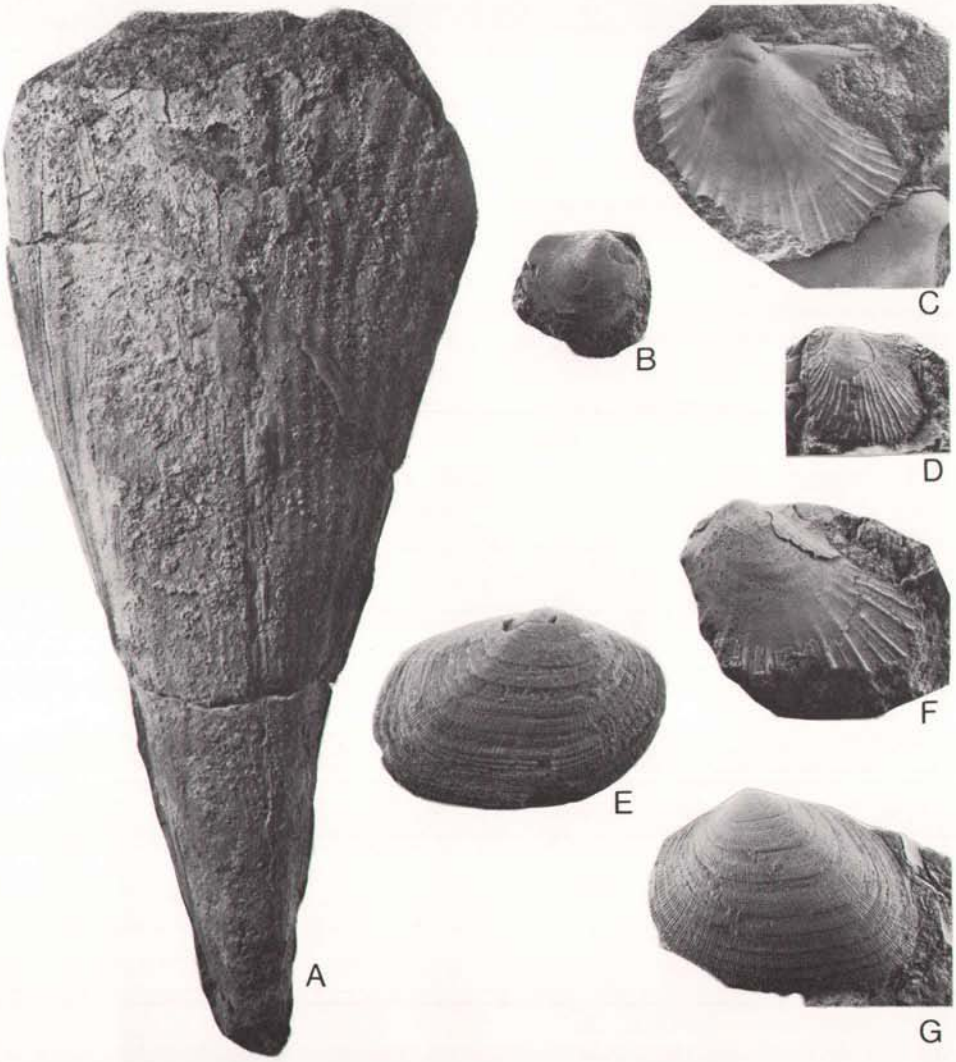

Fig. 6. *Pinna (Pinna) lanceolata* J. Sowerby, 1821.
A. MGUH 15424 from GGU 235407; bivalved specimen, right view; × 1. Pernaryggen Mb, Hartz Fjeld.
Oxytoma (Oxytoma) inequivalve (J. Sowerby, 1819)
B. MGUH 15425 from GGU 235514; bivalved specimen, right view; × 2. Pernaryggen Mb, Kronen.
C. MGUH 15426 from GGU 137415; left valve; × 1. Pernaryggen Mb, Hartz fjeld.
D. MGUH 15427 from GGU 235401; left valve; × 1. Pernaryggen Mb, Hartz Fjeld.
F. MGUH 15428 from GGU 235538; left valve; × 1. Pernaryggen Mb, Hartz Fjeld.
Lopatinia (Lopatinia) callomoni sp. nov.
E. MGUH 15429 from GGU 235554; bivalved specimen, right view; × 1. Aldinger Elv Mb, locality 3.
G. MGUH 15430 from GGU 235573; left valve (holotype); × 1. Aldinger Elv Mb, valley north of Cardioceraskløft.

Musculus (Musculus) fischerianus (d'Orbigny, 1845)

Fig. 7 G–H

1843 *Modiola pulcherrima* (Roemer); Fischer, p. 134 (*non* Roemer, 1836).
*1845 *Mytilus fischerianus* sp. nov.; d'Orbigny, p. 464, pl. 39, figs 26–28.
1955 *Musculus fischerianus* (d'Orbigny); Gerasimov, p. 135, pl. 21, fig. 5.

Material. 2 specimens from the Pernaryggen Member at Hartz Fjeld (from GGU 235420, 235423).

Description. Small-sized, equivalve, strongly inequilateral shell, modioliform; umbones low, subterminal; both ventral and dorsal margins slightly convex; posterior end rounded. Anterior with about 8 to 9 rounded radial ribs which fade in strength towards the posterior. Posterior of shell with about 25 fine, rounded radial ribs separated by concave grooves of the same width. Central part of shell smooth apart from fine commarginal growth lines which, when crossing the ribbed parts of the shell, create a reticulate pattern in which the radial elements dominate.

Autecology. Judging from its cross-sectional shape, which is widest at a point above the middle of the height, *M. fischerianus* lived semi-infaunally (cf. Stanley, 1970), as an endobyssate, low-level suspension-feeder.

Subfamily Modiolinae Keen, 1958.

Genus *Modiolus* Lamarck, 1799.
Type species. Mytilus modiolus Linné, 1758.

Modiolus (Modiolus) bipartitus J. Sowerby, 1818

Fig. 7 C–D

*1818 *Modiola bipartita* sp. nov.; J. Sowerby, p. 17, pl. 210, fig. 4 (*non* fig. 3).
1929 *Modiola bipartita* J. Sowerby; Arkell, p. 55, pl. 2, figs 1–4, text-fig. 8.
1978 *Modiolus (Modiolus) bipartitus* J. Sowerby; Duff, p. 41, pl. 2, figs 28–33.

Fig. 7. *Modiolus (Strimodiolus) strajeskianus* (d'Orbigny, 1845).
A. MGUH 15431 from GGU 235463; bivalved specimen, right view; × 1. Aldinger Elv Mb, locality 25.
B. MGUH 15432 from GGU 235462; right valve; × 1. Aldinger Elv Mb, locality 25.
E. MGUH 15433 from GGU 235571; bivalved specimen, right view; × 1. Aldinger Elv Mb, Cardioceraskløft.
Modiolus (Modiolus) bipartitus J. Sowerby, 1818.
C, D. MGUH 15434 from GGU 235548; bivalved specimen, left (C) and dorsal (D) views; × 1. Pernaryggen Mb, Hartz Fjeld.

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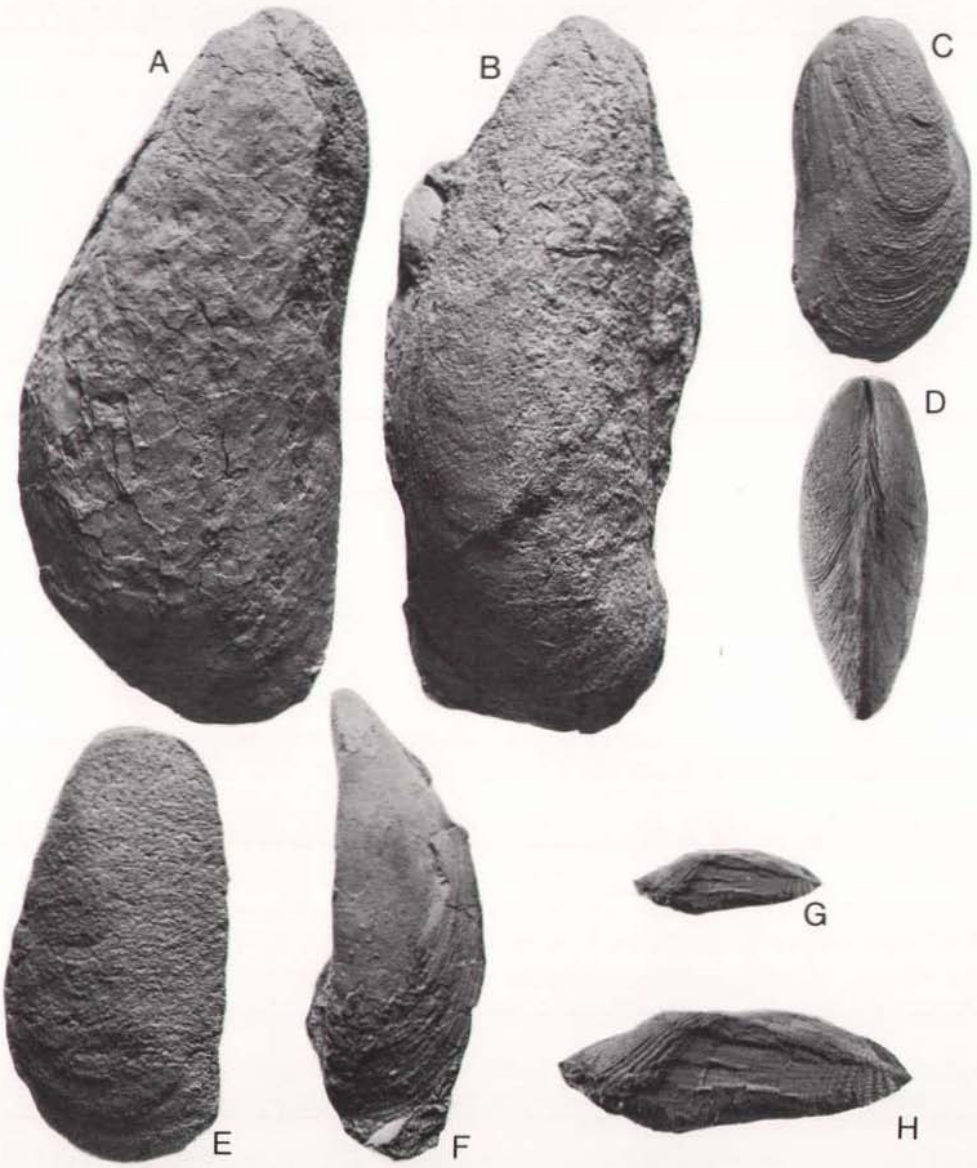

Fig. 7 *cont.*

Falcimytilus suprajurensis (Cox, 1925).
F. MGUH 15435 from GGU 235441; left valve; × 1. Pernaryggen Mb, Hartz Fjeld.
Musculus (Musculus) fischerianus (d'Orbigny, 1845).
G, H. MGUH 15436 from GGU 235420; bivalved specimen, right view; G, × 1; H, × 2. Pernaryggen Mb, Hartz Fjeld.

Material. 4 specimens from the Pernaryggen Member at Hartz Fjeld (from GGU 235411–235412, 235548–235549).

Description. Medium-sized *Modiolus,* umbones nearly terminal; hinge line short, anterior margin short and oblique; ventral margin slightly concave running obliquely downwards to meet the posterior margin which forms a wide arch running nearly parallel to the ventral margin up to the umbo. Umbonal ridge well defined and preceded anteriorly by shallow sulcus. Shell ornament consisting of growth lines which are more conspicuous on part of shell dorsal of umbonal ridge.

Measurement.	GGU sample	l	h	h/l (%)
	235548	3.7	3.1	83.8

Remarks. The Milne Land specimens agree well with *M. bipartitus* as described in detail by Arkell (1929, p. 55) from the Corallian of England. As this species occurs as early as Callovian, it is one of the long-ranging species of Jurassic bivalves.

Subgenus *Strimodiolus* subgen. nov.
Type species. Modiolus elongatus sp. nov.

Derivatio nominis. Stria (Lat.) = stripe, line.

Diagnosis. Elongate *Modiolus* with radial striae restricted to posterodorsal part of shell. Anteroventral part of shell smooth.

Remarks. Due to the presence of radial riblets, Zakharov & Shurygin (1978) placed *M. czekanowskii,* and Zakharov & Mesezhnikov (1974) *M. strajeskianus* tentatively within the genus *Musculus* (subfamily Crenellinae) rather than with *Modiolus* (subfamily Modiolinae). However, the ornament of *M. strajeskianus* (and likewise of *M. czekanowskii)* is usually very faint and often even absent, and is

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Fig. 8. *Modiolus (Strimodiolus) elongatus* sp. nov.
A. MGUH 15437 from GGU 235403; bivalved specimen, right view; × 1. Pernaryggen Mb, Hartz Fjeld.
E. MGUH 15438 from GGU 137509; bivalved specimen, left view; Hennigryggen Mb, Lingularyggen.
F, G. MGUH 15439 from GGU 235451; bivalved specimen (holotype), right (F) and dorsal (G) views; × 1. Pernaryggen Mb, Hartz Fjeld.
Modiolus (Strimodiolus) strajeskianus (d'Orbigny, 1845).
B. MGUH 15440 from GGU 235572; left valve; × 1. Aldinger Elv Mb, valley north of Cardioceraskløft.
Modiolus (Strimodiolus) czekanowskii (Lahusen, 1886).
C. MGUH 15441 from GGU 235403; bivalved specimen, left view; × 1. Pernaryggen Mb, Hartz Fjeld.
D. MGUH 15442 from GGU 137473; bivalved specimen, right view; × 1. Pernaryggen Mb, Hartz Fjeld.


A
B
C
D
E
F
G

moreover always restricted to the dorsal shell margin. As no other diagnostic features of *Musculus* are found, such as dysodont teeth and a crenulated shell margin, it seems most reasonable to keep these species as a subgenus within *Modiolus*.

Modiolus (Strimodiolus) czekanowskii (Lahusen, 1886)

Fig. 8 C–D

*1886 *Modiola Czekanowskii* sp. nov.; Lahusen, p. 5, pl. 2, figs 2, 2a.

Material. 18 specimens from the Pernaryggen Member at Hartz Fjeld and Kronen (from GGU 235403–235405, 235420–235423, 235427, 235440–235444, 235513, 235516, 234019, 137475).

Description. Medium-sized, transversely elongate, slightly conical shell, equivalve, highly inequilateral, moderately inflated. Umbones small, subterminal, prosogyrate; anterior end very short, convex; posterior end much larger and higher, well rounded; umbonal ridge faint and very broad, situated in the region of maximum inflation. Shell smooth except for very faint irregular growth lines and some very fine radial ribs running parallel and close to the dorsal margin.

Measurements.

GGU sample	l	h	h/l (%)
235403	6.0	2.4	40.0
137473	6.4	2.45	38.3
234019	7.3	2.5	34.2

Remarks. M. czekanowskii is closely related to *M. strajeskianus*; the latter differs in reaching a considerably larger size and in having a slightly different outline (fig. 8), less conical, but obliquely truncated posteriorly.

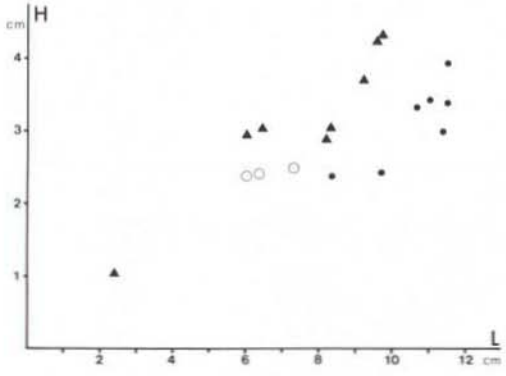

Fig. 9. Length/height ratio of *Modiolus (Strimodiolus) strajeskianus* (triangles), *Modiolus (S.) czekanowskii* (circles) and *Modiolus (S.) elongatus* (dots).

Modiolus (Strimodiolus) strajeskianus (d'Orbigny, 1845)

Figs 7 A–B, E; 8 B

*1845 *Mytilus strajeskianus* sp. nov.; d'Orbigny, p. 463, pl. 39, figs 22–23.
1911 *Modiola strajeskiana* d'Orbigny; Ravn, p. 467, pl. 33, fig. 9.
non v. 1936 *Modiolus strajeskianus* (d'Orbigny); Spath, p. 110, pl. 46, figs 4a–c.
1966 *Modiolus strajeskianus* (d'Orbigny); Zakharov, p. 122, pl. 44, figs 2–5.
1974 *'Musculus' strajeskianus* (d'Orbigny); Zakharov & Mesezhnikov, p. 137, pl. 28, fig. 2.

Material. 43 specimens from the Aldinger Elv Member, 5 specimens from the Cardiocerasløft Member at Cardiocerasløft, and 2 specimens from the Kosmocerasdal Member at locality 4 (from GGU 235452, 235460–235463, 235544, 235555–235556, 235561, 235571–235573).

Description. Medium to large-sized, moderately to strongly inflated *Strimodiolus.* Umbones subterminal; anterior margin very short, convex, ventral margin straight to slightly concave; posterior margin rounded, obliquely truncated; dorsal margin straight anteriorly and convex towards the posterior; maximum height of shell about one-third of length from the posterior end. Broad, rounded ridge running in a wide arch from the umbones to the posteroventral margins, in some specimens preceded anteriorly, particularly near the ventral margin, by a very faint sulcus.

Measurements.

GGU sample	l	h	h/l (%)
235572–1	8.3	3.05	36.7
235572–2	8.2	2.9	35.4
235460	9.6	4.25	44.3
235463	9.7	4.3	44.3
235462	9.2	3.7	40.2
235555	2.4	1.05	43.7
235571–1	6.45	3.05	47.3
235571–2	6.0	2.95	49.2

Remarks. M. strajeskianus differs from *M. czekanowskii* in being more inflated and having a different overall shape (see also Zakharov, 1966, fig. 19). *M. strajeskianus,* as defined here, exhibits a very wide range of variation and includes specimens which are relatively short, but fairly high and inflated as well as specimens which are elongate with the dorsal margin running subparallel to the ventral margin. End members of the range of variation look very different, but as all gradations are present and intermediate forms dominate, it seems inadvisable to split them into two species.

Modiolus (Strimodiolus) elongatus sp. nov.

Fig. 8A, E–G

v.1936 *Modiolus* sp. indet.; Spath, p. 111, pl. 48, fig. 2.
?1978 *Musculus*(?) *czekanowskii* (Lahusen); Zakharov & Shurygin, p. 111, pl. 2, fig. 6 only.

Holotype. MGUH 15439 from GGU 235451 from the Pernaryggen Member at Krebsedal.

Derivatio nominis. Elongatus (Lat.) = elongate.

Material. 14 specimens from the Pernaryggen Member at Hartz Fjeld, Kronen and Bays Fjelde; 11 specimens from the *Lingula* Bed of the Hartz Fjeld Formation at Lingularyggen (from GGU 235401–235405, 235434–235435, 235451, 235483, 235576, 235525, 237509, 137551).

Diagnosis. Large-sized, very elongate *Strimodiolus;* umbones subterminal; dorsal margin subparallel to ventral margin; dorsal half of shell sometimes bearing very faint radial striae.

Description. Large, equivalve, moderately inflated, strongly inequilateral shell; umbones anteriorly displaced, subterminal; anterior margin very short, convex; ventral margin straight to slightly concave; dorsal margin straight anteriorly, turning into a wide convex arch posteriorly and running subparallel to the ventral margin. Posterior rounded, but somewhat tapering. Maximum height of shell situated about two-thirds of distance from the anterior. Umbonal ridge broad, not very conspicuous, sometimes preceded anteriorly by very faint sulcus. The ornament consists of fine commarginal growth lines and, in the dorsal half of shell, equally fine radial striae. They are visible in well preserved specimens only.

Measurements.

GGU sample	l	h	h/l (%)
235451	11.5	3.95	34.3
235451	11.4	3.00	26.3
137501	10.7	3.35	31.3
235516	11.05	3.45	31.2
235435	9.7	2.75	28.3
235404	8.35	2.40	28.7
235483	11.5	3.40	29.6

Remarks. M. elongatus was described by Spath (1936, p. 111) from the Astartedal Member and the *Lingula* Bed as *Modiolus* sp. indet., as he was unable to relate it to any of the known species. *M. elongatus* differs from most other *Modiolus* by its very elongate shape (fig. 9). It resembles *M. scalprum* from the Liassic of England in size and elongation (Sowerby, 1821, pl. 248), but the latter species has a different outline. *M. elongatus* is very close to *M. czekanowskii,* but differs in outline. The specimen figured by Zakharov & Shurygin (1978, pl. 2, fig. 6) as *Musculus*(?) *czekanowskii* might well be a *M. elongatus* judging from their illustration. *Modiolus virgulinus* (Étallon) (Thurmann & Étallon 1862, p. 224, pl. 29, fig. 6) is also very similar except that the umbones of *M. elongatus* are less terminal and the height/length ratio is lower than in the former species in which, moreover, no radial ornament has been observed.

Autecology of *Modiolus.* In several cases, specimens of *Modiolus* were found preserved in their life position within the sediment. *M. (Strimodiolus) strajeskianus*

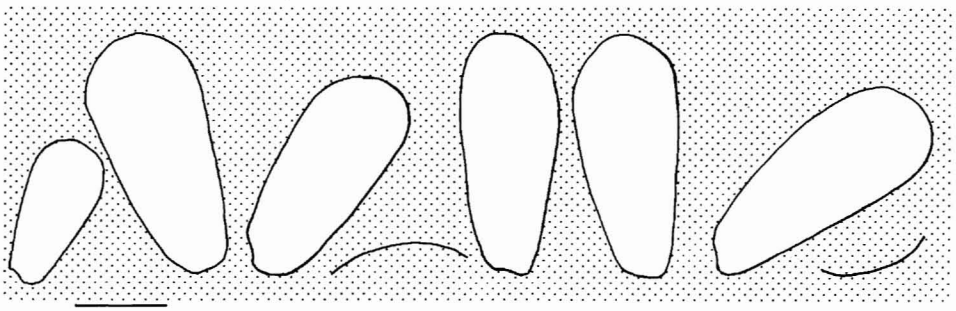

Fig. 10. Sketch of *Modiolus (S.) strajeskianus* preserved in life position. Scale: 2 cm. Aldinger Elv Member, Cardioceraskløft.

was observed in a vertical or steeply inclined position within the sediment (medium-grained sands of the Aldinger Elv Member at Cardioceraskløft) forming small clusters of 10 to 15 individuals (fig. 10). Obviously the species was partially buried and therefore can be classified as a semi-infaunal, byssate, high level suspension-feeder. A nearly identical life position was found in specimens of *M. (Str.) elongatus,* both in the Lingula Bed and in sandstones of the Pernaryggen Member at Kronen. In the latter, rare specimens of *M. (Str.) czekanowskii* were found in the same attitude. The latter two species were never found in clusters, and it seems that they lived as scattered individuals.

Stanley's (1970, p. 27; 1972) observation on the relationship between cross-sectional shape and epi- or semi-infaunal mode of life can be confirmed for these Upper Jurassic species: In all of them, the widest portion of the shell is between the dorsal margin and the centre of the shell, this being characteristic of a semi-infaunal mode of life.

M. bipartitus, which was not observed in life position, exhibits a similar cross-section. This, together with its wedge-shaped ventral region, favours an interpretation of *M. bipartitus* as a semi-infaunal byssate high level suspension-feeder, like the other Greenland *Modiolus* species.

Genus *Falcimytilus* Cox, 1937.
Type species. Mytilus suprajurensis Cox, 1925.

Falcimytilus suprajurensis (Cox, 1925)

Fig. 7 F

1871 *Mytilus unguiculatus* sp. nov.; Philipps, p. 330, pl. 15, fig. 7 (*non* Salter).
*1925 *Mytilus suprajurensis* sp. nov.; Cox, p. 142, pl. 1, fig. 9, pl. 3, fig. 2.

1929 *Mytilus suprajurensis* Cox; Cox, p. 168, pl. 4, fig. 1.
1937 *Mytilus (Falcimytilus) suprajurensis* Cox; Cox, p. 344, pl. 17, figs 1–3.
1955 *Dreissena*(?) *subfalcata* (Eichwald); Gerasimov, p. 69, pl. 36, fig. 5.
1965 *Mytilus (Falcimytilus) dietrichi* sp. nov; Cox, p. 40, pl. 3, figs 15–16.
1969 *Septifer*(?) *subfalcatus* (Eichwald); Gerasimov, p. 71, pl. 18, fig. 8.

Material. 2 specimens from the Pernaryggen Member at Hartz Fjeld (from GGU 235440–235441, 235540–235541).

Description. Medium-sized, equivalve, strongly inequilateral, inflated shell, sickle-shaped; umbones pointed and terminal. With strongly pronounced carina running from the umbo to the posteroventral margin causing a very sharp angulation of the valves. Dorsal margin convex, meeting posterior margin in a gentle curve; ventral margin concave; both form a very blunt angle at the posteroventral end. Shell moderately thick with fine commarginal growth lines. Internal features not visible.

Remarks. F. suprajurensis was described by Cox from the Portlandian of England, and, according to him (1937, p. 344) varies to some extent in width and curvature. In 1965, Cox described another species of *Falcimytilus (F. dietrichi)* from the Oxfordian of East Africa differing from *F. suprajurensis* mainly in being smaller. As the Milne Land specimens are intermediate in size between the two other species, it seems very likely that they all conspecific. *Dreissena*(?) *subfalcata* and *Septifer*(?) *subfalcatus* as figured by Gerasimov (1955, 1969) from the Volgian of Russia are identical with the Milne Land specimens, whilst d'Eichwald's original figure of *Modiola subfalcata* (1865, p. 533, pl. 21, fig. 14) from the Neocomian of northern Siberia may represent a different species (possibly conspecific with it: *Mytilus commaeformis* Zakharov, 1966, pl. 43, figs 1–2).

Autecology. The strongly pronounced carina of *F. suprajurensis* results in a flattened and even somewhat concave ventral region which would have served as an ideal area to rest on the substrate. The cross-sectional shape thus indicates that the species probably lived like Recent *Mytilus,* that is, fixed onto the substrate with a byssus. It can, therefore, be classified as an epibyssate low level suspension-feeder.

Fig. 11. *Pinna (Pinna) lanceolata* J. Sowerby, 1821.
A. MGUH 15443 from GGU 235541; bivalved specimen, right view; × 1. Pernaryggen Mb, Hartz Fjeld.
D. MGUH 15444 from GGU 137549; bivalved specimen, right view; × 1. Pernaryggen Mb, Hartz Fjeld.
Aguilerella aldingeri sp. nov.
B. MGUH 15445 from GGU 235555; right valve (holotype); × 1. Aldinger Elv Mb, locality 3.
Isognomon (Isognomon) volaticum Zakharov, 1966.
C. MGUH 15446 from GGU 235538; bivalved specimen, right view; × 1. Pernaryggen Mb, Hartz Fjeld.


A
B
C
D

Superfamily Pinnacea Leach, 1819. Family Pinnidae Leach, 1819.

Genus *Pinna* Linné, 1758.
Type species. Pinna rudis Linné, 1758.

Pinna (Pinna) lanceolata J. Sowerby, 1821

Figs 6 A; 11 A, D

*1821 *Pinna lanceolata* sp. nov.; J. Sowerby, p. 145, pl. 281.
v.1936 *Pinna constantini* P. de Loriol; Spath, p. 100, pl. 44, fig. 4, pl. 45, figs 5–6.

Material. 32 specimens from the Pernaryggen Member at Hartz Fjeld, Kronen and Bays Fjelde; 2 specimens from the *Lingula* Bed (Hartz Fjeld Formation) (from GGU 235403–235407, 235440–235441, 235468–235469, 235498–235502, 235507–235508, 235513, 235531, 235549, 137515, 137549, 137726).

Description. Very large, narrow, thin-shelled *Pinna;* dorsal margin slightly concave, ventral margin straight to weakly convex, both diverging slightly and regularly from the umbo towards the posterior end. Posterior margin truncate, forming blunt angles with the ventral and dorsal margins. Umbones blunt; with median carina running from the umbones to the posterior margin dividing shell into two nearly equal halves; area dorsal of the carina with 8 to 9 radial ribs which, in some cases, fade away towards the posterior end; area ventral to the carina with 5–8 radial ribs which are confined to the region adjacent to the carina; only the first 4–5 ribs are distinct, the others fade away towards the ventral margin. The ribs on the area ventral to the carina start about 1 cm from the umbones and increase in number with increasing distance. In addition there are regular concentric folds on the ventral half of the shell which fade away towards the median carina and are strongest near the ventral margin. Cross-section of the valves changes from quadrate near the umbones to diamond-shaped near the posterior margin.

Remarks. The Milne Land *Pinna* reach a size of over 25 cm. They have been described as *P. constantini* de Loriol by Spath (1936), a species which, judging from de Loriol's figure (1874, pl. 19, fig. 2) may be a synonym of *P. lanceolata,* but which seems to have straighter ventral and dorsal margins. The Milne Land specimens were later on included by Zakharov (1966, p. 69) in *P. suprajurensis* d'Orbigny, a species which has, however, a higher number of ribs (10–15) than *P. lanceolata* (8–9) on the dorsal part of the shell, but which is otherwise very similar. The Corallian specimens of *P. lanceolata* described in detail by Arkell (1933, p. 219, pl. 28, fig. 5, pl. 29, figs 1–3) seem to be narrower than the Milne Land forms; this may, however, largely be due to lateral crushing of the shells.

Autecology. At one horizon within the Pernaryggen Member (the so-called *Pinna* Bed) *P. lanceolata* occurs in high density with numerous individuals in life position

Fig. 12. *Pinna (P.) lanceolata* preserved in life position. *Pinna* Bed, Pernaryggen Mb, Hartz Fjeld. Scale in centimetres.

stacked closely to each other (see also Aldinger, 1935, p. 98 ff). They occupy a more or less vertical position within the sediment with the umbones directed downwards (fig. 12). This is identical to the life position of Recent *Pinna* which nearly all live as endobyssate suspension-feeders (e.g. Yonge, 1953). In the modern *Pinna carnea,* for example, the shell is usually about half buried in the sediment, although some specimens are found living epibyssate, attached to hard substrates (Stanley, 1970, p. 137). Trophic group: high level suspension-feeder.

Order Pterioida Newell, 1965. Suborder Pteriina Newell, 1965. Superfamily Pteriacea Gray, 1847. Family Bakevelliidae King, 1850.

Genus *Aguilerella* Chavan, 1951.
Type species. Perna kobyi de Loriol, 1901.

Aguilerella aldingeri sp. nov.

Fig. 11 B

Holotype. MGUH 15445 from GGU 235555 from the Aldinger Elv Member at locality 3.

Derivatio nominis. After H. Aldinger, the first person to make a detailed study of the Mesozoic geology of Milne Land.

Material. 46 specimens (partly moulds) from the Aldinger Elv Member at locality 3 (from GGU 235554–235556), and east of Bays Fjelde (234833–234834).

Diagnosis. Rhomb-shaped *Aguilerella* with straight anterior margin forming an angle of 70° to 80° with hinge line; umbones nearly terminal.

Description. Rhomb-shaped, weakly inflated shell; umbones nearly terminal, not protruding; dorsal margin straight, forming an angle between 70° and 80° with anterior margin which is straight and directed posteriorly. Ventral margin very convex, posterior margin gently convex to nearly straight towards junction with the dorsal margin. Shell thin; surface smooth or covered with some irregular growth lines. Ligament area narrow, with multiple ligament pits; anterior teeth missing; one narrow and subhorizontal posterior tooth in left valve, two in right valve.

Remarks. A. aldingeri can easily be separated from other Middle Jurassic to Lower Cretaceous *Aguilerella* species: *A. kobyi* (de Loriol, 1901, pl. 7, figs 5, 6, 6a) from the Oxfordian of Switzerland is more quadrate; *A. pseudoperna* Chavan (1952, pl. 2, figs 1–3) from the Oxfordian of Normandy is also more quadrate and has more prominent umbones; *A. obliqua* Lycett (1863, pl. 34, figs 2, 2a) from the Forest Marble (Bathonian) of England is far more oblique and narrows towards the ventral margin; *A. varians* Zakharov (1966, pl. 23, figs 1–7) from the Volgian of northern Siberia is also more oblique (the umbonal angle varying between 38° and 62°). The same is true of *A. anabarensis* (Krimgolts, 1953, pl. 6, figs 9–10) from the Russian Neocomian which has an umbonal angle between 48° and 59° (Zakharov, 1966, p. 80).

A. aldingeri occurs at only a few horizons within the Upper Oxfordian, but there occasionally forms pavements with only a few other species present.

Autecology. Like other bakevelliids, *A. aldingeri* was most probably byssate. It is here interpreted to have lived epifaunally, with either the straight anterior or dorsal margin resting on the substrate. A clustering habit, which seems likely, could not be proved. Trophic group: high level suspension-feeder.

Family Isognomidae Woodring, 1925.

Genus *Isognomon* Lightfoot, 1768.
Type species. Ostrea perna Linné, 1767.

Isognomon (Isognomon) volaticum Zakharov, 1966

Figs 11 C; 13 A–B; 14 A–B

v.1936 *Isognomon* aff. *I. bouchardi* (Oppel); Spath, p. 111, pl. 42, fig. 12, pl. 43, figs 1a, b.
*1966 *Isognomon volaticum* sp. nov.; Zakharov, p. 85, pl. 27, figs 1a, b, pl. 28, figs 1–2, pl. 29, fig. 2.

Material. 43 specimens from the Pernaryggen Member at Hartz Fjeld, Kronen and Bays Fjelde, and from the upper part of the Krebsedal Member at Kronen and Bays Fjelde (from GGU 235407, 235411–235412, 235420, 235423, 235427, 235440–235441, 235469, 235475, 235481, 235497–235502, 235506, 235512, 235522–235523, 235531, 235538, 235549, 137550).

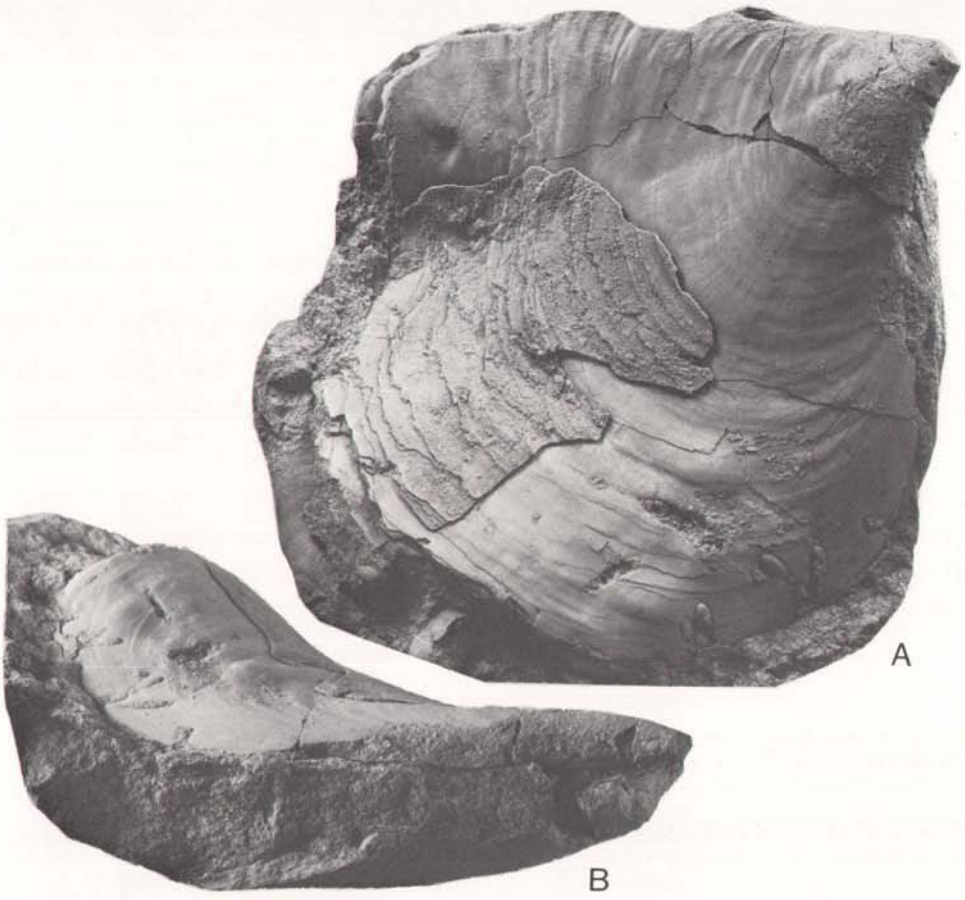

Fig. 13. *Isognomon (Isognomon) volaticum* Zakharov, 1966.
A, B. MGUH 15447 from GGU 235441; bivalved specimen, right (A) and anterior (B) views; × 0.75. Pernaryggen Mb, Hartz Fjeld.

Description. Shell large, thick, inequivalve and inequilateral, higher than long, compressed; umbones terminal, protruding slightly anteriorly; anterior margin concave below beak, then slightly convex or nearly straight. Ventral margin well rounded, posteroventral margin protruding wing-like. Posterodorsal margin also forming a wing (= posterior auricle) which is flat, but not distinctly set off from the more obtuse umbonal region. Shell smooth, with commarginal growth lines and lamellae. Young individuals with straight commissure; at the adult stage, commissure twisted to a varying degree with right valve concave and left valve convex. Pallial line entire, consisting of a row of small pits; adductor muscle scar large. Ligament external, height of ligament area varying, with parallel-sided, vertical

ligament pits which are regularly arranged and slightly wider than the intervals between them.

Measurements.	GGU sample	h	l	h_{lig}	α
	137549	13.0	–	1.4	–
	235531	10.2	8.7	–	83°
	235538	4.2	3.4	–	–
	235440	11.8	10.8	–	89°

Remarks. The Milne Land specimens are generally broader than the North Siberian ones and the posteroventral wing is less pronounced. Otherwise their features are identical. The Milne Land material exhibits a fair degree of variation, in particular with regard to outline and degree of shell torsion and the specific features are only found in adult specimens. *I. gibbum* (Eichwald, 1868, pl. 23, figs 1a, b) seems to differ in outline. Eichwald's original description and figure are, however, poor and *I. volaticum* might well prove to be a junior synonym of *I. gibbum.*

Autecology. I. volaticum has been found in nests in several cases preserved in life position. The species seems to have lived byssally attached in small clusters with the commissural plane vertical and the umbones buried in the sediment (Fürsich, 1980). It can thus be classified as a semi-infaunal, high level suspension-feeder.

Superfamily Pectinacea Rafinesque, 1815.
Family Oxytomidae Ischikawa, 1958.

Genus *Oxytoma* Meek, 1864.
Type species. Avicula muensteri Bronn, 1830.

Oxytoma (Oxytoma) inequivalve (J. Sowerby, 1819)

Fig. 6 B–F

*1918 *Avicula inequivalvis* sp. nov.; J. Sowerby, p. 78, pl. 244, figs 2,3.
v.1936 *Oxytoma expansa* (Phillips); Spath, p. 97, pl. 42, figs 4–7.
1978 *Oxytoma (Oxytoma) inequivalve* (J. Sowerby, 1819); Duff, p. 54, pl. 4, figs 7, 9, 11, 13, 15–19, 21–23, text-fig. 17.

Material. 51 specimens (mostly left valves) from Pernaryggen Member at Hartz Fjeld and Kronen; 2 specimens from the Cardioceraskløft Member at Cardioceraskløft (from GGU 235401–235405,

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Fig. 14. *Isognomon (Isognomon) volaticum* Zakharov, 1966.
A, B. MGUH 15448 from GGU 132550; steinkern, right (B) and anterior (A) views; × 0.75. Pernaryggen Mb, Hartz Fjeld.
C. MGUH 15449 from GGU 137549; interior of right valve; × 0.75. Pernaryggen Mb, Hartz Fjeld.


A
B
C

235411–235412, 235430, 235440–235441, 235443–235444, 235464, 235468–235469, 235486–235487, 235489, 235498, 235500–235502, 235510, 235514, 235536, 235538, 235540–235541, 235544, 235559, 235568, 235578).

Description. Inequilateral, very inequivalve, thin shell; left valve inflated, right valve only weakly convex. Hinge line long, straight, about four-fifths of shell length; left valve obliquely ovate, umbonal region strongly inflated, umbo salient, situated near the anterior end of shell; posterior auricle well developed, pointed, and with moderate to deep posterior subauricular sinus; anterior auricle small; ornament consisting of well spaced, rounded radial ribs between which fainter secondary ribs are intercalated. Right valve less inflated than left, smaller, subor-bicular; umbo situated about one-third of shell length from anterior end; posterior auricle large, pointed, but subauricular sinus less pronounced than in left valve; anterior auricle small, clearly separated from the flank by a groove, with byssal notch; anterior and posterior margins slightly convex, ventral margin well rounded; ornament not preserved.

Remarks. The specific identification of Jurassic *Oxytoma* has, in the past, posed major problems, particularly the distinction between *O. expansum* (Phillips) and *O. inequivalve:* This problem is discussed in Waagen (1901), Gillet (1924), Arkell (1933, p. 191), Cox (1940, p. 98), and more recently Duff (1978, p. 56). Despite the efforts of these authors, the classification of *Oxytoma* is still in need of clarification. Duff (1978, p. 57) uses the nearly equal size of the valves of *O. expansum* to make a distinction from *O. inequivalve* in which the right valve is considerably smaller than the left one. One bi-valved specimen from Milne Land, although not complete, shows the left valve to be considerably larger than the right valve, and it is on these grounds that the specimens, which Spath (1936, p. 97) identified as *O. expansum,* are referred to *O. inequivalve.* The same style of ribbing can be found in both species; thus ribbing seems to be unsuitable for specific determination. Most specimens from Milne Land are relatively small-sized.

Autecology. The well developed byssal notch identifies *O. inequivalve* as a byssate form, its oblique shape and the elongate posterior auricle may have facilitated the separation of exhalent and inhalent currents (Yonge, 1953). Stanley (1970, p. 32) noted that the presence of an elongate posterior wing in Recent Pteriidae usually seems to coincide with a free swinging mode of life (attached to alcyonarians). Jurassic *Oxytoma* may also partly have been pendant (see also Duff, 1978, p. 16) attached to hydrozoans etc., or bysally attached to shells and shell debris on the sea floor. Accordingly *O. inequivalve* can be classified either as a high level or low level suspension-feeder.

Family Entoliidae Korobkov, 1960.

Genus *Entolium* Meek, 1865.

Type species. Pecten demissus Phillips, as illustrated by Quenstedt, 1858.

Entolium (Entolium) corneolum (Young & Bird, 1828)

Fig. 15 C

*1828 *Pecten corneolus* sp. nov., Young & Bird, p. 234, pl. 9, fig. 5.
1978 *Entolium (Entolium) corneolum* (Young & Bird); Duff, p. 62, pl. 4, figs 25, 29, 30, pl. 5, figs 3–5, text-fig. 20.

Material. 14 specimens from the Kosmocerasdal Member at locality 4 (from GGU 235561, 235565).

Description. Equivalve and nearly equilateral shell, subovate to subcircular; umbones small, pointed, mesial; umbonal angle between 100°–105°. Auricles small, subequal; angle between anterior auricle of right valve and anterodorsal margin considerably more obtuse than that between posterior auricle and posterodorsal margin. Auricles separated from flank by faint groove. Anterodorsal margin straight or slightly concave, posterodorsal margin slightly concave; ventral, post-

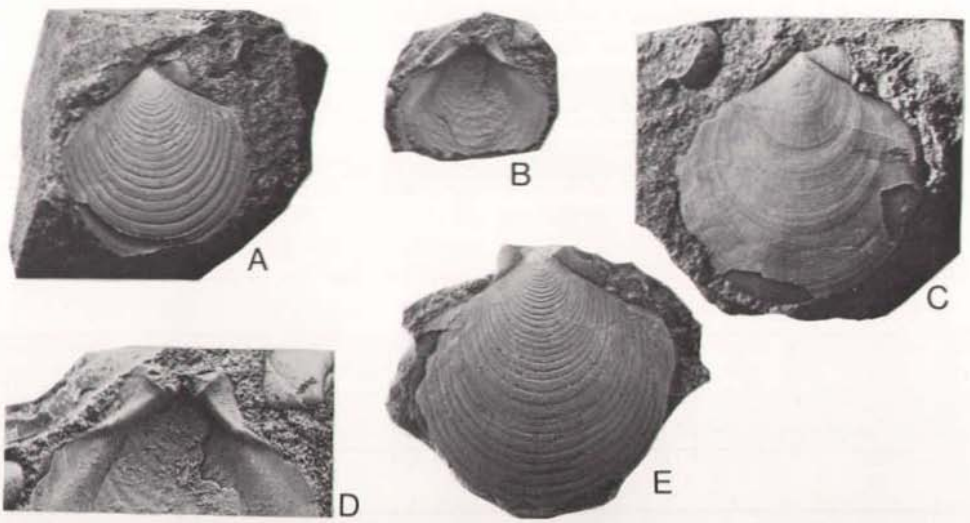


Fig. 15. *Entolium (Entolium) orbiculare* (J. Sowerby, 1817).
A. MGUH 15450 from GGU 235403; right valve; × 1. Pernaryggen Mb, Hartz Fjeld.
B, D. MGUH 15451 from GGU 235403; interior of right valve; B, × 1; D, × 2. Pernaryggen Mb, Hartz Fjeld.
E. MGUH 15452 from GGU 235405; bivalved specimen, right view; × 1. Pernaryggen Mb, Hartz Fjeld.
Entolium (Entolium) corneolum (Young & Bird, 1828).
C. MGUH 15453 from GGU 235561; right valve; × 1. Kosmocerasdal Mb, locality 4.

erior and anterior margins evenly rounded and suborbicular. Shell strongly compressed, very thin; ornament consisting of numerous, very fine commarginal growth lines which are also found on the auricles. Interior of shell not seen except auricular crurae.

Remarks. E. corneolum is quite common in the upper part of the Kosmocerasdal Member, but seems to be missing from higher horizons, including the Upper Oxfordian Aldinger Elv Member. It correponds in part to '*Pecten (Entolium)* cf. *P. (E.) demissus* Phillips' as recorded by Spath (1935, p. 56).

Autecology. There can be little doubt that like some Recent pectinids *E. corneolum* was free-living, mobile, and able to swim. This is indicated by the near-symmetry and thinness of the shell and the lack of a byssal notch (see also Duff, 1978 p. 16).

Entolium (Entolium) orbiculare (J. Sowerby, 1817)

Fig. 15 A–B, D–E

*1817 *Pecten orbicularis* sp. nov.; J. Sowerby, p. 193, pl. 86.
1843 *Pecten nummularis* sp. nov.; Fischer, p. 135, pl. 5, fig. 4.
v.1936 *Entolium nummularis* (Fischer); Spath, p. 103, pl. 41, figs 9, 10a–c, pl. 42, figs 11a–b.
v.1936 *Entolium* sp. ind.; Spath, p. 104, pl. 45, fig. 1.
v.1947 *Entolium nummularis* (Fischer); Spath, p. 37, pl. 5, figs 5, 6, 9.

Material. 204 specimens from the Pernaryggen Member at Hartz Fjeld, Kronen and Bays Fjelde (from GGU 235401–235407, 235411–235414, 235416, 235420–235423, 235427–235429, 235442–235444, 235464, 235468–235469, 235471–235472, 235475, 235482, 235489, 235491, 235494, 235498–235502, 235510–235511, 235513–235514, 235516, 235530, 235534, 235538, 235540, 235542, 235548, 235553, 235559, 235577); 7 specimens from the Cardioceraskløft Member at Cardioceraskløft (235544–235545).

Description. Suborbicular subequilateral, subequivalve shell; umbonal angle varying between 115° and 120° in adult specimens. Auricles relatively small, triangular, subequal on right valve; slightly projecting above hinge line; auricles of left valve equal; anterior auricle of right valve forming a less obtuse angle with flank than posterior auricle. Auricles distinctly set off from flank by thin groove. Antero- and posterodorsal margins slightly concave to straight, remaining margin well rounded; left valve slightly more inflated than right valve. Surface of left valve, including auricles, smooth, provided with very faint commarginal growth lines; on the right valve these growth lines are accompanied by grooves which are only sharply defined towards the ventral margin; the spaces between the grooves are about three times the width of the elevated grooves themselves. Interior of right valve with two auricular crurae, the anterior of which extends well beyond the auricle whilst the

posterior stops at about the point where the auricle meets the flank. On both sides of the small resilifer a thin groove extends which runs parallel to the hinge. Interior of left valve not observed.

Remarks. Judging from the variation found among species of Cretaceous *E. orbiculare* (figured, for example, in Woods, 1902, pl. 27, figs 1–13) it is difficult to find arguments for keeping the Upper Jurassic *E. nummulare* as a separate species. Although showing relatively little variation themselves, the Milne Land specimens fall well within the range of *E. orbiculare*. *E. nummulare* is, therefore, regarded here as a junior synonym of Sowerby's *E. orbiculare*. This species has been recently redescribed in detail by Dhondt (1971), who did not, however, refer to the Upper Jurassic specimens. *E. orbiculare* is thus a very long ranging species, arising at least in the Kimmeridgian and extending up to the Turonian. On Milne Land, it is one of the commonest species, forming a distinct association, but also occurring in several other faunal associations.

Autecology. In shape and size comparable to *E. corneolum*, *E. orbiculare* probably had a similar mode of life: free living on the substrate, and most likely capable of swimming for short distances like many Recent thin-shelled pectinids.

Family Pectinidae Rafinesque, 1815.

Genus *Camptonectes* Agassiz *in* Meek, 1864.
Type species. Pecten lens J. Sowerby, 1818.

Camptonectes (Camptonectes) morini (de Loriol, 1867)

Figs 16 A–C; 23 E

*1867 *Pecten Morini* de Loriol; de Loriol, p. 107, pl. 10, figs 6, 6 B.
v.1936 *Camptonectes morini* (P. de Loriol); Spath, p. 105, pl. 41, figs 5–6.
v.1936 *Camptonectes suprajurensis* (Buvignier); Spath, p. 106, pl. 41, figs 2–4, pl. 42, fig. 9, pl. 43, fig. 4.

Material. 69 specimens from the Pernaryggen Member at Hartz Fjeld, Kronen and Bays Fjelde, 6 specimens from the Cardioceraskløft Member at Cardioceraskløft, 3 specimens from the Kosmocerasdal Member at locality 4 (from GGU 235401–235407, 235411–235412, 235424–235425, 235427–235429, 235431, 235440–235441, 235443–235444, 235464, 235468–235469, 235481–235482, 235486–235487, 235489, 235491, 235505, 235513, 235528, 235538, 235540–235542, 235544, 235548–235557, 235561, 235567, 235578, 137417).

Description. Shell small to medium-sized, inequivalve, slightly inequilateral, subcircular; higher than long, right valve weakly inflated, left valve moderately inflated. Auricles distinct, anterior auricle nearly twice the length of posterior auricle; anterior auricle of right valve subtrapezoidal in outline, with deep byssal notch below ventral margin; ctenolium well developed. Left valve nearly symmetrical, right valve rather asymmetric with anterodorsal margin slightly concave. Shell ornament consisting of numerous fine, radial grooves usually punctate near the umbones; towards the ventral margin, the grooves frequently bifurcate. Ornament of auricles similar to that of the umbonal region, except on the anterior auricle of the right valve where the radial ornament is weakly developed and commarginal lamellae dominate. Umbonal angle usually around 90°.

Measurements.

GGU sample	l	h	h/l(%)	l_h	l_h/l(%)	l_{hant}	α
235404	1.95	2.05	105.1	1.10	56.4	0.55	–
137550	3.40	3.65	107.3	1.85	54.4	1.10	–
137417	3.25	3.50	107.7	1.80	55.4	1.05	–
235411	3.55	3.95	111.3	–	–	–	–
235468	2.60	2.85	109.6	–	–	–	–
235468	2.80	3.25	116.1	1.45	51.8	0.90	85°
235538	2.60	2.75	105.7	–	–	–	–
235549	3.55	4.00	112.7	–	–	–	90°

Remarks. Spath (1936, p. 105) described two species of small *Camptonectes* from Milne Land, *C. morini* and *C. suprajurensis* (Buvignier). There is, however, little doubt that Spath's specimens represent only one species, *C. morini,* and that the more asymmetric right valves were misidentified by Spath as *C. suprajurensis.*

Autecology. C. morini was most probably an epibyssate species, resting with its right valve on the sea floor.

Fig. 16. *Camptonectes (Camptonectes) morini* (de Loriol, 1867).

A. MGUH 15454 from GGU 137550; left valve; × 1. Pernaryggen Mb, Hartz Fjeld.

B. MGUH 15455 from GGU 137417; left valve; × 1. Pernaryggen Mb, Hartz Fjeld.

C. MGUH 15456 from GGU 235580; rubber cast of ornament of left valve; × 3. Pernaryggen Mb, Kronen.

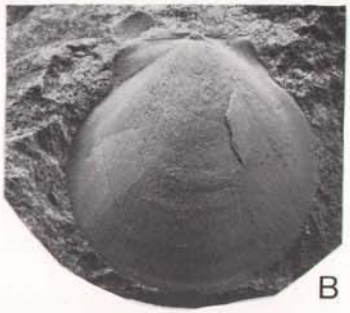
Camptonectes (Boreionectes) broenlundi (Ravn, 1911).

D. MGUH 15457 from GGU 235460; bivalved specimen, right view; × 1. Aldinger Elv Mb, locality 25.

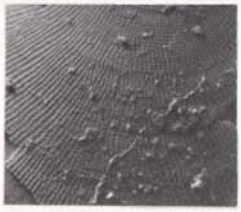
E. MGUH 15458 from GGU 235572; left valve; × 1. Aldinger Elv Mb, valley north of Cardioceraskløft.

F. MGUH 15459 from GGU 235572; right valve; × 1. Aldinger Elv Mb, valley north of Cardioceraskløft.

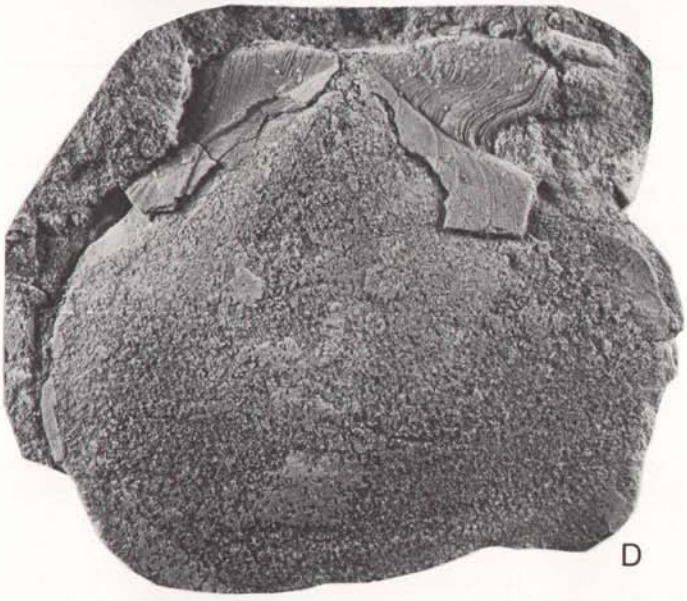
A



B



C



D

E

F

Subgenus *Boreionectes* Zakharov, 1965.
Type species. Pecten cinctus J. Sowerby, 1822.

Camptonectes (Boreionectes) praecinctus Spath, 1936

Figs 17 A, B; 18; 19 A, B

v.*1936 *Camptonectes praecinctus* sp. nov.; Spath, p. 104, pl. 40, fig. 6, pl. 41, fig. 1.
1965 *Camptonectes (Boreionectes) breviauris* sp. nov.; Zakharov, p. 73, pl. 1, fig. 1, pl. 2, figs 1–2.
1966 *Camptonectes (Boreionectes) breviauris* Zakharov; Zakharov, p. 48, pl. 14, pl. 15, figs 1–4.

Material. 16 specimens from the Pernaryggen Member at Hartz Fjeld, Kronen and Bays Fjelde (from GGU 235403–235405, 235413–235414, 235450, 235488, 235511, 235525, 235580, 137422, 137487, 137516, 137547).

Description. Very large, circular, nearly equilateral shell, inequivalve; left valve moderately convex, right valve slightly convex, flatter than left valve; shell thick, especially in the umbonal region, smooth except for growth lines. Auricles moderately large and elongate, with raised commarginal lamellae and radial rows of fine punctae. The posterior auricle is hardly separated from the flank, whilst the anterior one is distinctly set off by a groove. Auricles subequal in length, the anterior one with pronounced byssal notch and well developed ctenolium. Ligament pit small, triangular, in right valve flanked by two blunt teeth. Interior dorsal margin of auricles with numerous near-vertical grooves and ridges followed ventrally by a horizontal groove on each side. Pallial line pitted, parallel to margin, with sinus near byssal notch. Adductor muscle scar subcircular.

Measurements.

GGU sample	l	h	h/l (%)	l_h	l_h/l (%)
137422	16.5	16.3	98.8	9.7	58.7
137697	11.3	10.7	94.7	6.85	60.5
235405	17.1	15.6	91.2	–	–

Remarks. Zakharov (1965) grouped very large camptonectids from the Upper Jurassic into the subgenus *Boreionectes.* According to him (pers. comm., November 1979) his *C. breviauris* falls into the synonymy of *C. praecinctus,* their only difference being the shorter auricles of the former. As only a few complete specimens are available, it is difficult to establish the range of variation of the species. *C. cinctus* (J. Sowerby, 1822, p. 96, pl. 371) and *C. imperialis* (Keyserling, 1846, p. 295, pl. 15, figs 1–3) seem to be closely related to *C. praecinctus,* the main differentiating feature being the greater length of the auricles; the posterior auricle is in addition usually separated from the flank by a distinct groove. However,

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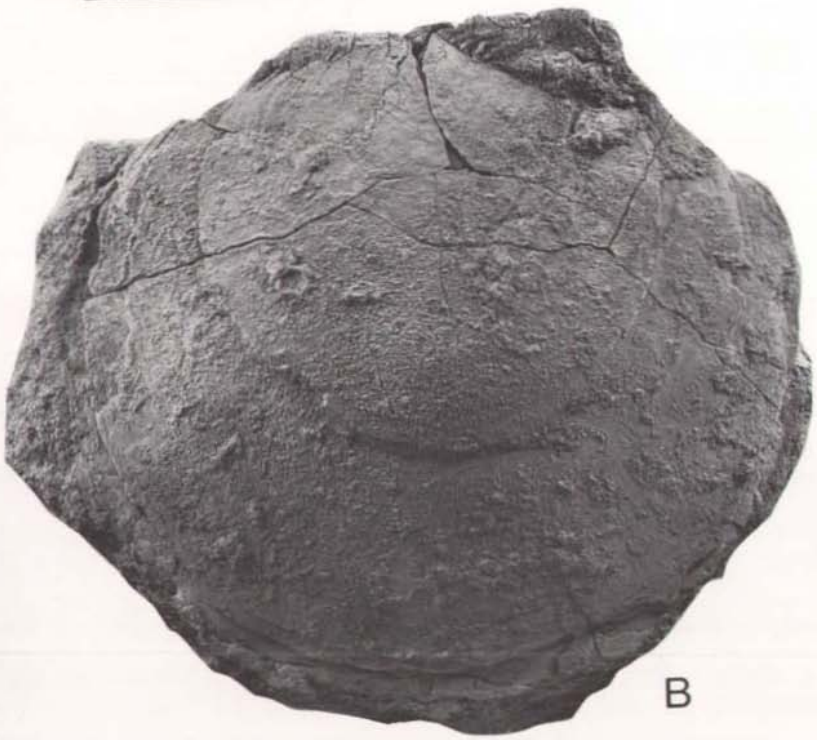
Fig. 17. *Camptonectes (Boreionectes) praecinctus* Spath, 1936.
A. MGUH 15460 from GGU 137422; interior of right valve; × 0.5. Pernaryggen Mb, Hartz Fjeld.
B. MGUH 15461 from GGU 235450; bivalved specimen, right view; × 0.5. Pernaryggen Mb, Hartz Fjeld.

A



B

Fig. 18. *Camptonectes (Boreionectes) praecinctus* Spath, 1936.
MGUH 15462 from GGU 235405; bivalved specimen, right view; × 0.5. Pernaryggen Mb, Hartz Fjeld.

detailed studies of more extensive material might prove that all of the above mentioned species should be regarded as synonyms in which case *C. cinctus* would have priority.

Autecology. Adult specimens are very thick-shelled (up to 7 mm) and must have lived stationary on the sea floor as low level suspension-feeders. The well developed ctenolium suggests that the individuals were bysally attached.

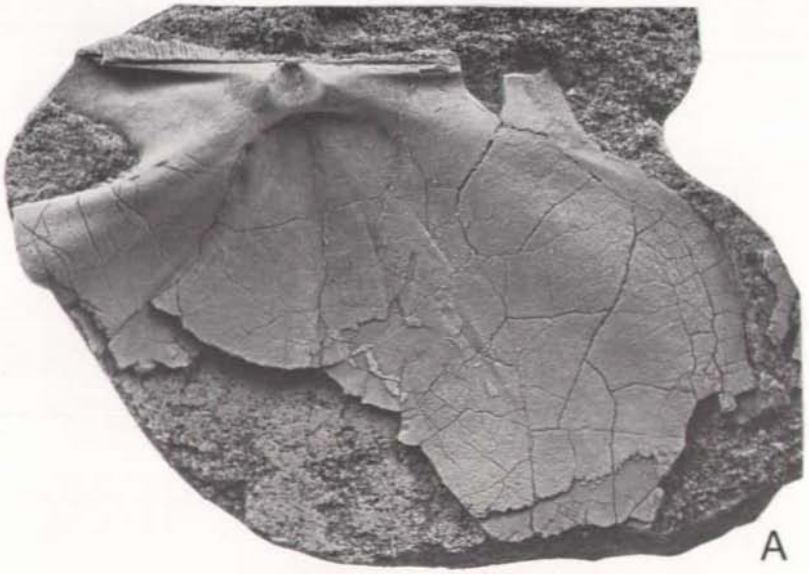
Camptonectes (Boreionectes) broenlundi (Ravn, 1911)

Figs 16 D–F; 20; 23 B, H

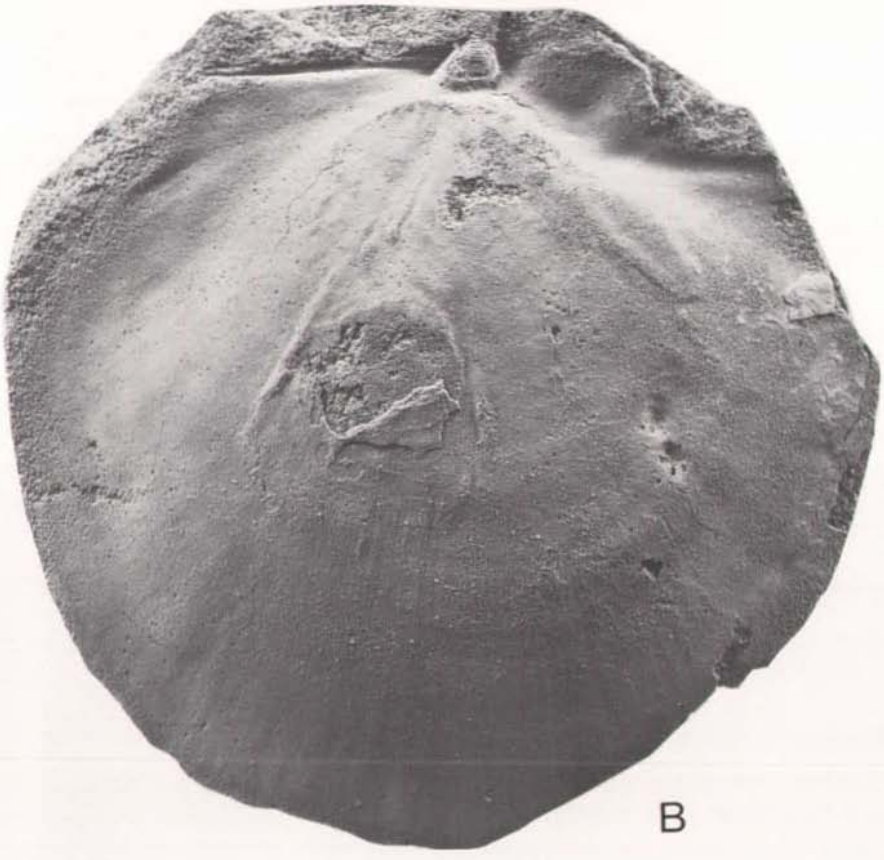
*1911 *Pecten (Camptonectes) broenlundi* sp. nov.; Ravn, p. 465, pl. 34, figs 5–6.
1966 *Camptonectes (Boreionectes) broenlundi* Ravn; Zakharov, p. 44, pl. 8, figs 1–2, pl. 9, fig. 1.

Material. 44 complete shells and numerous fragments from the Aldinger Elv Member at localities 3, 5, 25 and 26 (from GGU 235453–235456, 235458, 235460–235463, 235554–235556, 235572, 235573).

Fig. 19. *Camptonectes (Boreionectes) praecinctus* Spath, 1936.
A. MGUH 15463 from GGU 235488; interior of right valve; × 1. Pernaryggen Mb, Hartz Fjeld.
B. MGUH 15464 from GGU 137697; steinkern, right view; × 1. Pernaryggen Mb, Hartz Fjeld.



A



B

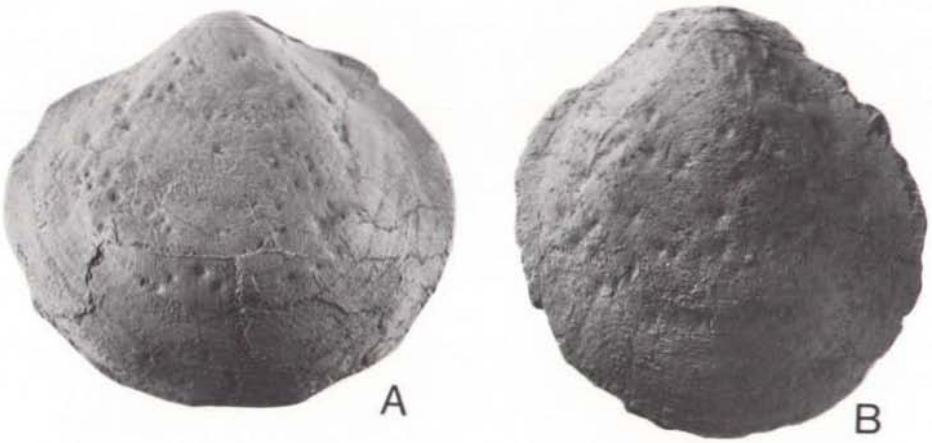


Fig. 20. Steinkerns of *Camptonectes (B.) broenlundi;* pits on the steinkerns correspond to swellings on the inside of the left valves. They represent the reaction of the animals to the activity of boring barnacles. A. MGUH 15465 from GGU 235461; × 0.75; B. MGUH 15466 from GGU 235461; × 0.75. Aldinger Elv Mb, locality 25.

Description. Large, inequivalve, equilateral, circular shell; right valve flat to very slightly convex, left valve inflated, strongly convex; shell thin. Length of auricles usually between 40 and 50% of shell length. Anterior auricle longer than posterior; with moderately deep byssal notch; both auricles of right valve separated from flanks by groove which is particularly distinct in the case of the anterior auricle; there is a well developed ctenolium. Umbonal angle increasing with size of shell; in young specimens usually between 90° and 100°, in adult specimens mainly around 110°. Surface of shell covered with very fine concentric striae which are cut by equally fine radially diverging grooves, this creating a reticulate pattern; ornament similar on auricles, but on anterior auricle of right valve fine commarginal lamellae dominant. Interior of shell smooth; hinge line with small triangular ligament pit.

Measurements.

GGU sample	l	h	h/l(4)	l_h	l_h/(%)	l_{hant}	α
235463	6.7	6.7	100.0	–	–	–	–
235580	8.9	9.0	101.1	–	–	–	–
235461	8.1	8.5	104.9	–	–	–	–
235554	8.25	8.3	100.6	3.4	40.9	1.9	–
235460	7.9	–	–	4.0	50.6	2.4	107°
235572	2.9	3.0	103.4	–	–	–	–
235572	6.3	6.4	101.6	–	–	–	–

Remarks. C. broenlundi is the commonest faunal element of the Aldinger Elv Member (hence its former name '*Pecten* Sandstone') where, in places, it forms densely packed shell beds. Despite the very high abundance of the species it is

difficult to extract complete specimens from the hard sandstone, and only rarely is the ornament preserved.

Autecology. The circular outline, thin shells and high umbonal angle indicate that *C. broenlundi* was probably able to swim. Most swimming pectinids rest with their right valve (which is usually the more convex) on the substrate. This was very probably the case with *C. broenlundi,* although the right valve is flat. Such a life position can be demonstrated by the presence of boring cirripeds and phoronids which – nearly exclusively – occur on the convex left valves. That they colonised the shells whilst the animals were still alive is shown by the fact that the bivalves reacted to the activity of the borers by depositing additional layers of shell material on the inside of the shell (fig. 20). The boring activity was thus obviously restricted to the exposed valve which must have been the left one.

Among swimming pectinids those are good swimmers in which the upper valve is more convex than the lower valve as this cross-sectional shape forms an efficient hydrofoil (Stanley, 1970, p. 38). By analogy, *C. (B.) broenlundi* was probably also a good swimmer.

Camptonectes (Boreionectes) cf. *C. (B).) validus* (Lindström, 1865)

Figs 21 A, B; 22

Material. 6 specimens from the Cardioceraskløft Member at Cardioceraskløft (from GGU 235545, 137687).

Description. Shell large, orbicular, inequivalve, equilateral, thin. Right valve flat, left valve moderately inflated. Auricles moderately long, about 50% of shell length; anterior auricle of right valve with byssal notch, and separated from flank by distinct groove. Maximum inflation of left valve slightly posterior and dorsal of centre; anterior part of left valve relatively flat. Shell smooth, perhaps due to wear.

Measurements.

GGU sample	l	h	h/l (%)
235545	9.9	10.1	102.0
235545	10.1	9.6	95.0

Remarks. Lindström's (1865, p. 15, pl. 3, figs 5–6) *Pecten validus* from Spitsbergen (see also Sokolov & Bodylevsky, 1931, pl. 3, figs 1–2) seems to be comparable in size and shape. However, as Lindström's specimens are incomplete, a precise comparison is impossible. The specimens figured here differ clearly from the other two *Boreionectes* species found on Milne Land. They are less inflated than *C. broenlundi* and *C. praecinctus* and, above all, exhibit a marked asymmetry of the inflation of the left valve.


A
B

Fig. 22. *Camptonectes (Boreionectes)* cf. *C. (B.) validus* (Lindström, 1865) MGUH 15468 from GGU 235545; bivalved specimen, left view; × 1. Cardioceraskløft Mb, Cardioceraskløft.

Autecology. In addition to resting with the flat right valve on the substrate, *C.* cf. *C. validus* was probably a moderately good swimmer. This is indicated by the planoconvex cross-section, the thin shell and the circular outline.

Subgenus *Camptochlamys* Arkell, 1930.
Type species. Pecten intertextus Roemer, 1839.

Camptonectes (Camptochlamys) sp.

Fig. 23 A

Material. 1 specimen from the Pernaryggen Member at Kronen (from GGU 235499).

Fig. 21. *Camptonectes (Boreionectes)* cf. *C. (B.) validus* (Lindström, 1865).
A, B. MGUH 15467 from GGU 235545; bivalved specimen, left (A) and right (B) views; × 1. Cardioceraskløft Mb, Cardioceraskløft.

Description. Medium-sized *Camptochlamys;* higher than long; right valve slightly convex, left valve moderately convex. Ornament of right valve consisting of numerous radial ribs which are crossed by numerous, nearly equally strong, concentric ribs creating a reticulate pattern.

Remarks. The poor preservation of the specimen does not allow a more precise identification.

Autecology. Epibyssate low level suspension-feeder.

Subgenus *Costicamptonectes* subgen. nov.

Derivatio nominis. Costa (Lat.) = rib.

Diagnosis. Camptonectes with ornament of a *Camptonectes* sensu stricto and radial ribs near the anterior margin.

Remarks. There are no other Mesozoic pectinid bivalves with such an ornament known in the literature. The divaricate punctate pattern is typical of *Camptonectes* s.s., whilst the radial ribs resemble those of *Chlamys* s.s. The combination of both features in one species justifies placement in a new subgenus.

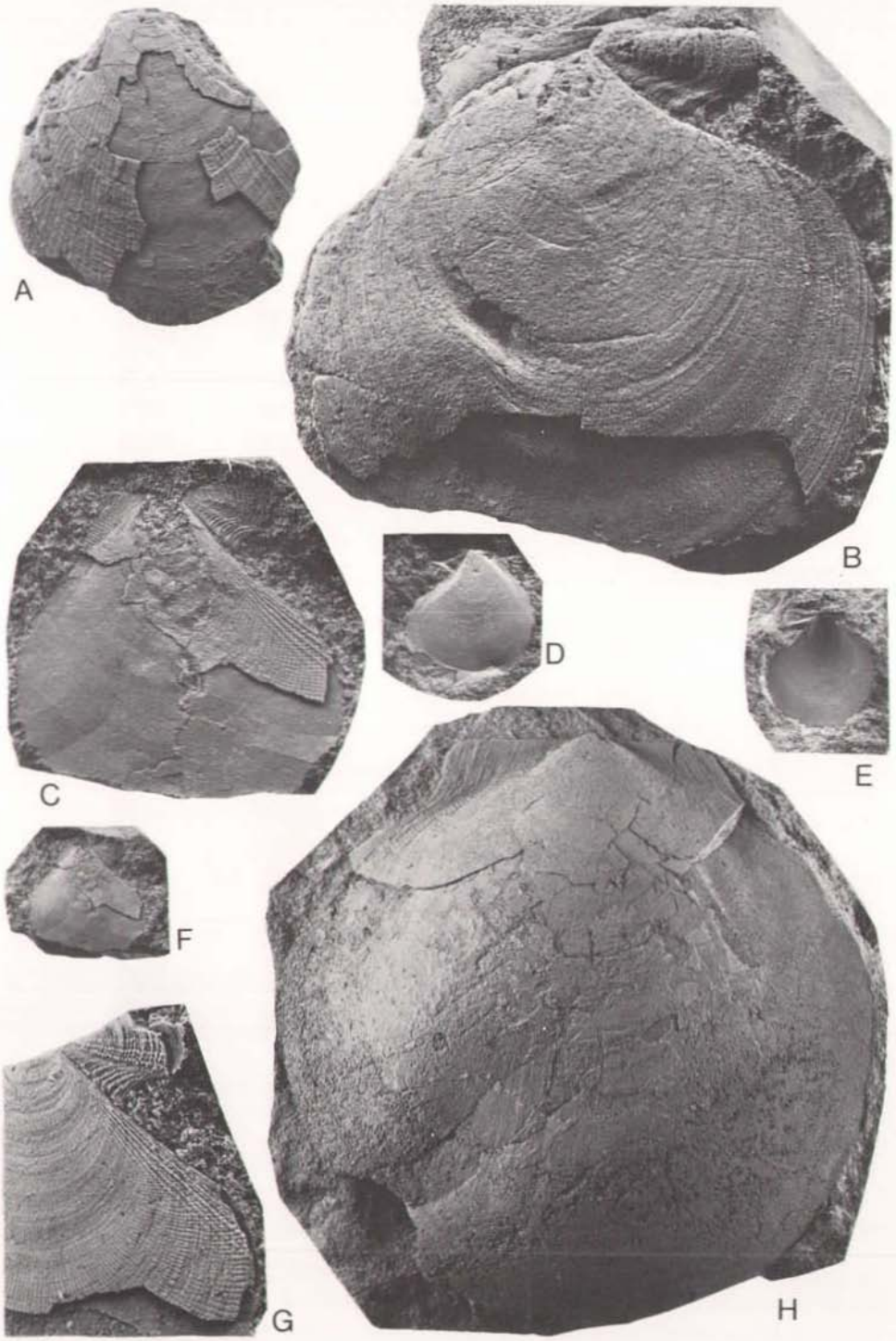
Camptonectes (Costicamptonectes) milnelandensis sp. nov.

Fig. 23 C, D, F, G

Holotype. MGUH 15472 from GGU 235561 from the Kosmocerasdal Member at locality 4.

Derivatio nominis. Milnelandensis (Lat.) = adjective to Milne Land.

Fig. 23. *Camptonectes (Camptochlamys)* sp.
A. MGUH 15469 from GGU 235499; bivalved specimen, right view; × 1. Pernaryggen Mb, Kronen.
Camptonectes (Boreionectes) broenlundi (Ravn, 1911).
B. MGUH 15470 from GGU 235456; right valve; × 1. Aldinger Elv Mb, locality 26.
H. MGUH 15471 from GGU 235554; left valve; × 1. Aldinger Elv Mb, locality 3.
Camptonectes (Costicamptonectes) milnelandensis sp. nov.
C, F. MGUH 15472 from GGU 235561; right valve (holotype); C, × 3; F, × 1. Cardioceraskløft Mb, Cardioceraskløft.
D. MGUH 15473 from GGU 235561; interior of right valve; × 1. Cardioceraskløft Mb, Cardioceraskløft.
G. MGUH 15474 from GGU 235561; ornament of right valve; × 4. Cardioceraskløft Mb, Cardioceraskløft.
Camptonectes (Camptonectes) morini (de Loriol, 1867).
E. MGUH 15475 from GGU 235404; interior of right valve; × 1. Pernaryggen Mb, Hartz Fjeld.


A
B
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G
H

Material. 4 specimens from the Kosmocerasdal Member at locality 4 (235561–1 to 235561–4).

Diagnosis. Small *Camptonectes,* right valve slightly convex, left valve unknown. Ornament consisting of fine radially diverging grooves which are punctate; anterior margin of right valve with about 8 to 10 fine radial ribs, 4 to 5 of them distinct, the others crowded towards anterior margin.

Description. Shell small, thin, oval, higher than long; only right valve known, which is slightly convex and inequilateral, the anteroventral part of shell being larger than the posterior part. Anterodorsal margin straight to slightly concave, anteroventral margin convex, well rounded. Auricles well developed, length about 50% of shell length; posterior auricles much smaller than the anterior, the latter separated from the flank by a groove; anterior auricle with byssal notch; ctenolium well developed. Ornament of shell consisting of numerous fine radially diverging punctate grooves which bifurcate towards the ventral margin. Near the anterior margin they are crossed by 8 to 10 fine radial ribs, the first 4 to 5 distinct, the remainder crowded towards the anterior margin. Ornament of posterior auricle consisting of radial punctate grooves, whereas on anterior auricle commarginal lamellae are more conspicuous.

Measurements.	GGU sample	l	h	h/l(%)	l_h	l_h/l(%)	l_{hant}
235561–1	1.55	–	–	0.7	45.2	0.4	
	235561–2	1.65	1.85	112.1	0.85	51.5	0.5

Remarks. C. milnelandensis resembles *C. lens* in shape and ornamentation, but differs in the presence of radial riblets near the anterior margin of the right valve. Unfortunately no left valves have been recovered so that the description is as yet incomplete.

Autecology. C. milnelandensis probably rested byssally attached with its right valve on the substrate and lived as a low level suspension-feeder.

Family Buchiidae Cox, 1953.

Genus *Buchia* Rouillier, 1845.
Type species. Avicula mosquensis von Buch, 1844.

Buchia lindstroemi (Sokolov, 1908)

*1908 *Aucella lindstroemi* sp. nov.; Sokolov, p. 11, pl. 1, fig. 16.
1981 *Buchia lindstroemi* (Sokolov, 1908); Zakharov, p. 72, pl. 5, figs 1–4, text-fig. 7 d.

Material. 2 specimens from the Bays Elv Member south of Bays Fjelde (from GGU 234071).

Remarks. The two specimens (one right and one left valve) are figured and briefly described by Surlyk & Zakharov (1982); they are mentioned here for the sake of completeness. Two further specimens, found in the Cardioceraskløft Member at Cardioceraskløft, probably also belong to this species, but are too badly preserved to allow precise identification.

Autecology. Compare *B. mosquensis.*

Buchia mosquensis (v. Buch, 1844)

Fig. 24 A–C, E

*1844 *Avicula mosquensis* sp. nov.; v. Buch, p. 537, pl. 6, fig. 1.
1904 *Aucella pallasii* Keyserling; Madsen, p. 178, pl. 6, fig. 7.
v.1936 *Buchia mosquensis* (v. Buch); Spath, p. 98, pl. 42, figs 1a–d, f–g (*non* pl. 42, fig. 1e)
1981 *Buchia mosquensis* (Buch, 1844); Zakharov, p. 83, pl. 9, fig. 12, pl. 10, figs 1–4, pl. 11, figs 1–8, pl. 12, figs 1–5, pl. 13, figs 1–6, text-figs 12, 24 d.

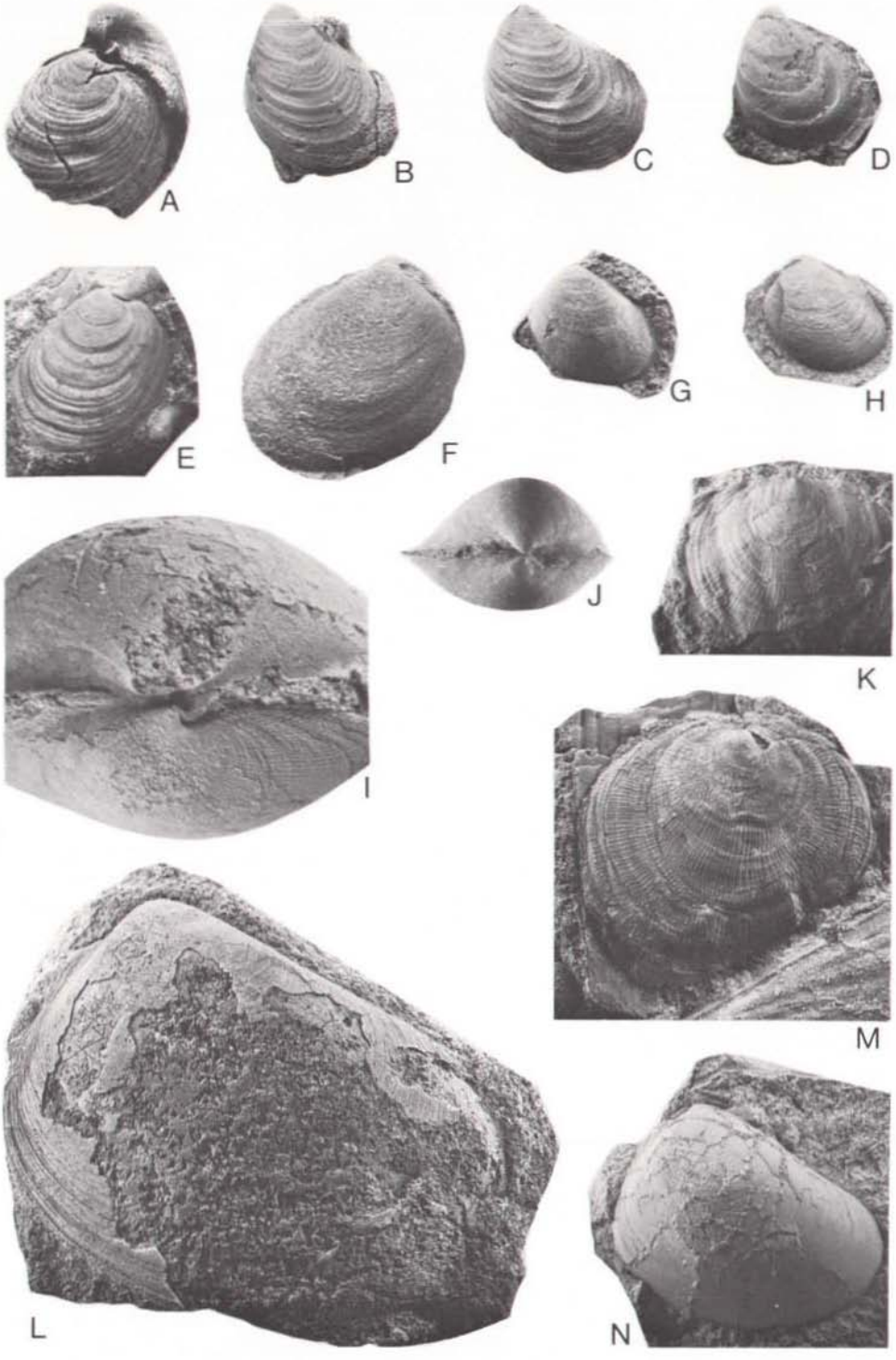
Material. 197 specimens from the Pernaryggen Member and Astartedal Member at Hartz Fjeld, Kronen and Bays Fjelde (from GGU 235401–235407, 235411–235412, 235416, 235420–235425, 235427–235429, 235440–235445, 235447, 235451, 235464, 235468–235469, 235474, 235478, 235482, 235485–235487, 235489, 235493, 235496–235498, 235500–235502, 235510, 235514, 235516, 235523, 235527, 235534–235535, 235538, 235540–235542, 235546, 235548, 235552, 235559–235560, 235577, 235580).

Description. Medium-sized, oblique, variable shell, much higher than long; highly inequivalve; right valve feebly convex with rounded keel running from the scarcely projecting umbo to the posteroventral margin; area anterior of keel flat. Left valve highly convex with strongly incurved umbo and beak which is slightly prosogyrate. Hinge line short, straight; with short posterior auricles; right anterior auricle small, extending towards left valve and thus not in the plane of the hinge line; resting in small triangular socket anterior of beak in left valve. Very distinct subauricular notch present.

General outline of shell obliquely ovate, elongate in a posteroventral direction; with broad, rounded anterior and less strongly convex posterior margin. Shell ornament consisting of irregular, well spaced, acute commarginal ribs of differing strength and sometimes very faint radial striae.

Remarks. B. mosquensis is the commonest *Buchia* species in Milne Land occurring at most horizons within the Volgian, although usually in low numbers. The shells exhibit a wide range of variation both with regard to ornament and shape.

Autecology. The presence of a distinct subauricular notch indicates that the species was byssate; nests of *B. mosquensis* found in near life position on ammonites


A
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N

suggest that the species lived in epifaunal clusters, with the umbo directed downwards and the animals resting on the anterodorsal margin and anterior side of the left umbo. Trophic group: medium level suspension-feeder.

Buchia rugosa (Fischer de Waldheim, 1837)

Fig. 24 D

*1837 *Inoceramus rugosa* sp. nov.; Fischer de Waldheim, p. 175, pl. 46, fig. 2.
v.1936 *Buchia rugosa* (Fischer); Spath, p. 100, pl. 42, figs 2a–b.
1981 *Buchia rugosa* (Fischer Waldheim, 1837); Zakharov, pl. 9, figs 1–11.

Material. 3 left valves from the Pernaryggen Member at Kronen (from GGU 235514, 235557).

Description. Medium-sized *Buchia,* similar to *B. mosquensis,* but with ornament consisting of few coarse commarginal folds and general shell shape less recurved than *B. mosquensis.*

Remarks. The very coarse ornament of the three Milne Land specimens distinguishes them from the otherwise very similar *B. mosquensis.*

Autecology. See *B. mosquensis.*

Fig. 24. *Buchia mosquensis* (v. Buch, 1844).
A. MGUH 15476 from GGU 235475; bivalved specimen; × 1. Pernaryggen Mb, Hartz Fjeld.
B. MGUH 15477 from GGU 235403; left valve; × 1. Pernaryggen Mb, Hartz Fjeld.
C. MGUH 15478 from GGU 235429; bivalved specimen, left view; × 1. Pernaryggen Mb, Hartz Fjeld.
E. MGUH 15479 from GGU 235429; right valve; × 1. Pernaryggen Mb, Hartz Fjeld.
Buchia rugosa (Fischer, 1837).
D. MGUH 15480 from GGU 235514; left valve; × 1. Pernaryggen Mb, Kronen.
Praebuchia kirghisensis (Sokolov, 1902).
F, J. MGUH 15481 from GGU 235458; bivalved specimen, right (F) and dorsal (J) views; × 1. Aldinger Elv Mb, locality 26.
G. MGUH 15482 from GGU 235460; left valve; × 1. Aldinger Elv Mb, locality 26.
H. MGUH 15483 from GGU 235554; left valve; × 1. Aldinger Elv Mb, locality 3.
I. MGUH 15484 from GGU 235554; bivalved specimen, dorsal view; × 5. Aldinger Elv Mb, locality 3.
Placunopsis radiata (Phillips, 1829).
K. MGUH 15485 from GGU 235428; left valve; × 1. Pernaryggen Mb, Hartz Fjeld.
M. MGUH 15486 from GGU 235441; left valve; × 1. Pernaryggen Mb, Hartz Fjeld.
Plagiostoma incrassatum (d'Eichwald, 1868).
L. MGUH 15487 from GGU 235486; left valve; × 1. Pernaryggen Mb, Kronen.
N. MGUH 15488 from GGU 235537; left valve; × 1. Pernaryggen Mb, Hartz Fjeld.

Genus *Praebuchia* Zakharov, 1981.
Type species. Praebuchia orientalis, Zakharov, 1981.

Praebuchia kirghisensis (Sokolov, 1902)

Figs 24 F–I

1902 *Aucella kirghisensis* sp. nov.; Sokolov, p. 374, pl. 14, figs 1–5.
1911 *Aucella kirghisensis* Sokolov; Ravn, p. 455, pl. 32, figs 2a–c.
1981 *Praebuchia kirghisensis* (D. Sokolow, 1902); Zakharov, p. 60, pl. 1, figs 5–7, pl. 2, figs 8–9, text-fig. 8a′–b′.

Material. 73 specimens from the Aldinger Elv Member at localities 3, 5 and 25 (from GGU 235452–235458, 235461–235463, 235554–235556, 235573); 1 specimen from the Kosmocerasdal Member at locality 4 (235565).

Description. Medium-sized, strongly inflated, obliquely-ovate shell, inequilateral, nearly equivalve; left valve more strongly inflated than right; umbones inflated, situated about one-third of shell length from the anterior end; beaks strongly incurved, orthogyrate or slightly prosogyrate. Anterior sector short, posteroventral part of shell long; anteroventral and posterodorsal margins near-parallel; right valve with small anterior auricle and well developed subauricular sinus. Shell very thin; surface covered with numerous very fine radial riblets which fade towards centre, and more prominent commarginal growth lines.

Remarks. The genus *Praebuchia* was erected by Zakharov (1981) and differs from *Buchia* mainly in the morphology of the hinge, particularly in the position and morphology of the ligament plate. *P. kirghisensis* is one of the commonest bivalves within the Aldinger Elv Member at Milne Land.

Autecology. The presence of a byssal notch indicates that *P. kirghisensis* was a byssate species probably resting on the anterior and umbonal region of the relatively less inflated right valve. In this way the posterior shell region (site of the inhalent canal) would have been at a considerable distance from the sea floor and, at the same time, the byssus would have extended straight into the substrate.

Family Terquemiidae Cox, 1964.

Genus *Placunopsis* Morris & Lycett, 1853.
Type species. Placunopsis fibrosa Laube, 1867.

Placunopsis radiata (Phillips, 1829)

Fig. 24 K, M

*1829 *Orbicula? radiata* sp. nov.; Phillips, p. 130, pl. 4, fig. 12.
1853 *Placunopsis jurensis* Roemer; Morris & Lycett, p. 6, pl. 1, figs 8a–b (*non* Roemer, 1836).

1861 *Placunopsis similis* sp. nov.; Whiteaves, p. 126, pl. 9, figs 1–2.
?1863 *Anomia* sp.; Dollfus, p. 88, pl. 15, fig. 5.
1865 *Anomia distracta* sp. nov.; d'Eichwald, p. 411, pl. 19, figs 1a–b.
1865 *Placunopsis jurensis* Roemer; d'Eichwald, p. 408, pl. 19, fig. 12 (*non* Roemer, 1836).
1867 *Placunopsis lycetti* sp. nov.; de Loriol, p. 116, pl. 11, fig. 5.
1874 *Placunopsis lycetti* Loriol; de Loriol, p. 229, pl. 25, fig. 9.
?1883 *Placunopsis* cf. *P. jurensis* Roemer; Lahusen, p. 91, pl. 1, fig. 12.
1929 *Placunopsis radiata* (Phillips); Arkell, p. 49, pl. 3, figs 4–5.
1930 *Anomia columbiana* sp. nov.; Crickmay, p. 53, pl. 14, figs 4–6.
1936 *Placunopsis radiata* (Phillips); Arkell, pl. 52, fig. 14.
v.1936 *Placunopsis* aff. *P. lycetti* Loriol; Spath, p. 109, pl. 42, fig. 13.
1955 *Anomia lycetti* (Loriol); Gerasimov, p. 121, pl. 22, fig. 10.
1966 *Anomia spathi* sp. nov.; Zakharov, p. 116, pl. 51, fig. 3, pl. 52, figs 2–3.
1969 *Anomia distracta* Eichwald; Gerasimov, p. 69, pl. 17, figs 1–2.

Material. 5 left valves from the Pernaryggen Member at Hartz Fjeld and Kronen (from GGU 235428, 235441, 235447, 235486–235487, 235580).

Description. Thin, medium-sized, inequivalve, suborbicular shell, variable in outline; left valve slightly convex; umbo submarginal, depressed; ornament consisting of numerous fine radiating striae, sinuous and frequently interrupted by commarginal growth lines and, at irregular intervals, by folds.

Remarks. As has been noted already by several authors (e.g. Arkell, 1929, p. 49) erosion of the tip of the umbo of the left valve often produced a foramen-like hole and this has caused many authors (see synonymy list) to place the species in the genus *Anomia.* There is, however, no byssal foramen in the right valve and consequently little doubt that the species is a *Placunopsis* and not an *Anomia.*

All larger *Placunopsis,* described so far in the literature, seem to belong to *P. radiata.* A highly variable outline as in *P. radiata* is quite usual in cemented bivalves and variable ornament is also fairly characteristic. *P. jurensis* (Roemer, 1836) is considerably smaller and may thus represent a second species (for different opinion see Arkell, 1937, p. vii) to which also *P. suprajurensis* and *P. raulinea* (Buvignier, 1852) as well as several other small *Placunopsis* would belong.

Autecology. P. radiata was a fixosessile species, which cemented its right valve onto hard substrates such as other shells or fragments of shell. Trophic group: low level suspension-feeder.

Superfamily Limacea Rafinesque, 1815. Family Limidae Rafinesque, 1815.

Genus *Limatula* Wood, 1839.
Type species. Pecten subauriculata Montagu, 1808.

Limatula consobrina consobrina (d'Orbigny, 1845)

Fig. 25 C, F

*1845 *Lima consobrina* sp. nov.; d'Orbigny, p. 477, pl. 42, figs 5–7.

Material. 16 specimens from the Pernaryggen Member af Hartz Fjeld and the Cardioceraskløft Member at Cardioceraskløft (from GGU 235447, 235468–235469, 235544, 235566, 235569).

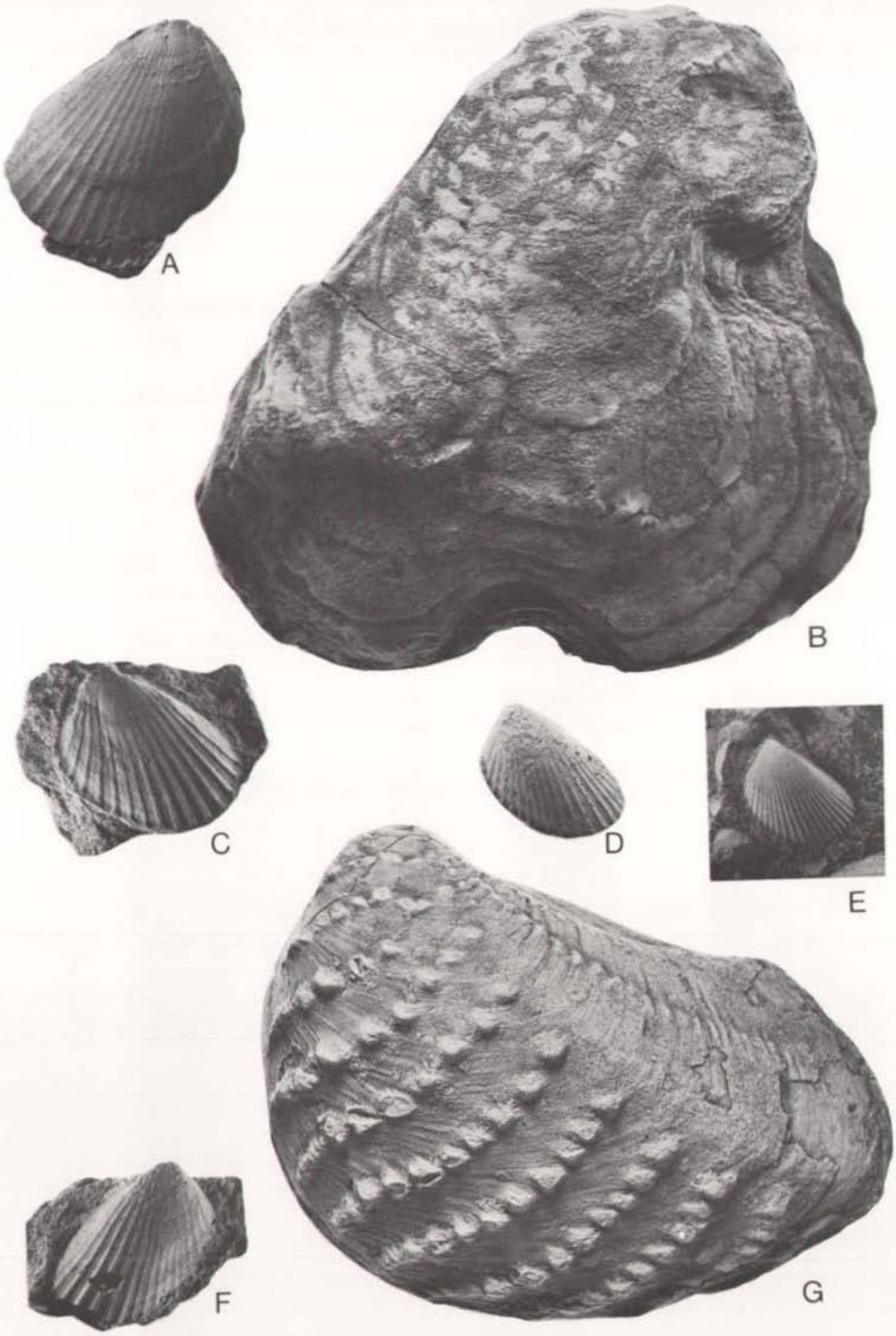
Description. Small, obliquely ovate shell, slightly higher than long, equivalve, auriculate, tumid; hinge line straight and short, auricles small and subequal; anterodorsal ridge absent. Ornament consisting of 15 to 17 (usually 16) strong radial ribs which are separated by broad, smooth and slightly concave sulci, at the ventral margin about twice the width of the ribs. The ribs are most conspicuous in the central part of the shell. Both anterior and posterior ends of shell smooth.

Measurements.	GGU sample	l	h	h/l(%)
	235468	1.9	2.2	115.8

Remarks. L. consobrina is widespread in the Boreal Upper Jurassic, but also occurs in the Subboreal Province (e.g. Normandy). In Milne Land it is rare except for one horizon in the Cardioceraskløft Member, where it forms a significant part of the benthic fauna.

Autecology. The broad, flattened anterior of the shell provides an ideal resting area from which the byssus could have extended straight down into the sediment. In terms of trophic group, *L. consobrina* was a medium level suspension-feeder.

Fig. 25. *Pseudolimea* cf. *P. arctica* (Zakharov, 1966).
A. MGUH 15489 from GGU 235522; bivalved specimen, right view; × 1. Pernaryggen Mb, Bays Fjelde.
Liostrea(?) sp. indet. 1
B. MGUH 15490 from GGU 235517; bivalved specimen right view; × 1. Pernaryggen Mb, Kronen.
Limatula consobrina consobrina (d'Orbigny, 1845).
C. MGUH 15491 from GGU 235544; left valve; × 1. Cardioceraskløft Mb, Cardioceraskløft.
F. MGUH 15492 from GGU 235489; right valve; × 1. Pernaryggen Mb, Kronen.
Limatula consobrina multicostata subsp. nov.
D. MGUH 15493 from GGU 235489; bivalved specimen (holotype), left view; Pernaryggen Mb, Kronen.
E. MGUH 15494 from GGU 235403; left valve; × 1. Pernaryggen Mb, Hartz Fjeld.
Myophorella (Myophorella) ingens (Lycett, 1872).
G. MGUH 15495 from GGU 137430; left valve; × 1. Pernaryggen Mb, Hartz Fjeld.


A
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Limatula consobrina multicostata subsp. nov.

Fig. 25 D, E

Holotype. MGUH 15493 from GGU 235489 from the Pernaryggen Member of Kronen.

Material. 7 specimens from the Pernaryggen Member at Hartz Fjeld and Kronen (235403–235405, 235489, 235491, 235516, 235546).

Derivatio nominis. Multicostatus (Lat.) = with many ribs.

Diagnosis. Shape and outline like *Limatula consobrina consobrina,* but with 19–22 radial ribs.

Measurements.	GGU sample	l	h	h/l(%)
	235489–1	1.9	2.1	110.5
	235489	1.2	1.3	108.3

Remarks. L. consobrina multicostata differs solely by its greater number of ribs, five of the specimens having 19, the remaining two 20 and 22 respectively. The available material is not sufficient to argue for a separation at the species level. *L. consobrina multicostata* overlaps stratigraphically with *L. consobrina consobrina* although they do not occur in the same beds.

Autecology. As *L. consobrina consobrina.*

Genus *Plagiostoma* J. Sowerby, 1814.
Type species. Plagiostoma gigantea J. Sowerby, 1814.

Plagiostoma incrassatum (d'Eichwald, 1868)

Fig. 24 L, N

*1868 *Lima incrassata* sp. nov.; d'Eichwald, p. 476, pl. 21, figs 3a–b.
v.1936 *Lima (Plagiostoma)* sp. nov. ?indet.; Spath, p. 106, pl. 46, fig. 5, pl. 47, fig. 10.
1955 *Lima incrassata* Eichwald; Gerasimov, p. 109, pl. 22, fig. 9.
1966 *Lima (Plagiostoma) incrassata* Eichwald; Zakharov, p. 64, pl. 17, figs 1–2.
1969 *Lima (Plagiostoma) incrassata* Eichwald; Gerasimov, p. 66, pl. 12, fig. 1.

Material. 20 specimens from the Pernaryggen Member at Hartz Fjeld and Kronen (from GGU 235411–235412, 235420–235423, 235428, 235430, 235443–235444, 235451, 235486–235487, 235491, 235496–235497, 235537, 235546).

Description. Obliquely ovate, opisthocline shell, length slightly exceeding height, moderately inflated; shell smooth except for very faint growth lines. Posterior

auricle larger than anterior, with growth lines more conspicuous than on rest of shell. Ligament pit broad; anterior umbonal ridge well defined, straight to slightly concave, with excavated lunule in front of it.

Remarks. The Milne Land specimens correspond closely to d'Eichwald's figure of *Lima incrassata.* Another smooth species, *Plagiostoma calvata* Zakharov (1966, p. 66, pl. 18, figs 1–5) is less elongate, but otherwise very similar. Most Milne Land specimens have been bored by cirripedes or phoronids, which is unusual considering the very low overall percentage of bored shells in the Pernaryggen Member.

Autecology. Like most other limids, *P. incrassatum* was epibyssate. Very likely it rested on the substrate on its anterior umbonal ridge similar to the Triassic *P. lineatum* (see Seilacher, 1954). In terms of trophic group *P. incrassatum* was a high level suspension-feeder.

Plagiostoma sp. indet.

Material. 3 fragmented specimens (from GGU 235420–235423, 235486–235487) from the Pernaryggen Member at Hartz Fjeld and Kronen.

Remarks. A second, much rarer species of *Plagiostoma* has distinct radial ribs which are separated by broad sulci about $2^1/_2$ times the width of the ribs. As no complete specimen is available, no specific identification can be attempted.

Genus *Pseudolimea* Arkell *in* Douglas & Arkell, 1932.
Type species. Plagiostoma duplicata J. de C. Sowerby, 1827.

Pseudolimea cf. *arctica* (Zakharov, 1966)

Fig. 25 A

v.1936 *Lima (Pseudolimea)* aff. *L. (P.) blakei* Cox; Spath, p. 107, pl. 45, figs 7a, b.

Material. 2 specimens from the Pernaryggen Member at Bays Fjelde (from GGU 235522).

Description. Small-sized, slightly longer than high, obliquely ovate shell, moderately gibbous; anterior umbonal ridge ill-defined. Umbones salient dorsal to hinge line; beaks situated in the centre of moderately long cardinal area; auricles of nearly equal size. Ornament consisting of 22 ribs; posterodorsal and anterodorsal parts of shell smooth.

Measurement.	GGU sample	l	h	n_{ribs}
	235522	3.3	3.1	22

Remarks. As in both specimens no details of the ribbing has been preserved, no precise identification is possible. However, both shape and number of ribs closely compare to *Pseudolimea arctica* Zakharov (1966, p. 62, pl. 16, figs 6–11). Most likely, the Milne Land specimens belong to this species.

Autecology. Epibyssate, low level suspension-feeder, probably resting with one of the valves on a firm substrate.

Suborder Ostreina Férussac, 1822. Superfamily Ostreacea Rafinesque, 1815. Family Gryphaeidae Vyalov, 1936. Subfamily Gryphaeinae Vyalov, 1936.

Genus *Liostrea* Douvillé, 1904.
Type species. Ostrea sublamellosa Dunker, 1846.

Liostrea plastica (Trautschold, 1860)

Fig. 26 A–B, D

*1860 *Ostrea plastica* sp. nov.; Trautschold, p. 339.
1935 *Ostrea* sp. ind.; Spath, p. 54, pl. 9, fig. 6, pl. 10, fig. 4.
v.1936 *Ostrea bononiae* Sauvage; Spath, p. 102, pl. 39, figs 10–12, pl. 49, figs 6a–b.
1966 *Liostrea plastica* (Trautschold); Zakharov, p. 112, pl. 37, fig. 4, pl. 38, fig. 2.

Material. 64 specimens from the Pernaryggen Member at Hartz Fjeld (from GGU 235406–235407, 235411–235412, 235429–235430, 235447, 235480, 235498, 235500–235502, 235538, 235549) and Kronen (235486–235487, 235489, 235491, 235507–235508, 235557, 235559).

Description. Medium-sized to large *Liostrea,* relatively thin-shelled, very variable in outline, but mainly oval to subcircular. Left valve reflecting the form of the encrusted surface; right valve moderately to strongly convex, with well developed umbo. Ornament of right valve consisting of concentric folds of varying strength; xenomorphic ornament, corresponding to the morphology of the encrusted surface, is frequently present.

Remarks. L. plastica is the commonest oyster within the Upper Jurassic of Milne Land. It exclusively encrusted ammonite shells, usually growing from the umbilicus outwards. The xenomorphic ornament is often therefore that of whorl flanks of ammonites (fig. 26 A, B).

Autecology. Cemented low level suspension-feeder. The relationship between *L. plastica* and the ammonites which served as a substrate (*Epipallasiceras* is a particularly common substrate) is still not clear. Cope (1968) found the same oyster as well as *Liostrea multiformis* encrusting ammonites in the Kimmeridgian of south-

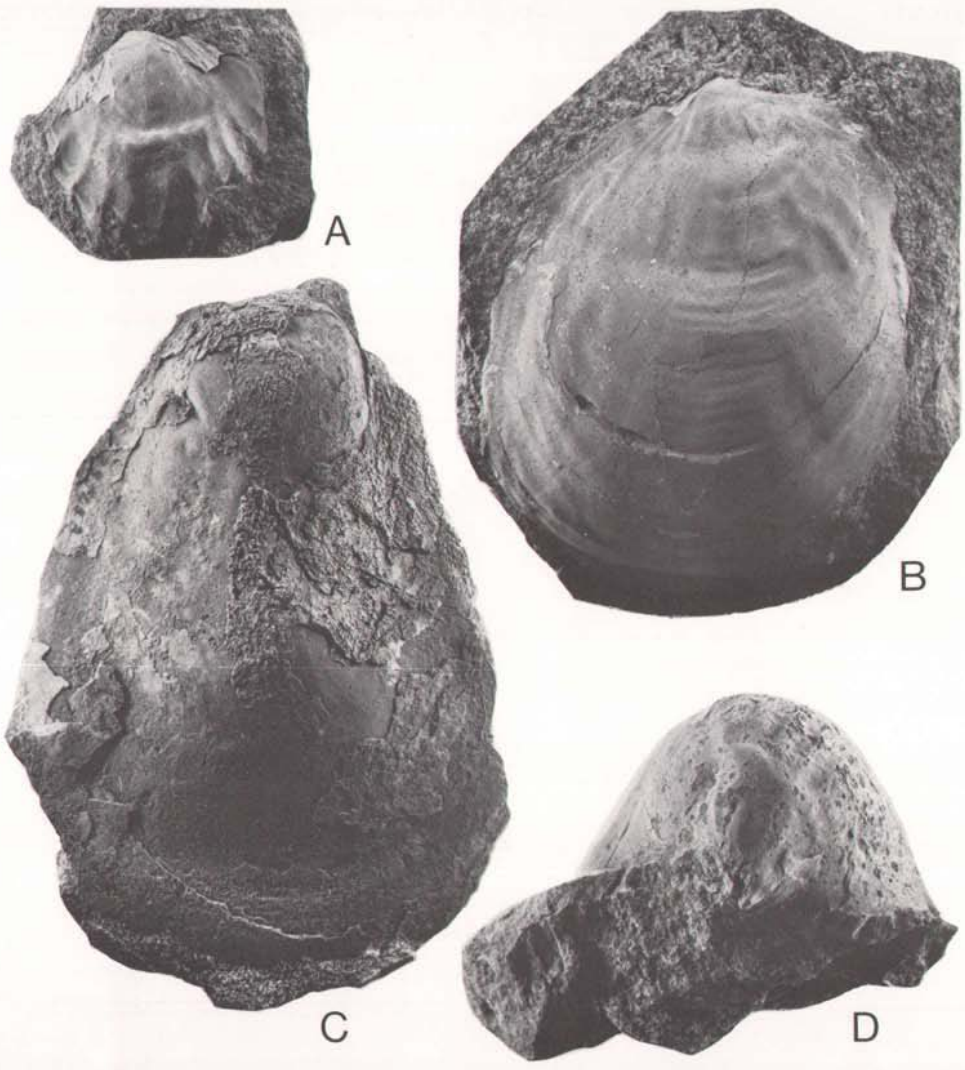

Fig. 26. *Liostrea plastica* (Trautschold, 1860).
A. MGUH 15496 from GGU 235447; right valve; × 1. Pernaryggen Mb, Hartz Fjeld.
B. MGUH 15497 from GGU 235480; right valve; × 1. Pernaryggen Mb, Hartz Fjeld.
D. MGUH 15498 from GGU 235557; bivalved specimen, dorsal view; × 1. Krebsedal Mb, Kronen.
Liostrea(?) sp. indet. 2
C. MGUH 15499 from GGU 235453; bivalved specimen, right view; × 1. Aldinger Elv Mb, locality 26.

ern England. According to him, the oysters were largely confined to the lower surface of the ammonites lying on the sea floor, whereby the region around the peristome and part of the opposite whorl section (that is the areas in actual contact with the sea floor) are usually free of oyster encrustation. He concluded that

growth of the oysters was post-mortem and that encrustation took place on the side of the ammonite shell facing the substrate.

In the Milne Land examples usually both sides of the ammonite are encrusted, frequently by several individuals. If the encrustation took place post-mortem, it more probably started on the side of the ammonite shell facing upwards, as it is highly unlikely that the convex right valves of *L. plastica* could have grown within the narrow space (if indeed any existed at all) between the ammonite shell and the substrate. Reworking of the ammonite shells, during which the encrusted and therefore heavier shell surface came to rest on the substrate, is then a prerequisite to enable colonisation on both surfaces. However, symmetrical encrustation could equally have been the result of epizoic growth during the life time of the ammonites. The following facts support this: a) the restriction of *L. plastica* to ammonites although plenty of other hard substrates were available (e.g. large *Isognomon, Camptonectes* etc.); and b) the relatively thin shells of *L. plastica* as compared to most other oysters of comparable size. Unfortunately the available material is not well enough preserved to allow reconstruction of growth directions and thus confirm or reject the possibility of pre-mortem encrustation, but it is hoped to gain further information from material from other parts of the Jurassic. For the moment the possibility cannot be dismissed that *L. plastica* did not belong to the benthos, but lived commensally on ammonites.

Liostrea(?) sp. indet. 1

Fig. 25 B

Material. 1 specimen (from GGU 235517) from the Pernaryggen Member at Kronen.

Description. Large, pear-shaped, thick-shelled, flat, lobate oyster; surface ornament consisting of coarse commarginal growth rugae.

Remarks. With only one specimen available for study it is not possible to evaluate the range of variation in *Liostrea(?)* sp. indet. 1. A precise generic and specific designation seems inadvisable as no internal features of the shell such as ligament pit and shape and position of the muscle scar are seen.

Autecology. The single specimen of *Liostrea(?)* sp. indet. 1 is cemented on a large shell of *Isognomon volaticum.* Trophic group: low level suspension-feeder.

Liostrea(?) sp. indet. 2

Fig. 26 C

Material. 3 specimens from the Aldinger Elv Member south-west of Kronen, locality 25 (from GGU 235453–235455).

Description. Medium- to large-sized *oyster*; outline oval, higher than long. Left valve convex, right valve flat or slightly concave. Attachment area small. Shell surface covered with irregular concentric growth lines or smooth.

Remarks. These specimens are again kept in an informal position for the same reason as given above. One of the specimens resembles *Deltoideum delta* (Smith) and *L. praeanabarensis* Zakharov (1966, pl. 38, figs 3–6, pl. 39, figs 1–2, pl. 40, figs 1–2), but the figured specimen is rather different. As all three specimens come from one horizon, it seems unlikely that several species are represented, but that all belong to one highly variable species.

Autecology. The specimens seem to have had only a small attachment area; they might in fact have spent some part of their lives resting freely on the sea floor. They can be classified as cemented or reclining low level suspension-feeders.

Subfamily Exogyrinae Vyalov, 1936.

Genus *Nanogyra* Beurlen, 1958.
Type species. Gryphaea nana J. Sowerby, 1822.

Nanogyra nana (J. Sowerby, 1822)

*1822 *Gryphaea nana* sp. nov.; J. Sowerby, p. 114, pl. 383.

For synonymy and extensive description see Arkell (1930, p. 175) and Pugaczewska (1971).

Material. 19 specimens from the Pernaryggen Member at Hartz Fjeld and Kronen, 1 specimen from the Aldinger Elv Member at locality 26 (from GGU 235401–235405, 235468–235469, 235514, 235555–235556).

Description. Small, kidney-shaped to oval oyster, very variable in shape; left valve strongly convex, right valve flat; umbones directed posteriorly and spiral. Ornament consisting of growth lamellae.

Autecology. Compared to its abundance in the Upper Oxfordian of Northwest Europe, *N. nana* is rare in the Upper Jurassic of Milne Land. It usually occurs in small clusters with the individuals commonly cemented to each other. It can be classified as an epifaunal cemented, low level suspension-feeder.

Subclass Palaeoheterodonta Newell, 1965. Order Trigonioida Dall, 1889. Superfamily Trigoniacea Lamarck, 1819. Family Trigoniidae Lamarck, 1819.

Genus *Myophorella* Bayle, 1878.
Type species. Myophorella nodulosa Bayle, 1878 (= *Trigonia nodulosa* Lamarck, 1801).

Myophorella (Myophorella) ingens (Lycett, 1872)

Fig. 25 G

*1872 *Trigonia ingens* sp. nov.; Lycett, p. 24, pl. 8, figs 1–3, pl. 36, figs 5–6.
v.1936 *Trigonia* aff. *T. thurmanni* Contejean; Spath, p. 113, pl. 41, fig. 8, pl. 42, fig. 10.
v.1936 *Trigonia* sp.; Spath, p. 113, pl. 41, fig. 7.

Material. 12 specimens from the Pernaryggen Member at Hartz Fjeld, Kronen and Bays Fjelde (from GGU 235401–235405, 235442, 235509, 235540–235541, 137430).

Description. Medium to large, moderately inflated, subtrigonal shells; umbones prominent, orthogyrate, situated about a quarter of shell length from the anterior. Anterior region short; anterior margin evenly convex, sweeping round to gently convex ventral margin. Posteroventral margin obliquely truncated, nearly straight, forming a rounded obtuse angle with the ventral margin. Posterodorsal margin straight near the umbo and slightly concave towards the posterior, forming an obtuse angle with the posterior margin. With rounded carina running from the umbones to the posteroventral margins; another carina circumscribes the concave escutcheon. The latter carina consists of a series of low tubercles, elongated in the direction of the growth lines and disappearing towards the posterior end. Posterior area nearly flat, relatively broad, subdivided by shallow groove running along the middle, of which the ventral is another row of tubercles, again elongate in the direction of growth lines and becoming less conspicuous towards the posterior end. Flank of shell ornamented with rows of strong, blunt tubercles which, in a faint arch, sweep forward towards the anterior margin. Sometimes their course is sigmoidal recurving towards the ventral margin near the anterior shell margin. In addition most of the shell is covered with coarse, commarginal lamellae.

Interior of shell smooth, pallial line entire, muscle scars deeply set. At the posterior margin there is a distinct swelling corresponding to the position of the areal groove on the outside of the shell.

Remarks. Fahrenkohl (1844, p. 796, pl. 19, fig. 2) figured a *Myophorella* from the Upper Jurassic of the Moscow region as *Lyriodon intermedium.* This species appears to be very similar to the Milne Land specimens, but the specimen figured by Fahrenkohl is distorted. Only if better preserved specimens of *M. intermedia* become available, can it be decided whether the Milne Land specimens must be referred to Fahrenkohl's species with *M. ingens* then being a junior synonym.

Autecology. Other Jurassic *Myophorella* are frequently found in life position (e.g. Stanley, 1977; Fürsich, 1980) with the posterior end at the sediment/water interface and the anterior directed down into the sediment. Although it could not be observed in its original position, its seems safe to assume an identical growth position for *Myophorella (M.) ingens*. Trophic group: low level suspension-feeder.

Subclass Heterodonta Neumayr, 1884. Order Veneroida Adams & Adams, 1856. Superfamily Lucinacea Fleming, 1828. Family Lucinidae Fleming, 1828. Subfamily Myrteinae Chavan, 1969.

Genus *Discomiltha* Chavan, 1952.
Type species. Discomiltha Oehlerti Bigot *in* Chavan, 1952.

Discomiltha lirata (Phillips, 1829)

Fig. 27A, B, D, F

*1829 *Lucina lirata* sp. nov.; Phillips, p. 140, pl. 6, fig. 11.
v.1936 *Lucina* sp. nov. aff. *L. inaequalis* d'Orbigny; Spath, p. 123, pl. 46, figs 1a–b only.

Material. 77 specimens from the Krebsedal Member at Hartz Fjeld (from GGU 235479, 137453, 137461), 7 specimens from the Pernaryggen Member at Hartz Fjeld (from GGU 235427, 235464, 235467, 235551) and 2 specimens from the Aldinger Elv Member at locality 25 (235452, 235461).

Description. Medium-sized, inequilateral shell, suborbicular to subrectangular; degree of inflation variable; anterior region variably produced; umbones prominent, submesial, small (but acute), prosogyrate, situated slightly posterior of centre. Lunule asymmetric, shallow, sharply bounded; escutcheon deep, elongate. The external ligament which occupies the escutcheon is often preserved. Posterodorsal margin slightly convex forming an obtuse angle with the straight, sometimes obliquely truncated, posterior margin. Ventral margin only feebly convex forming another obtuse angle with the posterior margin. These obtuse angles are caused by a faint posterior radial sulcus. Anterior margin well rounded, anterodorsal margin concave. Interior of shell commonly with faint grooves; pallial line entire, posterior adductor scar oval, anterior one very long, narrow, slightly arcuate, and separated for more than half its length from the pallial line (fig. 28). Hinge of left valve with 2 cardinal teeth and 1 obscure anterior lateral. Right valve with 2 cardinals, the anterior of which is partly obscured by lunule development. Shell surface covered with numerous widely spaced commarginal lamellae, with finer growth lines between.

Remarks. The shape of the adductor scars, the hinge and the grooved shell interior place *Lucina lirata* Phillips in *Discomiltha,* as defined by Chavan (1969, p. N499) (see also Duff, 1978). The species seems to be fairly variable. Individuals from large populations (e.g. concretions in the upper part of the Krebsedal Member, at the ridge south of Pinnadal) show considerable differences in inflation, degree of enlargement of the anterior region, surface ornamentation and degree of posterior truncation. Although the specimens from the Pernaryggen Member are generally somewhat larger, it is impossible to separate them taxonomically, their hinge and outline being identical to specimens from the Krebsedal Member. The specimen figured by Spath (1936, pl. 46, figs 1a–b) represents an extreme case of posterior

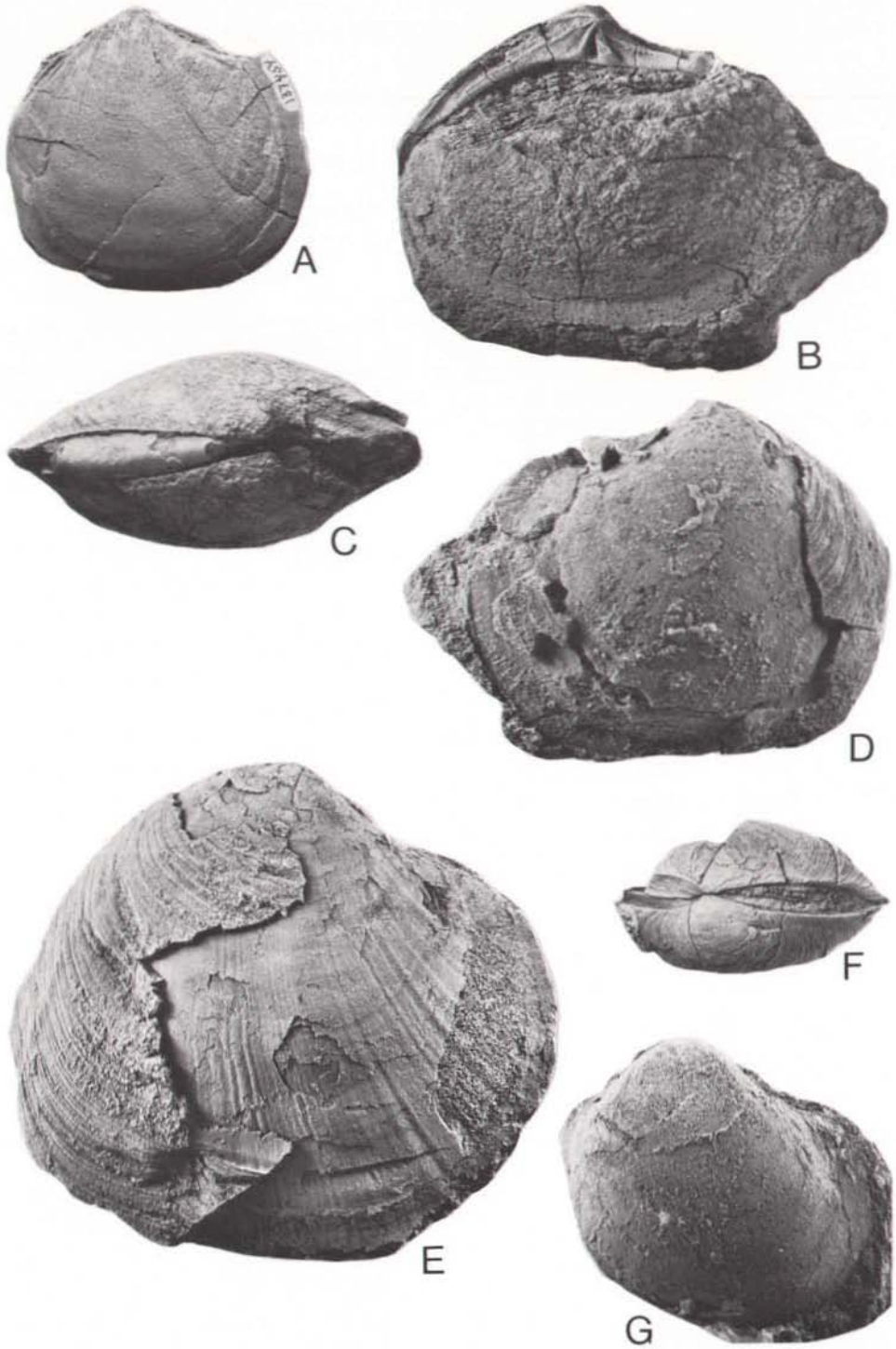
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Fig. 28. Muscle scars and pallial line of *Discomiltha lirata*. MGUH 15500 from GGU 137454; bivalved specimen, right view; × 1. Krebsedal Mb, Hartz Fjeld.

truncation and resembles *Lucina inaequalis* d'Orbigny (1845, p. 459, pl. 39, figs 6–8) more closely than *D. lirata*. However, there is a complete range of variation between Spath's specimen and Phillips' and as the latter's name has historical precedence over d'Orbigny's, it is herein referred to *D. lirata*.

Autecology. Most Recent lucinids live deeply buried in the sediment having constructed mucus-lined tubes for the inhalent and exhalent currents (e.g. Stanley, 1970, p. 148 ff.). They occupy a variable position within the sediment. Whilst the inhalent tube is always connected to the surface of the sediment, the exhalent tube can also be directed downwards into the sediment. Most Recent lucinids seem to be fairly slow burrowers. Since *D. lirata* exhibits a morphology closely comparable to Recent relatives, it is likely to have had a similar mode of life. Like them it can be classified as a low level, deep burrowing suspension-feeder.

Discomiltha(?) sp. A

Fig. 27 C, E

v.1936 *Lucina*(?) sp. indet.; Spath, p. 124, pl. 48, fig. 7.
v.1936 *Lucina* sp. nov. ?indet.; Spath, p. 124, pl. 50, fig. 9a–b.
v.1936 *Lucina* sp. nov. cf. *L. inaequalis* d'Orbigny; Spath, p. 123, pl. 50, figs 8a–b.

Fig. 27. *Discomiltha lirata* (Phillips, 1829).
A. MGUH 15500 from GGU 137454; steinkern, right view; × 1. Krebsedal Mb, Hartz Fjeld.
B, D. MGUH 15501 from GGU 235427; hinge (B) and exterior (D) of left valve; × 1. Pernaryggen Mb, Hartz Fjeld.
F. MGUH 15502 from GGU 137441; bivalved specimen, dorsal view; × 1. Krebsedal Mb, Hartz Fjeld.
Discomiltha(?) sp. A
C. MGUH 15503 from GGU 235575; bivalved specimen, dorsal view; × 1. Pernaryggen Mb, Hartz Fjeld.
E. MGUH 15504 from GGU 235575; bivalved specimen, right view; × 1. Pernaryggen Mb, Hartz Fjeld.
Unicardium aceste d'Orbigny, 1850
G. MGUH 15505 from GGU 235462; left valve; × 1. Aldinger Elv Mb, locality 25.

Material. 8 specimens from the Pernaryggen Member at Hartz Fjeld (from GGU 235480, 235548, 235575, 137456).

Description. Shell large (largest specimen 7.7 cm in length), suborbicular; umbones submesial, small, acute, prosogyrate; posterior margin well rounded, without marked posterodorsal angularity; weak angularity at the posteroventral junction. Ventral margin evenly, but sometimes only faintly, convex; anterior margin well rounded; with faint posterior radial depression; escutcheon deep, lanceolate, completely filled by external ligament; lunule shorter, asymmetric, similar to but deeper than that of *D. lirata.* Interior of shell with numerous fine grooves; hinge and muscle scars not seen. Shell ornament quite variable, consisting of numerous irregular commarginal lamellae of varying strength.

Remarks. Although their general shape is very close to the other Greenland lucinid, *D. lirata,* these specimens are here only tentatively referred to *Discomiltha* as the critical features for a generic identification (hinge, muscle scars) are not seen. They could well, however, represent gerontic individuals of *D. lirata* differing from it by larger size, a more rounded posterior, and a somewhat deeper lunule.

Autecology. See under *D. lirata.*

Family Mactromyidae Cox, 1929.

Genus *Unicardium* d'Orbigny, 1850.
Type species. Corbula cardioides Phillips, 1829.

Unicardium aceste d'Orbigny, 1850

Fig. 27 G

1850 *Unicardium Aceste* sp. nov.; d'Orbigny, p. 366, no. 307.
v.1936 *Mactromya verioti* (Buvignier); Spath, p. 122, pl. 46, figs 2–3.

Material. 4 specimens (from GGU 235460–235462) from the Aldinger Elv Member 2.5 km south-west of Kronen, 2 specimens (235420) from the Pernaryggen Member at Lingularyggen, and 2 specimens from the *Lingula* Bed at Lingularyggen (235437).

Description. Globose, rounded, somewhat elongate shell; umbones broadly inflated, slightly prosogyrate, situated about two-thirds of shell length from the posterior. Ornament consisting of commarginal ribs which vary in strength between the various specimens.

Remarks. The specimens from the Oxfordian Aldinger Elv Member closely match specimens from the Corallian of England referred to *U. aceste* by Arkell (1934, pl.

42, figs 1–5). Similarly, the two specimens from the Middle Volgian Pernaryggen Member fall well within the range of *U. aceste* as do the specimens from the still higher *Lingula* Bed. The latter also resemble *U. verioti* (Buvignier, 1852, pl. 17, figs 1–5) and have been described under this name by Spath (1936), but are less tumid than Buvignier's original.

Autecology. The lack of a pallial sinus suggests that *U. aceste* was a shallow burrower. However, many Recent lucinids construct mucus-lined tubes for feeding purposes and live deeper down in the sediment; the same could have been true of *U. aceste.* Trophic group: low level suspension-feeder.

Superfamily Crassatellacea Férussac, 1822. Family Astartidae d'Orbigny, 1844. Subfamily Astartinae d'Orbigny, 1844.

Genus *Astarte* J. Sowerby, 1816.
Type species. Venus scotica Maton & Rackett, 1807.

Astarte (Astarte) praeveneris praeveneris Zakharov, 1970

Figs 29 A–C

*1970 *Astarte (Astarte) praeveneris praeveneris* sp. et subsp. nov.; Zakharov, p. 54, pl. 3, figs 2–5.

Material. 25 specimens from the Pernaryggen Member at Hartz Fjeld and Kronen (from GGU 235401–235405, 235440–235441, 235467, 235494, 235540–235541, 235560).

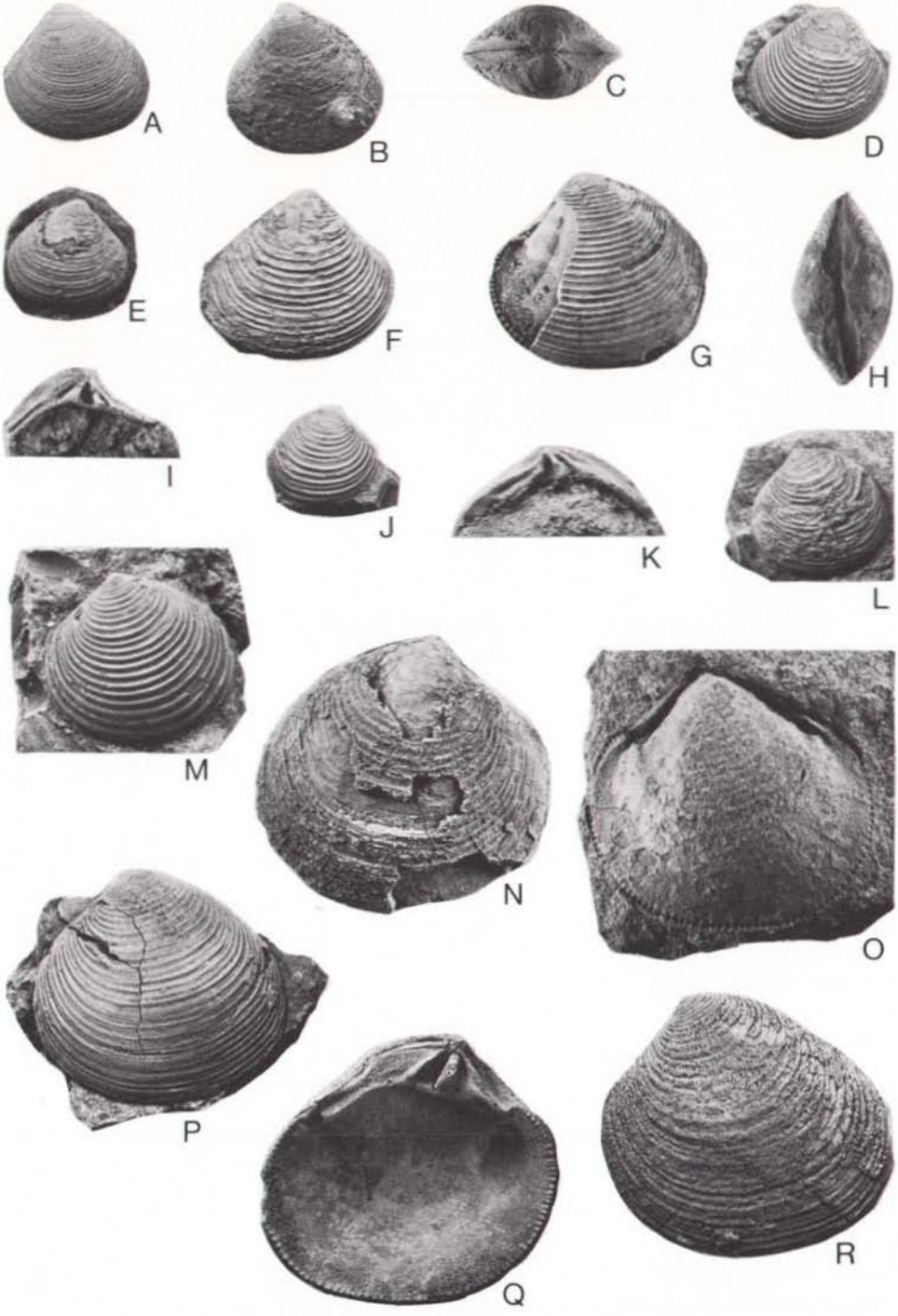
Description. Medium-sized, moderately inflated, triangular shell; umbones produced, pointed, prosogyrate, situated slightly anteriorly of centre. Posterodorsal margin gently convex, sloping, forming a rounded, very obtuse angle with the posteroventral margin. Ventral and anteroventral margins convex, evenly rounded; anterodorsal margin slightly concave. Lunule moderately deep, bordered by a faint ridge; escutcheon long, lanceolate, well defined. Inner margin denticulated. Hinge with 2 cardinals, 1 posterior lateral and 1 anterior lateral tooth in each valve.

Shell ornament consisting of numerous fine commarginal ribs.

Measurements.

GGU sample	l	h	h/l(%)	l_l	l_l/l(%)	l_e	l_e/l(%)
235467	1.92	1.90	98.9	0.45	23.4	1.00	52.1
235541	2.09	2.00	95.7	0.52	24.9	1.13	54.1
235440	2.20	2.12	96.4	0.65	29.5	1.18	53.6

Autecology. Several specimens of *A. praeveneris praeveneris* are encrusted by the inarticulate brachiopod *Orbiculoidea latissima.* In most cases the brachiopod is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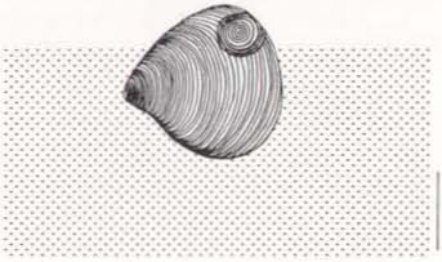

Fig. 30. Reconstructed life position of *Astarte* (*A.*) *praeveneris praeveneris* with *Orbiculoidea latissima* (Sowerby) encrusting the posteroventral part of shell. Sketch of MGUH 15507 from GGU 235540; Pernaryggen Mb, Hartz Fjeld. Scale: 1 cm.

situated near the posteroventral margin suggesting that this part of the shell was of particular attraction to the brachiopod. In two cases *Orbiculoidea* specimens are found in this position on both valves. This strongly suggests that the encrustation took place while the bivalve was alive, and it seems likely that the brachiopods benefited from the inhalent current entering the bivalve shell in the posteroventral region. This commensal relationship provides us with a clue towards the life position of *A. praeveneris praeveneris:* it must have lived semi-infaunally or very shallowly buried in the sediment, orientated vertically with the posterior end frequently exposed and allowing colonisation by *Orbiculoidea* (fig. 30). Trophic group: low level suspension-feeder.

Fig. 29. *Astarte* (*Astarte*) *praeveneris praeveneris* Zakharov, 1970.
A. MGUH 15506 from GGU 235441; bivalved specimen, left view; × 1. Pernaryggen Mb, Hartz Fjeld.
B, C. MGUH 15507 from GGU 235540; bivalved specimen, left (B) and dorsal (C) views; × 1. Pernaryggen Mb, Hartz Fjeld.
Astarte (*Astarte*) *praeveneris maimechaensis* Zakharov, 1970.
D. MGUH 15508 from GGU 235431; right valve; × 1. Pernaryggen MB, Hartz Fjeld.
E. MGUH 15509 from GGU 235528; right valve; × 1. Pernaryggen Mb, Bays Fjelde.
Astarte (*Astarte*) cf. *A. (A.) veneris* d'Orbigny, 1845.
F, H. MGUH 15510 from GGU 235499; bivalved specimen, right (F) and dorsal (H) views; × 1. Pernaryggen Mb. Kronen.
G. MGUH 15511 from GGU 235509; bivalved specimen, left view; × 1. Pernaryggen Mb, Kronen.
I. MGUH 15512 from GGU 235499; hinge of left valve; × 1. Pernaryggen Mb, Kronen.
Neocrassina (*Pressastarte*) *pelops* (d'Orbigny, 1850).
J, K. MGUH 15513 from GGU 235540; hinge (K) and exterior of right valve (J); J, × 1; K, × 2. Pernaryggen Mb, Hartz Fjeld.
L. MGUH 15514 from GGU 235540; left valve × 1. Pernaryggen Mb, Hartz Fjeld.
Eriphyla (*Lyapinella*) *saemanni* (de Loriol, 1867).
M. MGUH 15515 from GGU 137478; left valve; × 1. *Lingula* Bed, Hennigryggen Mb, Lingularyggen.
N. MGUH 15516 from GGU 137527; bivalved specimen, right view; × 1. Pernaryggen Mb, Hartz Fjeld.
O. MGUH 15517 from GGU 235427; internal cast of left valve; × 1. Pernaryggen Mb, Hartz Fjeld.
P. MGUH 15518 from GGU 235437; left valve; × 1. *Lingula* Bed, Hennigryggen Mb, Lingularyggen.
Q, R. MGUH 15519 from GGU 235437; interior (Q) and exterior (R) of left valve; × 1. *Lingula* Bed, Hennigryggen Mb, Lingularyggen.

Astarte (Astarte) praeveneris maimechaensis Zakharov, 1970

Figs 29 D–E

*1970 *Astarte (Astarte) praeveneris maimechaensis* sp. et subsp. nov.; Zakharov, p. 57, pl. 3, fig. 8, pl. 4, figs 1–3.

Material. 67 specimens from the Pernaryggen Member at Hartz Fjeld, Kronen and Bays Fjelde (from GGU 235411–235414, 235420–235423, 235431, 235472, 235516, 235518, 235528).

Description. Medium-sized, moderately inflated shell; umbones pointed, prosogyrate, situated anteriorly of shell centre; posterodorsal margin faintly convex, posteroventral and anteroventral margins well rounded; anterodorsal margin slightly concave. Inner margin crenulated. Lunule moderately broad; escutcheon long, lanceolate; both poorly defined. Shell ornament consisting of strong, rounded, commarginal ribs which are separated by grooves twice to three times their width.

Hinge as in *A. (A.) praeveneris praeveneris.*

Measurements.

GGU sample	l	h	h/l(%)	l_l	l_l/l(%)	l_e	l_e/l(%)
235413	1.58	1.47	93.0	0.50	31.6	0.80	50.6
235431	1.95	1.79	91.8	0.58	29.7	0.81	41.5
235528	1.65	1.48	89.7	–	–	0.88	53.3
235528	1.67	1.57	94.0	–	–	0.89	53.3

Remarks. A. (A.) praeveneris maimechaensis differs from *A. (A.) praeveneris praeveneris* mainly by possessing a slightly lower height/length ratio, by being more coarsely ribbed and by lacking a sharply defined escutcheon and lunule.

Autecology. A. praeveneris maimechaensis most likely lived like *A. praeveneris praeveneris,* that is as a very shallow burrowing, low level suspension-feeder.

Astarte (Astarte) cf. *A. (A.) veneris* d'Orbigny, 1845

Fig. 29 F–I

Material. 55 specimens from the Pernaryggen Member at Hartz Fjeld and Kronen (from GGU 235428, 235430, 235451, 235464, 235483, 235490, 235494, 235496–235497, 235499, 235504, 235509, 235514, 235534, 235536–235537, 235548).

Description. Medium-sized, rounded triangular, moderately inflated shell, longer than high. Umbones situated in anterior half of shell, prominent, prosogyrate. Posterodorsal margin slightly convex, anterodorsal margin distinctly concave; remaining margin well rounded. Lunule and escutcheon bordered by distinct ridge; escutcheon long, lanceolate; lunule also long, but wider. Shell ornament consisting of numerous rounded commarginal ribs, separated by intervals twice their width.

These intervals may show faint riblets. Interior margin crenulated; hinge as in *A. praeveneris;* pallial line entire, muscle scars impressed.

Measurements.	GGU sample	l	h	h/l(%)	l_i	l_i/l(%)	l_e	l_e/l(%)
	235499	2.80	2.42	86.4	0.91	32.5	1.35	48.2
	235509	3.03	2.80	92.4	0.97	32.0	1.46	48.2

Remarks. In outline these specimens resemble *A. (A.) veneris* as figured by Zakharov (1970, pl. 4, figs 4–11). However, the specimens from northern Siberia do not exhibit regular ribbing, but irregular growth lines only. Thus the Milne Land specimens differ in their ornament, but not so much as to suggest that they could not represent extreme variation in this character within *A. (A.) veneris.*

Autecology. Encrusting *Orbiculoidea latissima* found in a similar position to those on *A. praeveneris praeveneris* indicate that *A. (A.)* cf. *A. (A.) veneris,* too, lived as a very shallow burrowing, partly exposed low level suspension-feeder.

Genus *Neocrassina* Fischer, 1886.
Type species. Astarte obliqua Deshayes, 1830.

Neocrassina (Pressastarte) pelops (d'Orbigny, 1850)

Fig. 29 J–L

*1850 *Astarte Pelops* sp. nov.; d'Orbigny, p. 363.
1927 *Astarte Pelops* d'Orbigny; Cottreau, p. 48, pl. 46, figs 3–4.
1970 *Neocrassina (Pressastarte)* ex gr. *N. (P.) trembiazensis* (Lor.); Zakharov, p. 104, pl. 13, figs 51-c.

Material. 2 specimens from the Pernaryggen Member at Hartz Fjeld (from GGU 235540, 235541).

Description. Small, thick, compressed to weakly inflated shell; umbones prominent, sweeping forward, pointed; anterodorsal margin slightly concave, remaining margin convex; lunule and escutcheon sharply delineated; escutcheon long, lanceolate; lunule much shorter, lanceolate. Shell surface ornamented with numerous strong, rounded, commarginal ribs whose strength and distance from each other sometimes vary.

Hinge of right valve with 2 cardinals, 1 anterior and 1 posterior lateral. Anterior cardinal fused with lateral.

Measurements.	GGU sample	l	h	h/l(%)	l_i	l_i/l(%)	l_e	l_e/l(%)
	235540	1.55	1.40	90.3	0.20	14.3	0.57	36.8
	235540	1.89	1.80	95.2	–	–	–	–

Autecology. Recent astartids are mainly very shallow burrowing, low level suspension-feeders. As there are no epizoans on the two specimens from Milne Land, it is

impossible to make exact statements about their life position. The life orientation could probably vary just as in Recent astartids (e.g. Stanley, 1970, p. 145).

Subfamily Eriphylinae Chavan, 1952.

Genus *Eriphyla* Gabb, 1867.
Type species. Eriphyla umbonata Gabb, 1864.

Eriphyla (Lyapinella) saemanni (de Loriol, 1867)

Fig. 29 M–R

*1867 *Astarte saemanni* sp. nov.; de Loriol, p. 68, pl. 6, fig. 9.
v.1936 *Astarte* aff. *A. saemanni* P. de Loriol; Spath, p. 115, p. 47, figs 1, 3, 5 (only).

Material. 57 specimens from the Pernaryggen Member and Aldinger Elv Member at Hartz Fjeld, Kronen and Bays Fjelde (from GGU 235428, 235430, 235464, 235483, 235489–235490, 235499, 235504, 235509, 235513–235514, 235534, 235536–235537, 235548, 235575) and 9 specimens from the *Lingula* Bed at Lingularyggen (235435, 235437, 137478).

Description. Large, thick, moderately inflated, orbicular to elongate-ovate shell; umbones prominent, directed forward, pointed. Margins well rounded except for anterodorsal margin, which is slightly concave, and posterodorsal margin, which is sometimes only faintly convex. Lunule and escutcheon bordered by sharp ridge; both deeply excavated and lanceolate; lunule much shorter and somewhat broader than escutcheon. On several specimens the ligament is still preserved.

Shell ornamented with numerous strong commarginal ribs and faint growth lines. In some specimens from the *Lingula* Bed the surface ornament becomes less strong with increasing distance from the umbones.

Interior margin crenulated; muscle impressions distinct, posterior one orbicular, anterior one oval; pallial line with a shallow pallial inflexion; umbonal cavity large.

Hinge with 2 cardinals, 1 anterior lateral and 1 posterior lateral tooth in each valve. Anterior cardinal of right valve fused with anterior lateral. Posterior cardinal of left valve not reaching margin of hinge plate. Nymphs broad, long.

Measurements.

GGU sample	l	h	h/l(%)	l_l	l_e	l_e/l(%)	l_{ant}	l_{ant}/l(%)
137527	4.28	4.00	93.4	1.02	2.10	49.1	1.70	39.7
235427	4.00	3.60	90.0	–	–	–	1.22	30.5
235437	4.25	3.84	90.3	0.73	1.96	46.1	1.30	30.6
235437	4.20	3.80	90.5	–	2.18	51.9	1.40	33.3
235437	3.60	3.28	91.1	–	1.76	48.9	1.35	37.5
235437	3.84	3.45	89.8	–	–	–	–	–
137478	2.60	2.40	92.3	–	–	–	–	–

Remarks. In his original description of *Astarte saemanni,* de Loriol (1867) did not refer to the pallial line. The Milne Land examples clearly show a shallow pallial inflexion and therefore must be referred to Zakharov's subgenus *Lyapinella* which is a member of the genus *Eriphyla.* The Milne Land specimens exhibit a fair degree of variation with regard to outline and ornament, and it is particularly among the specimens from the stratigraphically younger *Lingula* Bed that the outline is often more oblique-ovate and the ornament less pronounced. Such specimens closely resemble *E. (Lyapinella) asiatica* Zakharov (1970, p. 114, pl. 14, figs 10–11, pl. 15, figs 1–7). The latter are, however, on the whole, even less strongly ribbed and often considerably more elongate. As, on the other hand, very orbicular, coarsely ribbed specimens occur within one population from the *Lingula* Bed (e.g. fig. 29 M) it is safe to keep all of them within *E. (Lyapinella) saemanni,* although they clearly represent a transitional stage to *E. (Lyapinella) asiatica* Zakharov.

Autecology. The presence of a shallow pallial sinus indicates that the species probably burrowed to a greater depth than other astartids hitherto described. Trophic group: low level suspension-feeder.

Superfamily Cardiacea Lamarck, 1809. Family Cardiidae Lamarck, 1809. Subfamily Protocardiinae Keen, 1951.

Genus *Protocardia* v. Beyrich, 1845.
Type species. Cardium hillanum J. Sowerby, 1813.

Protocardia (Protocardia) striatula (J. de C. Sowerby, 1829)

Fig. 31 A–E

*1829 *Cardium striatulum* sp. nov.; J. de C. Sowerby, p. 101, pl. 553, fig. 1.
1844 *Cardium concinnum* sp. nov.; v. Buch, p. 537, pl. 6, fig. 2.
v.1936 *Protocardia* sp. juv. indet.; Spath, p. 124, pl. 43, figs 5a–c, pl. 50, fig. 5.

Material. 15 specimens from the Kosmocerasdal Member at locality 4 (from GGU 235561, 235564, 235565), 44 specimens from the Aldinger Elv Member at locality 26 (235453–235456, 235458, 235460) and in the valley north of Cardiocerasknøft (235573), 24 specimens from the Pernaryggen Member at Hartz Fjeld, Kronen and Bays Fjelde (235401–235407, 235427, 235440–235441, 235464, 235468–235469, 235486–235487, 235510, 235513–235514, 235516, 235523, 235527, 235537, 235540–235542, 235549, 235568) and 16 specimens from the Astartedal Member at Hartz Fjeld and Lingularyggen (235418–235419, 235424–235425, 235432, 235449, 235465, 235476).

Description. Small to medium-sized, equivalve shell, subcircular to subquadrate in outline; shell nearly as high as long, inflated; thickness between 35 and 42% of length; umbones mesial, inflated, prominent, slightly prosogyrate; anterodorsal margin short, straight, forming a very obtuse angle with the anterior margin which

is well rounded and curves round, without a break, into the convex margin; posterior margin obliquely truncate to gently convex; posterior of shell with up to 20 radial riblets which are usually not very prominent; rest of shell smooth apart from very faint growth lines.

Measurements.	GGU sample	l	h	h/l(%)	d	d/l(%)
	235460	2,27	2.10	92.5	0.82	36.1
	235453	1.75	1.55	88.5	0.74	42.3
	235573	1.62	1.42	87.6	–	–
	235542	1.28	1.20	93.7	0.45	35.1

Remarks. Jurassic species of *Protocardia* are in an urgent need of revision (as already noted by Duff, 1978). Upper Jurassic *Protocardia* from the Boreal Realm are usually referred to *P. concinna* (v. Buch, 1844). Von Buch's figure (which is not very well drawn) as well as d'Orbigny's (1845, pl. 38, figs 11–13) and d'Eichwald's (1868, pl. 25, figs 13a–d) do not differ significantly from *P. striatula* (see recent description by Duff, 1978, p. 102, pl. 12, figs 7–11, 13). It thus does not seem justified to keep *P. concinna* as a separate species. As early as 1845, d'Orbigny regarded both species as identical, but argued that Sowerby's *C. striatulum* was

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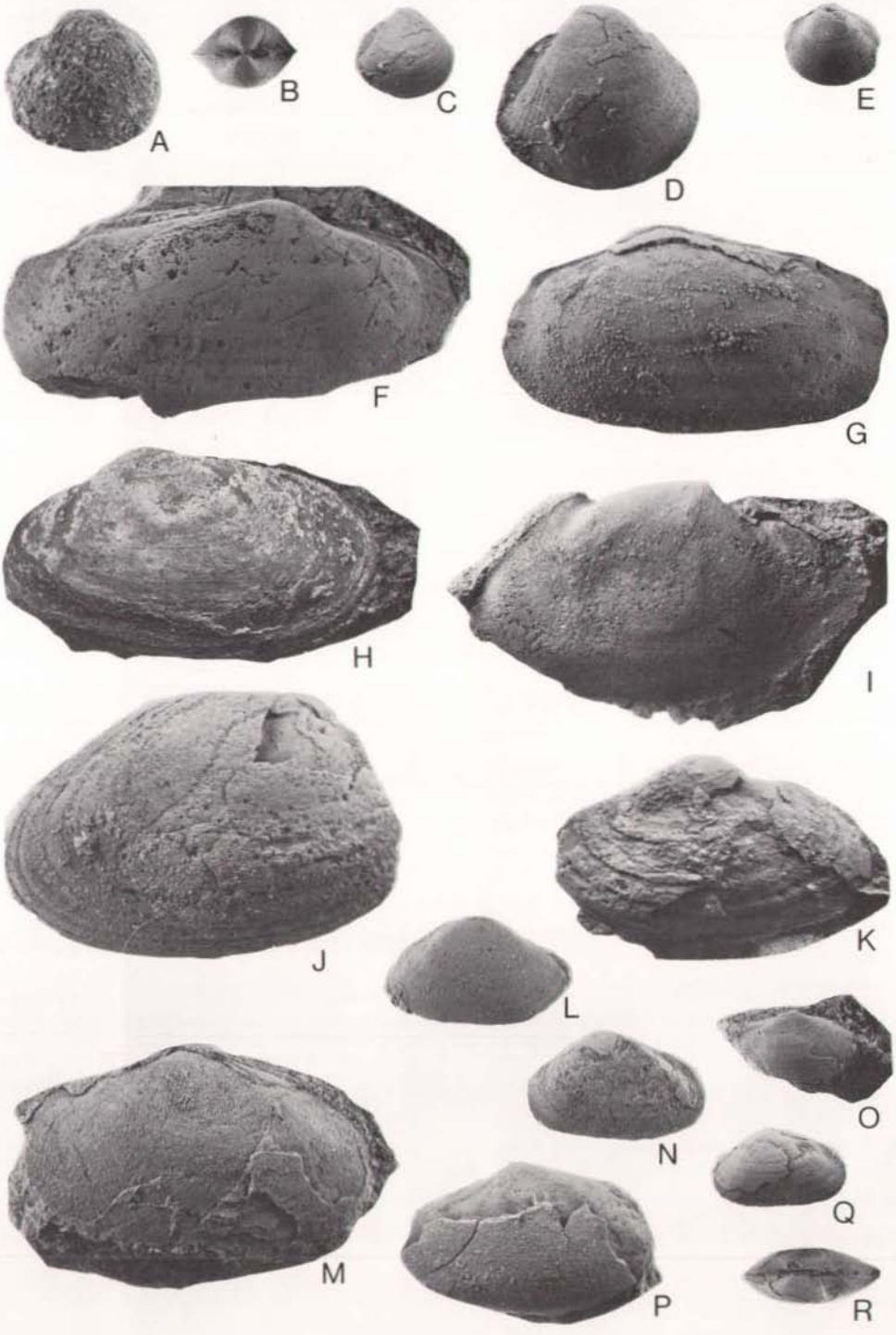
Fig. 31. *Protocardia* (*Protocardia*) *striatula* (J. de C. Sowerby, 1829).
A. MGUH 15520 from GGU 235460; bivalved specimen, left view; × 1. Aldinger Elv Mb, locality 25.
B-D. MGUH 15521 from GGU 235540; bivalved specimen, dorsal (B) and right (C,D) views; B, C, × 1; D, × 2. Pernaryggen Mb, Hartz Fjeld.
E. MGUH 15522 from GGU 235542; bivalved specimen, left view; × 1. Pernaryggen Mb, Hartz Fjeld.
Quenstedtia laevigata (Phillips, 1829).
F. MGUH 15523 from GGU 235580; right valve; × 1. Pernaryggen Mb, Kronen.
Quenstedtia parallela (Trautschold, 1866).
G. MGUH 15524 from GGU 235467; bivalved specimen, left view; × 1. Pernaryggen Mb, Hartz Fjeld.
Quenstedtia grewinki Boden, 1911.
H. MGUH 15525 from GGU 235471; left valve; × 1. Pernaryggen Mb, Hartz Fjeld.
Tancredia (*Tancredia*) *magna* sp. nov.
I. MGUH 15526 from GGU 235555; internal cast of right valve; × 1. Aldinger Elv Mb, locality 3.
J. MGUH 15527 from GGU 235555; right valve (holotype); × 1. Aldinger Elv Mb, locality 3.
Tancredia (*Tancredia*) *donaciformis* Lycett, 1850.
L. MGUH 15528 from GGU 235458; bivalved specimen, right view; × 1. Aldinger Elv Mb, locality 26.
Corbicellopsis laevis (J. de C. Sowerby, 1827).
K. MGUH 15529 from GGU 235458; left valve; × 1. Aldinger Elv Mb, locality 26.
M. MGUH 15530 from GGU 235452; left valve; × 1. Aldinger Elv Mb, locality 26.
P. MGUH 15531 from GGU 235555; left valve; × 1. Aldinger Elv Mb, locality 3.
Corbicellopsis cf. *C. lorioli* Cox, 1929.
N. MGUH 15532 from GGU 235403; bivalved specimen, left view; × 1. Pernaryggen Mb, Hartz Fjeld.
Corbicellopsis uniodes de Loriol, 1875.
O. MGUH 15533 from GGU 235514; left valve; × 1. Pernaryggen Mb, Kronen.
Corbicellopsis lorioli Cox, 1929.
Q, R. MGUH 15534 from GGU 235540; bivalved specimen, left (Q) and dorsal (R) views; × 1. Pernaryggen Mb, Kronen.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already occupied by *C. striatulum* Brocchi (1814, p. 507, pl. 13, figs 5a–b) and therefore not available. The latter species, however, is not a *Protocardia,* and *P. striatula* (J. de C. Sowerby) therefore has priority over *P. concinna* (v. Buch).

A detailed revision of the many species of Jurassic *Protocardia* will most certainly show that several more species – hitherto kept separate – can be grouped with *P. striatula,* for example *P. dyonisea* (Buvignier, 1852, pl. 13, figs 28–29).

Autecology. Most likely *Protocardia* was, like most other cardiids (Stanley, 1968, p. 216), a shallow burrower endowed with short siphons and therefore living with its posterior region more or less at the sediment/water interface. Its globose shell suggests that it was a relatively slow burrower. Trophic group: low level suspension-feeder.

Superfamily Tellinacea de Blainville, 1814. Family Quenstedtiidae Cox, 1929.

Genus *Quenstedtia* Morris & Lycett, 1855.
Type species. Pullastra oblita Phillips, 1829.

Quenstedtia parallela (Trautschold, 1866)

Fig. 31 G

1846 *Thracia laevigata* Phillips; Rouillier, pl. B, figs 7a–b (*non* Phillips, 1829).
1848 *Thracia laevigata* Phillips; Rouillier, p. 266.
*1866 *Pleuromya parallela* sp. nov.; Trautschold, p. 9, pl. 2, figs 1a–d.
1955 *Quenstedtia parallela* (Trautschold); Gerasimov, p. 74, pl. 8, figs 8a–b.
?1969 *Quenstedtia parallela*(Trautschold); Gerasimov, p. 79, pl. 6, figs 12a–b.

Material. 3 specimens from the Pernaryggen Member at Hartz Fjeld (from GGU 235467–235468, 235540).

Description. Elongate, compressed, smooth shell; ventral margin straight for most part and running parallel to dorsal margin; anterior margin well rounded; posterior end truncate; umbones depressed, only slightly prominent, situated slightly anterior of centre; region of greatest shell thickness posterior of shell centre. With broad, well rounded, obtuse ridge running from the umbo towards the posteroventral margin without actually reaching it.

Remarks. The Milne Land specimens correspond closely to Trautschold's (1866) description of *Q. parallela. Q. laevigata* (Phillips, 1829) is very similar, but even more elongate. Nevertheless, statistical treatment of large populations might show that the species are synonymous.

Autecology. *Quenstedtia* possesses a small pallial sinus indicating a moderately deep burrowing mode of life. The compressed elongate shell suggests that the species was a fairly rapid burrower. Trophic group: low level suspension-feeder.

Quenstedtia laevigata (Phillips, 1829)

Fig. 31 F

*1829 *Psammobia laevigata* sp. nov.; Phillips, p. 170, pl. 4, fig. 5.

Material. 1 specimen from the Pernaryggen Member at Kronen (from GGU 235580).

Description. Elongate shell; dorsal and ventral margins nearly straight and subparallel; posterior margin subrectangular, anterior end rounded-acute; umbones depressed and broad, situated about one-third of shell length from the anterior; with obtuse ridge running from the umbones towards the posterodorsal margin.

Remarks. The Milne Land specimen is intermediate between *Q. laevigata* and *Q. elongata* Hudleston, 1878. The main distinguishing features of the latter are its greater elongation and weaker development of an umbonal ridge (see Arkell, 1934, p. 298). Considering, however, the existence of intermediate forms such as the Milne Land specimen, it is very likely that *Q. elongata* Hudleston, 1878, represents only a variety of *Q. laevigata* and does not merit specific separation. *Q. jouberti* Cox, 1965 (p. 120, pl. 19, fig. 5) is also very similar and may be a synonym.

Autecology. Compare *Q. parallela.*

Quenstedtia grewinki Boden, 1911

Fig. 31 H

*1911 *Quenstedtia grewinki* sp. nov.; Boden, p. 182, pl. 6, figs 6, 6a.

Material. 2 valves from the Pernaryggen Member at Hartz Fjeld (from GGU 235471).

Description: Elongate-ovate shell, comparatively compressed; umbones salient, depressed, situated about two-fifths of shell length from the anterior. Anterior margin rounded and slightly tapering, ventral margin slightly convex; posterior margin well rounded, posterodorsal margin subparallel to ventral margin.

Shell surface provided only with commarginal growth lines.

Remarks: The specimens correspond closely to Boden's (1911) figure of *Q. grewinki.* They differ from *Q. gibbosa* Hudleston in having a rounded posterior margin, being more elongate and having more salient umbones.

Autecology. Compare *Q. parallela.*

Family Tancrediidae Meek, 1864.

Genus *Tancredia* Lycett, 1850.
Type species. Tancredia donaciformis Morris & Lycett, 1855.

Tancredia (Tancredia) magna sp. nov.

Fig. 31 I–J

Holotype. MGUH 15527 from GGU 235555 from the Aldinger Elv Member at locality 3.

Material. 8 specimens from the Aldinger Elv Member at locality 3 and locality 25 (from GGU 235452, 235463, 235555).

Derivatio nominis. Magnus (Lat.) = large.

Diagnosis. Large, obliquely elongate *Tancredia* with obliquely truncated posterior end and very wide posterior gape. Anterior end tapering.

Description. Shell large (usually between 6 and 8 cm in length), obliquely elongate, the posteroventral margin forming the lowest point of the shell. Posterodorsal margin of shell short, straight, horizontal; posterior margin obliquely truncated forming a blunt angle with the posterodorsal margin. Posteroventral margin rounded and merging into the slightly convex ventral margin, which turns upwards to meet the tapering anterior end. Umbones mesial, small, depressed and prosogyrate; wide posterior gape, especially wide posterodorsally. Shell moderately thick, covered with coarse commarginal growth lines. Hinge plate very thick; hinge of right valve with 2 cardinals and 2 posterior lateral teeth some distance from the beak.

Remarks. None of the species of *Tancredia* described so far seems to fit the Milne Land specimens. *T. jarneri* (Ravn, 1911) is of similar size, but lacks the pronounced posterior gape and possesses a different outline.

T. hartzi (Spath, 1936, p. 121, pl. 48, figs 4, 5a, b, pl. 50, fig. 2) from the *Lingula* Bed differs in having a posterior ridge and sulcus.

Autecology. Although the existence of siphons could not be ascertained by the presence of a pallial sinus, it seems likely, on the grounds of the extreme posterior gape, that *T. magna* had well developed siphons and was therefore a deep burrowing species. Trophic group: low level suspension-feeder.

Tancredia (Tancredia) donaciformis Lycett, 1850

Fig. 31 L

*1850 *Tancredia donaciformis* sp. nov.; Lycett, p. 424, pl. 11, fig. 8.

Material. 3 specimens from the Aldinger Elv Member at locality 26 (from GGU 235458).

Description. Medium-sized elongate *Tancredia;* posterior margin obliquely truncated, anterior margin subangular; dorsal margins straight, anterodorsal margin sloping more steeply than posterodorsal margin; ventral margin slightly convex; umbones mesial, prosogyrate, slightly depressed; with pronounced ridge running from the umbo to the posteroventral margin. Shell surface smooth, apart from faint commarginal growth lines; hinge not visible.

Remarks. The specimens resemble *T. donaciformis* very closely in shape, but are considerably smaller than the holotype from the early Mid-Jurassic. The difference in size does not, however, justify a separation at the species level, and the Milne Land specimens are therefore referred to Lycett's species.

Autecology. The pallial line of *T. donaciformis* turns up abruptly at the posterior end. This, together with the slight posterior gape of some specimens, suggests that *T. donaciformis* was a moderately deep burrowing, low level suspension-feeder.

Genus *Corbicellopsis* Cox, 1929.
Type species. Corbis laevis J. de C. Sowerby, 1827.

Corbicellopsis unioides (de Loriol, 1875)

Fig. 31 O

*1875 *Corbicella unioides* sp. nov.; de Loriol, p. 65 (pars), pl. 14, figs 11a–c only.
1929 *Corbicellopsis unioides* (de Loriol); Cox, p. 582, pl. 13, figs 3–5.
1929 *Corbicellopsis unioides* (de Loriol); Cox, p. 178, pl. 5, fig. 5.
v.1936 *Corbicella* cf. *C. unioides* de Loriol; Spath, p. 120, pl. 46, fig. 9.

Material. 2 specimens from the Pernaryggen Member at Kronen (from GGU 235514) and Hartz Fjeld (235468).

Description. Elongate, ovate, compressed shell; umbones depressed, slightly prosogyrate, situated in the anterior half of shell; dorsal margins moderately sloping, ventral margin gently convex; anterior and posterior margin slightly tapering, posterior margin more so. Shell thin, smooth.

Remarks. The Milne Land specimens closely correspond to de Loriol's original figure of *C. unioides.*

Corbicellopsis lorioli Cox, 1929

Fig. 31 Q–R

1875 *Corbicellopsis unioides* sp. nov.; de Loriol, p. 65 (pars), pl. 14, figs 9a–b, 10a–b only.
*1929 *Corbicellopsis lorioli* sp. nov.; Cox, p. 581, pl. 13, fig. 7.
1929 *Corbicellopsis lorioli* Cox; Cox, p. 178, pl. 6, fig. 2.

Material. 14 specimens from the Pernaryggen Member at Hartz Fjeld and Kronen (from GGU 235424–235425, 235486–235487, 235516, 235540, 235559), 5 specimens from the Aldinger Elv Member of the valley north of Cardioceraskløft (235573).

Description. Elongate, ovate, compressed shell, nearly twice as long as high; ventral margin running for the most part parallel to dorsal margin; umbones anterior of centre, broad and depressed; without umbonal ridge; anterior and posterior margins well rounded; region of greatest shell thickness posterior of centre. Shell surface smooth.

Remarks. Cox (1929) erected *C. lorioli* as a new name for forms within de Loriol's (1875) hypodigm for *C. unioides,* differing from the holotype of *C. unioides* in having less prominent umbones, well rounded anterior and posterior margins, and a ventral margin which largely runs parallel to the dorsal margin.

Corbicellopsis cf. *C. lorioli* Cox, 1929

Fig. 31 N

v.1936 *Corbicella(?)* sp. ind.; Spath, pl. 50, fig. 10.

Material. 17 specimens from the Pernaryggen Member at Hartz Fjeld and Kronen (from GGU 235403, 235406–235407, 235440–235442, 235468, 235472, 235490, 235513, 235540–235541).

Description. Comparable in size and outline to *C. lorioli,* but with the following distinguishing features: umbones more pronounced and nearly mesial; dorsal margins sloping at a greater angle.

Remarks. Due to their poor state of preservation, it cannot be decided whether these forms are only variants of *C. lorioli* or whether they constitute a separate species. Co-occurrence supports the former view.

Corbicellopsis laevis (J. de C. Sowerby, 1827)

Fig. 31 K, M, P

*1827 *Corbis laevis* sp. nov.; J. de C. Sowerby, p. 156, pl. 580.
1934 *Corbicella laevis* (J. de C. Sowerby); Arkell, p. 289, pl. 39, figs 1–5, text-fig. 65.

Material. 28 specimens from the Aldinger Elv Member at locality 26 (from GGU 235453–235458) and locality 3 (235555–235556).

Description. Elongate-ovate, thick, smooth shell; umbones mesial, depressed, moderately prominent; posterior margin well rounded; anterodorsal margin slightly concave, ventral margin regularly curved; anterior end tapering and narrower than posterior end, which in some cases exhibits a slight oblique truncation. Left valve with strong, triangular, cardinal tooth, posterior cardinal only feebly developed (lateral not preserved).

Remarks. Some of the Milne Land specimens are less rostrate than the specimens figured by Arkell (1934, p. 289, pl. 34, figs 1–5) from the Corallian of England, and in some of them the posterior is slightly obliquely truncated. In outline, the latter specimens more closely resemble *Quenstedtia gracilis* Arkell (1934, p. 300, pl. 40, fig. 8). The dentition of the latter, which is known only as a single specimen from the Lower Calcareous Grit of Yorkshire, is not clear and it might in fact be a *Corbicellopsis* rather than a *Quenstedtia,* representing extreme variation within *C. laevis.*

Autecology of *Corbicellopsis.* All three *Corbicellopsis* species were infaunal, low level suspension-feeders. Their compressed and partly wedge-shaped form suggests that they were fairly rapid burrowers. The pallial line cannot be seen, but it is known to have been either entire and somewhat truncated, or to have contained a small pallial sinus (e.g. Arkell, 1934, p. 289; Cox, 1929). Thus *Corbicellopsis* probably had short siphons and therefore did not live right at the sediment-water interface, but further down in the sediment.

Superfamily Arcticacea Newton, 1891. Family Arcticidae Newton, 1891.

Genus *Arctica* Schumacher, 1817.
Type species. Arctica vulgaris Linné, 1767 (= *Venus islandica,* Linné, 1767).

Arctica syssollae (Keyserling, 1846)

Fig. 32 A–E

*1846 *Cyprina syssollae* sp. nov.; Keyserling, p. 309, pl. 17, figs 17–22.
?1911 *Cyprina syssollae* Keyserling; Ravn, p. 479, pl. 35, fig. 6.
1933 *Cyprina syssollae* Keyserling; Frebold, p. 29, pl. 1, fig. 14.
1978 *Arctica syssollae* (Keyserling); Zakharov & Schurygin, p. 145, pl. 7, fig. 4.

Material. 94 specimens from the Aldinger Elv Member at locality 3 (from GGU 235554–235555), at locality 25 (235452–235463), and the valley north of Cardioceraskløft (235573).

Description. Variable, ovate, slightly elongate shell; height between 79 and 88% of length; umbones near-mesial to slightly anterior of centre, prominent, moderately inflated and strongly prosogyrate; umbonal angle varying between 91° and 119°, but usually between 100° and 107°. Posterodorsal margin straight to faintly convex; posterior margin truncate to slightly convex, in the former case with an obtuse angle between posterior and posterodorsal margin; ventral margin gently convex, anterior margin well rounded, anterodorsal margin distinctly concave; neither lunule nor escutcheon developed; shell surface usually covered with commarginal growth lines which may be rather coarse. Pallial line entire. Hinge plate with distinct ligament nymphs; hinge very close to that of Recent *Arctica islandica,* each valve with 3 cardinal teeth, and 2 anterior and 1 posterior lateral.

Measurements.

GGU sample	l	h	h/l(%)	α
235453	3.3	2.65	80.3	100°
235460	5.95	5.25	88.2	101°
235460	3.6	2.85	79.2	103°
235460	4.4	3.6	81.8	113°
235573	6.3	5.0	79.4	112°
235463	5.3	4.45	83.9	106°
235463	4.8	3.8	79.2	112°
235461	5.45	4.6	84.4	103°
235457	5.65	4.65	82.3	105°
235457	5.1	4.2	82.3	104°

Remarks. A. syssollae exhibits a fair range of variation. The Milne Land specimens are very close to Keyserling's (1846) original figures which depict considerable variation in the length/height ratio. Although mainly preserved as steinkerns, casts of the hinge could be obtained in several cases, and these show that the species clearly belongs to the genus *Arctica* as has already been suggested by Zakharov & Schurygin (1978). Ravn's (1911) *Cyprina syssollae* is only preserved as fragments and can only be tentatively referred to Keyserling's species. *A. orientalis* Zakharov & Schurygin (1978, p. 142, pl. 6, figs 3–4, pl. 7, fig. 5) and *A. humiliculminata* Schurygin (1978, p. 140, pl. 4, figs 10–12, pl. 5, figs 2–6) differ by larger umbonal angle, and *A. eichwaldi* (Schmidt, 1872, p. 149, fig. 6) and *A. jenisseae* (Schmidt, 1872, p. 150, fig. 7) differ quite clearly in outline, the former having less prominent umbones and the latter being much shorter.

A. syssollae occurs in great abundance at some levels within the Aldinger Elv Member, sometimes forming shell pavements.

Autecology. Recent *Arctica islandica* does not possess siphons and, as the foot is too weak for burrowing, lives epifaunally, resting with one of its valves on the sediment. As it lacks the ability to escape when buried under a sudden influx of sediment (Schäfer, 1962, p. 423), it occurs in the North Sea in areas without large-scale sediment movements.

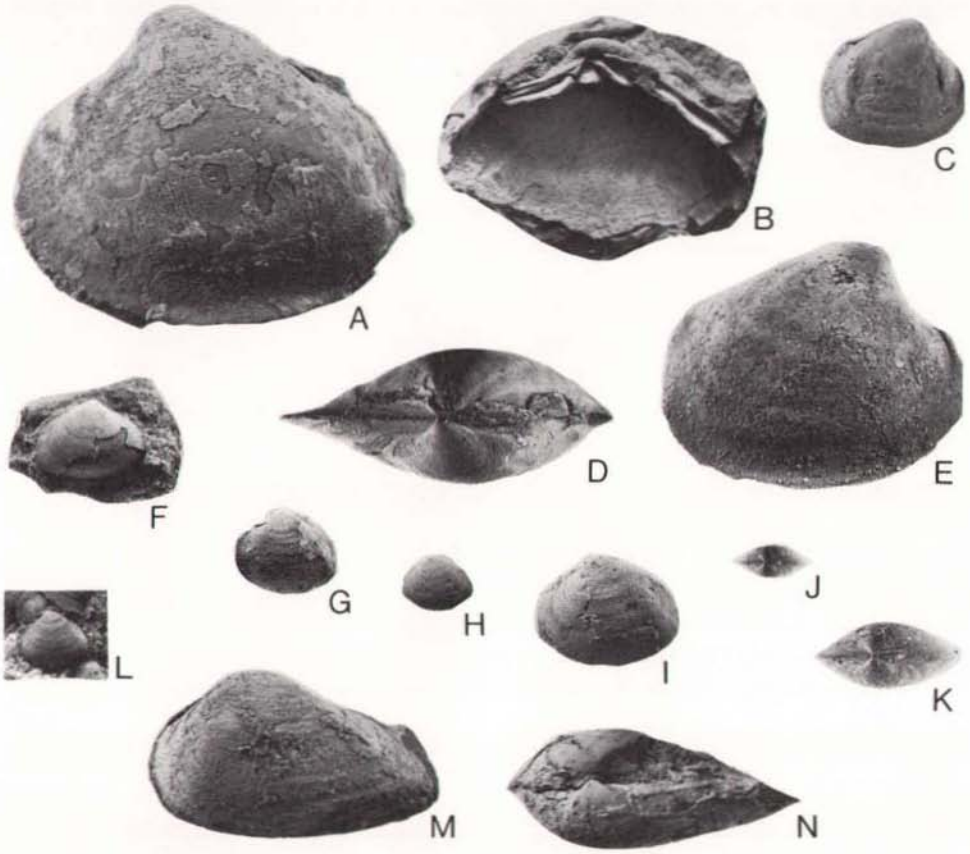


Fig. 32. *Arctica syssollae* (Keyserling, 1846).
A. MGUH 15535 from GGU 235458; internal cast of left valve; × 1. Aldinger Elv Mb, locality 26.
B. MGUH 15536 from GGU 235453; rubber cast of hinge of right valve; × 1. Aldinger Elv Mb, locality 26.
C. MGUH 15537 from GGU 235453; steinkern, right view; × 1. Aldinger Elv Mb, locality 26.
D. MGUH 15538 from GGU 235555; bivalved specimen, dorsal view; × 1. Aldinger Elv Mb, locality 3.
E. MGUH 15539 from GGU 235453; steinkern, right view; × 1. Aldinger Elv Mb, locality 26.
Isocyprina (*Venericyprina?*) *birkelundi* sp. nov.
F. MGUH 15540 from GGU 235537; right valve (holotype); × 1. Pernaryggen Mb, Hartz Fjeld.
G. MGUH 15541 from GGU 235559; bivalved specimen, left view; × 1. Pernaryggen Mb, Kronen.
H-K. MGUH 15542 from GGU 235401; bivalved specimen, left (H,I) and dorsal (J,K) views; H, J, × 1; I, K, × 2. Pernaryggen Mb, Hartz Fjeld.
L. MGUH 15543 from GGU 235440; left valve; × 1. Pernaryggen Mb, Hartz Fjeld.
Pronoella (*Pronoella?*) *superjurensis* sp. nov.
M, N. MGUH 15544 from GGU 235489; bivalved specimen (holotype), left (M) and dorsal (N) views; × 1. Pernaryggen Mb, Kronen.

It is difficult to make statements about the mode of life of Jurassic *Arctica syssollae.* It might have lived in a similar way to *A. islandica,* but could also have lived as a very shallow burrower. The occurrence of the Jurassic species in cross-bedded sands, which probably formed a rather mobile, high energy substrate, suggests that it might have been better adapted to such environments than *A. islandica,* perhaps due to the possession of a stronger foot. This would have enabled the species to burrow, as well as to escape rapid burial. Trophic group: low level suspension-feeder.

Genus *Hartwellia* Kitchin, 1926.
Type species. Astarte hartwellensis J. de C. Sowerby, 1845.

Hartwellia (Hartwellia) kharoschovensis (Rouillier & Vosinsky, 1848)

Fig. 34 A–D, F

1847 *Cyprina kharoschovensis* sp. nov.; Rouillier & Vosinsky, p. 421.
1848 *Cyprina kharoschovensis* Rouillier & Vosinski; p. 285, pl. 4, figs 32 A, B, 33 A–C.
non 1911 *Cyprina kharoschovensis* Rouillier; Ravn, p. 478, pl. 35, fig. 4.

Material. 43 specimens from the Pernaryggen Member and Astartedal Member at Hartz Fjeld, Kronen and Bays Fjelde, and from the *Lingula* Bed (Hennigryggen Member) at Lingularyggen (from GGU 235420, 235424, 235427, 235441, 235451, 235465, 235499, 235513, 235528, 235536, 235542, 235559, 235575, 137557).

Description. Thick, elongate shell; umbones moderately prominent, situated about one-third of shell length from the anterior; anterior margin well rounded, ventral margin evenly curved, forming blunt angle with the truncated and slightly tapering posterior margin. Posterodorsal margin long, nearly straight; anterodorsal margin short. With ill-defined umbonal ridge. Lunule moderately large, but ill-defined except near beak where it is bounded by overhanging ridge; escutcheon very long and broad, moderately deep and clearly delineated by ridges. Interior of shell smooth; ovate to subquadrangular muscle scars placed fairly dorsally; pallial line with small sinus.

Hinge plate thick, right valve with 2 anterior laterals, 3 cardinals and 1 remote posterior lateral tooth. Hartwelliid tuberosity present; left valve with 1 anterior lateral, 3 cardinals and 1 posterior lateral; anterior lateral linked to 2a; laterals cross-striate.

Shell ornament consisting of distinct commarginal ribs for 5 to 10 mm from the umbones; remainder of shell covered with commarginal growth lines, sometimes of varying prominence.

Measurements.

GGU sample	l	h	h/l(%)
235465	2.80	1.80	64.3
235420	5.50	3.75	68.2
235559	4.85	3.20	65.9
235575	4.85	3.15	64.9
235451	5.05	3.70	73.3
235542	4.90	3.40	69.4

Remarks. Most of the material consists, unfortunately, of badly preserved steinkerns, but in some specimens the preservation of shell allowed preparation of the hinge which closely fits Casey's (1952) description of *Hartwellia* sensu stricto. While there can be little doubt as to the subgeneric position of the specimens, the assignation to a species is more difficult, as *H. kharoschovensis* in the past has been interpreted quite differently, and its difference to *H. cancriniana* (d'Orbigny, 1845) has not always been very clear (for examples see Gerasimov, 1955, pl. 7, figs 1–4; 1969, pl. 6, figs 15, 17). However, the Milne Land material corresponds well to Rouillier & Vosinsky's original figures (particularly 1848, pl. H, fig. 32). Apart from differences in the hinge (see Rouillier & Vosinsky, 1847, p. 422) *H. kharoschovensis* seems to be characterized by an umbonal ridge, which is missing in *H. cancriniana.* In addition, there appears to be no posterior truncation in *H. cancriniana.*

Autecology. In several cases, *H. kharoschovensis* and other *Hartwellia* species (described below) were found in their life position, that is vertically embedded in the sediment with the anterior pointing downwards (Fürsich, 1980). *Hartwellia* thus seems to have been a burrowing, low level suspension-feeder. The small pallial sinus suggests that it burrowed down to only intermediate depths.

Hartwellia (Hartwellia) groenlandica (Spath, 1936)

v.*1936 *Pseudotrapezium groenlandicum* sp. nov.; Spath, p. 125, pl. 49, figs 7a–c.

Material. 16 specimens from the Pernaryggen, Astartedal and Hennigryggen Member at Lingularyggen, Hartz Fjeld and Kronen (from GGU 235411, 235416, 235418, 235420, 235424–235425, 235514, 137474).

Description. Shell large, rounded triangular, very thick, elongate; umbones large, very prominent, situated in the anterior half of shell; beaks acute, prosogyrate. Anterior margin rounded, ventral margin strongly convex, forming an obtuse angle with the somewhat tapering and truncated posterior margin; posterodorsal margin fairly straight. With faint umbonal ridge. Lunule weakly developed, bounded clearly by overhanging ridges only at the umbo; with strongly developed very long lanceolate escutcheon, which is bounded by ridges.

Hinge with 3 cardinals and 1 posterior lateral tooth in each valve, with 2 anterior laterals in right and 1 in left valve. Small pallial sinus present.

Surface ornament consisting of commarginal growth lines and irregular growth constrictions; near umbo with costate, *Astarte*-like sculpture.

Remarks. Spath's (1936) *Pseudotrapezium groenlandicum* has all the morphological features of a *Hartwellia* s.s. such as the umbonal ridge, and the hinge. As most specimens are deformed or fragmented, not much can be added to Spath's description or figures.

Autecology. Low-level suspension-feeder burrowing at intermediate depths.

Hartwellia (Hartwellia) borealis sp. nov.

Fig. 34 G–I

Holotype. MGUH 15552 from GGU 235498 from the Pernaryggen Member at Kronen.

Material. 43 specimens from the Pernaryggen Member at Kronen, Hartz Fjeld and Bays Fjelde (from GGU 235403–235405, 235491, 235494, 235496–235502, 235507–235508, 235522–235523, 235534, 235537, 235577).

Derivatio nominis. Borealis (Lat.) = northern.

Diagnosis. Hartwellia with very small and deep escutcheon and strong umbonal ridge.

Description. Large, thick, elongate shell; umbones prominent, sweeping forward, situated about two-fifths of shell length from the anterior; anterior end well rounded; ventral margin strongly to moderately convex, meeting obliquely truncated posterior margin at obtuse angle; posterodorsal margin straight, forming another obtuse angle with the posteroventral margin; with distinct umbonal ridge; area dorsal of umbonal ridge slightly concave; lunule not well defined, small; escutcheon lanceolate, very narrow, deep and delineated by ridges. Pallial line entire.

Hinge of left valve with 3 cardinals, 2b knob-shaped, 2a and 4b slender; with 2 laterals, PII and AII only weakly developed and separated from 2a; with distinct groove between 4b and nymph plate; hinge of right valve unknown.

Surface ornament consisting of numerous very fine commarginal growth lines.

Measurements.

GGU sample	l	l_{ant}	l_{ant}/l(%)	h	h/l(%)	d	d/l(%)
235498–1	4.25	1.7	40.0	3.0	70.6	1.95	45.9
235498	–	2.2	–	4.0	–	2.50	–
235496	5.35	2.45	42.8	3.1	57.9	–	–

Remarks. Spath (1936, p. 126) mentioned the existence of other *Hartwellia* species than *H. groenlandica* in Milne Land, but did not have sufficiently well preserved material for a description. The present species differs from *H. groenlandica* by its less prominent umbones, the narrow escutcheon and by being more elongate, and from *H. kharoschovensis* (Rouillier & Vosinsky, 1848) and *H. hartwellensis* (Sowerby, 1846) by its narrow escutcheon. *H. swindonensis* (Blake, 1880, p. 232, pl. 10, fig. 2) possesses a longer posterodorsal margin. *H. cancriniana* (d'Orbigny, 1845) differs in hinge and overall shape.

If the complete hinge of *H. borealis* were known, it might show significant differences to other hartwelliid species which might necessitate its placement into a new subgenus. However, the present material does not justify this.

Autecology. Unlike the other *Hartwellia* species from Milne Land *H. borealis* does not possess a pallial sinus and was therefore probably a shallow burrower with the posterior end placed at the depositional interface. Trophic group: low level suspension-feeder.

Hartwellia (Hartwellia) sp. A

Fig. 34 E

Material. 4 specimens from the Pernaryggen Member at Hartz Fjeld and Kronen (from GGU 235467, 235540).

Description. Large oval shell; umbones prominent but depressed, situated anteriorly of centre; beaks acute, prosogyrate; anterior and ventral margins well rounded, posterior end rounded-truncate; posterodorsal margin straight; with ill-defined lunule and broad, lanceolate escutcheon bordered by ridges; umbonal ridge faintly visible in and restricted to the umbonal region. Shell surface covered with commarginal growth lines and constrictions except at the umbo where *Astarte*-like ribbing is present. Hinge of left valve resembling that of *Hartwellia* s.s.

Remarks. This is probably another new species of *Hartwellia. H.* sp. A differs from the others in being less elongate and more rounded. The closest resemblance is to *H. cancriniana* (d'Orbigny, 1845, pl. 38, figs 26–27), but it differs from the latter in sloping more strongly posteriorly. The available material is, however, not sufficiently well preserved to allow a detailed description. The species is therefore referred to as *Hartwellia (Hartwellia)* sp. A.

Autecology. Analogous to other species of *Hartwellia.*

Genus *Isocyprina* Röder, 1882.
Type species. Cardium cyreniforme Buvignier, 1852.

Isocyprina (Venericyprina?) birkelundi sp. nov.

Fig. 32 F–L

v.1936 *Pseudisocardia* (?) sp. indet.; Spath, p. 127, pl. 48, figs 9a–b.

Holotype: MGUH 15540 from GGU 235537 from the Pernaryggen Member at Hartz Fjeld.

Material. 582 specimens from the Pernaryggen Member at Hartz Fjeld, Kronen and Bays Fjelde (from GGU 235401–235405, 235415, 235427, 235440–235441, 235464, 235468–235469, 235480, 235489, 235491, 235493, 235499, 235510, 235513–235514, 235516, 235522, 235537–235538, 235540–235542, 235546, 235559).

Derivatio nominis. After Tove Birkelund.

Diagnosis. Small, smooth *Isocyprina* with slight oblique posterior truncation and faint umbonal ridge. Hinge like that of *Venericyprina,* but lateral teeth not cross-striate and 2a hardly separated from AII.

Description. Small, moderately inflated, variable in outline, subtrigonal to circular shell; shell height usually about four-fifths of length. Umbones small, moderately prominent, prosogyrate, mesial to slightly anterior of centre. Umbonal angle usually between 95° and 100° (fig. 33). Posterodorsal margin straight to slightly convex, sloping; posterior margin with slight oblique truncation, frequently forming an obtuse angle with the ventral margin, which is evenly rounded; anterior margin well rounded; anterodorsal margin concave; with faint obtuse ridge running from the umbo to the posteroventral margin. Shell thin, ornamented with numerous very fine commarginal growth lines. Pallial line entire.

Hinge as in *Venericyprina,* but lateral teeth not cross-striate and 2a hardly separated from AII.

Remarks. I. birkelundi is one of the commonest bivalves in the Pernaryggen Member of Milne Land and usually occurs in great numbers. Its shape is very similar to several species of *Eocallista* described by de Loriol (1875), but its dentition is clearly that of an *Isocyprina.* In two cases it was possible to develop the hinge of the right valve. There are two anterior lateral teeth and three cardinals, 3a and 1 joined to the laterals and 3b slightly bifid. One posterior lateral is also present. The laterals are not cross-striate and 2a of the left valve does not seem to be very distict from AII. In the latter two features the hinge does not correspond to that of a typical *Venericyprina* (Casey, 1952), and this is the reason why *I. birkelundi* is only tentatively referred to this subgenus. Furthermore, the pallial line of

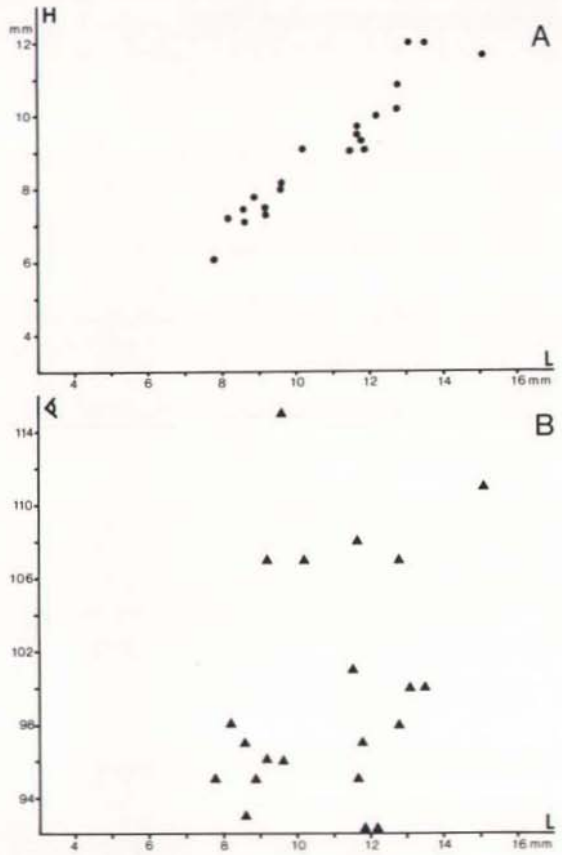


Fig. 33. Length/height ratio (A) and length/umbonal angle relationship (B) of *Isocyprina* (*Venericyprina?*) *birkelundi*. Collections from Pernaryggen Mb.

the Greenland species is entire, whilst that of the type species of *Venericyprina (V. argillacea)* is slightly sulcate.

Differences in the hinge distinguish *I. birkelundi* from several Upper Jurassic species of very similar shape (e.g. *Anisocardia veneriformis* de Loriol 1874, p. 47, pl. 13, fig. 24; *Eocallista intermedia* de Loriol, 1875, p. 46, pl. 13, figs 20a–c, 21). *Isocyprina elongata* Cox, 1924 as figured by him in 1929 (pl. 5, fig. 4) is very close in shape, but there is no reference to an umbonal ridge. *I. carinella* (Buvignier, 1852, pl. 15, figs 31–33) is also very close, but seems to have a different hinge and less prominent umbones.

The Milne Land species was figured by Spath (1936) as *Pseudisocardia*(?) sp. indet.

Autecology. Not much can be said about the mode of life of *I. birkelundi*. Lacking a pallial sinus it most likely was a very shallow burrowing form with the posterior end of the shell situated at the depositional interface. Trophic group: low level suspension-feeder.

Genus *Pronoella* Fischer, 1887.
Type species. Venulites trigonellaris v. Schlotheim, 1820.

Pronoella(?) (Pronoella?) superjurensis sp. nov.

Fig. 32 M–N

Holotype. MGUH 15544 from GGU 235489 from the Pernaryggen Member at Kronen.

Material. 4 specimens from the Pernaryggen Member at Kronen (from GGU 235489, 235490).
Derivatio nominis. Superus (Lat.) = upper; jurensis (Lat.) = Jurassic.

Diagnosis. Elongate cuneiform *Pronoella(?)* with obliquely truncated posterior and well developed umbonal ridge.

Description. Shell medium-sized, elongate, cuneiform; umbones prominent, slightly prosogyrate, inflated, situated about one-third of shell-length from the anterior; anterior well rounded; ventral margin slightly convex; posterodorsal margin straight, sloping fairly steeply and forming an obtuse angle with the posterior, which is obliquely truncated; with ridge running from the umbones to the posteroventral margin.

Shell covered with faint to conspicuous commarginal growth lines. Hinge unknown.

Measurement.	l	l_{ant}	h
holotype	3.75	1.1	2.15

Discussion. The Milne Land specimens are closest in shape to *Pronoella pindiroensis* Cox (1965, p. 108, pl. 17, figs 12–17) from the Bajocian(?) of Tanganyika. The latter differs in being less elongate and more triangular in outline. No other comparable forms are known from the Upper Jurassic of Europe and northern Russia. Although Casey (1952) grouped comparable *Pronoella* into a new subgenus *Gythemon* (which also differs somewhat in dentition), Cox (1965) showed that, according to the dentition, the specimens from East Africa should be grouped with *Pronoella* s.s. As the hinge could not be developed in any of the Milne Land specimens, the generic and subgeneric assignment remains doubtful. On the grounds of their resemblance to the Tanganyika specimens they are tentatively placed in *Pronoella* s.s.

Spath (1936, p. 126, pl. 48, figs 1a–b, pl. 50, fig. 6) described *Pronoella*(?) sp. indet. aff. *P. nuculaeformis* (Roemer) from the Pernaryggen Member; all his specimens are actually crushed examples of *Pleuromya triangularis* sp. nov. They differ markedly from *P. superjurensis* in being larger, less elongate and more pronouncedly triangular.

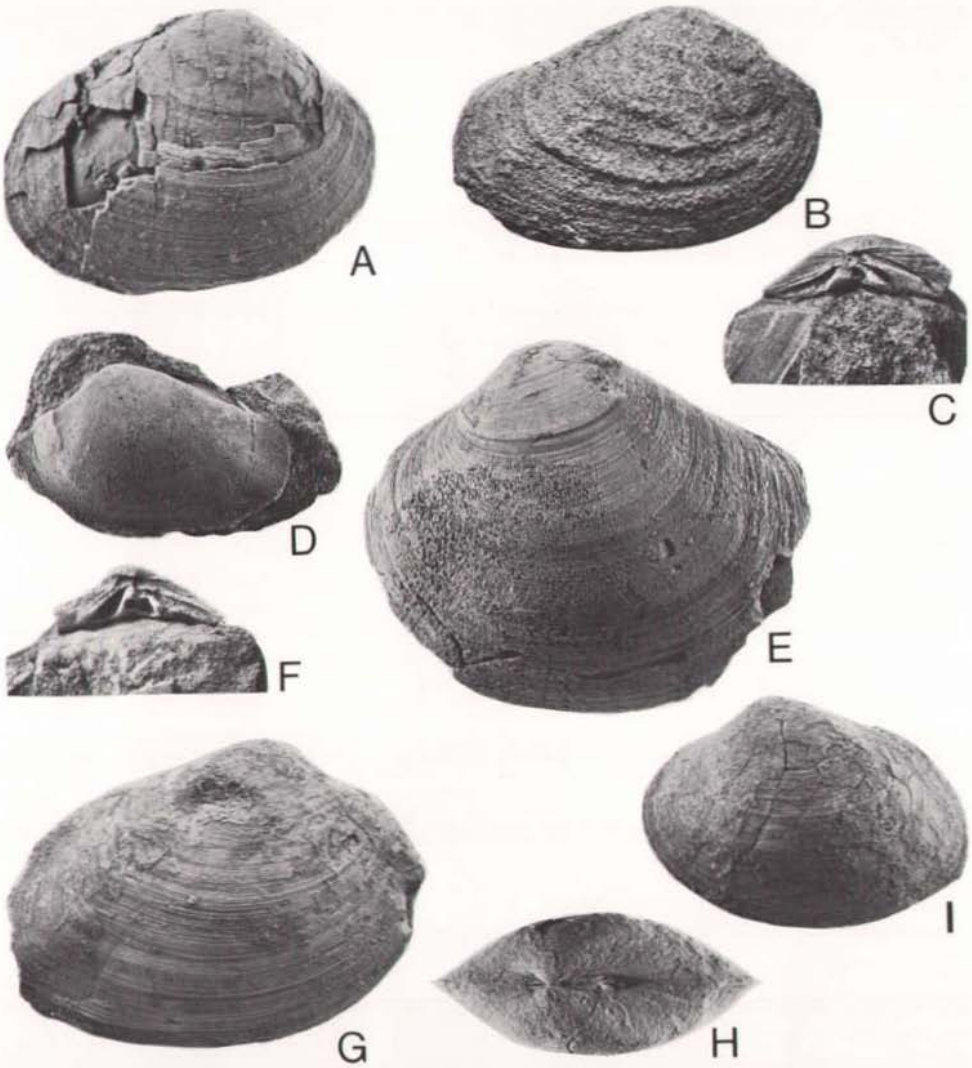


Fig. 34. *Hartwellia* (*Hartwellia*) *kharoschovensis* (Rouillier & Vosinsky, 1848).
A. MGUH 15545 from GGU 235451; right valve; × 1. Pernaryggen Mb, Hartz Fjeld.
B. MGUH 15546 from GGU 235575; bivalved specimen, right view; × 1. Pernaryggen Mb, Hartz Fjeld.
C. MGUH 15547 from GGU 235424; hinge of right valve; × 1. Astartedal Mb, Lingularyggen.
D. MGUH 15548 from GGU 235513; internal cast of left valve; × 1. Pernaryggen Mb, Kronen.
F. MGUH 15549 from GGU 235424; hinge of left valve; × 1. Astartedal Mb, Lingularyggen.
Hartwellia (*Hartwellia*) sp. A
E. MGUH 15550 from GGU 235467; left valve; × 1. Pernaryggen Mb, Hartz Fjeld.
Hartwellia (*Hartwellia*) *borealis* sp. nov.
G. MGUH 15551 from GGU 235498; bivalved specimen, right view; × 1. Pernaryggen Mb, Kronen.
H, I. MGUH 15552 from GGU 235498; bivalved specimen (holotype), left (I) and dorsal (H) views; × 1. Pernaryggen Mb, Kronen.

Autecology. According to Casey (1952) the pallial line of *Pronoella* is entire or exhibits only a small sinus. *Pronoella(?) superjurensis* was therefore probably an infaunal bivalve burrowing to shallow or intermediate depths. Trophic group: low level suspension-feeder.

Subclass Anomalodesmata Dall, 1889. Order Pholadomyoida Newell, 1965. Superfamily Pholadomyacea Gray, 1847. Family Pholadomyidae Gray, 1847.

Genus *Pholadomya* G. B. Sowerby, 1825.
Type species. Pholadomya candida G. B. Sowerby, 1825.

Pholadomya (Pholadomya) hemicardia Roemer, 1836

Fig. 35 A–D

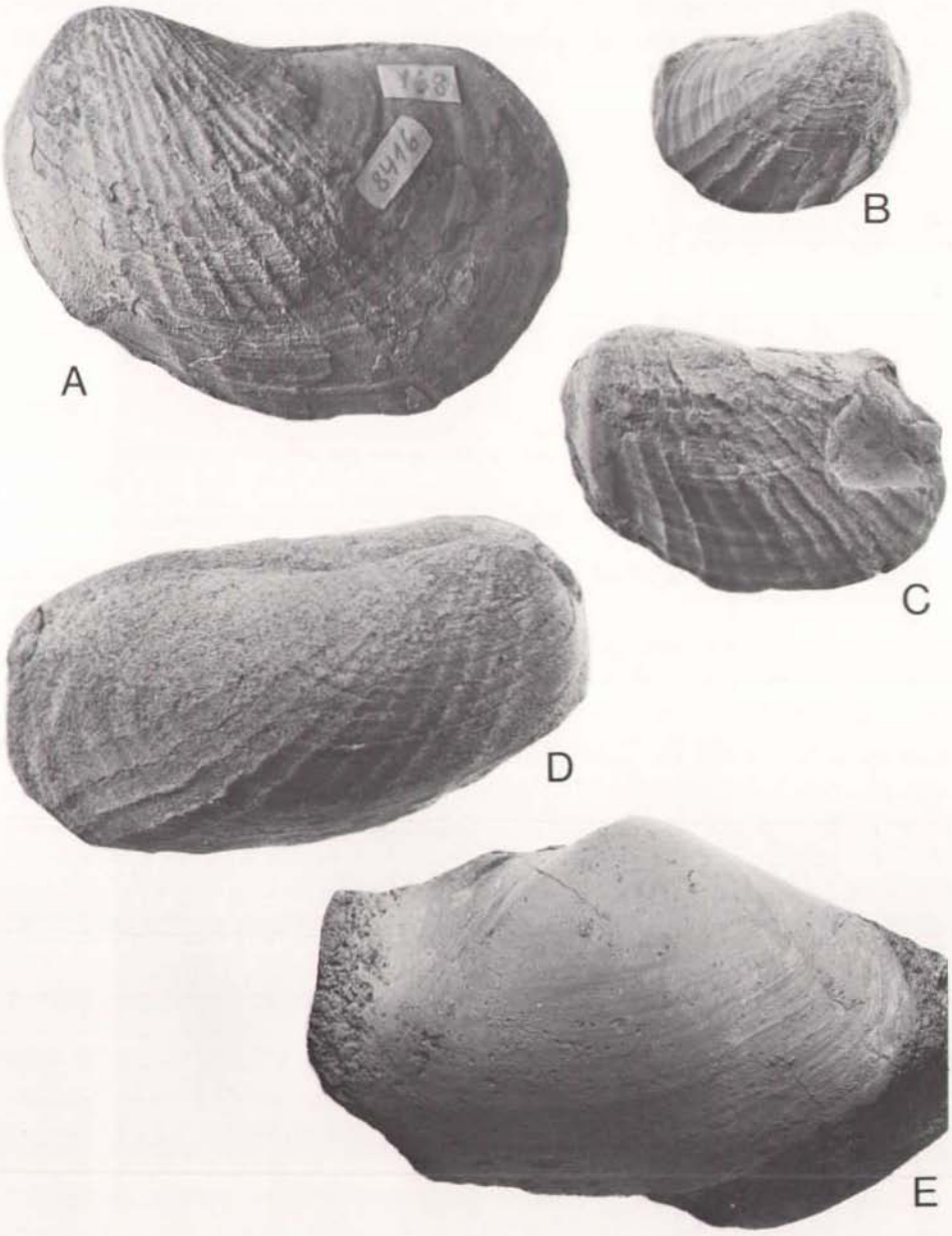
*1836 *Pholadomya hemicardia* sp. nov.; Roemer, p. 131, pl. 9, fig. 18.
1935 *Pholadomya hemicardia* Roemer; Arkell, p. 336, pl. 46, figs 5–7.
v.1936 *Pholadomya* aff. *P. inaequiplicata* Stanton; Spath, p. 131, pl. 44, figs 2a–b, pl. 45, figs 3a–b.

Material. 9 specimens from the Pernaryggen Member, 1 specimen from the *Lingula* Bed of the Hartz Fjeld Formation, and 12 specimens from the Kosmocerasdal Member at locality 4 (from GGU 235427, 235440–235441, 235522, 235531, 235564, 137477).

Description. Shell medium-sized, inflated, elongate, inequilateral, equivalve; gaping posteriorly; umbones well rounded, salient, situated about one-quarter to one-fifth of shell length from the anterior; anterior end short, truncated; posterior end more produced; hinge line long and straight; ventral margin moderately convex. Posterior elongate, well rounded. Ornament consisting of 8 to 14 radial ribs which are distributed over the whole surface except the posterodorsal and anterodorsal region; with well developed growth lines. Between the second and the third rib from the anterior a faint shallow sulcus is usually developed (see also Moesch's description and figures of *P. hemicardia* (1878, p. 58, pl. 23, figs 1–6).

Fig. 35. *Pholadomya* (*Pholadomya*) *Hemicardia* Roemer, 1836.
A. MGUH 8416; bivalved specimen, left view; × 1. Original to Spath (1936, pl. 44, figs 2a, b). Pernaryggen Mb, Hartz Fjeld.
B. MGUH 15553 from GGU 235564; bivalved specimen, right view; × 1. Kosmocerasdal Mb, locality 4.
C. MGUH 15554 from GGU 137477; bivalved specimen, left view; × 1. *Lingula* Bed, Hennigryggen Mb, Lingularyggen.
D. MGUH 15555 from GGU 235440; bivalved specimen, right view; × 1. Pernaryggen Mb, Hartz Fjeld.
Goniomya (*Goniomya*) *literata* (J. Sowerby, 1819).
E. MGUH 15556 from GGU 235488; internal cast of right valve; × 1. Pernaryggen Mb, Kronen.

Remarks. The Milne Land specimens were described by Spath (1936) as *P.* aff. *P. inequiplicata* Stanton. Stanton's species (1899, pl. 74, fig. 4) has, however, nearly twice as many ribs (that is 20) as the average Milne Land specimen, and Spath's specimens were subsequently referred by Zakharov (1974, p. 156, pl. 34, fig. 6, pl.



35, figs 1–2) to this new species *P. lyapinensis,* which was based on material from the Volgian of the subarctic Urals. The latter material, however, bears little resemblance to the Milne Land specimens which clearly fall into the morphological range of *P. hemicardia.*

Autecology. The elongate posterior and the posterior gape suggest that, like other members of the family Pholadomyidae, *P. hemicardia* lived deeply buried in the sediment connected to the sediment/water interface by fairly long and thick siphons. Trophic group: low level suspension-feeder.

Genus *Goniomya* Agassiz, 1841.
Type species. Mya angulifera J. Sowerby, 1819.

Goniomya (Goniomya) literata (J. Sowerby, 1819)

Figs 35 E, 36 C–D

*1819 *Mya? literata* sp. nov.; J. Sowerby, p. 45, pl. 224, fig. 1.
1935 *Goniomya literata* (J. Sowerby); Arkell, p. 344, pl. 48, figs 1–7.

Material. 11 specimens from the Kosmocerasdal Member at locality 4, the Aldinger Elv Member at locality 26, the Bays Elv Member at Hartz Fjeld, the Krebsedal Member at Hartz Fjeld, the Cardiocerasløft Member at Cardiocerasløft and the Pernaryggen Member at Hartz Fjeld and Kronen (from GGU 235440–235441, 235453, 235479, 235486–235488, 235516, 235544, 235565, 235578, 137728).

Description. Shell medium-sized, subequivalve, inequilateral, elongate-oval, thin, moderately inflated. Umbones broad, submesial, beaks prosogyrate to almost orthogyrate. Posterior gape moderately wide, anterior gape narrow. Pallial sinus present. Ornament consisting of V-shaped ribs which intersect faint commarginal growth lines. An imaginary line bisecting the angle of the Vs runs from the umbones to the ventral margin in a slightly posterior direction. The ribs closest to the umbo rarely meet at a point, but are nearly always joined by a short rib running parallel to the growth lines. In adult specimens, the V-shaped ribs die out towards the ventral margin, which is commonly smooth. The extreme anterior and posterior sectors of the shell are also smooth.

Remarks. G. literata is the commonest *Goniomya* in the Upper Jurassic. In Milne Land it occurs, albeit rarely, from the Middle Oxfordian to the Middle Volgian.

Two specimens from the Pernaryggen Member demonstrate that *G. literata* can attain a fairly large size (the height of one specimen measuring 5.0 cm) and that two-thirds of the shell can be smooth except for very fine commarginal growth lines, the ornament being restricted to the umbonal region in these specimens.

They are not typical, but rather illustrate the large variation with regard to ornamentation.

Autecology. Like all pholadomyaceans, *G. literata* was a deep burrowing suspension-feeder with large siphons.

Goniomya (Goniomya) bicarinata sp. nov.

Fig. 36 A–B

v.1936 *Goniomya* aff. *G. sulcata* Agassiz; Spath, p. 129, pl. 44, fig. 1.
?1974 *Goniomya* cf. *G. dubois* Agassiz; Zakharov & Mesezhnikov, p. 157, pl. 35, fig. 3.

Holotype. MGUH 15557 from GGU 235540 from the Pernaryggen Member of the north-eastern corner of Hartz Fjeld.

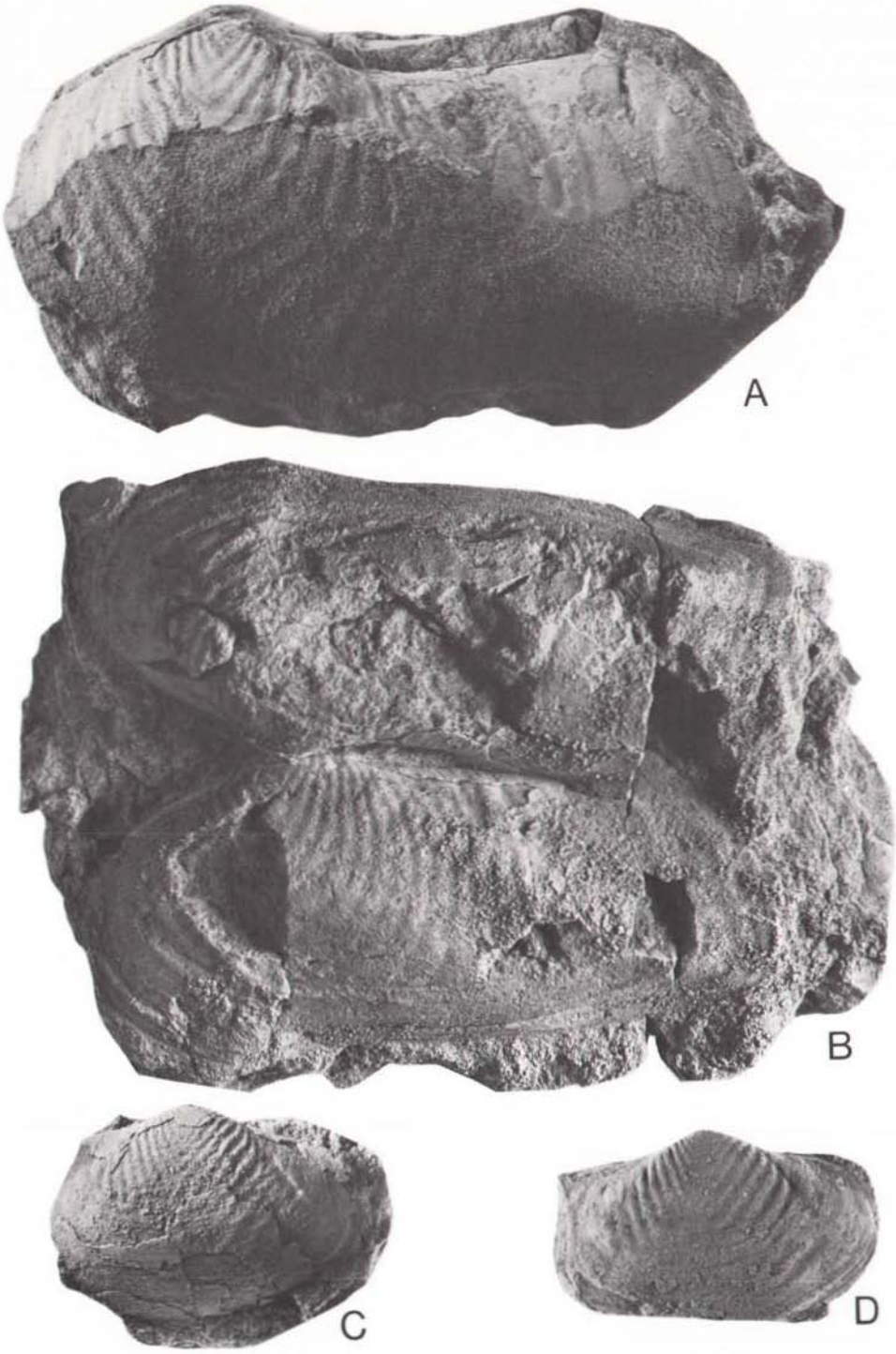
Material. 3 specimens from the Pernaryggen Member at Hartz Fjeld (from GGU 235401–235402, 235464, 235540).

Derivatio nominis. Bicarinatus (Lat.) = with two ridges.

Diagnosis. Very large, elongate *Goniomya* with V-shaped ribs which only meet near the umbo and die out towards the ventral and posterior margins. Ill-defined ridge running from umbo in a slightly anterior direction towards the ventral margin followed posteriorly by shallow, broad sulcus. Second ridge running from umbo to posteroventral margin. Posterodorsal margin concave, posterior end slightly flared and obliquely truncated.

Description. Specimens of *G. bicarinata* reach up to 13 cm in length. The umbones are situated about one-third of the shell length from the anterior end. Anterior part of shell short, anterior margin well rounded. Ventral margin slightly convex, posterior margin obliquely truncated, slightly flared; posterodorsal margin convex. Posterior end with very wide gape, anterior gape moderate. A prominent ridge runs from the umbo to the posteroventral margin and a second, ill-defined ridge from the umbo to the ventral margin. The latter ridge is followed posteriorly by a shallow broad sulcus which dies out posteriorly. The two ridges and the ventral margin form a large triangle which accounts for about half the shell. The ornament consists partly of V-shaped ribs, the apices of which forming a line running towards the ventral margin in a vertical or slightly posterior direction. Only the ribs of the dorsal half of the shell meet; the others become faint and die out towards the ventral margin, which is usually smooth except for fine commarginal growth lines. The ribs become similarly faint towards the posterior end of the shell where they tend increasingly to run parallel to the growth lines.

Measurement.	l	h	h/l(%)	l_{ant}	l_{ant}/l(%)
holotype	10.2	5.1	50.0	3.2	31.4


A
B
C
D

Remarks. Spath (1936) compared this rare species with Agassiz's *Goniomya sulcata* (1842, pl. 1b, figs 9–12, pl. 1c, figs 13–14, pl. 1, figs 8–9) which is based on material from the Middle Jurassic of the Swiss Jura. The latter species is undoubtedly very close, although all of Agassiz's figured specimens seem distorted by compaction, which renders a comparison very difficult. Apart from the fact that the Milne Land specimens are more than twice the length of Agassiz's specimens, (which should not on its own be regarded as justification for a specific separation), there is no indication of a posterior ridge, and the sulcus is better defined and directed far more posteriorly than in *G. bicarinata.*

G. bolchovitinovae Koshelkina (1960, p. 112, pl. 24, fig. 3) also exhibits an anterior ridge and sulcus, but apparently no posterior ridge is present. Koshelkina's figures (see also 1962, pl. 32, fig. 5 and 1963, pl. 24, fig. 1) hardly show any V-shaped ornament.

G. cf. *G. dubois* as figured by Zakharov & Mesezhnikov (1974) may well represent *G. bicarinata,* but the limited available information precludes its definite inclusion in the synonymy of *G. bicarinata. G. literata* can be distinguished very easily by its different overall shape and lack of any ridges or sulcus.

Autecology. Specimens of *G. bicarinata* have been found vertically embedded in life position. The wide posterior gape and the strongly elongate shell indicate that *G. bicarinata* was a fairly deep burrowing species probably with non-retractile siphons. Most likely, it burrowed deeper than *G. literata.* Like the latter it was a low level suspension-feeder.

Genus *Pachymya* J. de C. Sowerby, 1826. Subgenus *Arcomya* Roemer (ex Agassiz), 1839.

Type species. Solen helveticus Roemer (ex Thurmann), 1839.

Pachymya (Arcomya) sinuata (Agassiz, 1843)

Fig. 37 D–E

*1843 *Arcomya sinuata* sp. nov.; Agassiz, p. 169, pl. 10, figs 4–6.
1935 *Arcomya sinuata* Agassiz; Arkell, p. 342, pl. 50, fig. 6.

Fig. 36. *Goniomya* (*Goniomya*) *bicarinata* sp. nov.
A. MGUH 15557 from GGU 235540; bivalved specimen (holotype), left view; × 1. Pernaryggen Mb, Hartz Fjeld.
B. MGUH 15558 from GGU 235401; bivalved specimen, × 0 .75. Pernaryggen Mb, Hartz Fjeld.
Goniomya (*Goniomya*) *literata* (J. Sowerby, 1819).
C. MGUH 15559 from GGU 235453; right valve; × 1. Aldinger Elv Mb, locality 26.
D. MGUH 15560 from GGU 235453; right valve; × 1. Aldinger Elv Mb, locality 26.

Material. 4 specimens from the Pernaryggen Member at Kronen and Hartz Fjeld (from GGU 235440, 235506–235508, 235516).

Description. Very elongate shell; umbones salient, but somewhat depressed, and situated about one-third of shell length from the anterior; ventral margin straight, running parallel to hinge line; posterior rounded-rectilinear, posterodorsal margin gently sloping; anterior margin convex, slightly tapering; region of greatest shell thickness slightly posterior of shell centre; shell gaping at the anterior and even more so at the posterior end. With escutcheon and lunule, both delineated by faint ridges; shell surface covered with coarse commarginal growth lines.

Autecology. A. sinuata is very elongate and gapes posteriorly; these features suggest that it might have been a relatively deep burrower, although the existence of a pallial sinus is controversal. Trophic group: low level suspension-feeder.

Family Pleuromyidae Dall, 1900.

Genus *Pleuromya* Agassiz, 1843.
Type species. Mya gibbosa J. de C. Sowerby, 1823.

Pleuromya uralensis (d'Orbigny, 1845)

Figs 37 A–C, 38 A–H

*1845 *Pholadomya uralensis* sp. nov.; d'Orbigny, p. 168, pl. 40, figs 13–14.
?1846 *Panopaea rugosa* Goldfuss; Keyserling, p. 314, pl. 18, fig. 8 only.
1868 *Pholadomya uralensis* d'Orbigny; d'Eichwald, p. 755, pl. 27, fig. 2.
1903 *Pholadomya* cf. *P. uralensis* d'Orbigny; Ilovaisky, p. 260, pl. 9, figs 31a–b.
1923 *Pleuromya tellina* Agassiz var. *donacina* Agassiz; Lewinski, p. 82, pl. 14, figs 4a–b.
v.1936 *Homomya* aff. *H. hortulana* Agassiz; Spath, p. 132, pl. 47, figs 11a–b.
1955 *Pleuromya egregia* sp. nov.; Gerasimov, p. 77, pl. 9, figs 6–8.

Material. 126 specimens from the Pernaryggen Member at Hartz Fjeld, Kronen and Bays Fjelde (from GGU 235401–235407, 235416, 235420–235423, 235429, 235440–235441, 235447, 235464, 235467–235469, 235472, 235489, 235496, 235498, 235500–235502, 235505, 235509, 235526, 235531, 235537, 235540–235541, 235544–235548, 235550, 235561, 235565, 235580, 137413, 137415, 137419, 137654, 137672, 137710).

Description. Shell equivalve, elongate ovate, strongly inflated; with narrow anterior and moderately wide posterior gape; umbones prominent and broadly rounded, situated one-third to one-fifth of shell length from the anterior. Anterior short, rounded to slightly truncated; posterior long, tapering; anteroventral margin

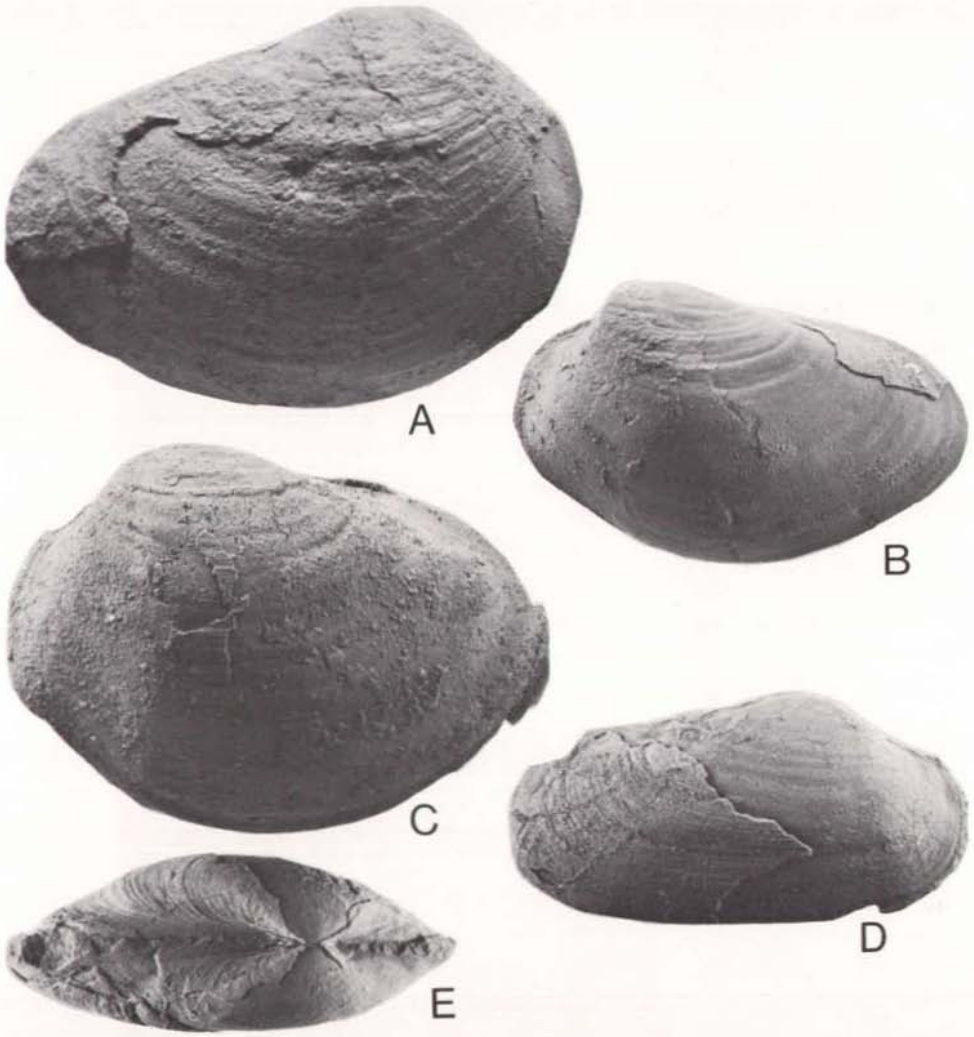


Fig. 37. *Pleuromya uralensis* (d'Orbigny, 1845).
A. MGUH 15561 from GGU 235547; bivalved specimen, right view; × 1. Pernaryggen Mb, Hartz Fjeld.
B. MGUH 15562 from GGU 137413; bivalved specimen, left view; × 1. Pernaryggen Mb, Hartz Fjeld.
C. MGUH 15563 from GGU 235469; bivalved specimen, left view; × 1. Pernaryggen Mb, Hartz Fjeld.
Pachymya (*Arcomya*) *sinuata* (Agassiz, 1843).
D, E. MGUH 15564 from GGU 235507; bivalved specimen, right (D) and dorsal (E) views; × 1. Pernaryggen Mb, Kronen.

slightly sinuous; ventral margin very convex. A broad, conspicuous to scarcely noticeable sulcus runs from the umbo to the anteroventral margin. Shell thin and with commarginal growth lines and plications. Pallial line with deep sinus.

Measurements.	GGU sample	l	l_{ant}	l_{ant}/l(%)	h	h/l(%)	d	d/l(%)
	235440	7.05	2.00	28.4	5.10	72.3	3.90	55.3
	235440	7.15	2.10	29.4	5.30	74.1	3.75	52.4
	235440	6.40	0.90	14.1	4.55	71.1	3.50	54.7
	235441	7.20	2.35	32.6	5.10	70.8	3.85	53.5
	235441	7.75	2.40	30.9	5.10	65.8	3.95	50.9
	235420	7.50	2.30	30.7	5.05	67.3	3.85	51.3
	235407	6.40	1.95	30.5	4.30	67.2	3.30	51.6
	235505	6.10	1.70	27.9	3.80	62.3	2.90	47.5
	137415	6.45	1.85	28.7	4.15	64.3	3.40	52.7

Remarks. D'Orbigny's holotype of *P. uralensis* is a distorted specimen. Fossil pholadomyids are frequently distorted as a result of sediment compaction and this has often induced taxonomists to found new species for grossly or even slightly distorted specimens. A recent example is provided by Koshelkina (1962) who erected several new species of *Homomya (H. schilo,* pl. 19, fig. 2; *H. obscondita,* pl. 19, fig. 1; *H. deflecta,* pl. 18, fig. 7; *H. frivola,* pl. 19, fig. 3; *H. lepideta,* pl. 18, fig. 6; *H. difficulta,* pl. 31, fig. 2) for specimens which have all been affected by compaction. Some of them might be synonyms of *P. uralensis,* but no decision can be made without seeing the material. Where compaction has affected vertically preserved *P. uralensis,* there is a tendency for the sulcus running from the umbo to the anteroventral margin to be emphasised as well as for the anterior region to be shortened, the latter leading to more pronounced and acute umbones and an even more strongly convex ventral margin – just as in d'Orbigny's holotype.

Greenland specimens were described and figured by Spath (1936) as *Homomya* aff. *H. hortulana.* However, *H. hortulana* Agassiz (1843, pl. 15) has a different shape. In particular the sulcus, where present, runs down from the umbones to the ventral margin in a slightly posterior direction, quite unlike the anterior direction in *P. uralensis.* The Milne Land specimens display a high degree of variation. The very variable development of the sulcus running from the umbones to the anteroventral margin has already been remarked upon by Spath (1936, p. 132).

The shape varies considerably from relatively high and short to less high and more elongate (fig. 38). In fact within one sample transitional stages to *Pleuromya*

Fig. 38. *Pleuromya uralensis* (d'Orbigny, 1845).

A. MGUH 15565 from GGU 137710; distorted bivalved specimen, left view; × 1. Pernaryggen Mb, Kronen.

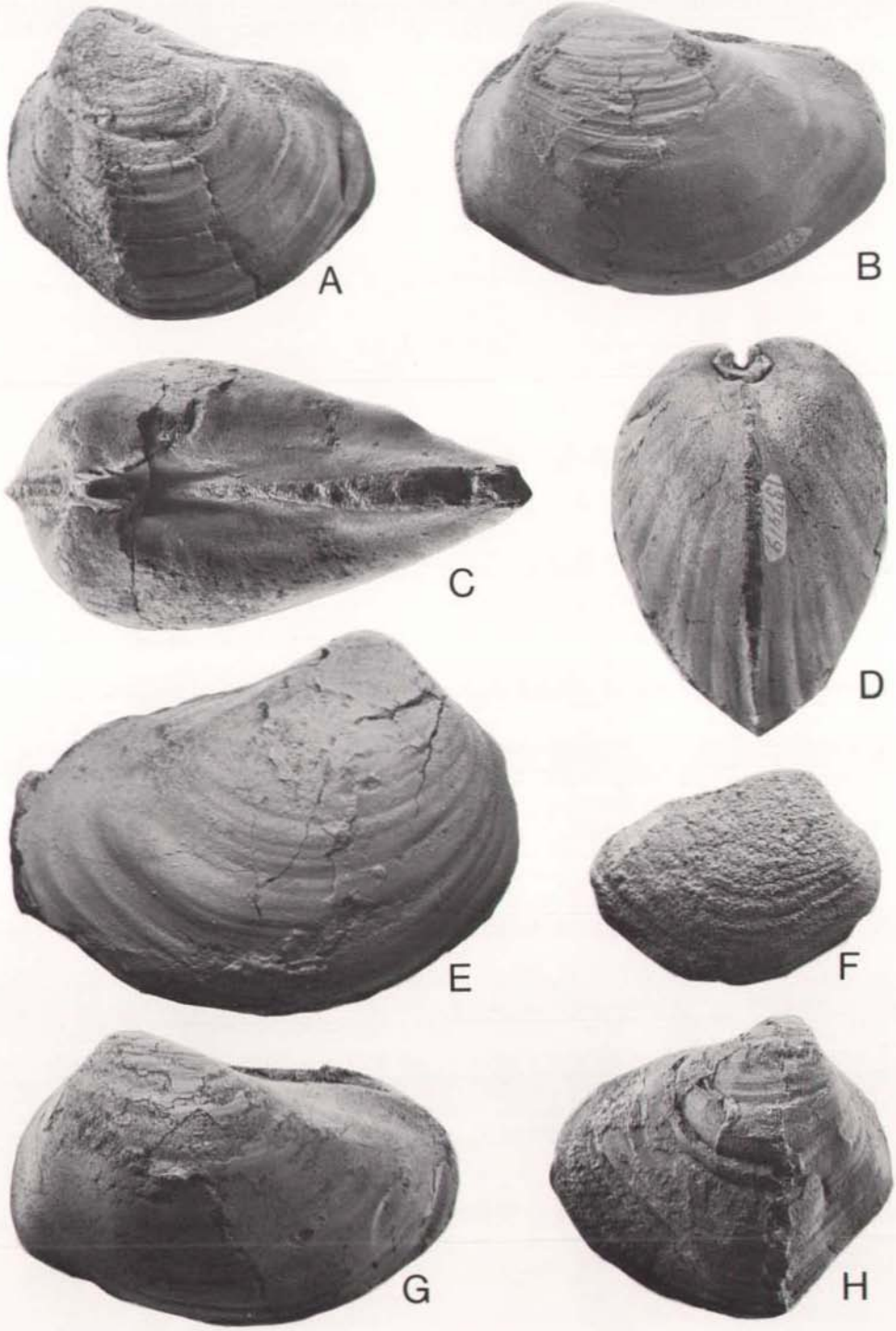
B. MGUH 15566 from GGU 137413; bivalved specimen, left view; × 1. Pernaryggen Mb, Hartz Fjeld.

C-E. MGUH 15567 from GGU 137419; bivalved specimen, dorsal (C), anterior (D) and right (E) views; × 1. Pernaryggen Mb, Hartz Fjeld.

F. MGUH 15568 from GGU 137654; bivalved specimen, right view; × 1. Pernaryggen Mb, Hartz Fjeld.

G. MGUH 15569 from GGU 137415; bivalved specimen, left view; × 1. Pernaryggen Mb, Hartz Fjeld.

H. MGUH 15570 from GGU 235496; distorted bivalved specimen, right view; × 1. Pernaryggen Mb, Kronen.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uniformis (described below) can be found; in several cases it is hardly possible to assign a specimen with certainty to one or the other species. This might imply that we are, in fact, dealing with only one very variable species. However, as the end members of the morphological range are quite distinct and form the bulk of the material, whilst intermediate phenotypes are rare, it seems more likely that two species are present exhibiting some overlap in morphology. Whatever the case, forms referred here to *P. uralensis* must at the very least be related to *P. uniformis*, and so cannot be placed in the genus *Homomya* as was considered appropriate by some earlier authors (see above and synonymy list).

Pleuromya uniformis (J. Sowerby, 1813)

Fig. 39 A–D

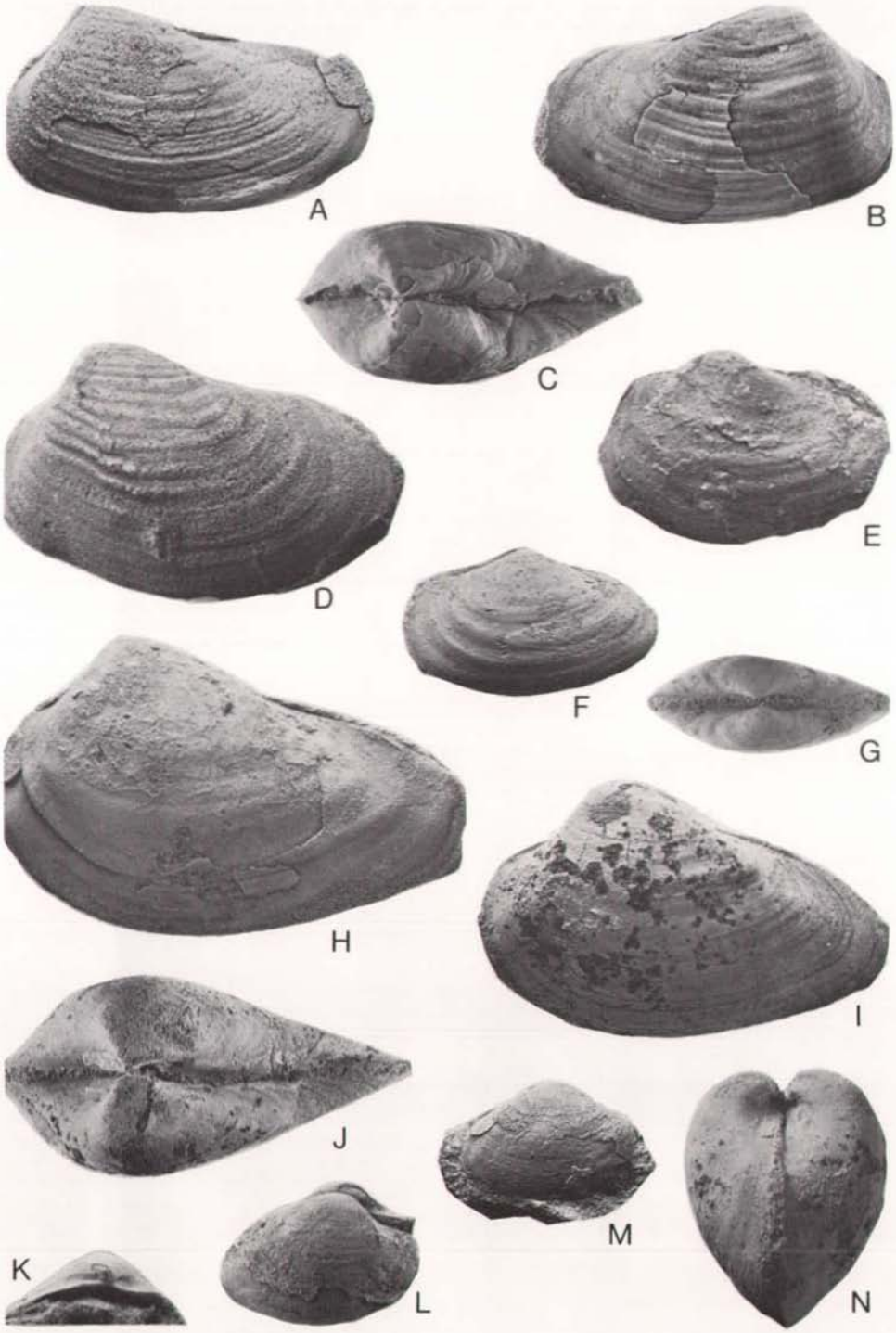
*1813 *Unio uniformis* sp. nov.; J. Sowerby, p. 83, pl. 33, fig. 4.
v.1936 *Pleuromya tellina* Agassiz; Spath, p. 128, pl. 45, figs 4a–b, pl. 50, figs 1a–b.

For extensive synonymy list see Arkell (1935, p. 325) and Duff (1978, p. 116).

Material. 124 specimens from the Pernaryggen Member at Hartz Fjeld, Kronen and Bays Fjelde (from GGU 235401–235405, 235411–235412, 235418–235425, 235427–235428, 235432, 235440–235442, 235451, 235467–235469, 235490, 235507–235508, 235511, 235513–235514, 235517, 235522, 235525, 235527, 235531, 235538, 235540–235541, 235547–235548, 235559); 13 specimens from the Cardioceraskløft Member at Cardioceraskløft (235545) and 7 specimens from the Kosmocerasdal Member at locality 4 (235561, 235565).

Description. Elongate, inflated shell; umbones inflated, prominent, situated between one-third and a quarter of shell length from the anterior; beaks orthogyrate;

Fig. 39. *Pleuromya uniformis* (J. Sowerby, 1813).
A. MGUH 15571 from GGU 235451; bivalved specimen, left view; × 1. Pernaryggen Mb, Hartz Fjeld.
B, C. MGUH 15572 from GGU 235531; bivalved specimen, right (B) and dorsal (C) views; × 1. Pernaryggen Mb, Bays Fjelde.
D. MGUH 15573 from GGU 235451; bivalved specimen, left view; × 1. Pernaryggen Mb, Hartz Fjeld.
Pleuromya uniformis var. *peregrina* (d'Orbigny, 1845).
E. MGUH 15574 from GGU 235468; bivalved specimen, left view; × 1. Pernaryggen Mb, Hartz Fjeld.
F, G. MGUH 15575 from GGU 137695; steinkern, left (F) and dorsal (G) views; × 1. Pernaryggen Mb, Hartz Fjeld.
Pleuromya triangularis sp. nov.
H. MGUH 15576 from GGU 137653; bivalved specimen, left view; × 1. Pernaryggen Mb, Hartz Fjeld.
I, J, N. MGUH 15577 from GGU 235560; steinkern (holotype), left (I), dorsal (J) and anterior (N) views; × 1. Pernaryggen Mb, Kronen.
Pleuromya zakharovi sp. nov.
K. MGUH 15578 from GGU 235573; hinge of left valve; × 1. Aldinger Elv Mb, locality 5.
L. MGUH 15579 from GGU 235573; bivalved specimen, right view; × 1. Aldinger Elv Mb, locality 5.
M. MGUH 15580 from GGU 235573; right valve (holotype); × 1. Aldinger Elv Mb, locality 5.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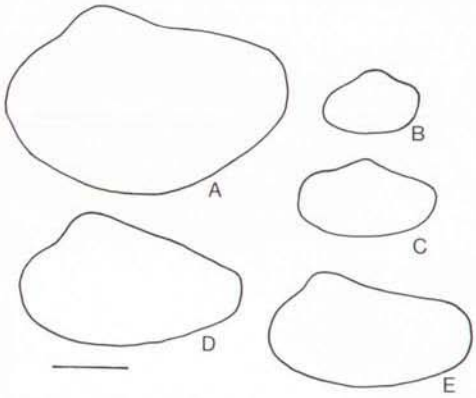

Fig. 40. Outline of the *Pleuromya* species occurring in the Upper Jurassic of Milne Land. A. *Pleuromya uralensis;* B. *Pleuromya zakharovi;* C. *Pleuromya uniformis* var. *peregrina;* D. *Pleuromya triangularis;* E. *Pleuromya uniformis.* Scale: 2 cm.

anterodorsal margin concave, anterior margin truncated, forming an obtuse angle with the slightly convex ventral margin. Lowest, most ventrally situated point on shell usually in posterior half; posterior margin slightly tapering, well rounded; posterodorsal margin subparallel to ventral margin. Obtuse ridge running from the umbo to the anteroventral margin, commonly followed posteriorly by a shallow sulcus which finds its expression at the ventral margin in a slight sinuosity. Posterior end with distinct gape. Surface covered with irregular, conspicuous, commarginal folds.

Measurements.

GGU sample	l	l_{ant}	l_{ant}/l(%)	h	h/l(%)	d	d/l(%)
235451	6.3	1.7	26.9	3.5	55.5	2.7	42.8
235451	6.0	1.6	26.7	3.7	61.7	2.9	48.3
235451	5.3	1.4	26.4	3.1	58.5	2.3	43.4
235403	5.65	1.7	30.0	3.1	54.8	2.3	40.7
235531	5.5	2.0	36.3	3.5	63.6	2.7	49.1
235531	5.2	1.7	32.7	3.3	63.5	2.4	46.1
235467	6.1	1.8	29.5	3.3	54.1	2.5	40.9
137551	5.55	1.7	30.6	3.4	61.3	2.5	45.0
235511	3.75	1.35	36.0	2.2	58.7	–	–
235540	7.0	2.3	32.8	3.7	52.8	2.9	41.4
235513	2.3	0.65	28.3	1.5	65.2	1.1	47.8

Remarks. P. uniformis is one of the most variable and long-ranging species of Jurassic bivalves. Arkell (1935, p. 328) was unable to distinguish between forms from the Inferior Oolite (Bajocian) and Portlandian. Specimens from the Pernaryggen Member do not exhibit particularly high variability within any one population, but differences in the mean form of populations from different levels are considerable. They all fall well within the range of *P. uniformis* as defined by Arkell. It is possible that studies of large populations of *P. uniformis* from different horizons within the Jurassic would reveal differences between populations which, in fact, would make it possible to split them into two or more species. However, it is

usually very difficult to obtain material well enough preserved, most specimens having suffered some degree of compactional distortion.

Some of the specimens from the Pernaryggen Member are very similar to *P. varians* Agassiz as figured by de Loriol (1896, pl. 11, fig. 6) or to *Venus unioides* Roemer (1836, pl. 8, fig. 6), species not found in Arkell's synonymy list for *P. uniformis,* but clearly within the morphological range of the species. Specimens from the Volgian of the Subarctic Urals (Zakharov & Mesezhnikov, 1974, pl. 37, figs 2a–b, 3a–b) are also very similar to the Greenland specimens from the Volgian as is de Loriol's *Pleuromya tellina* Agassiz (Loriol, Royer & Tombeck, 1872, pl. 10, figs 5–8) from the Upper Jurassic of Haute Marne. Corallian (Upper Oxfordian) specimens (Arkell 1935, pl. 45, figs 1–13) are generally smoother with the umbones in a more mesial position. The same is true of some Oxfordian specimens from Milne Land.

As has already been commented upon there seems to be a continuous series of forms between typical *P. uniformis* and *P. uralensis,* a species which is generally higher and has a more strongly upward-sloping anteroventral margin.

Pleuromya uniformis (J. Sowerby, 1813) var. *peregrina* (d'Orbigny, 1845)

Fig. 39 E–G

1845 *Panopaea peregrina* sp. nov.; d'Orbigny, pl. 40, figs 10–12.

Material. 6 specimens from the Pernaryggen Member and Hennigryggen Member (*Lingula* Bed) at Hartz Fjeld and Lingularyggen (from GGU 235468, 137457, 137656, 137695).

Description. Shell medium-sized, only moderately inflated; umbones orthogyrate, less produced than in other *Pleuromya,* rounded, slightly depressed, situated about one-third of shell length from the anterior; anterior margin well rounded, anterodorsal margin subparallel to ventral margin, which is only moderately convex; posterior end slightly tapering; pallial sinus very deep.

Shell gaping posteriorly. Surface of shell smooth except for fine commarginal growth lines; anterior sulcus not developed.

Measurements.	GGU sample	l	l_{ant}	l_{ant}/l(%)	h	h/l(%)	d	d/l(%)
	137656	3.4	1.4	41.2	2.1	61.7	1.4	41.2

Remarks. Only few specimens from the Upper Jurassic of Milne Land fit this description, but they are quite distinct and can easily be separated from other *Pleuromya.* They differ from *P. uniformis* (described above) by having a more mesially situated umbo, a smooth shell and no sulcus, and they are higher in relation to length and considerably more compressed. Arkell (1935, pl. 45, figs

8–10) figured very similar specimens from the *Trigonia hudlestoni* Bed at Kingston Bagpuize, but regarded them as mere variants of *P. uniformis* having found intermediate specimens linking them to more typical forms. For this reason, the Milne Land specimens, although showing no intermediates to *P. uniformis* as figured in figs 39A–D, are included under *P. uniformis,* but given varietal recognition as *P. uniformis* var. *peregrina* (d'Orbigny). The Milne Land specimens closely fit the holotype of *Panopaea peregrina* d'Orbigny (1845, pl. 40, figs 10–12).

This variety is particularly common in the *Lingula* Bed of the Hennigryggen Member.

Pleuromya triangularis sp. nov.

Fig. 39 H–J, N

v.1936 *Pronoella*(?) sp. ind. aff. *P. nuculaeformis* (Roemer); Spath, p. 126, pl. 48, figs 1a–b, pl. 50, figs 6a–b.

1974 *Gresslya*(?) aff. *G. alduini* (Fischer de Waldheim); Zakharov & Mesezhnikov, p. 159, pl. 37, figs 4a–c.

Holotype. MGUH 15577 from GGU 235560 from the Pernaryggen Member at Kronen.

Material. 123 specimens from the Pernaryggen Member at Hartz Fjeld, Kronen and Bays Fjelde (from GGU 235407, 235411–235412, 235416, 235429, 235440–235441, 235451, 235464, 235468, 235472, 235488, 235494, 235496–235502, 235509, 235514, 235516–235517, 235523, 235530–235531, 235536–235537, 235539–235542, 235546–235548, 235560).

Derivatio nominis. Triangularis (Lat.) = triangular.

Diagnosis. Strongly inflated *Pleuromya* with triangular outline.

Description. Shell inflated, triangular; greatest width of shell in the umbonal region; umbones inflated, very prominent, slightly prosogyrate, situated between one-third and a quarter of shell length from the anterior; ventral margin strongly convex; most ventrally situated point of shell directly below umbones; anterior margin short, well rounded; posterior end sharply tapering and obliquely truncated; hinge line long and nearly straight, that of left valve with short, rounded protuberance followed posteriorly by a niche; pallial line with deep sinus; posterior gape only slight. Shell thin and smooth except for generally faint commarginal growth rugae.

Measurements.

GGU sample	l	l_{ant}	l_{ant}/l(%)	h	h/l(%)	d	d/l(%)
235560	5.9	2.0	33.9	3.8	64.4	2.85	48.3
235560	5.5	1.6	29.1	3.8	69.1	2.7	49.1
235560	5.35	1.9	35.5	3.5	65.4	2.6	48.6
235530	5.2	1.7	32.7	3.3	63.5	2.5	48.1
137653	6.8	1.9	27.9	4.3	63.2	3.1	45.6

Remarks. There can be little doubt that *P. triangularis* represents a new species, differing in the following respects from *P. uniformis:* less elongate, ventral margin strongly convex, non-sulcate; sharply tapering, umbones more pronounced and anterior margin non-truncate. The species rarely occur together in the same bed, and where they do, one of them is usually much more abundant. *P. triangularis* differs from *P. alduini* (Brongniart) in having a well rounded anterior and in lacking the conspicuous commarginal ribbing of the latter.

Spath (1936) having only badly squashed specimens at hand figured *P. triangularis* as *Pronoella*(?) sp. ind. aff. *P. nuculaeformis* (Roemer). There is, indeed, a certain similarity in shape between the Milne Land specimens and *Eocallista nuculaeformis* (Roemer, 1836). However, the hinge, which it was possible to develop in one case, is that of a typical *Pleuromya* (e.g. Cox, 1969, p. N 843, fig. F 21). It is quite likely that some of the specimens described by authors as *Eocallista nuculaeformis* without knowledge of the hinge are, in fact, examples of *P. triangularis.* A steinkern similar to *P. triangularis* was described by Roemer (1836, pl. 6, figs 5a–b) as *Nucula gigantea* without the evidence of taxodont dentition. The specimen in fact possesses more strongly developed muscle scars than is characteristic of *P. triangularis.* Zakharov & Mesezhnikov's (1974) figured specimens of *Gresslya(?)* aff. *G. alduini* (Fischer de Waldheim) are most likely a variant of *P. triangularis* with more conspicuous growth rugae.

Pleuromya zakharovi sp. nov.

Fig. 39 K–M

Holotype. MGUH 15580 from GGU 235573 from the Aldinger Elv Member at locality 5.

Material. 36 specimens from the Aldinger Elv Member at locality 5 and locality 25 (from GGU 235452, 235461–235463, 235573).

Derivatio nominis. After V. A. Zakharov.

Diagnosis. Small, thick-shelled *Pleuromya* with submesial umbones and without posterior gape.

Description. Relatively small-sized and thick-shelled *Pleuromya;* umbones slightly prosogyrate, prominent, rounded, submesial, slightly anterior of midline; anterodorsal margin excavated, anterior margin well rounded, ventral margin fairly convex; most ventrally situated point of shell in posterior half; posterior sector somewhat tapering, obliquely truncated to rounded in outline; posterodorsal margin slightly convex, sloping; without posterior gape. Hinge that of a typical *Pleuromya.* Shell covered with faint commarginal growth lines.

Fig. 41 *Pleuromya uniformis* preserved in life position. *Pinna* Bed, Pernaryggen Mb, Hartz Fjeld. Scale in centimetres.

Remarks. The largest shell recorded measured 3.1 cm in length and 2.3 cm in height; most valves are around 2.5 to 2.8 cm in length and 1.8 to 2.0 cm in height. The variation within a population seems relatively low, the overwhelming majority of specimens closely resembling the figured specimens. They differ from other Upper Jurassic *Pleuromya* in Milne Land in (a) being relatively short; (b) not exhibiting a sulcus (as is present in *P. uralensis* and *P. uniformis*); (c) the relatively mesial position of the umbones; (d) their relatively thick shells, and (e) their small size (fig. 40). As they even differ from variants of *P. uniformis,* which occur in other parts of the world (e.g. as figured by Arkell 1935, pl. 45, figs 1–13), it seems justified to keep them as a separate species.

Autecology of *Pleuromya.* At various horizons within the Pernaryggen Member each of *Pleuromya uralensis, P. uniformis* and *P. triangularis* has been found in life position, that is more or less vertically orientated with the anterior end pointing into the sediment. Whilst *P. triangularis* was invariably found in a strictly vertical position, a large number of *P. uniformis* showed some degree of deviation from the vertical (e.g. fig. 41). The life positions of these species is comparable with that of modern myaceans such as *Mya*. The deep pallial sinus and the wide posterior gape point to the existence of large, fused siphons which probably could not be retracted into the shell. Thus the three *Pleuromya* species closely resemble Recent deep-burrowing myaceans such as *Mya arenarea,* which usually rests 25 to 30 cm deep in the sediment and, in the adult stage, is unable to re-burrow when excavated by currents or storms. The Milne Land forms were almost certainly low level suspension-feeders like all other known myaceans.

P. uniformis var. *peregrina* and *P. zakharovi* were not found in life position. The existence of a deep pallial sinus in the former suggests a similar mode of life to *P. uniformis.* In contrast, the relatively thick shell, lack of a posterior gape, and smaller posterior section in *P. zakharovi* may indicate that this species burrowed to shallower depths than other *Pleuromya* species.

Superfamily Pandoracea Rafinesque, 1815. Family Thraciidae Stoliczka, 1870.

Genus *Thracia* Leach *in* J. de C. Sowerby, 1823.
Type species. Thracia pubescens Lamarck, 1819 (= *Mya pubescens* Pulteney, 1799).

Thracia (Thracia) depressa (J. de C. Sowerby, 1823)

Fig. 42 A–F

*1823 *Mya depressa* sp. nov.; J. de C. Sowerby, p. 19, pl. 418.
v.1936 *Thracia incerta* (Deshayes) Thurmann sp.; Spath, p. 133, pl. 48, fig. 3, pl. 50, fig. 4.
v.1936 *Thracia* cf. *T. depressa* (J. de C. Sowerby); Spath, p. 134, pl. 50, fig. 3.

Material. 72 specimens from the Pernaryggen Member at Hartz Fjeld, Kronen and Bays Fjelde (from GGU 235401–235402, 235418, 235424–235425, 235432, 235440–235442, 235476, 235479, 235485, 235493–235497, 235507–235508, 235534, 235536, 235542, 235566–235568, 235570, 137726, 137710).

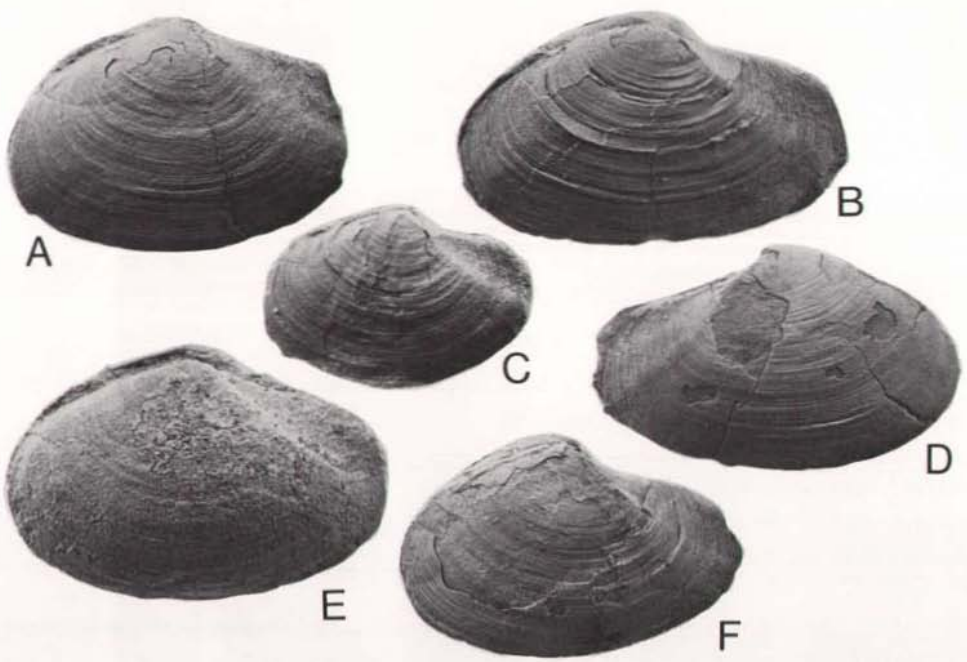

Fig. 42. *Thracia* (*Thracia*) *depressa* (J. de Sowerby, 1823).
A. MGUH 15581 from GGU 235493; bivalved specimen, left view; × 1. Pernaryggen Mb, Kronen.
B. MGUH 15582 from GGU 235496; bivalved specimen, left view; × 1. Pernaryggen Mb, Kronen.
C. MGUH 15583 from GGU 235493; bivalved specimen, left view; × 1. Pernaryggen Mb, Kronen.
D. MGUH 15584 from GGU 137726; bivalved specimen, right view; × 1. Pernaryggen Mb, Kronen.
E. MGUH 15585 from GGU 137710; bivalved specimen, left view; × 1. Pernaryggen Mb, Kronen.
F. MGUH 15586 from GGU 235493; bivalved specimen, left view; × 1. Pernaryggen Mb, Kronen.

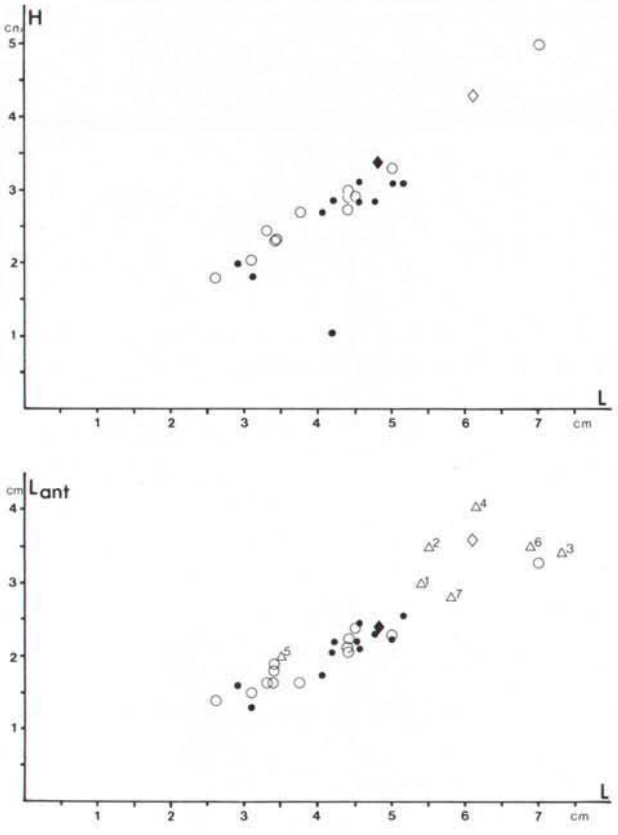

Fig. 43. Length/height and length/anterior length relationships of *Thracia* (*T.*) *depressa.*
Dots: population from GGU 235496; Pernaryggen Mb, Kronen; open circles: other specimens from the Pernaryggen Mb of Milne Land; open rhomb: holotype of *Mya depressa* J. de C. Sowerby (1823, pl. 418); black rhomb: holotype of *Tellina incerta* Thurmann *in* Roemer (1836, pl. 8, figs 7a,b); 1: specimen of *T. depressa* from the Upper Oxford Clay (Duff, 1978, pl. 13, fig. 23); 2: specimen of *T. depressa* from the Upper Oxford Clay (Duff, 1978, pl. 13, fig. 22); 3: *Thracia incerta* of de Loriol (1872, pl. 11, fig. 10); 4: *Thracia incerta* of de Loriol (1872, pl. 11, fig. 10); 5: *Thracia depressa* of de Loriol (1872, pl. 11, fig. 11); 6: *Corimya lata* of Agassiz (1845, pl. 34, fig. 2); 7: *Corimya lata* of Agassiz (1845, pl. 34, fig. 3).

Description. Shell thin, compressed, elongate, inequilateral, inequivalve; right valve larger than the left, which it overlaps. Umbones opisthogyrate, but less prominent than in most *T. depressa.* Posterior margin truncate, posterior end gaping. With faint ridge running from the umbo to the posteroventral margin; anterodorsal margin less steeply sloping than in the holotype of *T. depressa.* Ventral margin gently convex; anterior margin broadly rounded. Surface with fine commarginal striae. Pallial line with sinus.

Remarks. Thracia depressa appears to be a very variable species. In the past, more elongate forms, which in addition possess less prominent umbones and have a less steeply sloping anterodorsal margin, have been classified as *T. incerta* (Thurmann *in* Roemer, 1836). However, Arkell (1936, p. 356) considered that both *T. depressa* and *T. incerta* might grade into each other. Duff (1978) recently studied populations of *Thracia* from the Oxford Clay (Callovian to Lower Oxfordian) of England and confirmed that the short, high forms intergrade with the more elongate ones. At the same time he did not exclude the possibility that very elongate speci-

mens from the Kimmeridgian and Portlandian (such as *T. incerta* as figured by Cox, 1929, pl. 5, fig. 6) may, in fact, constitute a separate species.

The Milne Land specimens again exhibit a wide morphological range (fig. 43) although elongate forms dominate. There is, however, no suggestion of a bimodal distribution.

Autecology. The elongate compressed form of *T. depressa* makes it very well suited to burrowing. The presence of a pallial sinus and the gaping posterior indicate that the species must have possessed long siphons and therefore was deep burrowing. According to Yonge (1937) Recent *Thracia pubescens* produce mucus-lined tubes in the sediment, through which the inhalent and exhalent currents flow. These enable the species to burrow even deeper than is allowed by the length of the siphons, the mucus-lined tubes serving as an extension of these organs. Trophic group: low level suspension-feeder.

OTHER BENTHIC FAUNAL ELEMENTS FROM THE UPPER JURASSIC OF MILNE LAND

Apart from the bivalves described in the foregoing there are several species which have not been discussed because their poor preservation made their description pointless. For the sake of completeness, they are listed below in stratigraphical order. In addition there are several specimens which, although undoubtedly belonging to other species than those mentioned in the text, could not be identified precisely, usually owing to poor preservation and lack of diagnostic features (such as the hinge in heterodonts).

Kosmocerasdal Member:
- *Meleagrinella ovalis* (Phillips, 1829)
- *Nicaniella* sp.

Cardiocerasklø ft Member:
- *Inoceramus* sp. 2
- *Prorokia* sp. 2

Gråkløft Member:
- *Inoceramus* sp. 1
- *Prorokia* sp. 1

Pernaryggen Member:
- *Bakevellia* sp.
- *Buchia* ex gr. *B. russiensis* (Pavlow, 1907)
- *Isocyprina (I.)* cf. *I. (I.) cyreniformis* (Buvignier, 1852)
- *Corbulomima* sp.
- xylophagan bivalve
- *'Pleuromya elongata'* (Agassiz, 1843)

Thus, altogether 90 to 95 species of bivalves are recorded from the Upper Jurassic of Milne Land, the majority (65) from the Pernaryggen Member. For the intended palaeosynecological analysis not only bivalves, but also the remaining benthic invertebrate fauna was studied and identified. In the following tables, (Appendix 1) faunal lists for each member of the Upper Jurassic of Milne Land are given. They are based on much larger samples than those of earlier authors (e.g. Spath, 1935, 1936) and serve as basic data for the intended palaeobiogeographical analysis.

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APPENDIX 1

Table 1. Faunal list of the Kosmocerasdal Member

Bivalves:
- *Grammatodon (Cosmetodon) keyserlingii*
- *Modiolus (Strimodiolus) strajeskianus*
- *Oxytoma* sp.
- *Meleagrinella ovalis*
- *Entolium (E.) corneolum*
- *Camptonectes (C.) auritus*
- *Camptonectes (Costicamptonectes) milnelandensis*
- *Praebuchia kirghisensis*
- *Nicaniella* sp.
- *Protocardia (P.) striatula*
- tancrediid(?) bivalve
- *Pholadomya (P.) hemicardia*
- *Goniomya (G.) literata*
- *Pleuromya uralensis*
- *Pleuromya uniformis*

Gastropods:
- *Dicroloma bononiensis*
- *Chenopus (Quadrinervus)* sp.

Serpulids:
- *Ditrupa nodulosa*
- *Serpula (Cycloserpula) intestinalis*
- *Serpula (Dorsoserpula)* sp.
- *Serpula (Tetraserpula)* sp.

Brachiopods:
- *Lingula* sp.
- *'Terebratula'* sp.

Table 2. Faunal list of the Aldinger Elv Member

Bivalves:
- *Grammatodon (Cosmetodon) keyserlingii*
- *Lopatinia callomoni*
- *Modiolus (Strimodiolus) strajeskianus*
- *Aguilerella aldingeri*
- *Meleagrinella ovalis*
- *Oxytoma (O.)* sp.
- *Camptonectes (C.) auritus*
- *Camptonectes (Boreionectes) broenlundi*
- *Praebuchia kirghisensis*
- *Plagiostoma* sp.
- *Liostrea(?)* sp. 1
- *Liostrea(?)* sp. 2
- *Nanogyra nana*
- *Discomiltha lirata*
- *Unicardium aceste*
- *Protocardia (P.) striatula*
- *Tancredia (T.) magna*
- *Tancredia (T.) donaciformis*
- *Corbicellopsis lorioli*
- *Corbicellopsis laevis*
- *Arctica syssollae*
- cyprinid sp.
- *Goniomya (G.) literata*
- *Pleuromya zakharovi*

Gastropods:
- *neritinid sp. A*
- *Neritopsis* sp.
- *Ampullina* sp.
- *Amberleya* sp.
- *Pseudomelania (Oonia)* sp.
- *Chenopus (Quadrinervus)* sp.

Serpulids:
- *Ditrupa nodulosa*
- *Serpula (Cycloserpula) intestinalis*
- *Serpula (Cycloserpula)* sp.

Echinoderms:
- *Pentacrinites* ossicles

Table 3. Faunal list of the Cardioceraskløft Member

Bivalves:
- *Mesosaccella choroschowensis*
- *Grammatodon (G.) schourovskii*
- *Modiolus (Strimodiolus) strajeskianus*
- *Inoceramus* sp.
- *Oxytoma (O.) inequivalve*
- *Entolium (E.) orbiculare*
- *Camptonectes (C.) morini*
- *Camptonectes (Boreionectes)* cf. *C. (B.) validus*
- *Buchia lindstroemi*
- *Limatula consobrina*

Liostrea sp.
Prorokia sp. 2
Protocardia (P.) sp.
Pholadomya (P.) sp.
Goniomya (G.) literata
Pleuromya uralensis
Thracia (T.) depressa

Gastropods:
Amberleya cf. *A. jasikoviana*
Pseudomelania sp.
Brachiopods:
'Terebratula' sp.
Rhynchonella sp.
Polychaets:
Ditrupa nodulosa

Table 4. Faunal list of the Gråkløft Member

Bivalves:
Inoceramus sp. 1
Buchia sp.
Prorokia sp. 1

Table 5. Faunal list of the Krebsedal Member

Bivalves:
Nuculoma variabilis
Mesosaccella choroschowensis
Grammatodon (G.) schourovskii
Pinna (P.) lanceolata
Inoceramus sp.
Isognomon (I.) volaticum
Oxytoma (O.) sp.
Entolium (E.) orbiculare
Camptonectes (C.) morini
Camptonectes (Boreionectes) praecinctus
Buchia mosquensis
Buchia cf. *B. rugosa*
Limatula consobrina
Liostrea plastica
Discomiltha lirata
Astarte (A.) sp.
Eriphyla (Lyapinella) saemanni
Isocyprina (Venericyprina?) birkelundi
Pholadomya (P.) hemicardia
Goniomya (G.) literata
Pleuromya triangularis
Pleuromya uniformis
Pleuromya uralensis
Thracia (T.) depressa
Gastropods:
Purpurina sp.
Turritella sp. nov. aff. *T. molarium*
Scaphopods:
Dentalium sp.
Brachiopods:
Taimyrothyris sp.
Russirhynchia(?) sp.
Arthropods:
Glyphea rostrata
Echinoderms:
cidaroid spines and plates

Table 6. Faunal list of the Pernaryggen Member

Bivalves:
Nuculoma variabilis
Mesosaccella choroschowensis
Solemya(?) sp.
Grammatodon (G.) schourovskii
Grammatodon (Cosmetodon) keyserlingii
Musculus (M.) fischerianus
Modiolus (M.) bipartitus
Modiolus (Strimodiolus) czekanowskii
Modiolus (Strimodiolus) elongatus
Falcimytilus suprajurensis
Pinna (P.) lanceolata
Bakevellia sp.
Inoceramus sp.
Inoceramus sp.
Isognomon (I.) volaticum
Oxytoma (O.) inequivalve
Entolium (E.) orbiculare
Camptonectes (C.) morini
Camptonectes (Boreionectes) praecinctus
Camptonectes (Camptochlamys) sp.
Buchia mosquensis

Buchia rugosa
Buchia ex gr. *B. russiensis*
Placunopsis radiata
Limatula consobrina consobrina
Limatula consobrina multicostata
Plagiostoma incrassatum
Plagiostoma sp.
Pseudolimea cf. *P. arctica*
Liostrea plastica
Liostrea(?) sp. 1
Nanogyra nana
Myophorella (M.) ingens
Discomiltha lirata
Discomiltha(?) sp. A
Unicardium aceste
Astarte (A.) praeveneris praeveneris
Astarte (A.) praeveneris maimechaensis
Astarte (A.) cf. *A. (A.) veneris*
Neocrassina (Pressastarte) pelops
Eriphyla (Lyapinella) saemanni
Protocardia (P.) striatula
Quenstedtia parallela
Quenstedtia laevigata
Quenstedtia grewinki
Corbicellopsis unioides
Corbicellopsis lorioli
Corbicellopsis cf. *C. lorioli*
Hartwellia (H.) kharoschovensis
Hartwellia (H.) groenlandica
Hartwellia (H.) borealis
Hartwellia (H.) sp. A
Isocyprina (Venericyprina?) birkelundi
Pronoella(?) (P.?) superjurensis
Corbulomima sp.
xylophagan bivalve
Pholadomya (P.) hemicardia
Goniomya (G.) literata
Goniomya (G.) bicarinata
Pachymya (Arcomya) sinuata
Pleuromya uralensis
Pleuromya uniformis
Pleuromya uniformis var. *peregrina*
Pleuromya triangularis
Thracia (T.) depressa

Gastropods:
Pleurotomaria sp.
neritinid sp. B
neritinid sp. C
Sulcoactaeon peroskianus
Pseudomelania sp.
Turritella sp. nov. aff. *T. molarium*
Brachytrema keyserlingiana
Brachytrema incerta
Amberleya pulchra
Purpurina sp.
Neritopsis sp.
Calliomphalus sp.
Procerithium(?) sp.
Pseudorhytidopilus sp.

Brachiopods:
Lingula zeta
Orbiculoidea latissima
Russirhynchia(?) sp.
Taimyrothyris sp.

Bryozoans:
fan-shaped ectoprocts
cructose ectoprocts

Arthropods:
Glyphea rostrata
Eryma cf. *E. ventrosa*

Serpulids:
Serpula (Cycloserpula) intestinalis
Serpula (Tetraserpula) sp.
Serpula (Dorsoserpula) sp.

Table 7. Faunal list of the Astartedal Member

Bivalves:
Nuculoma variabilis
Mesosaccella choroschowensis
Solemya sp.
Grammatodon (G.) schourovskii
Pinna (P.) lanceolata
Inoceramus sp.
Oxytoma (O.) sp.
Entolium (E.) orbiculare
Camptonectes (C.) morini
Buchia mosquensis
Discomiltha sp.
Astarte (A.) sp.
Eriphyla (Lyapinella) saemanni
small astartid sp.
Protocardia (P.) striatula
Corbicellopsis lorioli
Hartwellia (H.) kharoschovensis
Hartwellia (H.) groenlandica
Isocyprina (Venericyprina?) birkelundi
Corbulomima sp.
shallow burrowing heterodont
Pleuromya uniformis
deep burrowing pholadomyacean
Thracia (T.) depressa

Gastropods:
Delphinula sp.
Neritopsis sp.
Pseudorhytidopilus sp.
Pseudomelania sp.
Brachytrema keyserlingiana
Scaphopods:
Dentalium sp.
Brachiopods:
Orbiculoidea latissima
Taimyrothyris sp.
Arthropods:
Glyphea rostrata
Echinoderms:
Pentacrinites ossicles

Table 8. Faunal list of the Lingula Bed (Hennigryggen Member)

This list is by no means exhaustive

Bivalves:
Grammatodon (Cosmetodon) keyserlingii
Modiolus (Strimodiolus) elongatus
Pinna (P.) lanceolata
Isognomon (I.) volaticum
Oxytoma (O.) inequivalve
Entolium (E.) orbiculare
Camptonectes (C.) morini
Buchia sp.
Pseudolimea sp.
Unicardium aceste
Astarte sp.
Neocrassina (Pressastarte) sp.
Eriphyla (Lyapinella) saemanni
Protocardia (P.) striatula
Tancredia hartzi
Corbicellopsis aff. *C. portlandica*
Corbicellopsis unioides
Hartwellia (H.) groenlandica
Isocyprina (Venericyprina?) birkelundi
Pholadomya (P.) hemicardia
Pleuromya uniformis var. *peregrina*
Thracia (T.) depressa
Gastropods:
Sulcoactaeon peroskianus
Scaphopods:
Dentalium sp.
Brachiopods:
Lingula zeta

APPENDIX 2

List of principal localities from which bivalves were collected. Locality numbers refer to the numbering system in Callomon, Birkelund & Fürsich (unpublished).

A. Region north of Hartz Fjeld.
3. Nordvestelv, 1.2 km east of the junction with Nordøstelv (GGU sample 235554–235556).
4. Valley south-east of the mouth of Nordøstelv (GGU sample 235561–235565).
5. Valley north of Cardioceraskløft (GGU sample 235572–235574).
7. Upper Cardioceraskløft (GGU sample 235544–235545, 235578).

B. Hartz Fjeld region.
9. Ridge leading up to the northern corner of Hartz Fjeld (GGU sample 235534–235542).
11. Ridge leading up to the north-eastern corner of Hartz Fjeld, at foot of basalt dyke (GGU sample 235546–235550).
14. Northern slope of ridge south of Pinnadal (GGU sample 235468–235479).
15. Ridge south of Astartedal (GGU sample 235464–235466).
16. First ridge north of Krebsedal (GGU sample 235438–235450).
17. Ridge south of Krebsedal (GGU sample 235401–235419).
18. East slope of Slottet (GGU sample 235427–235434).
19. Lingularyggen (GGU sample 235426).
20. Glaukonitbjerg (GGU sample 235420–235425).

C. Kronen region.
23. Pernaryggen, east of Kronen (GGU sample 235486–235520, 235557–235559).
D. Region between Kronen and Bays Fjelde.
25. Vestelv, 2.5 km south-west of Kronen (GGU sample 235452, 235460–235463).
26. Valley 3.5 km south of top 530 (GGU sample 235453–235459).
E. Bays Fjelde region.
34. Bays Fjelde, slope south-east of top 810 (GGU sample 235522–235528).

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