

MEDDELELSER OM GRØNLAND

UDGIVNE AF

KOMMISSIONEN FOR VIDENSKABELIGE UNDERSØGELSER I GRØNLAND

Bd. 110 · Nr. 4

DE DANSKE EKSPEDITIONER TIL ØSTGRØNLAND 1926—39

UNDER LEDELSE AF LAUGE KOCH

PERMIAN PELECYPODS OF
EAST GREENLAND

BY

NORMAN D. NEWELL

WITH 5 PLATES

KØBENHAVN

C. A. REITZELS FORLAG

BIANCO LUNOS BOGTRYKKERI A/S

1955

ABSTRACT

WOLF MAYNC'S (1942) able stratigraphic summary of the facies complex of the East Greenland Permian clearly demonstrates the special importance of these rocks in the world scheme of Permian geology. The Greenland succession of marine Permian invertebrates furnishes new evidence bearing on the correlation of the European Upper Permian sequence (Zechsteinian, i. e., post-Artinskian) with age equivalents of other regions. According to MAYNC'S evidence the entire sequence of the East Greenland Permian is Zechsteinian in age, hence, is referred to the Upper Permian series.

Indirect correlation with the West Texas sequence, by way of the Urals and India, indicates that the Upper Permian of Greenland and Europe is approximately equivalent in age to the Guadalupian, and possibly as young as the unfossiliferous Ochoan, of Texas. In accordance with growing European usage it would be advantageous to refer the Texas Wolfcampian (Sakmarian) and Leonardian (Artinskian) to the Lower Permian series, and the Guadalupian (Wordian, Capitanian) and Ochoan to the Upper Permian series. A "middle Permian" series is an anomaly without a place in any existing international scheme of classification.

Twenty-three species of pelecypods, four of them new, from the Upper Permian are herein described, and three, of which one is new, from the Lower Triassic of Greenland. The majority of the Permian forms are well known elements of the Zechsteinian fauna, widely distributed at high and intermediate latitudes in Europe. The suggestion is made that this fauna lived in cool waters, even though limestone reefs are known in Zechsteinian deposits.

INTRODUCTION

Rocks of late Paleozoic age in East Greenland were first recognized during studies by a Danish expedition under L. MYLIUS-ERICHSEN (1906—1908), but systematic investigation of these rocks was first undertaken and continues as part of the great work of a series of geological expeditions under the leadership of LAUGE KOCH on behalf of the Government of Denmark. Accumulation of knowledge of this Permian sequence is one of many major scientific accomplishments of Koch and his co-workers.

One of the most recent, and certainly the most notable contribution to date on the Greenland Permian, is the comprehensive treatise "Stratigraphic und Faziesverhältnisse der oberpermischen Ablagerungen Ostgrönlands" by WOLF MAYNC,¹⁾ in which a regional interpretation of Permian stratigraphy is attempted for the first time.

Field conditions in East Greenland are relatively difficult. Exposures are frequently interrupted by great areas of snow and ice. Consequently, stratigraphic studies, and especially the collecting of fossils, necessarily are still reconnaissance in nature. Nevertheless, collections now available are sufficient for many valid conclusions.

The present investigation is devoted to collections of Permian, and a few Triassic pelecypods obtained by various members of the several Danish expeditions. I have not visited East Greenland and, therefore, have depended on the important works of FREBOLD (1931, 1932, 1933) and MAYNC (1942), and on collection labels, for stratigraphic data.

Twenty-three species of pelecypods from the Upper Permian, and three Lower Triassic pelecypods from East Greenland are herein described and discussed. Acknowledgment is made to Dr. ALFRED G. FISCHER for aid during the early part of this study.

¹⁾ Meddelelser om Grønland, Bd. 115, No. 2, 128 pp., 6 Taf., 1942.

THE PERMIAN SUCCESSION

The East Greenland Permian succession is fully developed on, and near, Clavering Ø (74° 15' N. lat.) where MAYNC (*op. cit.*) recognizes the following stratigraphic facies.

Lower Triassic

Permian

5. Red series
4. Martinia limestone
3. "Posidonomya" shales
2. Productus limestone
1. Reef dolomite and limestone

Pre-Permian.

These units interfinger laterally in a complex manner. For example, the Reef limestone is thought to have been deposited contemporaneously with black shales of the Posidonia ("Posidonomya") beds, and the Red series is thought, by MAYNC, to be approximately equivalent to the Martinia limestone. The Productus limestone is a lithofacies, which is repeated at several horizons and laterally replaces adjacent units, as interpreted by MAYNC (1942, Taf. 6).

The majority of the pelecypods were collected in the Reef (and equivalent) limestone, Posidonia shale, and the Red series. Each of these facies is characterized by distinctive associations, which obviously depend on special ecologic circumstances, rather than differences in geologic age. Pelecypods of distinctive types occur also in the Productus and Martinia limestones, but they are very minor elements of faunas dominated by brachiopods and bryozoans.

The several facies will be considered below.

GEOLOGIC AGE AND PALEOCLIMATE OF THE GREENLAND PERMIAN

FREBOLD (1931, 1932, 1933) has clearly demonstrated that a fauna characteristic of the European Zechstein is well represented in East Greenland. Unfortunately, most of FREBOLD's collections were taken from exotic blocks of white limestone in a conglomerate of early Triassic age (Cape Stosch formation). This fauna was not found *in situ*, and fixed stratigraphically, until MAYNC discovered it in the Reef limestone in the lower part of the Greenland succession.

Faunal correlation of the German Zechstein with the English Magnesian limestone and the Kungur-Kazan beds of Russia appears to be fairly well established, although, of course, stratigraphic limits probably are not precisely the same in the three regions. Furthermore, it has always been the rule to consider these beds as comprising an Upper Permian series. Although correlations within this Zechsteinian province are not particularly difficult, correlation with beds of equivalent age in other important Permian provinces has been uncertain. Fusulinids and ammonoids, on which basic zonation of the marine Permian is generally based, are unknown in the Zechsteinian province, hence, the range of the European Upper Permian, in terms of other regions, is somewhat controversial. Recent recognition of species of the ammonoid genus *Cyclolobus* in the Martinia limestone, by MILLER and FURNISH (1940a) at last provides concrete evidence that the enclosing rocks are as young as the highest ammonoid zone of the Permian, the zone of *Cyclolobus*. MAYNC (*op. cit.*) has concluded, from his field studies, that the Martinia beds are approximately equivalent in age to beds containing characteristic Zechsteinian assemblages. This, of course, does not necessarily mean that all of the Zechsteinian of Europe is as young as the *Cyclolobus* zone. In the area just west of the Urals beds containing Zechsteinian faunas (Kungur-Kazan) overlie the Artinskian stage, which is approximately equivalent to the Leonardian of Texas (Miller and Furnish, 1940b). Accordingly, it appears that the Zechsteinian is mainly younger than Leonardian and ranges as high as the Upper Permian of other regions. In Russia, the top of the Lower Permian is defined at the top

of the Artinskian beds, and succeeding Paleozoic strata (Kungurian, Kazanian, Tartarian) are classed as Upper Permian. Comparison of the European and Texas nomenclature and approximate correlations are as follows:

	<i>Europe</i>		<i>Texas</i>
Upper Permian	{ Tartarian Kazanian Kungurian }	Zechsteinian	Ochoan
			Capitanian
			Wordian } Guadalupian
Lower Permian	{ Artinskian Sakmarian }		Leonardian
			Wolfcampian

Upper Permian faunas of Europe and Greenland have little in common with Guadalupian faunas of Texas, in spite of strong probability that they are about the same age. Known differences in type and distribution of Upper Permian faunas indicate that the Zechsteinian and Guadalupian seas lay in separate and ecologically unlike provinces. The Guadalupian faunas are similar in facies to those of the Mediterranean and Himalayan areas (Tethys). These faunas, furthermore, are alike in being limited, so far as I am aware, to low latitudes. They are characterized by rich diversity, and by the occurrence of certain distinctive types of brachiopods (Richthofenids, *Leptodus*, etc.). Fusulines are prolific in these faunas. The Zechsteinian faunas, on the other hand, are not nearly so varied and are characterized by complete absence of fusulines.

It is interesting to speculate on the reasons for these facies differences. In general, the Zechsteinian, and similar (e. g., Phosphoria) faunas tend to be limited to higher latitudes, whereas the Guadalupian (Tethyan) type of fauna is limited to lower and intermediate latitudes. This evidence, inadequate though it may be, suggests climatic differentiation during the later Permian. If climatic control was responsible for the marked differences in these faunas, it seems probable that the Tethyan faunas, judging from their diversity of type, lived in relatively warm waters, and the Zechsteinian faunas lived in cool waters. MAYNC (*op. cit.*, p. 81) believes, however, that the Greenland Permian was deposited in warm waters.

LITHOFACIES AND PALEOECOLOGY

Reef limestone facies. — The key to an understanding of the difficult facies relationships of the East Greenland Permian was discovered by MAYNC (*op. cit.*) on Clavering Ø, where metamorphosed older Paleozoics are overlain by massive, white or buff limestone and dolomite in which stratification is obscure or lacking. Intraformational (autigenen, primäre) breccias derived from penecontemporaneous destruction of the massive rock by currents, or waves, are common throughout this part of the sequence, both within and marginal to the massive unit. The massive unit, ranging up to about 100 meters thick, is the "Zechstein Reef limestone", of MAYNC. It is rather abruptly replaced to the southward, on Clavering Ø, by a basin of black, bituminous shales, the Posidonia facies. Although more field facts are needed, this relationship is remindful of the reef-basin relationships in West Texas where the Capitan reef limestone is abruptly replaced on the front by bituminous and clastic beds of the Delaware Mountain group.

MAYNC has identified and listed many of the characteristic species of the Zechsteinian in the Reef limestone. Mainly, these are pelecypods, brachiopods, bryozoans, and a few solitary corals. Unfortunately, very few of these Reef limestone fossils were available for the present study. Possibly MAYNC's identifications were made in the field.

Pelecypods, belonging mainly to byssiferous, cemented, and rock boring types are so diverse and numerous as to form a conspicuous element of the fauna. Gastropods and cephalopods, on the other hand, are rare, or unknown. Brachiopods are dominated by a few species of productids. The brecciated character of much of the Reef limestone suggests penecontemporaneous destruction at or above wave base in the topographically high parts of the reef. The prevailing light colors of the rock result from a relatively low content of iron and hydrocarbons. These criteria suggest deposition in well aerated waters, heavily populated by scavengers and other organisms capable of utilizing essentially all proteins, fats, etc., as fast as they accumulated in the reef environment. These conditions are characteristic concomitants of reef deposition, and indeed, may be considered requisite environmental fac-

tors for reef growth. Probably the Reef limestone was deposited in very shallow waters, ranging from 10 or 15 fathoms to sea level. All extensive organic reefs, even those of cold waters, are today limited to shallow waters except where they are rapidly subsiding.

It is by no means clear that the Greenland Reef limestone deposits, or for that matter the so-called reefs of the English Permian, were deposited mainly by organisms. Matrix adherent to the fossils in the collections at hand is somewhat re-crystallized; it may have had either an organic or an inorganic origin. MAYNC reports matrix of shell detritus between breccia blocks throughout the Reef limestone, but the blocks, themselves, certainly are not composed of recognizable shells. In fact, the contained fossils are scattered through the rock and form only a fraction of the limestone.

MAYNC (*op. cit.*) refers frequently to "korallogener" limestone and dolomite, in the reef facies. However, the only direct reference to fossil corals appears to pertain to solitary corals. Solitary corals, to my knowledge, rarely are important rock formers, and never have been reef formers. There is no indication that MAYNC referred to colonial corals. Indeed, colonial corals are very poorly represented in the Upper Permian, and I am not aware that Permian *coral* reefs occur anywhere in the world. For these reasons, I judge that MAYNC may have mistaken massive bryozoans (fistuliporoids?), such as are common in Permian reefs elsewhere, for corals.

At present it is not certain but it is probable that organisms were mainly responsible for the lime deposits of the Reef facies, and relative proportions of the recognizable fossil groups have not been determined.

FREBOLD (1931, 1932, 1933) described most of the Greenland Permian fossils available to him. Among other collections, he devoted much attention to fossiliferous boulders (weissen Blöcke) of limestone contained in a conglomerate of early Triassic age at Kap Stosch (Cape Stosch formation). A few of the blocks contain pelecypods of the Lower Triassic (*Claraia stachei*, *Promyalina groenlandica*, *Myalina* cf. *meeki*), but other blocks contain a characteristic Zechsteinian fauna in which pelecypods, brachiopods, and bryozoans are predominant. MAYNC believes that these boulders were derived from the Reef limestone. FREBOLD's efforts to compare the Greenland faunas with particular parts (i. e., lower, middle, and upper parts of the Zechstein) of the German succession led to the conclusion that the Permian faunas from Kap Stosch pertained to the lower and middle Zechstein. While FREBOLD's methods are logical, I doubt that the succession in Germany and England is so much the result of progressive evolution as an effect of fluctuating and shifting environments.

The following Permian pelecypods from the Cape Stosch formation are herein discussed:

Pseudomonotis speluncaria
Ps. sparsicostata
Procrassatella plana
Cypricardinia? permica
Schizodus obscurus
Astartella vallisneriana
Parallelodon striatus
Plagiostoma? permiana
Bakevella antiqua
B. bicarinata
Liebea squamosa
Lithophaga consobrina
Stutchburia? modioliformis
Pleurophorus sp.

The majority of these species are widely distributed in Europe and Britain. The most southerly occurrences probably do not reach south of about 50° N. latitude, and the most extensive development is at higher latitudes. Distribution is great of many elements of this fauna in the Arctic from Timan and the Kanin Peninsula of Russia westward, by way of Spitzbergen and Greenland, to the Arctic Islands of Canada, where relatively little paleontological work has been done on the Permian. The fauna has little in common with known faunas of the United States.

Productus limestone facies. — The term "Productuskalk" was employed by MAYNC (*op. cit.*) for thin limestones (a few cm. to about 5 m) of dark brown color, at various horizons throughout the Permian succession. Generally, these beds lie above the Reef limestone, but to the south of Clavering Ø, where they occur interbedded with black shales of the *Posidonia* facies, they probably are detrital tongues of material shed by the Reef limestones.

The fossil animal communities are characterized by several species of Productids, large Neospirifers, Orthotetidinids, bryozoans, solitary corals, and, in the black shale areas, a rare *Posidonia*, and plant fragments. Locally, the rock may be crowded with the shells of a single brachiopod species, forming shell pavements. Records do not indicate whether these shells have been transported and concentrated.

The only pelecypods recognized in this facies are the pectinoids *Posidonia permica*, n. sp., and *Streblochondria? maynci*, n. sp., both of which species are closely similar to forms high in the Guadalupian of West Texas (Bell Canyon formation).

The evidence indicates that the benthonic communities of the *Productus* facies flourished on firm, dark-colored mud bottom, in waters rich in organic detritus. Burrowing pelecypods and gastropods are not represented. Perhaps they were displaced by the profusion of mud-dwelling *Productids*. The pectinoids probably were attached by the byssus to seaweeds or bryozoans, well above the sea floor, and it is even possible, as pointed out below, that *Posidonia* was pseudoplanktonic. The dark color of the limestone is produced by bituminous material preserved, probably, under reducing conditions. Still, there was sufficiently good aeration for the support of a diverse benthonic fauna of shelled invertebrates.

Judging from the prevailing dark color and fine texture of the limestone, the sediments probably accumulated in relatively quiet waters, below depths of effective wave action. Sedimentation probably was sufficiently rapid to prevent complete destruction of organic detritus by scavengers.

Posidonia shale facies. — The *Posidonia* beds (*Posidonomyenschichten*) are a distinctive facies of bituminous, laminated, calcareous shales, and platy limestone, extending southward from the Reef limestone area, on Clavering Ø, to the Giesecke Bjerger, and beyond, at least 100 kilometers. The shales and limestones are dark-gray to black where fresh, and tend to become gray to tan on long exposure. On Clavering Ø, the dark rocks are replaced to the northward by white and cream-colored Reef limestone. MAYNC believes that the black shales interfinger with Reef limestone, hence, are equivalent to the latter, in age. Much of the transition occurs abruptly between Sneugleelv and Moskusokseelv within a space of three or four kilometers. A thin tongue of Reef limestone extends several kilometers to the south of these localities, immediately below the *Posidonia* facies. By analogy with facies relationships in the West Texas Permian it appears probable that the black shales were deposited in deep waters within a stagnant basin as suggested by FISCHER (1947, p. 22).

Locally, thin, fossiliferous beds of limestone of the *Productus* facies occur within the *Posidonia* shale. These apparently represent brief times of amelioration of bottom conditions, which, during most of the deposition of the black shales were inhospitable for many benthonic forms.

The fossils of the *Posidonia* facies form an unusual association, undoubtedly reflecting special ecological conditions under which these sediments were deposited. Fragmentary fish remains are common throughout the black shales (ALDINGER, 1935, 1937), at a few localities associated with remains of belemnoids and radiolarians (FISCHER, 1947). Fragmentary, unidentifiable plant remains are fairly common in the collection at hand. By far the commonest fossil of the *Posidonia* facies

is the pectinoid *Posidonia permica*, n. sp., the fragile valves of which are common throughout the black shales and limestones. Locally, the rocks are crowded with these shells. Another pelecypod, *Plagiostoma? polita*, n. sp., is very rare, and these two species comprise the pelecypod components of the fauna. FISCHER (*op. cit.*, p. 8) has also observed tiny gastropods in association with the Greenland *Posidonia*.

Fossil fish are comparatively rare fossils in Permian faunas, and belemnoids are, as yet, unknown outside of Greenland. Presumably, very unusual conditions of preservation were involved in sedimentation of the *Posidonia* facies. FISCHER (*op. cit.*, p. 22) suggests that the nekton did not normally live in the *Posidonia* basin. Waters of a stagnant basin, low in oxygen and high in hydrogen sulphide, would provide the relative sterility and reducing conditions favorable for preservation of articulated fish skeletons. He thinks that possibly the swimming and floating forms were periodically swept into the *Posidonia* basin from normal waters of the open ocean and were destroyed there by toxic waters. A parallel theory may be suggested: Waters at intermediate and shallow depths supporting a rich pelagic biota might be periodically poisoned during storms as foul bottom muds are stirred up and spread through the waters. In either case the bottom is postulated as relatively sterile, and free from vagrant bottom dwellers that normally utilize the organic detritus and stir the bottom sediments. The enormous numbers of shells of *Posidonia permica* in these rocks require some special explanation. Either this species lived on the bottom under conditions that excluded common benthonic forms, or the shells were introduced after death. Neither possibility can be excluded. Both *Posidonia permica* and *Plagiostoma? polita* probably were byssiferous, and they may well have lived attached to floating seaweed or to seaweed standing well above the bottom. The exceeding thinness of the pelecypod valves and the small size of the gastropods associated with them are in harmony with this suggestion. Throughout the known geologic range of *Posidonia* (Mississippian to Jurassic) species of the genus are generally limited to dark shales, which commonly contain pelagic forms such as fishes and cephalopods.

In the collection before me there are several scores of chips and slabs of rock from the *Posidonia* facies, representing many localities. The rock consists of black, fine-grained, calcareous mudstone, which is delicately laminated, and almost fissile in structure. The more calcareous specimens are quite homogeneous, with little or no banding. These rocks are gray to brown, or tan, on weathered surfaces. Probably the original sediments were subjected to decrease in volume during loss of connate water. Compaction necessarily involves flattening and thinning of original laminae, so that primary features, such as worm burrows, would

be greatly compressed in the vertical dimension. However, disturbance of the original lamination, as for example, by burrowing organisms, would be clearly shown. Evidence of such disturbance is lacking in the material before me. In addition to the circumstantial biologic evidence, discussed above, the preservation of uninterrupted delicate laminae, and lack of indications of burrowing or creeping benthos, or of current and wave action, suggests deposition in a stagnant basin sufficiently deep that surface currents and waves did not agitate the bottom sediments. Presumably, there was no effective annual turnover of the waters.

Martinia limestone facies. – The *Martinia* limestone consists typically of cliff-forming fossiliferous, bluish-gray limestone, which weathers to yellowish, or light brown. It is flecked by abundant flakes of mica, according to MAYNC (*op. cit.*). Stratification is fairly coarse, beds being 20 to 50 centimeters thick. Bedding planes are somewhat uneven, and are marked by thin bands of marly clay. Ripple marks and animal trails are common. A maximum thickness of about 60 meters is reached on southeastern Clavering Ø. MAYNC (*op. cit.*, p. 25) records numerous brachiopods (e. g., *Martinia*, *Chonetes*) among which productids and spiriferids are subordinate, in contrast to the *Productus* facies. He reports bryozoans, corals, *Posidonia* (rare), gastropods, trilobites, nautiloids, and ammonoids. In the last group the occurrence of *Cyclolobus* is especially noteworthy because this genus characterizes the highest ammonoid zone of the Permian (Himalayas, Madagascar).

The only pelecypod from the *Martinia* facies in our collection is an indeterminate *Cyrtorostra*, a distinctive, but long ranging, heavy-shelled pectinoid. In the United States *Cyrtorostra* is found in characteristic association with bryozoan-productid communities (Leonard, Word, Capitan and Phosphoria formations). Very likely representatives of *Cyrtorostra* lived attached by the byssus to bryozoan zoaria or to seaweeds. The relatively heavy shell does not suggest an active adult existence.

Of the several facies represented in the Greenland Permian, the *Martinia* facies contains the most varied faunas. Data are insufficient, of course, but the diversity in type of the faunas, the even stratification, the trails and ripple marks are reminiscent of deposits of shelf seas of other regions, for example, the Phosphoria formation of the Rocky Mountain region.

The *Martinia* facies is limited, apparently, to the southeast coast of Clavering Ø. Relationships immediately to the south are concealed by lack of exposures on Gael Hamkes Bugt. Following the belt of Permian outcrops northward, the *Martinia* facies is replaced abruptly (between Moskusokseelv and Productuselv) by thin-bedded yellowish sandy lime-

stone containing productids, large gastropods, and, especially, *Chonetes*. A few kilometers to the northward (at Forposten) apparently equivalent beds contain characteristic fossils of the Zechsteinian Reef facies, such as *Pleurohorridonia scoresbyensis* Dunbar, *Liebea squamosa*, nautiloids, etcetera.

Redbeds facies. — Outcrops of fossiliferous, reddish sandstones and sandy limestones occur along the coast of Wollaston Forland, along Young Sund, just northeast of Clavering Ø, and outcrops of similar rocks are found on Depot Ø, far to the southeast, in Nathorsts Fjord.

Red rocks of Depot Ø (Depot Island formation, Koch, 1929; Säve-Söderbergh, 1937) overlie relatively unfossiliferous, gray limestone, black shales, and white sandstone. Probably the non-red rocks correspond to some part of the Permian section of Clavering Ø. Fossils collected by KOCH and HARRIS from the redbeds, a few feet above the white sandstone were studied by ROSENKRANTZ (1929) who regarded them as indicative of the Permian. The identifications of ROSENKRANTZ were not, however, diagnostic. FREBOLD (1931c) identified Eotriassic ammonoids from a gray, shaly limestone immediately above the redbeds and he identified "*Spirifer cameratus*" (*Neospirifer pseudocameratus*, Girty?), certainly a Paleozoic fossil, in a boulder of the conglomerate at the base of the redbeds.

Fossils from the Depot Island formation before me are as follows:

1. *Palaeocosmomya kochi*, n. sp. (*Grammysia* of Rosenkrantz).
2. Astartid?
3. Indeterminate pelecypod (*Leda* of Rosenkrantz).

There is little about this evidence to indicate the geologic age of the enclosing sediments. Säve-Söderbergh (1937) measured a detailed section of the Depot Island formation at the type locality. In red sandstone immediately overlying the beds containing *Palaeocosmomya* ("*Grammysia*") he reports a well-preserved brachiopod fauna, containing, among others, the productid *Juresania juresanensis*. If this species is correctly identified then certainly the redbeds are Paleozoic. There is, however, insufficient faunal evidence for detailed comparison with the fauna of the red series of Clavering Ø.

Both Säve-Söderbergh and MAYNC consider the Depot Island formation to be the temporal equivalent of the Red series of the northern area. The best evidence for this correlation is the lithic similarity and like stratigraphic position below the Triassic in both areas.

The Red series of northeastern Clavering Ø and the Wollaston Forland consists of up to about 30 meters of platy, finegrained, dark red to brown calcareous sandstone, separated from underlying Reef

limestone by a few feet of *Productus* limestone facies. A few thin beds of the latter facies occur locally at several horizons within the Red series.

MAYNC (*op. cit.*) considers the Red series to represent a shoreward facies, equivalent to platy, yellowish, sandy limestone, and the Martina facies, to the south. As might be anticipated of a shore facies, the Red series contains a number of pelecypods. In the collections at hand are:

Nuculana speluncaria
Promytilus cf. *priscus*
Allorisma elegans
Crassiconcha groenlandica
Aviculopecten sp.

MAYNC (*op. cit.*, p. 47) also reports *Schizodus obscurus*.

This assemblage really has nothing in common with the pelecypods of the Depot Island formation, even if the horizons may be equivalent in age. The species *Nuculana speluncaria*, *Allorisma elegans*, and *Crassiconcha groenlandica*, like *Palaeocosmomya kochi* were burrowers, probably inhabiting moderately firm bottom in well aerated waters. Presumably, the waters were shallow, and the bottom not far below sea level. *Aviculopecten* sp. and *Schizodus obscurus* probably were active, like their modern counterparts, and may not have been so dependent on the character of the local bottom sediments.

List of pelecypods investigated in this study.

Depot Island formation

Palaeocosmomya kochi, n. sp.
Indeterminate form 1. (Astartid?)
Indeterminate form 2. (Lucinoid?)

Red series

Nuculana speluncaria
Promytilus cf. *priscus*
Allorisma elegans
Crassiconcha groenlandica
Schizodus obscurus

Martina limestone

Cyrtorostra sp.

Posidonia shale

Posidonia permica. n. sp.
Plagiostoma? *polita*, n. sp.

Productus limestone

Streblochondria? maynci, n. sp.*Posidonia permica*, n. sp.Cape Stosch formation (Lower Triassic eg.), Permian blocks
(= Reef limestone)*Pseudomonotis speluncaria**Ps. sparsicostata**Procrassatella plana**Cypricardina? permica**Schizodus obscurus**Astartella vallisneriana**Parallelodon striatus**Plagiostoma? permica**Bakevellia antiqua**B. bicarinata**Liebea squamosa**Lithophaga consobrina**Stutchburia? modioliformis**Pleurophorus* sp.

Cape Stosch formation, Lower Triassic blocks

*Claraia stachei**Promyalina groenlandica*, n. sp.*Myalina (Myalinella) cf. meeki*

Reef limestone

Schizodus obscurus.Genus **Nuculana** LINK 1807.*Nuculana speluncaria* (GEINITZ).

Pl. 4, fig. 6.

Nucula speluncaria GEINITZ (1848) p. 9, pl. 4, figs. 6a—b.*Leda speluncaria* GEINITZ (1861) p. 68, pl. 13, figs. 25—31; NETSCHAJEW (1894) p. 251.*Leda cf. speluncaria* FREBOLD (1932) p. 27, pl. 1, fig. 10.

Characterized by acuminate siphonal extension, and by fine, uniformly spaced concentric ridges (fila). Only one specimen (fig. 6) shows the shell configuration well. This is 15 mm long, and 7.5 mm high. It closely resembles *Nuculana obesa* (White) of the uppermost Kaibab formation (upper Leonardian) of Arizona, except for the fact that the

American form appears to be much more robust than this species, adults of which are about one-half the size of those of *N. obesa*.

Distribution. — In Greenland, the species occurs in the Red series, fine-grained, reddish-buff sandstone on the Wollaston Forland (LK 5). The species is characteristic of the German Zechsteinian and has been reported also from Kazanian beds of Russia.

Genus ***Pseudomonotis*** BEYRICH 1862.

Pseudomonotis speluncaria (SCHLOTHEIM).

Pl. 3, figs. 1—5, 7, 8, 10—12.

Gryphites speluncaries SCHLOTHEIM (1816) p. 30, pl. 5, figs. la—c.

Avicula speluncaria GEINITZ (1848) p. 10, pl. 4, figs. 18—19; (1861) p. 74, pl. 14, figs. 5—7.

Monotis speluncaria KING (1850) p. 155, pl. 13, figs. 5—21.

Pseudomonotis speluncaria FREBOLD (1931a) p. 18, pl. 2, figs. 1—12; pl. 3, fig. 1.

?*Pseudomonotis speluncaria* NETSCHAJEW (1894) p. 207, pl. 7, fig. 6;

MASLENNIKOW (1935) p. 61, pl. 1, figs. 8a—b.

This species is represented in the Greenland collections by juvenile individuals only, none of which is more than half grown. There is, therefore, some uncertainty regarding the mature characters. The specimens before me tend to be orbicular, without more than a trace of the posterior lobation characteristic of adult *P. speluncaria*. In shells less than 10 mm, judging from published illustrations, representatives of the species from Britain and Germany show little or no posterior lobation, and generally, the shallow sulcus of the ventral valve, which delimits the posterior lobe, does not appear until later. One individual from Greenland (pl. 3, fig. 1) shows no lobation, even though it is about 20 mm high. It appears that the posterior part of the shell behind the sulcus exhibits allometric acceleration of growth in the later ontogeny, so that large shells show disproportionate development in this region.

Probably the most striking feature of the Greenland shells is their relative smoothness, only very faint costellae being visible on the umbones of some individuals, and there is no trace of concentric frills.

The byssal notch of the right valve is well defined and open. Evidently it was functional during much of the ontogeny. This indicates that the animal was not permanently cemented to the substratum. There is no clearly defined cicatrix of attachment at the umbo of the right valve such as characterizes many species of *Pseudomonotis*. However, at a shell height of from 3 mm to 5 mm, as shown in growth lines, the right valve is somewhat smoother than at later growth stages. This area around the beak commonly is delimited by faint growth wrinkles. This may be an attachment cicatrix, but one cannot be certain from the

material at hand. If the shells were attached for a short period during the early ontogeny, they certainly were not permanently cemented. At present, I am inclined to doubt that the presence or absence of a cicatrix in this group is of generic rank.

Discussion. — Any suite of individuals of *Pseudomonotis* from a single locality and horizon characteristically exhibits great extremes of variation in form and ornamentation. Unfortunately, the nature of this variability has never been quantitatively assessed. In almost every studied fauna several "species", or "varieties" have been distinguished. Lacking large series of specimens, however, one usually is at a loss to decide whether or not there is but one or many populations represented in a collection.

These, the "oysters" of the Permian seas, undoubtedly owe much of the variability of form to the habit of fixation, with the consequent irregularities of growth. KING (1850), to whom we are indebted for the best, although inadequate, description of *P. speluncaria*, included nearly smooth and coarsely ornamented, but otherwise similar shells in this species. Evaluation of this apparent variability of ornamentation must await revision of the species.

Kazanian representatives of the species, as interpreted by NETSCHAJEW (1894) and MASLENNIKOV (1935), are more finely ribbed than the typical Zechstein forms. So little work has been done on the Russian material that nothing is known concerning the range of variability.

Distribution. — This species is highly characteristic of the Zechsteinian of western Europe, Britain, and East Greenland. Apparently, it is not as common in Russia, but has been cited from beds of the Kazanian series at several localities. The Greenland specimens before me are from several boulders (nos. 10, 15, 45, 60, 65, 179) in a conglomerate of Lower Triassic age, the Cape Stosch formation, Kap Stosch East Greenland. MAYNC (1942, p. 99) cites *P. cf. speluncaria*, and *P. aff. speluncaria in situ*, in Reef limestone, low in the Permian sequence on Clavering Ø (Zachengrat, and Forposten).

Pseudomonotis sparsicostata FREBOLD.

Pl. 3, figs. 6, 9, 13—16.

Pseudomonotis sparsicostata FREBOLD (1933) p. 29, pl. 3, figs. 20—22.

Slightly higher than long, or orbicular, radially ornamented shells, with poorly developed posterior lobation. Radial costae well developed, variable in number, resulting from erratic suppression of secondary and tertiary costae. Right valve evidently cemented throughout life to substratum; byssal notch obsolescent.

Discussion. — Several names have been used for Zechstein forms similar to this. KING (1950) included smooth and ornamented shells in both *P. speluncaria* and *P. radialis*. He regarded both species as highly variable in this respect. Quantitative aspects of this variability have not yet been made known, and it is possible that KING's interpretation was too broad. As described by KING, *P. radialis* (PHILLIPS) differs from *P. speluncaria* in having a relatively great ratio of height to length, and little or no lobation. FREBOLD (1933) distinguished *P. sparsicostata* from *P. speluncaria* by the rather broad, sparse costae of some of his specimens. There is, however, considerable variation in number and shape of costae in the Greenland material.

As interpreted here, admittedly on inadequate material, *P. sparsicostata* was permanently cemented by the right valve after an early free existence, as deduced from the growth lines. A very small right valve referred to the species (pl. 3, fig. 9) exhibits symmetrical and uninhibited growth. A mature right valve (pl. 3, fig. 13) bears a clearly defined cicatrix of attachment between shell heights ± 12 mm and 30 mm. This is similar to the shells for which *Prospondylus* ZIMMERMAN (1886) and *Eumicrotis* MEEK (1864) were proposed. It may be necessary to employ *Eumicrotis* for these ostreiform shells because *Prospondylus* clearly is a junior synonym of that genus and is not available.

Occurrence. — This species has been collected in boulders (nos. 12, 15, 45) in the Lower Triassic Cape Stosch formation at Kap Stosch, East Greenland. A single specimen (pl. 3, fig. 16) was collected by WOLF MAYNC at locality 2334, Zechstein Reef limestone on Clavering Ø.

Genus **Streblochondria** NEWELL 1937.

Streblochondria? Maynci NEWELL, n. sp.

Pl. 1, fig. 15—16.

Orbicular pectinoids with slight backward obliquity (opisthocline) and obsolescent posterior auricles. About 30 costae, including intercalated secondaries over the anterior half of the left valve, and an equal number of slightly finer costae on the right valve formed from bifurcation of primaries. Umbonal angle approximately 100°.

Discussion. — This species is closely related to the more slender *S. ?guadalupensis* (GIRTY), in which the umbonal angle is about 85° (NEWELL, p. 86, 1937). I erroneously (*op. cit.*) gave the stratigraphic position of the latter species as "Bone Spring limestone" (Artinskian). Girty's type specimens came from the Pinery member of the upper Delaware Mountain formation (Capitanian), hence, they are probably

about the same age as the Greenland *S. ?maynci*. These two specimens have the form of *Streblochondria* and the ornamentation of *Aviculopecten* and cannot properly be referred to either. Whenever adequate material of these and related species can be obtained they can serve as basis for a new genus.

Occurrence. — MAYNC's locality 1883 (Bed 3, Productuskalk, Brachiopoddal, Wollaston Forland), and locality 432 (Bed 3, Productuskalk, Productuselv, Clavering Ø) East Greenland.

Genus **Cyrtorostra** BRANSON 1930.

Oxytoma of authors, in part.

Blanfordina REED 1944.

Cyrtorostra sp.

Pl. 2, fig. 3.

This genus is represented in the Greenland collections by a fragmentary interior of a single valve (left?). Specific determination is impossible. Representatives of *Cyrtorostra* are as yet unknown in Britain and Germany, but the genus is found in the Russian Kazanian and possibly also Artinskian, *Cyrtorostra atava caucasica* (LICHAREW), *C. duplicostata* (NETSCHAJEW), and *C. laticostata* (NETSCHAJEW). In the United States the genus ranges from the Leonardian to the top of the Guadalupian, inclusive.

Occurrence. — The single specimen was collected by MAYNC (*loc.* 144), Martinia limestone, east of Brinkley Bjerg, south coast of Clavering Ø, East Greenland.

Genus **Posidonia** BRONN 1828.

Posidonomya BRONN 1837.

Posidonia permica NEWELL, n. sp.

Pl. 2, figs. 5, 6.

Shell delicate, mytiloid, with strong forward (prosocline) obliquity. Beaks prominent, slender, situated at anterior extremity of the hinge. Umbonal angle 70° to about 90°, increasing with ontogenetic age. Surface ornamented in early stages by concentric irregular undulations, later by fine concentric striae spaced about 1 mm apart, posteroventrally. The largest individual in the collection measures about 70 mm high (restored) and 50 mm long. Hinge characters doubtful because of poor preservation.

Discussion. — This species differs from Carboniferous representatives of *Posidonia* s. s. in the abbreviation of the anterior part of the shell which scarcely extends beyond the umbonal ridge, somewhat resembling certain species of *Myalina*, in this respect. A similar form occurs in black shales of the Bell Canyon formation (Capitanian), Delaware Basin, West Texas. These forms should be referred to the subgenus *Posidoniella*.

Posidonia characterizes a particular facies in the late Paleozoic and early Mesozoic. Usually it occurs in bituminous, muddy sediments containing plant debris, fish remains and cephalopods. Benthonic forms, such as brachiopods, bryozoans, and corals are generally absent in the *Posidonia* facies. In the Greenland *Posidonia* beds there are thin intercalations of dark limestones containing brachiopods and bryozoa (*Productuskalk* facies). Individuals of *Posidonia* are rare in this facies. The common associates in the typical *Posidonia* facies are multitudes of *Posidonia permica*, fish remains, belemnite rostra and hooks. Fragments of unidentifiable plants are associated with the shells of *Posidonia*. The lightness of the shell, and the usual associates of the genus suggests a pseudoplanktonic habit, and it is possible that these forms lived attached by the byssus to floating plants.

Occurrence. — *P. permica* is abundant in the “*Posidonomya*” black shales, which constitute one of the most extensive facies in the Greenland Permian. Specimens examined in this study were collected by many field geologists at a number of localities near Kap Stosch; east and south coast of Clavering Ø; central and southern Giesecke Bjerger; and Gastisdal, Gauss Halvø.

Genus *Claraia* BITTNER 1900

Claraia stachei BITTNER

Pl. 1, fig. 9.

Claraia stachei SPATH (1930) p. 46, pl. 9, figs. 1a—d; pl. 10, figs. 5a, b; (1935) p. 69, pl. 21, figs. 3—9.

?NEWELL and KUMMEL (1942) p. 955, pl. 3.

This species is abundantly represented in the Lower Triassic of East Greenland, and has been adequately described by SPATH, whose material was collected *in situ*. The specimen before me is from a boulder (no. 11) in the basal Lower Triassic Cape Stosch formation, at Kap Stosch, and presumably it is older than many of the occurrences of the species cited by SPATH in East Greenland. This appears to be a typical representative of the species and does not differ significantly from SPATH's material. I am inclined to believe that the form from Wyoming and Idaho, described by NEWELL and KUMMEL under this name, should

be separated at least as a distinct subspecies. It bears distinctly coarser radial ornamentation than the Greenland form.

Genus **Plagiostoma** SOWERBY 1812.

Plagiostoma? permiana (KING).

Pl. 4, figs. 4, 5.

Lima permiana KING (1850 p. 154, pl. 13, fig. 4; GEINITZ (1861) p. 81, pl. 15, figs. 4—6; NETSCHAJEW (1894) p. 173; FIEBOLD (1931c) p. 16, pl. 1, figs. 28—29.

Shell ovoid, broadly convex, with evenly rounded margins and inconspicuous umbones and beaks. Surface smooth, ornamented only with zig-zag pattern of alternating light and dark stripes. Beaks approximately one-third shell length behind anterior margin.

Discussion. — The group of small, smooth Limids, to which this belongs, first appears in Artinskian horizons of Europe and North America (Leonardian). *P. ?deltoideum* GIRTY, from the Bone Spring and Capitan formations of West Texas, is similar to *P. ?permianum*, but is somewhat more slender than this species.

It is self evident that these shells are not Limas in the strict sense, nor are they closely similar to the Jurassic genotype of *Plagiostoma*. Too little is known about them as yet to warrant proposal of a new name.

Occurrence. — Found in boulders (no. 42) of the Lower Triassic Cape Stosch formation, Kap Stosch, East Greenland. The species is a characteristic fossil of the Magnesian limestone of England, Zechstein of Germany, and the Kazan beds of Russia.

Plagiostoma? polita NEWELL, n. sp.

Pl. 4, figs. 1—3.

Valves subcircular, equivalve, nearly "equilateral", so that it is difficult in many cases to distinguish anterior from posterior; profile symmetrical, with moderate convexity, umbones well defined, but not prominent. Surface smooth, glossy, with faint growth lines and in some shells ornamented by very faint traces of costellae.

Measurements (mm).

Specimen	H	L
Holotype	3.4	3.4
2	2.5	2.6
3	2.3	2.3
4	2.1	2.0

Discussion. — This species is represented in our collection by many individuals crowded together in a single fragment of micaceous and carbonaceous dark gray siltstone. They are associated with what appear to be remains of macerated plants. The fragility of the shells suggests that they may have led a pseudoplanktonic existence, attached by the byssus to floating plants. There are no associated benthonic forms. This species probably is not a *Plagiostoma*, but the material at hand does not permit a more practical assignment. Although clearly distinct, this form is remindful of *Monotis? gregaria* MEEK and WORTHEN, 1870, from the Pennsylvanian of Illinois. That species, however, is distinctly ornamented with radial costellae.

Occurrence. — Rare in the Posidonia shale, near Kap Stosch (LK 2), East Greenland.

Genus **Bakevellia** KING 1848.

Bakevellia antiqua (MUNSTER).

Pl. 4, figs. 9—13, 15a—c.

Avicula antiqua MUNSTER (1826) p. 126, pl. 116, fig. 7.

Gervillia antiqua GEINITZ (1861) p. 78, pl. 14, figs. 17—20.

Bakevellia antiqua KING (1850) p. 167, pl. 14, figs. 28—34; NETSCHAJEW (1894) p. 221, pl. 7, figs. 17, 21; pl. 8, fig. 25; FREBOLD (1931a) p. 25, pl. 3, figs. 11—14.

Shell strongly inflated, nearly equivalve. the right valve being only slightly less convex than the left; surface ornamented only with irregular lines of growth; anterior auricle quadrate, and generally not extended behind the marginal sinus.

Measurements (mm).

	L	H	*a
Fig. 9	14.4	9.7	33°
Fig. 10	12.3	9.3	34°
Fig. 11	7.4	5.1	31°
Fig. 12	11.8	9.5	48°
Fig. 13	10.5	7.1	37°
Fig. 15	8.2	6.4	27°

*a Angle alpha. Measured between umbonal ridge and posterior margin of the hinge.

Occurrence. — This species is abundant in some of the blocks of transported Permian limestone (e. g., 60, 285, 304) in the Lower Triassic Cape Stosch formation, at Kap Stosch. It is characteristic of the Upper Permian of England, Germany, and European Russia.

Bakevellia bicarinata KING.

Pl. 4, figs. 16—19.

Bakevellia bicarinata KING (1850) p. 170, pl. 14, figs. 41—42.*Bakevellia ceratophaga* FREBOLD (1931c) p. 15, pl. 1, figs. 21—23.

This shell is relatively longer and less convex than the associated *B. antiqua* and possesses an extended posterior auricle which forms an acute angle at the extremities. The anterior end of the hinge of the left valve forms an angle of about 90° or more with the front margin of the shell. Extending from the beak of the left valve to the pedal margin are two thin costellae bounding a triangular smooth area with margin divergent at about 23°. An equivalent area is not differentiated on the right valve.

Measurements.

	L	H	/a
Fig. 16	7.7	5	32°
Fig. 17	8.4	6	29°
Fig. 19	10.1	5.2	33°

Occurrence. — This species and its near relatives are widely distributed in the Permian. Unpublished material now under study by me includes representatives from the Leonard, Bone Spring, and Word formations of West Texas, and the Phosphoria formation, Wyoming. There is some variation in form in the group. Probably it should be considered a polymorphic species, with several geographic subspecies. The species is known from the Magnesian Limestone of England, and it probably occurs also in Germany and Russia in equivalent beds. I do not see any reason for classing this form as a synonym of *B. ceratophaga* (SCHLOTHEIM) 1817, as has been done by many authors. That species, so far as I know, does not possess the distinctive carinae on the anterior part of the left valve.

In Greenland this species occurs in the transported Permian blocks of the Lower Triassic Cape Stosch formation, at Kap Stosch (block 19).

Genus *Promyalina* KITTL 1904.*Promyalina Groenlandica* NEWELL, n. sp.

Pl. 5, figs. 11, 12, 13.

Myalina aff. *schamarae* SPATH 1930) p. 51, pl. 10, fig. 10; pl. 12, figs. 2, 3; (1935) p. 70, pl. 20, fig. 12; pl. 21, fig. 15.

Shell rounded, upright, moderately inflated, right valve slightly flatter than the left, beaks not extended; surface smooth; ligamental

furrows fine, narrowly spaced; a single triangular tooth in the right valve rests in a socket overlying a similar tooth in the left valve.

Discussion.—In 1942 (NEWELL and KUMMEL, 1942, p. 956) KUMMEL and I regarded the Greenland Myalinas of the *schamarae* type as conspecific with similar forms from Wyoming and Idaho for which we proposed the name *M. spathi*. Examination of material from the white blocks of the Cape Stosch formation convinces me that these are consistently different from typical *schamarae* of eastern Siberia and from *spathi*. These two, on the other hand, are alike, being more slender, and in usually being distinctly oblique.

KITTL (1904) based *Promyalina* on material from near Sarajevo supposed to correlate with the Upper Permian Bellerophonkalk of the Alpine region farther to the west. Examination of his publication convinces me that the fauna in question may as well be early Triassic as Late Permian in age. Species of *Promyalina* are highly characteristic of the Lower Triassic and are not reported from the Permian, excepting KITTL's dubious reference. Most probably, this genus was derived from the Pennsylvanian *Selenimyalina* NEWELL 1942, which lacks a tooth in the left valve. Otherwise the two are similar.

Occurrence. — This species is abundant in some of the transported blocks of limestone of the Lower Triassic Cape Stosch formation at Kap Stosch. It is also reported by SPATH (*op. cit.*) *in situ* in the Lower Triassic, at several localities in East Greenland.

Genus **Promytilus** NEWELL 1942.

Promytilus cf. *priscus* NEWELL.

Pl. 5, fig. 8.

Promytilus priscus NEWELL (1942) p. 40, pl. 1, figs. 1, 2, 5—7.

A single, poorly preserved left valve from the Greenland Permian recalls *P. priscus* from the Upper Pennsylvanian beds of Kansas and Nebraska. However, this form lacks the ventral sinus characteristic of the Pennsylvanian species.

Occurrence. — Red series, Upper Permian, Permdal, Wollaston Forland, East Greenland.

Genus **Myalina** DE KONINCK 1842.

Myalina (*Myalinella*) cf. *meeki* DUNBAR.

Pl. 5, figs. 9, 10.

Myalina meeki NEWELL (1942) p. 60, pl. 14, figs. 7—10, 12—14.

This form is similar to *M. meeki* from the Lower Permian of Kansas but is distinctly more convex than that species.

Occurrence. — Found in direct association with *Promyalina groenlandica*, hence, of Early Triassic age, in transported blocks of white limestone in the Cape Stosch formation, Kap Stosch, East Greenland.

Genus **Liebea** WAAGEN 1881.

Liebea squamosa (SOWERBY).

Pl. 5, figs. 14, 15.

Mytilus squamosus SOWERBY (1829) p. 120; KING (1850), p. 159, pl. 14, fig. 1.

Aucella hausmanni GEINITZ (1861) p. 72, pl. 14, figs. 8—16.

Liebea hausmanni NETSHAJEW (1894) p. 217; FREBOLD (1931a) p. 2, pl. 3, figs. 4—10.

Liebea squamosa NEWELL (1939) p. 587, pl. 68, figs. 1—5; (1942) p. 73, pl. 13, figs. 3—5.

A few of the transported blocks of white limestone at Kap Stosch are crowded with characteristic representatives of this well known species. Most of the individuals exhibit the usual arcuate dorsal margin so distinctive of the species. An occasional individual, however, shows limited development of a posterior auricle (fig. 14).

Occurrence. — Common in Permian boulders of the Lower Triassic Cape Stosch formation. A characteristic guide fossil of the Magnesian limestone of England, the Zechstein of Germany, and the Kazan of Russia.

Genus **Lithophaga** BOLTEN 1898.

Lithophaga consobrina (EICHWALD).

Pl. 5, figs. 6, 7.

Nucula consobrina EICHWALD (1860) p. 996, pl. 32, figs. 18, 19.

Modiola consobrina NETSCHAJEW (1894) p. 226, pl. 10, fig. 4.

Lithodomus permianus FREBOLD (1933) p. 28, pl. 3, fig. 19.

Lithodomus consobrinus MASLENNIKOW (1935) p. 74, pl. 2, fig. 17.

Shell elongate, slender, strongly biconvex, expanding gradually backward; beaks inconspicuous, located just back of the anterior extremity; surface marked by irregular lines of growth.

Measurements (mm).

	L	H
Fig. 6	24	9
Fig. 7	18.5	8

Discussion. — FREBOLD (1933) makes no reference to EICHWALD's species, with which possibly he was not familiar. There is little doubt that *L. permianus* is conspecific with *L. consobrina*.

Occurrence. — Widely distributed in the Upper Permian of Russia, but unknown in the western Zechstein seaway of Germany and England. In the Greenland Permian the species was found in transported white blocks of the Cape Stosch formation, Kap Stosch (block 15).

Stutchburia ETHERIDGE 1900.

Stutchburia? modioliformis (KING).

Pl. 5, figs. 1—5.

Pleurophorus modioliformis KING (1844) p. 32.

Cardiomorpha modioliformis KING (1850 p. 180, pl. 14, figs. 18—23; NETSCHAJEW (1894) p. 309, pl. 10, figs. 3—2.

Mytilius pallasii de VERNEUIL (1845) p. 316, pl. 19, figs. 16a—i, k.

Modiolopsis pallasii GEINITZ (1861) p. 70, pl. 12, figs. 29—31; NETSCHAJEW (1894) p. 228, pl. 8, figs. 1—4.

Netschajewia pallasii TSCHERNYSHEW (1939) p. 143, pl. 35, figs. 10—11.

Shell strongly biconvex, modioliform, beaks nearly terminal, anterior lobed well defined and occupied by the anterior adductor; height increases regularly backward, so that anterior part of shell is relatively slender; slight sinus behind anterior lobe marks pedal position; surface marked by irregular growth lamellae, and rarely by faint radial costellae; ligament opisthodontic and external, lunule and escutcheon lacking.

Measurements (mm).

	H	L
Fig. 1	2.5	3.5
Fig. 3	7.0	3.6
Fig. 3	7.0	12.3
Fig. 4	4.5	8.1
Fig. 5	12.0	19.0

Discussion. — There is considerable uncertainty regarding the generic status of this and similar species of the Permian. After dismissing assignments of some of the early investigators to *Pleurophorus*, *Mytilus* and *Cardiomorpha*, there still remain *Myoconcha*, *Stutchburia* and *Netschajewia*, all of which names are in current use for what may constitute a single genus. Until hinge characters are made known for the various Permian species in question, the proper generic assignment will remain uncertain.

The species before us *S. ?modioliformis* (KING), including *S. ?pallasii*, which I believe is a synonym, is quite variable in ornamentation. Many shells of the species are ornamented with radial costellae, whereas others are completely devoid of radial ornamentation.

Occurrence. — Widely distributed in the Upper Permian of Europe. In Greenland the species is sparingly represented in the faunas of the white blocks of limestone of the Cape Stosch formation at Kap Stosch (blocks 15, 19 and 185).

Genus **Parallelodon** MEEK 1866.

Parallelodon striatus (SCHLOTHEIM).

Pl. 4, figs. 7, 8.

Mytilites striatus SCHLOTHEIM (1817) p. 31, pl. 6, figs. 3a—c.

Byssoarca striata KING (1850) p. 172, pl. 14, figs. 7—9.

Arca striata GEINITZ (1861) p. 66, pl. 13, figs. 33, 34.

Macrodon striatum FREBOLD (1931c) p. 13, pl. 1, fig. 20; NETSHAJEW (1894) p. 246, pl. 10, fig. 17.

Shell elongate trapezoidal in form, with beaks situated about one-fourth to one-fifth of the shell length from the anterior extremity, the relative distance decreasing in larger shells. Surface ornamented with narrow radial costae which are slightly thickened at points of intersection with concentric ridges (fila), producing a beaded appearance. In one valve, about 10 mm long, there are about 46 ribs; in another, about 20 mm long, there are approximately 51 ribs. New costae appear by intercalation during growth. A slight pedal gape lies just ahead of a midpoint of the valve margins, and the growth trace of the gape is accentuated by relatively wide spacing of the costae that intersect the margin at the pedal gape. Umbonal ridge forms an angle of about 27° with the hinge margin. Posterior margin meets hinge margin at about 125°.

Occurrence. — This species is represented in collections from the "White blocks" (no. 12), in the Lower Triassic Cape Stosch formation at Kap Stosch, East Greenland. It is widely distributed in the Upper Permian of England, Germany and Russia.

Genus **Pleurophorus** KING 1844.

Pleurophorus sp.

Pl. 4, fig. 14.

Pleurophorus costatus FREBOLD (1931c) p. 14, pl. 1, fig. 19; (1933) p. 24, pl. 3, fig. 16.

Representatives of the genus *Pleurophorus* are quite rare in the Greenland Permian. The available material is fragmentary or poorly preserved, hence, I do not attempt specific identification. It would not be surprising if further collecting confirms FREBOLD's identification with

P. costatus, since that species is highly characteristic of the Zechstein faunas.

Occurrence. – White blocks (nos. 15, 29) Cape Stosch formation, Kap Stosch.

Genus **Cypricardinia** HALL 1859.

Cypricardinia? permica LICHAREW.

Pl. 1, figs. 2–5.

Cypricardinia permica LICHAREW (1931) p. 33, pl. 1, figs. 11–13; pl. 2, figs. 3–4.

Slender, linguiform, modioloid shells approximately 2/3 as high as long. Surface ornamented by flattened imbricating growth lamellae which increase logarithmically away from the beaks. Faint radial costellae are visible on unworn shells.

Discussion. – LICHAREW (1931) has shown that Upper Paleozoic shells, commonly referred to *Cypricardinia*, may differ considerably from the Devonian genotype. Until the latter is reinvestigated there must be some uncertainty about the generic status of the Permian species. The dentition of the Greenland form (pl. 1, fig. 2) is like that of well-preserved material from West Texas representing several species. There are two anterior cardinal teeth in the left valve, and one in the right valve. Two to three lamellar posterior “lateral” teeth occur in both valves.

Occurrence. – LICHAREW’s specimens were from Kazanian beds along the Vaga River in northern Russia. In East Greenland the species was found in boulders (nos. 12, 181) of the Lower Triassic Cape Stosch formation, Kap Stosch.

Genus **Astartella** HALL 1858.

Astartella vallisneriana (KING).

Pl. 1, figs. 11–14.

Astarte vallisneriana KING (1850) p. 194, pl. 16, fig. 1; GEINITZ (1861) p. 62, pl. 13, figs. 24–25; NETSCHAJEW (1894) p. 309, pl. 10, fig. 23.

Small, subquadrate shells with closely spaced concentric lamellar ridges. There is a close superficial resemblance to certain species of *Edmondia* in which, however, the escutcheon and lunule of *Astartella* are lacking.

Discussion. – Robust examples of *Astartella* apparently are not common above the Wolfcampian-Sakmarian horizons. Representatives of the genus in Leonardian-Artinskian and younger formations in the

Permian rarely are longer than 7 or 8 mm. *Astartella subquadrata* GIRTY from the Yeso and San Andres formations of New Mexico, *A. vallisneriana* (KING), and *A. tunstallensis* (KING) from the Magnesian limestone are of this group. Probably they cannot be distinguished without statistical analysis. Indeed, it is quite probable that the last two are one species because they are found associated together.

Distribution. — Widespread in the German and English Zechstein. The species has been reported in the Russian Artinskian, and the very similar *A. permocarbonica* (TSCHERNYSCHIEW) is widely reported in the Russian Kazanian. In Greenland the species is common in the transported boulders (nos. 12, 138) of the Lower Triassic Cape Stosch formation, Kap Stosch.

Genus **Procrassatella** YAKOWLEW 1928.

Procrassatella plana (GOLOWKINSKY).

Pl. 1, fig. 1.

Schizodus planus GOLOWKINSKY (1868) p. 358, pl. 3, figs. 21—23; NETSCHAJEW (1894) p. 275, pl. 11, fig. 3; FREBOLD (1931a) p. 17, pl. 1, fig. 7.

Procrassatella plana YAKOWLEW (1928) p. 119, text fig. 1.

A single external mold of a right valve from Greenland was referred by FREBOLD to GOLOWKINSKY's species. With necessary caution required by the paucity of material there is little reason to doubt the validity of the identification. *Procrassatella plana* does not closely resemble any other species thus far discovered.

Occurrence. — Boulder no. 46, Lower Triassic Cape Stosch formation, Kap Stosch, East Greenland. The species has been reported a number of times from the Russian Kazanian (Krasnowidowo, Vaga River, Vym River), but is unknown, so far as I am aware, in Western Europe.

Genus **Schizodus** MURCHISON and VERNEUIL 1844.

Schizodus obscurus (SOWERBY).

Pl. 1, figs. 6—8, 10.

Azinus obscurus SOWERBY, Manual of Conchology, v. 4 (1831), p. 12, pl. 314 (upper figure).

Schizodus obscurus KING (1850) p. 189, pl. 15, figs. 23—24; NETSCHAJEW (1894) p. 272, pl. 5, fig. 2.

Schizodus cf. *obscurus* FREBOLD (1931a) p. 13, 15, 16, Taf. 1, figs. 1—5.

Schizodus schlotheimi FREBOLD (1931a) p. 16, Taf. 1, fig. 6.

The Greenland material, consisting mainly of internal molds (steinkern) is not wholly satisfactory for specific determination. Internal molds in this genus generally do not faithfully reflect the external form of the siphonal region, on which many species and varieties have been based.

This is a robust *Schizodus*, only slightly longer than high (about 5/4, or 6/4), with rather a narrow siphonal area behind a broadly rounded siphonal ridge. The surface is quite smooth.

Discussion. — There is no reasonable doubt in my mind regarding the relationship of the Greenland material to the British species. LICHAREW has given the name *S. subobscurus* to the equivalent form in the Kazanian. It is supposed to be somewhat smaller and more evenly arcuate ventrally. These distinctions have not been convincingly demonstrated. Better material is needed for an adequate characterization both of *S. obscurus* and *subobscurus* because they certainly are closely related, if not identical.

Occurrence. — If the Russian *S. subobscurus* can be included in the synonymy of *S. obscurus* then the latter is widely distributed in Kazanian rocks of the Vaga and Vym rivers, in northern Russia, and at Krasnowidowo, on the Volga. It is a common fossil of the German Zechstein and the Magnesian Limestone in England. *S. obscurus* is common in boulders (43, 137 and 180) of the Lower Triassic Cape Stosch formation at Kap Stösch, East Greenland. WOLF MAYNC has collected representatives (pl. 1, fig. 6) of this species at the Karolbjerg, Clavering Ø, in Reef limestone.

Genus **Palaeocosmomya** FLETCHER 1946.

Palaeocosmomya kochi NEWELL, n. sp.

Pl. 2, figs. 1, 2.

Grammysia sp. FREBOLD (1931a) p. 25, Taf. 2, figs. 2, 2a.

Elongate, length-height ratio about 2.1, subcylindrical pelecypods of large size, ornamented by concentric narrow folds, which are interrupted by a shallow sigmoidal flexure (with crest behind, trough in front) near the middle of each valve; anterior part of shell, or pedal extremity, delimited by a well-defined sulcus; lunule and escutcheon well defined; pedal gape very slight, siphonal gape pronounced, lying above posterior extremity of shell.

Measurements (mm).

	Length	Height	Thickness	Anterior partial length ¹⁾
No. 1 (H)	132	64	77	45
2	122	60	65-70	31
3	95	70 ²⁾	61	19

Discussion. — This species belongs to the group of Permian shells which commonly have been referred to the genus *Goniomya*, a Pholadomyid having a Jurassic genotype. (See BRANSON, 1948, p. 612 for Permian references). FLETCHER (1946), being unwilling to refer Permian species to known Mesozoic genera, has proposed two new genera for Permian shells similar to *Goniomya*. These are *Undulomya* and *Palaeocosmomya*, based on Australian genotypes of about Artinskian age.

Undulomya differs from *Goniomya*, according to FLETCHER, by being somewhat attenuated posteriorly, by depressed umbones, and lack of a distinct lunule, although an escutcheon is well developed. Unlike *Goniomya*, the shell does not gape anteriorly, and gapes only moderately posteriorly. *Undulomya* is similar to *Goniomya* in ornamentation. Numerous closely spaced concentric folds form a succession of parallel V's, inclined toward the front of the shell. The anterior limb of each V is only approximately parallel with the anterior margin of the shell. The posterior limb of the V intersects the hinge line at a high angle.

The genus *Palaeocosmomya* differs from *Undulomya* in a more pronounced siphonal gape, and a Z-shaped flexure of the ornamentation immediately behind the pedal area. The rest of the recumbent Z is directed anteriorly, the trough, posteriorly. Both escutcheon and lunule are present.

From the geologically older Australian representatives of *Palaeocosmomya* the Greenland species differs considerably. The Greenland shells are longer and more inflated, being subcylindrical. The sigmoidal figure in the concentric folds is only shallowly developed, and the folds are greatly extended horizontally on the posterior part of the shell.

Occurrence. — This species was found in reddish Permian sandstone of the Depot Island formation (Bed 4 of Harris, locality LK 13) on Depot Ø, which MAYNC correlates with the Red series of Clavering Ø. *P. kochi* occurs only a few feet below beds containing a Lower Triassic ammonite fauna. That the species is Permian in age is best demonstrated by the fact that the productid *Juresania juresanensis* TSCHERN. was found immediately above *P. kochi* (MAYNC, p. 22, 1942). Thus *P. kochi* evidently occurs at or near the top of the Greenland Permian.

¹⁾ Distance from beaks to anterior extremity, measured parallel to the hinge.

²⁾ Height exaggerated because of marked shell obliquity.

Genus **Allorisma** KING 1845.*Allorisma elegans* KING.

Pl. 5, fig. 16.

Allorisma elegans KING (1844) p. 316 (1850) p. 198, pl. 16, figs. 3—5; GEINITZ (1861) p. 57, pl. 12, figs. 14, 17; NETSCHAJEW (1894) p. 319, pl. 10, fig. 14.

Solemya biarmica (part) KING (1850) pl. 16, fig. 7.

Allorisma cf. *sulcata* FREBOLD (1932) p. 32, pl. 1, fig. 15.

Shell moderately convex, elongate, subquadrate, about twice as long as high; beaks inconspicuous, located about one-fourth of the shell length behind anterior margin; surface of valves faintly ornamented with concentric undulations. The internal mold of a right valve in our collection (fig. 16) is 17 mm high, and 35 mm long.

Discussion. — This species is closely similar to *A. rothi* NEWELL, from the Whitehorse sandstone of Oklahoma and Texas (Capitanian), but has a relatively higher shell.

Occurrence. — Widely distributed in the Upper Permian of Europe and England. The single individual described above was collected in the Red series (*Schizodus* zone) at Permdal, Wollaston Forland, East Greenland.

Genus **Crassiconcha** NETSCHAJEW 1894.*Crassiconcha groenlandica* (FREBOLD).

Pl. 5, fig. 17.

Sanguinolites groenlandica FREBOLD (1932) p. 30, pl. 1, fig. 14.

Form moderately convex, subtrigonal, nearly equilateral, with prosogyre beaks placed slightly ahead of the middle of the shell; posterior, or siphonal one-third of the shell delimited by a shallow sulcus. Dimensions of figured specimen: Height, 31 mm; length, 45 mm. Another very fragmentary individual displays a shallow sulcus about one-third back of the anterior extremity, in addition to the posterior sulcus. The genotype, *C. stuckenbergi* NETSCHAJEW, possesses two sulci, but the shell is relatively higher, in proportion to length, than in *C. groenlandica*. The pallial line is obscured in the Greenland forms, although these specimens are internal molds. Presumably, there was a deep pallial sinus as occurs in the genotype species.

Occurrence. — Red series, Permdal, Wollaston Forland, East Greenland. The genus is thus far recorded elsewhere only in the Kazanian of Russia.

REFERENCES

- ALDINGER, H. 1935. Das Alter der jungpalaeozoischen Posidonomyaschiefer. Medd. om Grønland, Bd. 98, No. 4.
- 1937. Permische Ganoidfische aus Ostgrønland. Medd. om Grønland, Bd. 102, No. 3.
- BRANSON, CARL C. 1948. Bibliographic index of Permian invertebrates. Geol. Soc. America, Memoir 26.
- EICHWALD, E. VON 1860. Lethaea Rossica, ou Paléontologie de la Russie, t. 1.
- FISCHER, ALFRED G. 1947. A belemnoid from the late Permian of Greenland. Medd. om Grønland, Bd. 133, No. 5.
- FLETCHER, H. O. 1946. New Lamellibranchia from the upper Permian of Western Australia. Australian Mus. Records, vol. 21.
- FREBOLD, H. 1931a. Fauna, stratigraphische und paleogeographische Verhältnisse des östgrønlandischen Zechsteins. Medd. om Grønland, Bd. 84, No. 1.
- 1931b. Das marine Oberkarbon Ostgrønlands, leitende Fauna, Alterstellung, Paleogeographie. Medd. om Grønland, Bd. 84, No. 2.
- 1931c. Unterer mariner Zechstein in Ostgrønland und das Alter der Depot-Island Formation. Medd. om Grønland, Bd. 84, No. 3.
- 1932. Das Perm von Wollaston Vorland. Medd. om Grønland, Bd. 84, No. 8.
- 1933. Weitere Veitragte zur Kenntnis des oberen Palaozoikums Ostgrønlands. Medd. om Grønland, Bd. 84, No. 7.
- GEINITZ, H. B. 1848. Die Versteinerungen des deutschen Zechsteingebirges.
- 1861. Dyas oder Zechsteinformation und das Rotliegende.
- GOLOWKINSKY, N. A. 1868. O Permskoe formation. Vserossiiskoe Mineralogicheskoe Obschestvo, Materialen zur Geologie Russlands, Bd. 1.
- KING, W. 1844. On a new genus of Paleozoic shells. Annals Mag. Nat. Hist., vol. 14, No. 92.
- 1845. *Allorisma*, ein neues paläozoisches Muschel-Geschlecht. Neues Jahrb. für Mineralogie, pp. 254—255.
- 1850. A monograph of the Permian fossils of England. Palaeontographical Soc., Monograph 3.
- KOCH, L. 1929. Stratigraphy of Greenland. Medd. om Grønland, Bd. 73, No. 2.
- LICHAREW, B. K. 1931. Upper Permian of the Northern Province, Russia. All-Union Geological and Prospecting Institute, Trans., vol. 71.
- MASLENNIKOV, D. F. 1935. The upper Permian pelecypods of the northern region. Trans. centr. geol. and prosp. inst., No. 29 (Abt. B., Bd. 10, 1937—1938).
- MAYNC, WOLF. 1942. Stratigraphie und Faziesverhältnisse der oberpermischen Ablagerungen Ostgrønlands. Medd. om Grønland, Bd. 115, No. 2.
- MILLER, A. K., and FURNISH, W. M. 1940a. *Cyclolobus* from the Permian of Eastern Greenland. Medd. om Grønland, Bd. 112, No. 5.
- 1940b. Permian ammonoids of the Guadalupe Mountain region and adjacent areas. Geol. Soc. Am. Special Paper 26.

- MUENSTER, G. G. 1843. (In Goldfuss) Beiträge zur Petrefacten-Kunde.
- MURCHISON, R. I., and VERNEUIL, E. DE. 1844. Note sur les équivalents du système permien en Europe, etc. Bull. Soc. Géol. France, 2 me série, t. 1. (Séance du 3 Juin, 1844), pp. 475—517.
- NETSCHAJEW, A. W. 1894. Die Fauna der Permablagerungen des östlichen Teiles des europäischen Russlands. Kanzas Universitet, Obshchestvo Estestvoispytatelei, Trudy, Bd. 34, No. 6.
- NEWELL, NORMAN D. 1937. Late Paleozoic pelecypods: Pectinacea. Kansas State Geological Survey, vol. 10.
- 1939. Permian pelecypod genus *Liebea*. Jour. Paleontology vol. 13, pp. 589—593.
- NEWELL, NORMAN D., and KUMMEL, BERNHARD. 1942. Lower Eotriassic stratigraphy, western Wyoming and southeast Idaho. Geol. Soc. Am. Bull., vol. 53, pp. 937—996.
- ROSENKRANTZ, A. 1829. Marine Permian deposits in East Greenland. Medd. fra Dansk Geol. Forening. Bd. 7.
- SÄVE-SÖDERBERGH, G. 1937. On the Palaeozoic stratigraphy of Canning Land, Wegener Peninsula, and Depot-Island. Medd. om Grønland, Bd. 96, No. 5.
- SCHLOTHEIM, E. F. VON. 1816. Beiträge zur Naturgeschichte der Versteinerungen in geognostischer Hinsicht. Akad. Wiss. München, Denkschriften, Math-Phys., Bd. 6.
- SOWERBY, J. DE C. 1829. Mineral conchology, No. CIV, vol. 6.
- SPATH, L. F. 1930. The Eotriassic invertebrate fauna of East Greenland. Medd. om Grønland, Bd. 83, No. 1.
- 1935. Additions to the Eotriassic invertebrate fauna of East Greenland. Medd. om Grønland, Bd. 98, No. 2.
- TSCHERNYSCHEW, B. N. 1939. (In) Atlas of leading forms of fossil fauna. U.S.S.R., vol. 6.
- VERNEUIL, E. DE 1845. Paléontologie, (In) Murchison, de Verneuil and Keyserling, Geologie de la Russie, vol. 2.
- YAKOWLEW, N. N. 1928. *Procrassatella*, un genre nouveau de Permien. Vserossiiskoe Paleontologicheskii Obshchestvo, Ezhegodnik, Bd. 7, pp. 119—125.

PLATES

Plate 1.

Explanation of plate 1.

Fig. 1. *Procrassatella plana* (GOLOWKINSKY). Upper Permian, White Blocks (no. 46), Cape Stosch formation, Cape Stosch. Gutta percha squeeze of a right valve. (p. 31)

Figs. 2—5. *Cypricardinia? permica* LICHAREW. Upper Permian, White Blocks, Kap Stosch formation, Kap Stosch. 2, Hinge and beak of a left valve, block 12. 3, Left valve, block 12. 4, Right valve, block 181. 5, Large right valve, showing traces of radial costellae, block 12. (p. 30)

Figs. 6—8. *Schizodus obscurus* (SOWERBY). Upper Permian. 6, Rubber squeeze of small left valve, somewhat deformed, from "reef" limestone of Zechstein facies, Korallberg, Clavering Ø, 7, Rubber cast, imperfect interior of a left valve, white block 180, Kap Stosch formation, Cape Stosch. 8, Large left valve, white block (no. 7), Cape Stosch formation, Kap Stosch. (p. 31)

Fig. 9. *Claraia stachei* BITTNER. Lower Triassic, White Blocks (no. 11), Cape Stosch formation, Kap Stosch. (p. 22)

Figs. 11—14. *Astartella vallesneriana* (KING). Upper Permian, White Blocks, Cape Stosch formation, Kap Stosch. 11, A right valve, block 138. 12, Right valve, block 12. 13, Left valve, attached to *Pseudomonotis* valve (see pl. 3, fig. 13), white block 12. 14, Left valve, block 12. (p. 30)

Figs. 15, 16. *Streblochondria maynci* NEWELL, n. sp. Upper Permian, Productuskalk. 15, Right valve, Maync loc. 1883, (?) Brachiopoddal, Wollaston Forland. 16, Left valve, Maync loc. 432, bed 3, (?) Productuselv, Clavering .. (p. 20)

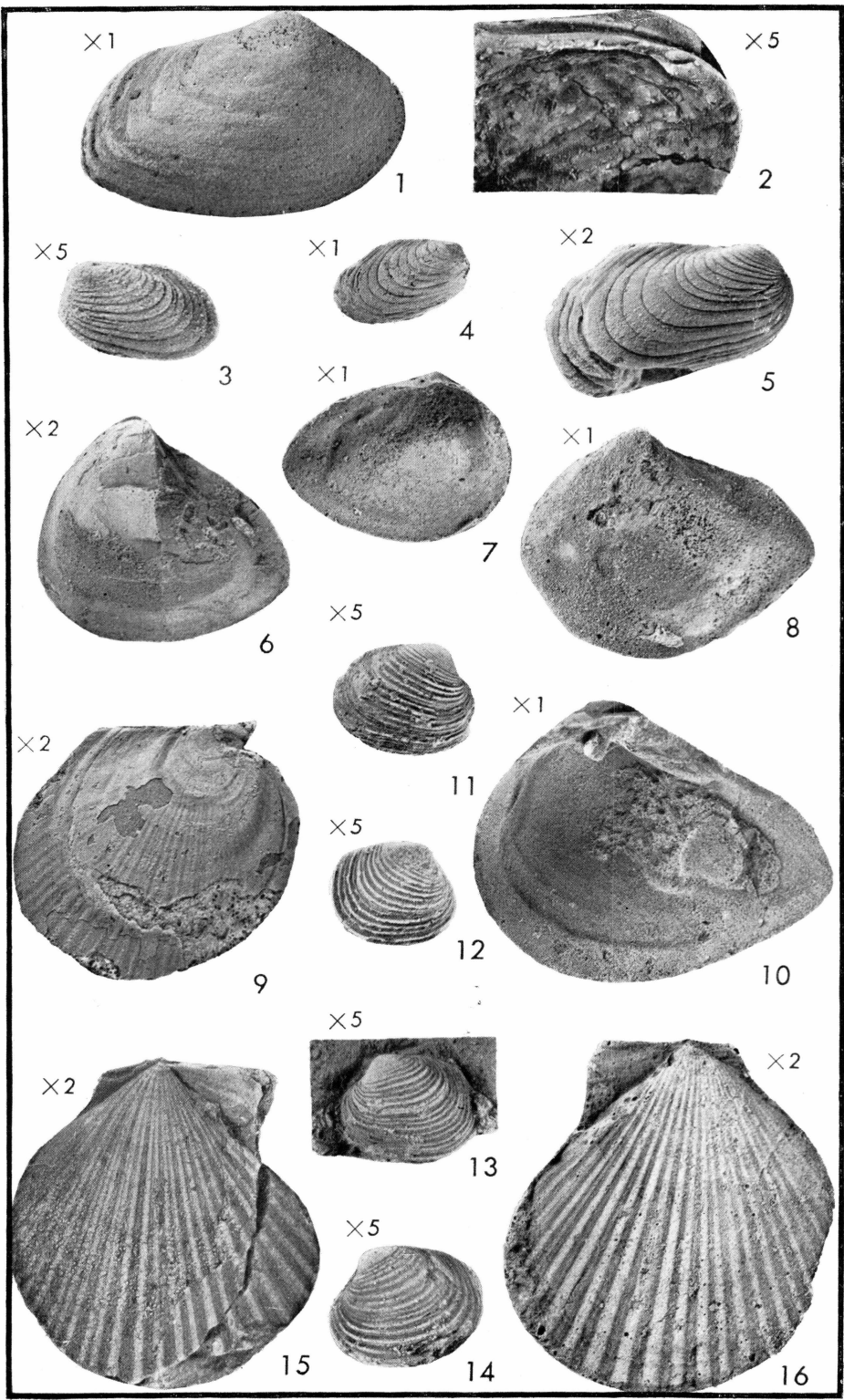


Plate 2.

Explanation of Plate 2.

Figs. 1—2. *Palaeocosmonya kochi* NEWELL, n. sp. Upper Permian, Depot Island formation, Depot Ø. 1 a—d, Views of a large individual, the holotype. 2, Left side view of another individual..... (p. 32)

Fig. 3. *Cyrtorostra* sp. Upper Permian, *loc.* 144, probably Martinia limestone, east of Brinkley Bjerg, Clavering Ø..... (p. 21)

Fig. 4—6. *Posidonia permica* NEWELL, n. sp. Upper Permian Posidonia beds. 4, a crushed large bivalved individual, the holotype, *loc.* Ma 52, Fiskeelv, Clavering Ø. 5, A characteristic internal mold of a left valve, *loc.* LK 14, southwest of Kap Stosch. 6, An unusually upright left valve, from LK 14, southwest of Kap Stosch..... (p. 21)

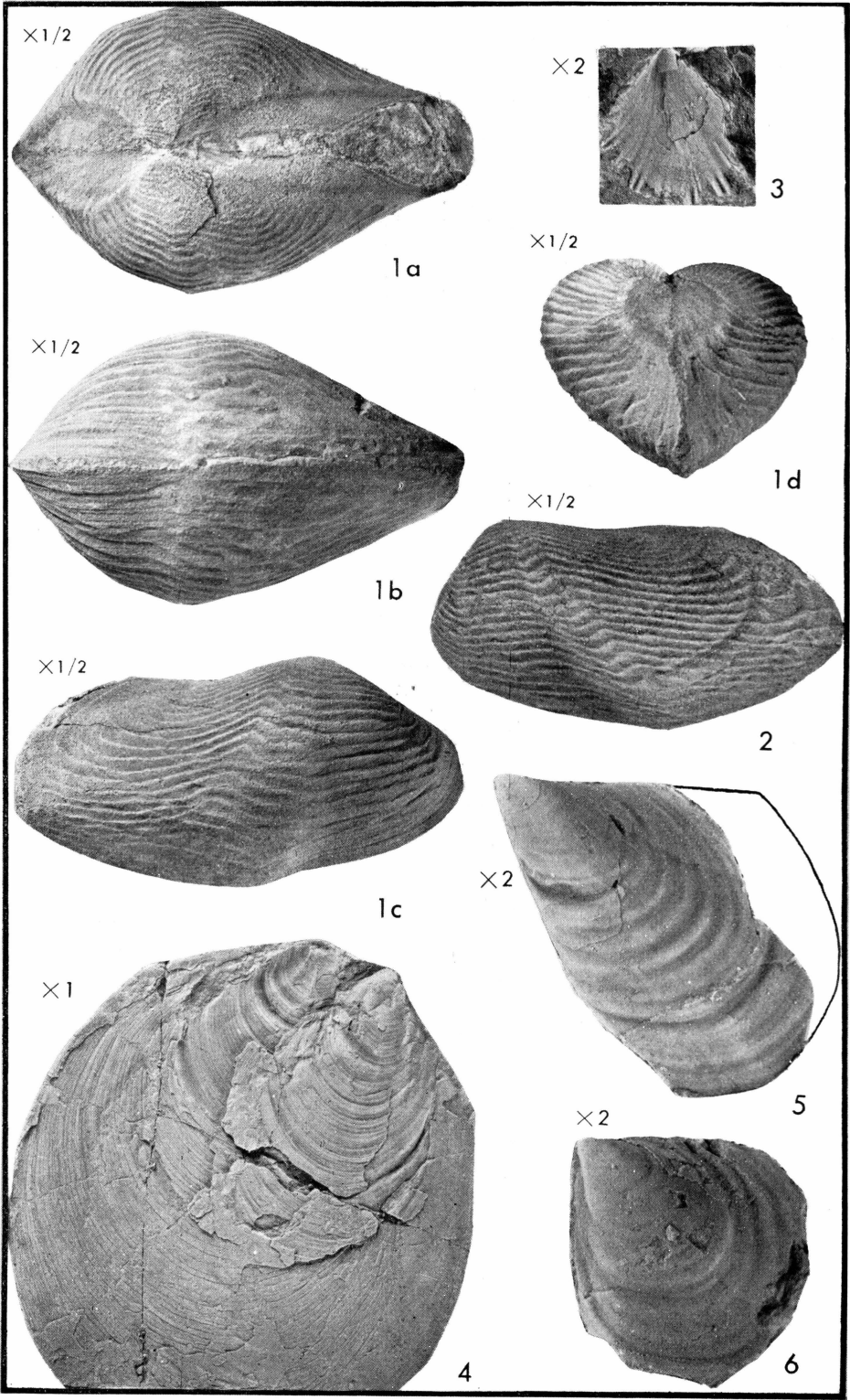


Plate 3.

Explanation of Plate 3.

Figs. 1—5, 7—8, 10—12. *Pseudomonotis speluncaria* (SCHLOTHEIM). Upper Permian, White Blocks, Cape Stosch formation, Kap Stosch. 1 a—b, A well preserved bivalved individual, block 10. 2 a—b, A small bivalved individual, block 179. 3, A costellate right valve, block 179. 4 a—b, A bivalved individual, block 179. 5, A mature right valve, block 65. 7, A nearly smooth left valve, block 45. 8, A costellate left valve, block 15. 10, Weakly costellate right valve, block 45. 11, Rugose right valve, block 179. 12, Right valve, block 60 (p. 18)

Figs. 6, 9, 13—16. *Pseudomonotis sparsicostata* FREBOLD. Upper Permian, White blocks, Cape Stosch formation, Kap Stosch. 6, A left valve, from block 15. 9, Fragmentary right valve of a juvenile, block no. ?. 13, A large right valve, showing cicatrix of attachment about one third of the diameter from the beak. The small *Astartella* attached to the umbo was overgrown by the larger shell, block 12. 14, An adult left valve, the holotype, block 15. 15, Rubber cast of a left valve having relatively fine ornamentation, block 45. 16, Large poorly preserved left valve referred to this species, Maync's locality 2334, Zechstein "reef" on Clavering Ø. (p. 19)

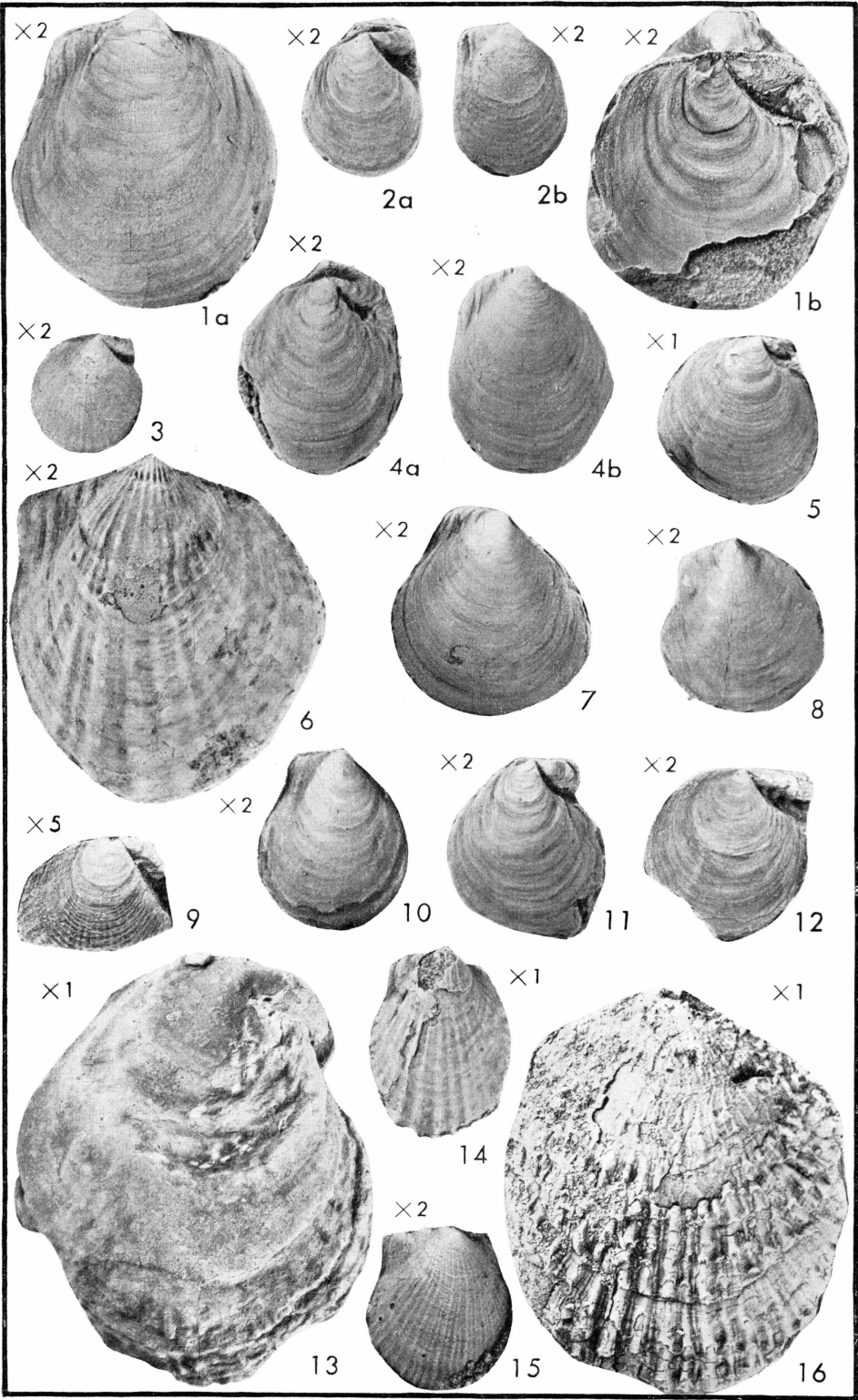


Plate 4.

Explanation of plate 4.

Figs. 1—3. *Plagiostoma ?polita* NEWELL, n. sp. Upper Permian. Posidonia shale, Kap Stosch. 1, A bivalved individual and an isolated right valve. 2, Bivalved individual. 3, The holotype, a relatively large right valve. (p. 23)

Figs. 4, 5. *Plagiostoma ?permiana* (KING). Upper Permian, White Blocks (no. 42), Cape Stosch formation, Kap Stosch. 4, Incomplete left valve, showing color pattern. 5, Larger left valve, with traces of color pattern. (p. 23)

Fig. 6. *Nuculana speluncaria* (GEINITZ). Upper Permian, Red series, Permdal, Wollaston Forland. A small left valve. (p. 17)

Figs. 7, 8. *Paralledon striatus* (SCHLOTHEIM). Upper Permian, White Block (no. 12), Cape Stosch formation, Kap Stosch. 7, Fragmentary right valve of moderate size. 8, Small right valve. (p. 29)

Figs. 9—13, 15. *Bakevella antiqua* (MUNSTER). Upper Permian, White Blocks, Cape Stosch formation, Kap Stosch. 9, An adult right valve, block 60. 10, An adult left valve, block 60. 11, A small, unusually rugose left valve, block 285. 12, A young left valve, block 60. 13, A relatively elongate left valve, block 304. 15a—c, A juvenile, block no. ? (p. 24)

Fig. 14. *Pleurophorus* sp. Upper Permian, White Blocks (no. 15), Cape Stosch formation, Kap Stosch. (p. 29)

Fig. 16—19. *Bakevella bicarinata* KING. Upper Permian, White Blocks, Cape Stosch formation, Kap Stosch. 16, A small left valve, block 101. 17, Right valve, block 12. 18, Interior view, showing hinge, block 12. 19, Left valve, block 101 .. (p. 25)

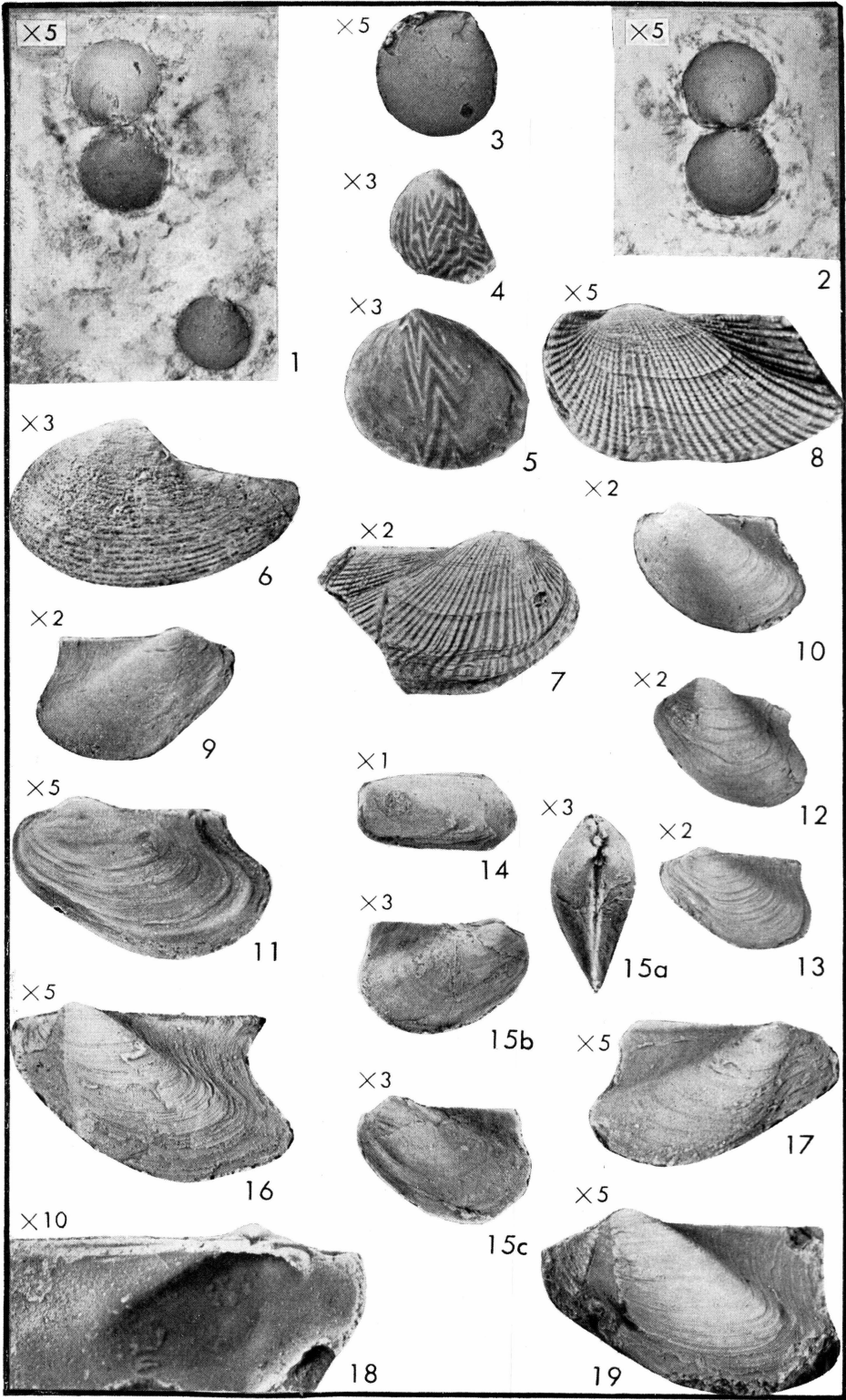


Plate 5.

Explanation of plate 5.

Figs. 1—5. *Stutchburia ?modioliformis* (KING). Upper Permian, White Blocks of Cape Stosch formation, Kap Stosch. 1a—c, A juvenile, block 185. 2, A somewhat larger individual, block 185. 3, A costellate form, block 19. 4, An unusually slender form, block 19. Relatively mature individual, block 15..... (p. 28)

Figs. 6, 7. *Lithophaga consobrina* (EICHWALD). Upper Permian, White Blocks of Cape Stosch formation, Kap Stosch. A handsome right valve, holotype of *Lithodomus permianus* (FREBOLD), block 15. 7, A smaller left valve, block 15.. (p. 27)

Fig. 8. *Promytilus* cf. *priscus* NEWELL. Upper Permian, Red series, Permdal, Wollaston Forland, An exfoliated left valve..... (p. 26)

Figs. 9, 10. *Myalina* cf. *meeki* DUNBAR. Lower Triassic, White Blocks, Cape Stosch formation, Kap Stosch. 9, Well preserved right valve, block 11. 10, Exfoliated left valve, block no. ?..... (p. 26)

Figs. 11—13. *Promyalina groenlandica* NEWELL. n. sp. Lower Triassic, White Blocks, Cape Stosch formation, Kap Stosch. 11, Hinge and beak of left valve, block 11. 12, Medium sized left valve, the holotype, block 11. 13, Small left valve, block 11..... (p. 25)

Figs. 14—15. *Liebea squamosa* (SOWERBY). Upper Permian, White Blocks, Cape Stosch formation, Kap Stosch. 14, An auriculate left valve. 15, Fragmentary left valve of more usual shape..... (p. 27)

Fig. 16. *Allorisma elegans* KING. Upper Permian, Red series, Permdal, Wollaston Forland. Imperfect mold of a right valve..... (p. 34)

Fig. 17. *Crassiconcha groenlandica* (FREBOLD). Upper Permian, Red series, Permdal, Wollaston Forland. Internal mold, right valve..... (p. 34)

