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PERMIAN BRACHIOPOD FAUNAS OF CENTRAL EAST GREENLAND

BY

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WITH 22 FIGURES IN THE TEXT AND 32 PLATES

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INTRODUCTION

Just before the beginning of the Second World War, Dr. LAUGE KOCH transmitted to the writer for critical study the extensive collections of Permian fossils that had been made by him and members of his field parties in the course of the geological survey of East Greenland during the years 1926—1939.

As received, the collections filled 60 shipping cases. The bulk of the material consisted of brachiopods, but there were several drawers of pelecypods, several of bryozoans, and a few cephalopods. According to plans agreed upon in advance, the nautiloids and ammonites were placed in the hands of Dr. A. K. MILLER for study, the pelecypods were entrusted to Dr. NORMAN D. NEWELL, the bryozoans to Dr. R. S. BASSLER, and the brachiopods were reserved for study by the writer. MILLER and FURNISH (1940) have published on the ammonites, and a former student of NEWELL, Dr. ALFRED G. FISCHER (1947), has described a new belemnite, the first to be discovered in Permian rocks. Because of the pressure of other work, Dr. BASSLER asked to be released from his obligation, and the bryozoa were then transferred to Dr. R. C. MOORE. Dr. NEWELL's study of the pelecypods, and the writer's study of the brachiopods appear herewith.

As received and unpacked, the brachiopod collections filled a storage case of 130 drawers. During the war years it was impossible for the writer to devote any considerable time to this task, and so its completion has been too long delayed.

As indicated in the catalogue of collections, the material was gathered by numerous field parties, from many localities, and during the course of 13 field seasons, each lot having its own identifying number by which it could be related to pertinent field data. The physical task of preparing, labeling, and identifying this large and complex mass of material has contributed to the delay.

Part of the material had been studied by HANS FREBOLD who published several papers on the faunas as the field work progressed, and described or identified many of the species. His studies, based upon individual collections as they came in, were somewhat of the nature

of reconnaissance reports and his conceptions of the faunas and their age relations underwent drastic changes during the course of his work. With the assembled collections available for monographic study, and with the important additional collections and the stratigraphic data published by Dr. WOLF MAYNC and others since 1933, it has been necessary to correct a number of FREBOLD's identifications and to conclude that all, rather than part, of the Permian faunas of Central East Greenland are of Upper Permian, Zechstein, age.

During the course of this work the writer has received valued assistance from three former students who during the time of their graduate studies at Yale aided in the sorting, preparation, and preliminary identification of the brachiopods. Dr. JOHN RODGERS, now my colleague in the geological department at Yale, spent many hours during the winter of 1940, sorting and classifying the rather large collection of WOLF MAYNC.

Dr. PRESTON E. CLOUD, now chief of the Paleontology and Stratigraphy Branch of the U. S. Geological Survey joined me to begin serious study of the collection in the fall of 1941, having received a post-doctoral Sterling Fellowship at Yale. Upon the outbreak of the war, however, he resigned to accept an appointment with the Strategic Minerals section of the U. S. Geological Survey in midwinter. In the meantine, however, he had assembled much of the pertinent paleontological literature, had built up a useful annotated bibliography, and had etched and otherwise prepared many of the specimens later used for illustration.

Finally Dr. JOHN TROELSEN worked on the collections as a graduate student research assistant during the winters of 1944—46. Having been in Ellesmere Land on a Danish Expedition when the war began and thus being unable to return to Copenhagen, he had made his way to the U. S. A. and to Yale, where he completed his graduate training and received a Ph. D. degree during the war years. Having been on a previous expedition to East Greenland, and being familiar with the Scandinavian languages, he was able to help in interpreting the field labels, identifying the collecting localities on maps and gathering additional literature. He also sorted out specimens for critical study and made preliminary identifications and descriptive notes.

It is a pleasure to acknowledge my indebtedness for all this help.

In making the photographs for the plates, the author had the faithful assistance of PERCY A. MORRIS of the Peabody Museum staff. His best thanks go also to Mrs. DORIS E. IRONS for her care and patience in the preparation and editing of the typescript. All the text figures were drawn by the author.

The many geologists who have assisted Dr. KOCH in securing this great collection of Permian fossils—probably the largest ever assembled

from the Arctic Region—deserve especial thanks. The task of gathering such materials in a region so rugged, so largely icebound, and so difficult of access, must have entailed hardships of heroic proportions, and should be remembered by all who have the opportunity to study their results in the comfort of the laboratory. Above all, I am indebted to Dr. LAUGE KOCH whose leadership has made possible the many amazing geological discoveries in East Greenland, and who has entrusted this fine collection to me for study.

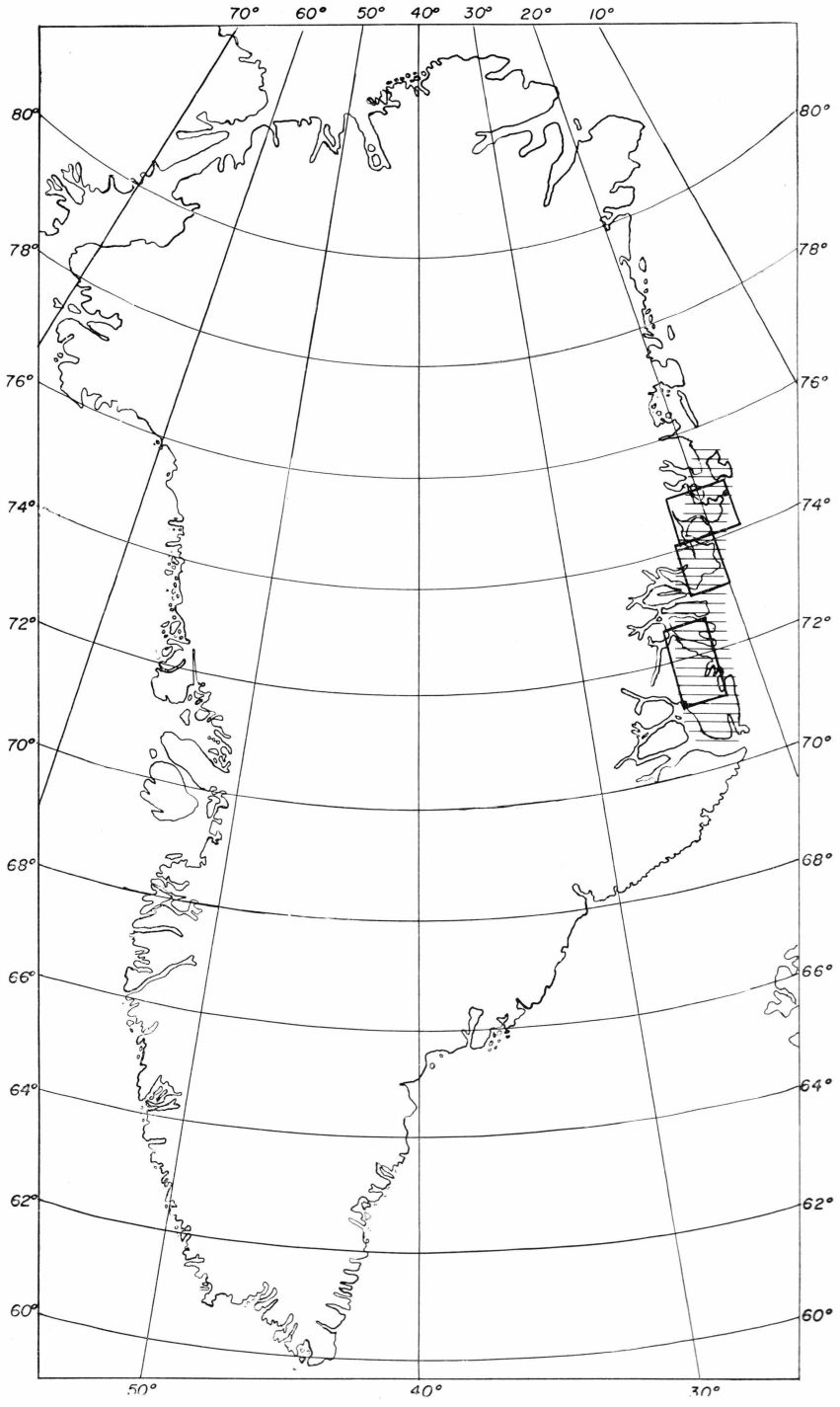

Fig. 1. Map of Greenland showing location of the Central East Greenland Permian Basin and the position of more detailed maps, figures 2, 7, 11.

STRATIGRAPHIC REVIEW

A brief review of the Permian stratigraphy in East Greenland will provide a basis for recording the distribution of the faunas. In this summary we have drawn upon the numerous accounts published in Meddelelser om Grønland by Dr. KOCH and his assistants. Most of these are progress reports dealing with local facets of the problem, but two, of more comprehensive scope, have been especially helpful. The first of these is MAYNC's "Stratigraphie und Faziesverhältnisse der Oberpermischen Ablagerungen Ostgrönlands" (MAYNC, 1942), which gives profile sections for many of the important outcrops; and the second is KOCH's "Report on the Expeditions to Central East Greenland, 1926—39, conducted by LAUGE KOCH" (KOCH, 1950), which includes large-scale maps on which all the Permian outcrops are shown. Our figures 2 to 14 have been based largely on these sources.

Nearly all the outcrops of Permian rocks fall within a narrow belt that begins near the mouth of Schucherts Flod in southern Scoresby Land and runs northward to the center of Wollaston Forland, a distance of some 250 miles (fig. 1). This belt of outcrop lies close along the western border of the Permian seaway that impinged against an old land mass of metamorphic and crystalline rocks of pre-Caledonian age. Following Permian deposition the basin continued to subside while a considerable thickness of Triassic, Jurassic, and Cretaceous formations accumulated. Post-Mesozoic uplift with large-scale normal faulting produced a series of plateaus now separated by deep glacial valleys and fjords. Permian outcrops are largely confined to the margins of these blocks and to valleys of small peripheral streams that have cut through the Mesozoic cover. As a result the outcrops are mostly small and discontinuous (see figs. 2, 7, and 11).

Lying as they do near the western margin of the basin of deposition, the Permian rocks commonly rest nonconformably on a crystalline or metamorphic floor, but locally they lie with angular discordance on Devonian or Lower Carboniferous strata. They vary considerably in thickness and show rapid and complex changes of facies that have been summarized by MAYNC (1942). A basal conglomerate, commonly of

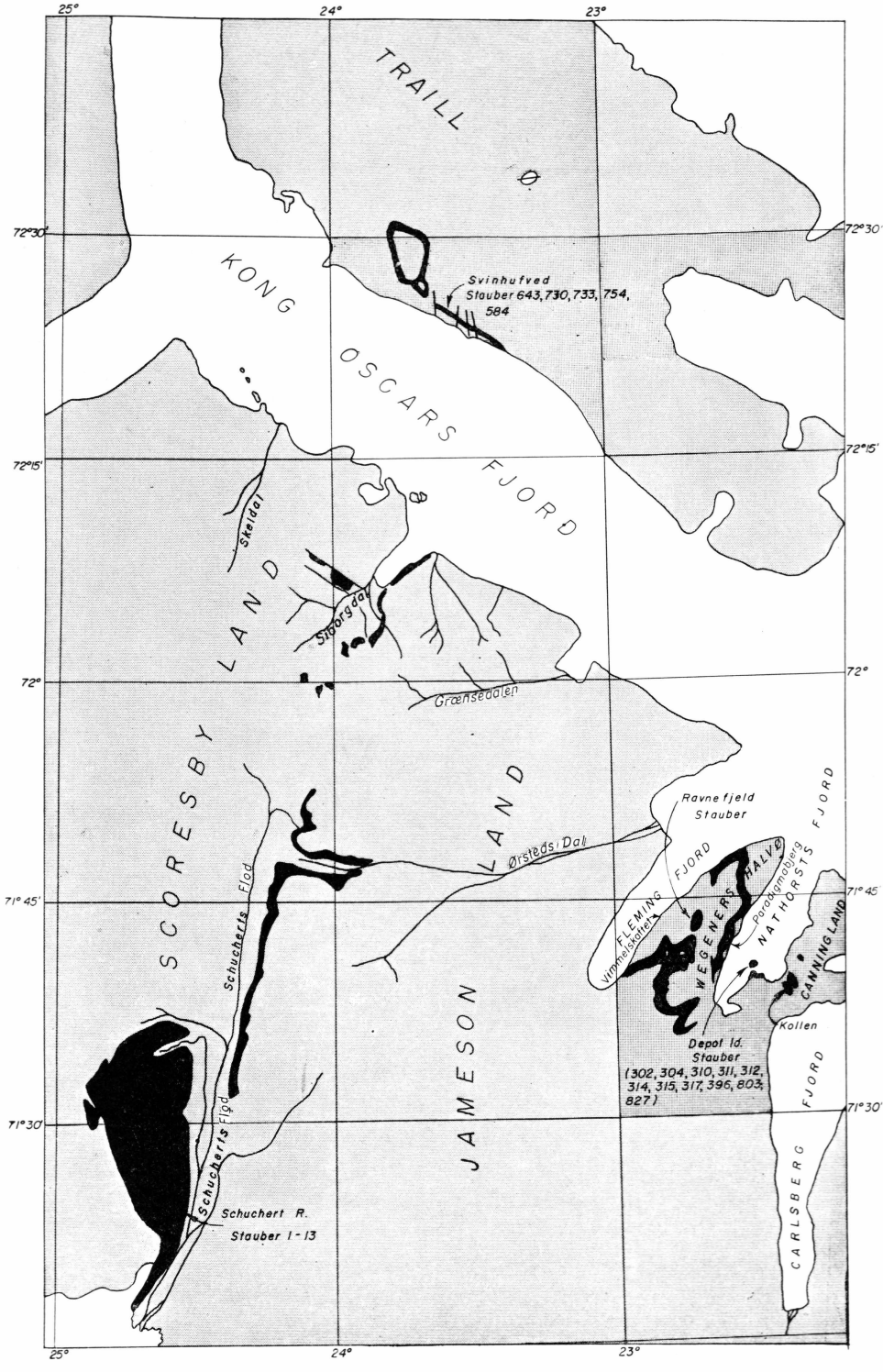

Fig. 2. Map showing Permian outcrops in Scoresby Land, the Nathorsts Fjord area, and Traill Ø. Adapted from KOCH (1950).

considerable thickness and locally including large blocks of older rocks, indicates high relief in the adjacent land on the west as Permian deposition began.

The region about Nathorsts Fjord is interesting because there the Permian beds are brought to the surface some 30 to 40 miles east of the main outcrop belt. It is noteworthy that no basal conglomerate is present in that area.

In reviewing the stratigraphy it will be convenient to begin in the south and follow the outcrop belt northward.

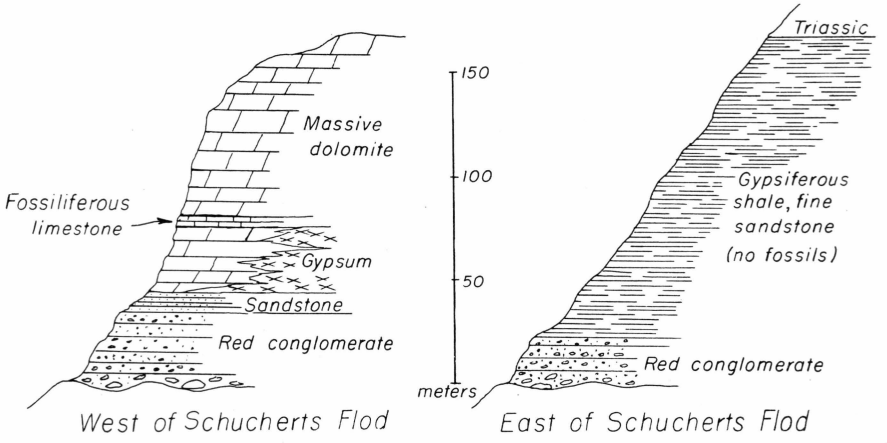

Fig. 3. Profile sections of the Permian beds in the Schucherts Flod Valley, southern Scoresby Land. Adapted from STAUBER (1940).

Scoresby Land.

Schucherts Flod area. The wide outcrop of Permian rocks west of Schucherts Flod (fig. 2) is a plateau from which the Mesozoic cover has been removed; the narrow belt of outcrop on the east side of the valley follows the face of steep bluffs that are capped by Triassic and Jurassic beds.

Dr. HANS STAUBER visited this area in 1938 and measured sections both east and west of Schucherts Flod (STAUBER, 1940, p. 9—11). That on the west (fig. 3) begins with a reddish conglomerate about 33 meters thick that includes boulders up to 1 meter in diameter. It rests on a surface of considerable relief cut on nonmarine Carboniferous rocks. The conglomerate has yielded no fossils and may be, in part at least, nonmarine. It is succeeded by 5 to 10 meters of well-bedded gray sandstone above which there is an abrupt change to massive light gray dolomite or to massive gypsum. The upper surface has been unevenly eroded so that only about 20 meters of the dolomite remains in the southern part of the area, but toward the north it increases to almost 133 meters. The

lower part of the dolomite is more or less gypsiferous and, along the strike, it is replaced locally by masses of white gypsum as much as 30 meters thick. At a level near the top of the gypsum, the dolomite includes a bed or lens of shelly limestone some 2 meters thick that is a veritable coquinite made largely of the shells of the productid, *Pleurohorridonia scoresbyensis* n. sp. This is the "Fossiliferous limestone" of our figure 3. STAUBER made a collection of some 13 cases of fossils from this bed but was unable to find fossils at other horizons in the section.

East of the river the Permian beds rest on the same erosion surface and have approximately the same thickness as those on the west side, but they differ notably in lithology in spite of the fact that the gap between is only about 5 miles (fig. 3). The basal red conglomerate is only some 6 meters thick in the eastern section where it is followed by about 130 meters of gypsiferous shale that includes thin interbeds of fine sandstone and gypsum, and a few calcareous layers. This complex is followed disconformably by marine Early Triassic. No fossils were found in this eastern outcrop. Since the Permian sections on opposite sides of the valley are subequal in thickness, rest on the same erosion surface, and both begin with a reddish conglomerate, it is evident that they are essentially contemporaneous. If this be true it is noteworthy that the basal conglomerate thins rapidly toward the east and that the overlying dolomite in the western section is replaced by gypsiferous shale toward the east with thick lenses of massive gypsum locally separating these two facies.

The shell-limestone lying near the middle of the western section has yielded the following fauna:

Streptorhynchus stoschensis n. sp. (c)
Chonetina noe-nygaardi n. sp.
Pleurohorridonia scoresbyensis n. sp. (ccc)
Rhynchopora kochi n. sp.
Dielasma elongatum
Camerophoria kochi n. sp.
Camerophoria sp. B
Camerophoria cf. *C. multiplicata*
Cleiothyridina maynci n. sp.
Cleiothyridina pectinifera
Pterospirifer alatus
Spirifer striato-paradoxus
Spiriferella keilhavii
Spiriferina multiplicata
Punctospirifer cristata
Odontospirifer mirabilis n. sp.
Choristites söderberghi n. sp.

Sieburgerdal area. BIERTHER studied the northern part of Scoresby Land in 1937 and mapped Permian outcrops along the edge of the plateau east of Sieburgerdal and Mesters Vig and in two small areas in a graben west of the river (fig. 2). He measured 4 profile sections of the Permian but has published only one generalized section for the area (1941, p. 8). This is represented graphically in our figure 4.

The basal conglomerate, with a maximum thickness of 18 meters, is chiefly made of pebbles of granite and gneiss. It rests with angular

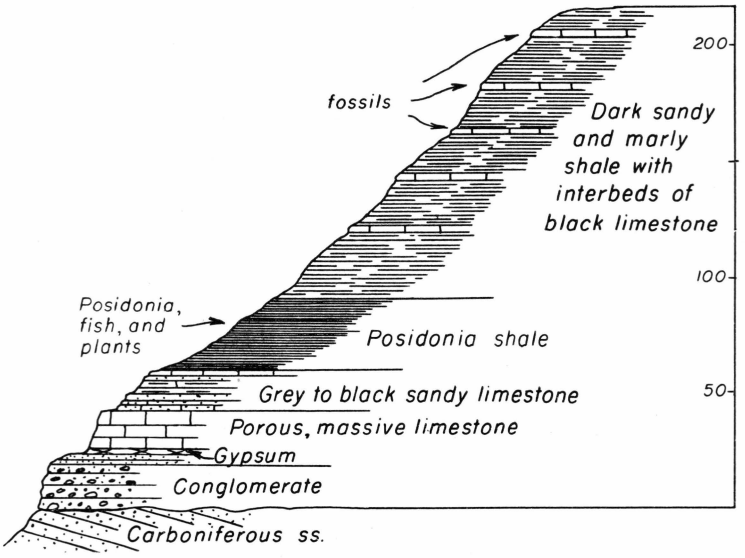

Fig. 4. Profile section of the Permian beds in the Sieburgerdal area, northern Scoresby Land. Adapted from STAUBER (1941).

discordance on nonmarine Carboniferous sandstones. Just above the conglomerate is a thin unit of fine and well-bedded sandstone, followed by a thin and variable bed of gypsum.

Light colored, porous, and massive limestone up to 25 meters thick succeeds the gypsum. It is unfossiliferous and includes isolated quartz pebbles.

The next unit, about 17 meters thick, is a complex of dark gray to black limestone, in part sandy and in part shaly. These dark beds are full of brachiopods. This is followed by about 30 meters of dark bituminous shale with scattered specimens of *Posidonia* and fish remains and fossil plants.

The rest of the section, between the *Posidonia* shale and the base of the Triassic, consists of dark shaly beds, in part sandy and micaceous and, in part marly, with thin beds of argillaceous, black shelly limestone intercalated at numerous horizons.

BIERTHER made extensive collections from 4 sections about Sieburgerdal but the field labels available to us do not indicate the exact location of either of them.

From bed 8 near the top of his Section 1, a very dark gray muddy limestone, we have identified the following fauna:

Muirwoodia greenlandica (cc)
Kochiproductus plexicostatus (c)
Liosotella hemispherica (c)
Liosotella vadosisinuata
Pleurohorridonia scoresbyensis
Sowerbina rudis (?) (r)
Camerophoria sp.
Cleiothyridina nielseni
Cleiothyridina maynci (c)
Spiriferella keilhavii (r)

From bed 8 of Section 4 we have identified the following:

Liosotella spitzbergiana
Liosotella vadosisinuata
Strophalosia pulchella
Muirwoodia greenlandica
Kochiproductus plexicostatus
Pleurohorridonia scoresbyensis
Waagenoconcha sp. (juvenile)
Cancrinella bolchovitinovae (cc)
Spiriferella keilhavii (r)

A small collection labeled "bed 8a of Section 5" has a matrix of typical Martiniakalk, a fine-grained, medium gray, impure limestone. This lot includes 4 species, of which the first listed is predominant and was evidently very abundant. The fauna is as follows:

Cancrinella bolchovitinovae (cc)
Liosotella vadosisinuata
Pleurohorridonia scoresbyensis
Waagenoconcha sp.

BIERTHER'S collections B(V), B(8), B(9), and B(XI) are not identified as to bed or section, but they resemble the other collections in lithology and in faunal composition, and it appears likely that they are from limestone layers in the upper half of the section.

Collection B(V) includes the following species:

Liosotella grandicosta (?)
Liosotella hemispherica (c)
Krotovia nielseni
Pleurohorridonia scoresbyensis
Hustedia troelseni

Collection B(8) includes the following fauna:

Liosotella hemispherica
Krotovia nielseni
Cancrinella bolchovitinovae (cc)
Waagenoconcha payeri (?)
Sowerbina rudis
Pleurohorridonia scoresbyensis
Muirwoodia greenlandica
Kochiproductus plexicostatus
Punctospirifer cristata (?)
Martinia greenlandica

Collection B(9) is from a black, more or less sandy limestone in which species of *Liosotella* occur in great abundance. The fauna includes:

Liosotella delicatula
Liosotella hemispherica
Liosotella vadosisinuata
Liosotella spitzbergiana (c)
Krotovia nielseni
Waagenoconcha sp.
Muirwoodia greenlandica
Kochiproductus plexicostatus
Pleurohorridonia scoresbyensis

Collection B(XI) includes the following:

Liosotella hemispherica
Liosotella vadosisinuata
Kochiproductus plexicostatus
Sowerbina rudis

Nathorsts Fjord Area.

Nathorsts Fjord area

The region about Nathorsts Fjord in eastern Jameson Land is interesting because it lies 30 to 40 miles east of the outcrops in Scoresby Land and farther from the Permian shoreline than any of the other outcrops. The Permian here rests with angular unconformity on Devonian

and Lower Carboniferous sandstone and is overlain disconformably by marine Lower Triassic and has a thickness of about 180 meters. Its stratigraphic relations are thus closely similar to those in Scoresby Land, and its thickness is nearly the same as in the Sieburgerdal area but about 70 meters thicker than in the Schucherts Flod area. Unlike the western sections, however, it has no basal conglomerate and is not gypsiferous.

Nathorsts Fjord was visited by KOCH in October 1926. He made a collection at Kumait on the east coast of Wegeners Halvö (KOCH, 1926, p. 98). The fauna was later studied by FREBOLD (1931, p. 11—19) who identified the following, interpreting it as Upper Carboniferous:

Productus porrectus KUTORGA [= *Kochiproductus plexicostatus*]
Productus timanicus STUCKENBERG [= *Sowerbina rudis*]
Productus inflatus MCCHESNEY [We have seen nothing like this sp.]
Productus cf. *cancriniformis* TSCHERNYSCHEW [= *Cancrinella bolchovitinovae*]
Productus cf. *weyprechti* TOULA [= *Muirwoodia greenlandica*]
Spirifer cf. *ravana* DIENER
Spirifer cf. *marcoui* WAAGEN
Spirifer aff. *cameratus* MORTON
Spirifer aff. *cameratus* MORTON
[= *Spirifer striato-paradoxus*]
Spiriferella parryana (TOULA) TSCHERNYSCHEW [= *S. keilhavii*]
Athyris planosulcata PHILLIPS [= *Cleiothyridina maynci*]
Streptorhynchus kempei ANDERSSON

NOE-NYGAARD studied the region in more detail during the fall of 1931 and the spring of 1932 when he had a base camp on the northern side of Wegeners Halvö (NOE-NYGAARD, 1934). At this time he followed the shore line of both Canning Land and Wegeners Halvö, prepared a geologic map of the area and measured 2 sections of the Permian strata. One of these was near the middle of the northwest coast of Wegeners Halvö, on the spur to the southwest of Vimmelskaftet (1934, p. 34) and another near the middle of the southeast coast, on Paradigmabjerg (1934, p. 36). These are represented graphically in figure 5.

In the Vimmelskaftet section the Permian beds are about 180 meters thick, resting with angular discordance on nonmarine Devonian sandstone and being disconformably succeeded by marine Lower Triassic. Unit 1, including some 93 meters of light gray dolomitic limestone, has yielded no fossils. Unit 2 consists of black carbonaceous shale but includes some calcareous beds near the middle that are fossiliferous; unit 3 includes limy sandstone with limestone cobbles; and units 4 and 6 are more sandy and have not yielded fossils. Unit 5 is a fossiliferous limestone bed.

The Paradigmabjerg section is thinner only because the base is not exposed. Unit 1 corresponds to the upper part of unit 1 in the previous section. Unit 2 consists of black, limy and carbonaceous shale in which abundant brachiopods and corals occur. Unit 5 of this section is sandy at the top but grades downward into light colored dolomitic limestone that is rich in productids.

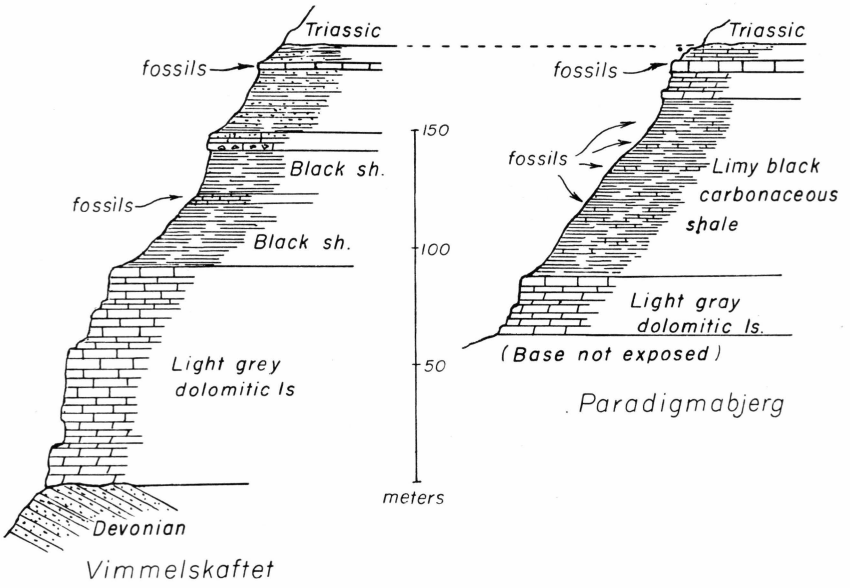

Fig. 5. Profile sections of the Permian strata in the Nathorsts Fjord area. Adapted from NOE-NYGAARD (1934).

SÄVE-SÖDERBERGH visited the area briefly in 1934 and again spent 8 days here in 1936. Although he concentrated on the Devonian strata, he also made Permian collections on Depot Ö, and especially on the slopes of Kollen. BÜTLER was a member of the expedition in 1936 and his account of the geology of Canning Land gives a summary of the Permian stratigraphy of the region (BÜTLER, 1948, p. 65—71). He shows that the Permian oversteps both Devonian and nonmarine Lower Carboniferous with a strong angular discordance.

The fine collection made by SÄVE-SÖDERBERGH on the slopes of Kollen have weathered from a dark shaly matrix and apparently represent zone 2 of the Paradigmabjerg section.

A good collection was also made by Dr. KOCH and his sailors from the north slope of Kollen when their ship lay at anchor for a couple of days near the adjacent shore in Nathorsts Fjord.

The latter collection, labeled "Sailors Collection," was gathered from the talus on the north slope of Kollen but the dark color of the

shaly matrix indicates that the fossils were weathering from the upper half of the section. The following species have been identified:

Streptorhynchus stoschensis
Liosotella vadosisinuata
Muirwoodia greenlandica
Kochiproductus plexicostatus
Pleurohorridonia scoresbyensis (c)
Sowerbina rudis
Camerophoria kochi
Cleiothyridina pectinifera (c)
Hustedia troelseni
Pterospirifer alatus

SÄVE-SÖDERBERGH's collection from the east slope of Kollen included the following fauna:

Liosotella grandicosta (cc)
Pleurohorridonia scoresbyensis
Sowerbina rudis
Camerophoria kochi
Cleiothyridina pectinifera (c)
Spiriferella keilhavii (cc)
Pterospirifer alatus (c)
Choristites söderberghi

From the north side of Kollen, SÄVE-SÖDERBERGH collected *Pleurohorridonia scoresbyensis.*

From the east side of Quenzels Bjerg he collected *Pleurohorridonia scoresbyensis*, *Rhynchopora kochi*, *Martinia greenlandica*, and a simple horn coral.

From the west side of the mountain Hesteskoen in Canning Land he collected *Liosotella grandicosta* and *Camerophoria kochi.*

Another collection made by KOCH in 1927 and labeled "Cape Brown" probably was from Kumait on Wegeners Halvö. It includes *Streptorhynchus stoschensis*, *Cancrinella bolchovitinovae*, *Cancrinella germanicus*, *Pleurohorridonia scoresbyensis*, and *Spiriferella keilhavii.* In this collection *Pleurohorridonia* is predominant.

A larger collection from the same locality was made by HARRIS in 1927. It has yielded the following species:

Chonetina noe-nygaardi
Liosotella spitzbergiana
Liosotella vadosisinuata
Liosotella hemispherica

Cancrinella germanicus (cc)
Muirwoodia greenlandica (c)
Kochiproductus plexicostatus (c)
Pleurohorridonia scoresbyensis (c)
Spirifer striato-paradoxus
Spiriferella keilhavii (c)

Traill Ø.

On Traill Ø, Permian outcrops are limited to the sea cliffs south and southeast of Svinhufvuds Bjerge. These were studied in 1936—37 by STAUBER who later described them very briefly and published three simple profile sections (STAUBER, 1938, p. 24, pl. 2). The best of these shows about 120 meters of Permian strata resting unconformably on nonmarine Carboniferous and overlain by marine Early Triassic (our fig. 6). At the base there is about 5 meters of conglomerate, but the rest of the section is largely shale including much gypsum and several beds of calcareous algae. About 35 meters below the top occurs a bed of

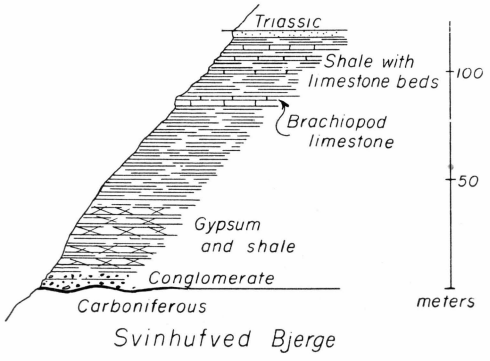

Fig. 6. Profile section of the Permian strata in the south slope of Svinhufvuds Bjerge, Traill Ø. Adapted from STAUBER (1948).

limestone, 2 to 3 meters thick, that is rich in fossils, chiefly brachiopods. From this bed upward the shales also yield brachiopods, pelecypods, and small horn corals.

From this area we have only 5 small collections (STAUBER's I—730, I—733, I—754, 1—584, and 1—643), all of which are presumed to have come from the brachiopod limestone bed.

The area was briefly described, with excellent illustrations, by NOE-NYGAARD (FREBOLD and NOE-NYGAARD, 1938) and in the same work FREBOLD described from the Permian beds the following fauna:

Productus cf. *porrectus* KUTORGA [= *Kochiproductus plexicostatus*]
Waagenoconcha humboldti D'ORBIGNY
Productus (Horridonia) cf. *timanicus* STUCKENBERG
Productus (Linoproductus?) cf. *weyprechti* TOULA [? = *Muirwoodia greenlandica*]
Spiriferella parryana TOULA [= *S. keilhavii* von Buch]
Spiriferella cf. *keilhavii* von Buch

Gauss Halvö.

The eastern part of Gauss Halvö is occupied by the basalt-capped Giesecke Bjerge, a plateau of nearly flat-lying Mesozoic strata. Deep erosion of its east, south, and western margins has exposed the underlying Permian beds in narrow and discontinuous belts along the flanks of the range as shown in figure 7. The subrectangular area thus defined is approximately 12 miles wide and some 25 miles long, north to south. It is on the strike of the exposure in Scoresby Land from which it is separated by a gap of some 60 miles in which Permian rocks fail to reach the surface. Along the line of strike north of Svinhufvuds Bjerge in Traill Ø and across Geographical Society Ø, the Triassic oversteps onto Lower Carboniferous, suggesting that this area was emergent during Permian time or that if Permian deposits were laid down they had been removed by uplift and erosion before early Triassic submergence. If Permian rocks are present, down dip to the east in this latitude, they are completely covered by Mesozoic strata.

MAYNC (1942, p. 56—75) has given profile sections of the best of the exposures in Gauss Halvö. Throughout this area the Permian beds are only 20 to 30 meters thick. They overstep the older formations—Lower Carboniferous, Devonian, and pre-Caledonian crystallines—with profound unconformity, but are disconformably overlain by Early Triassic marine beds.

A basal conglomerate is generally present, ranging in thickness up to 10 meters or more, and made of well-rounded pebbles and boulders of quartzite and other old rocks in a matrix of arkosic sandstone in the lower part and commonly of dolomite in the upper part. The boulders range up "to the size of skulls" or larger. Above the conglomerate comes platy dolomite beds and impure dolomitic limestone, commonly followed by the bluish-gray Martiniakalk and this in turn by dark, carbonaceous *Posidonia* shale. Within the latter in several of the sections a thin "Productus limestone" is interbedded. It is normally less than 3 meters thick but is richly fossiliferous. This is the source of most of the brachiopod collections.

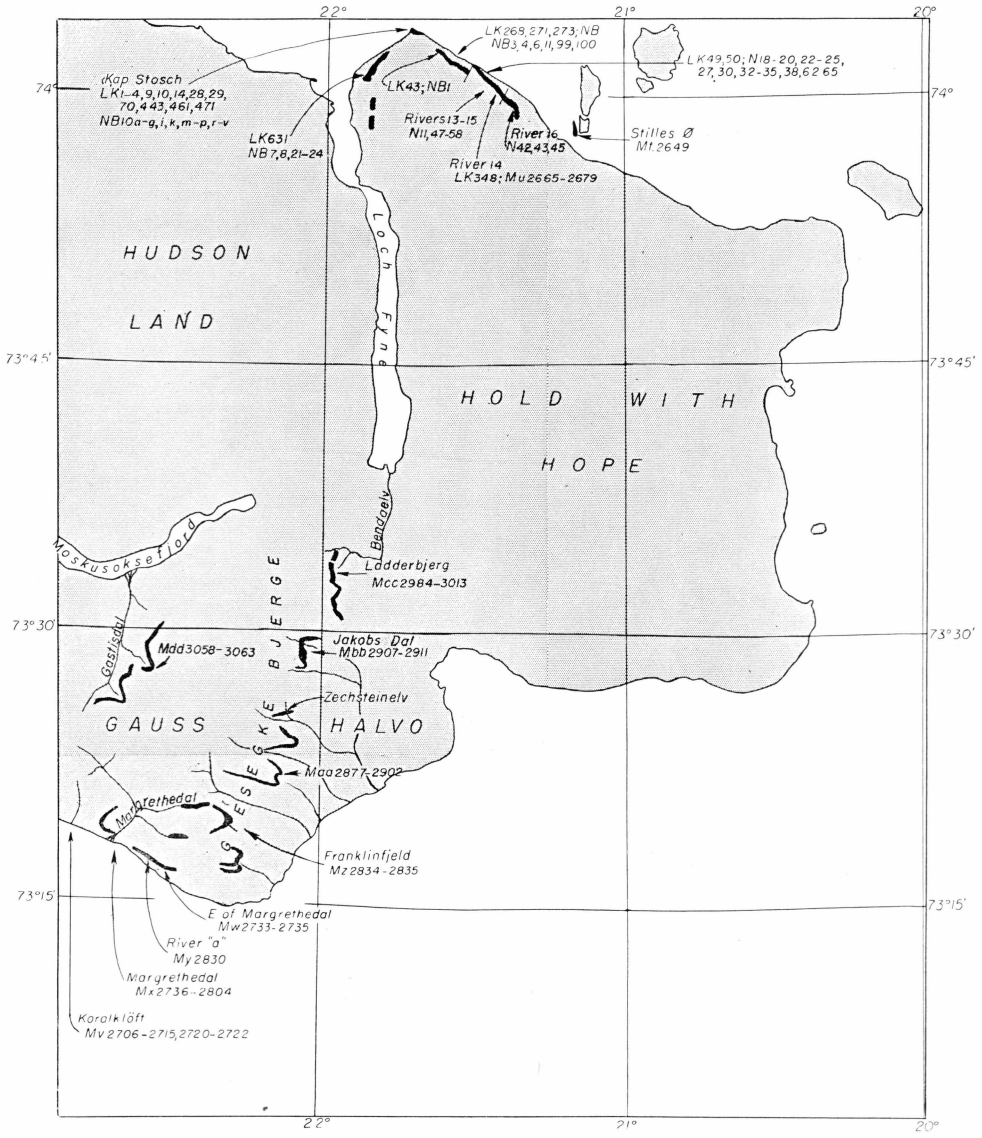

Fig. 7. Map showing Permian outcrops in Gauss Halvö and the Kap Stosch area. Adapted from Koch (1950).

Margrethedal. In Margrethedal and its tributaries Maync found numerous exposures of Permian beds but no good measurable section, and his collections from this area at the south end of the Giesecke Bjerge are not precisely located. The nearest profile section is that measured in Koralklöft, the brook next west of the mouth of Margrethedal (fig. 8). Maync's collections 2733—2804 have the lithology of the Martiniakalk and include the following fauna:

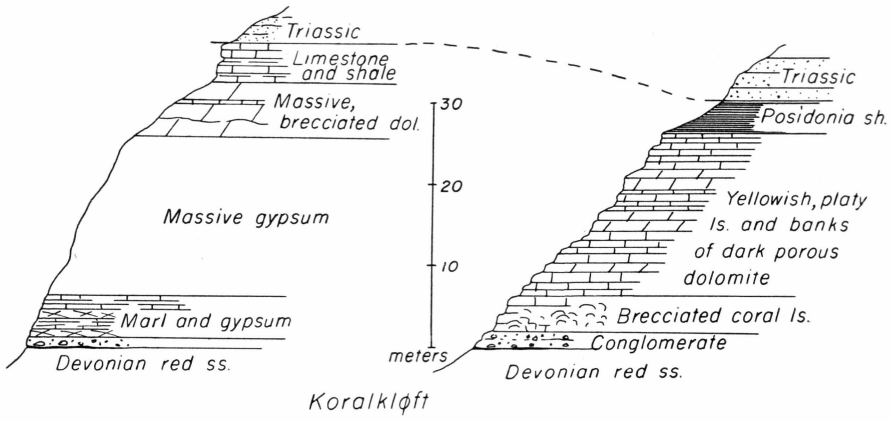

Fig. 8. Profile sections of the Permian strata in the Koralkløft, southern border of Gauss Halvö. Adapted from MAYNC (1942).

Liosotella hemispherica
Liosotella spitzbergiana
Liosotella vadosisinuata
Liosotella delicatula
Krotovia nielseni (c)
Sowerbina maynci
Pleurohorridonia scoresbyensis
Muirwoodia greenlandica (cc)
Camerophoria kochi
Dielasma elongatum
Cleiothyridina nielseni
Martinia greenlandica (c)
Spiriferella keilhavii
Fish scales

Zechsteindal. Some 15 miles to the east-northeast of Koralklöft, MAYNC measured a good section in Zechsteindal (fig. 9). This is near the middle of the east flank of the range. Here the basal conglomerate is about 5 meters thick and is followed by platy bituminous limestone with some interbedded black shale but without bedded gypsum. The middle part of the section is composed of gray Martiniakalk and the upper part of *Posidonia* shale. Interbedded in the latter and within a few meters of the top of the section is a thin bed of "Productus limestone" rich in fossils.

Gastisdal. A section along the bluffs east of Gastisdal and about 10 miles nearly due west of Zechsteindal (fig. 9) differs from the latter

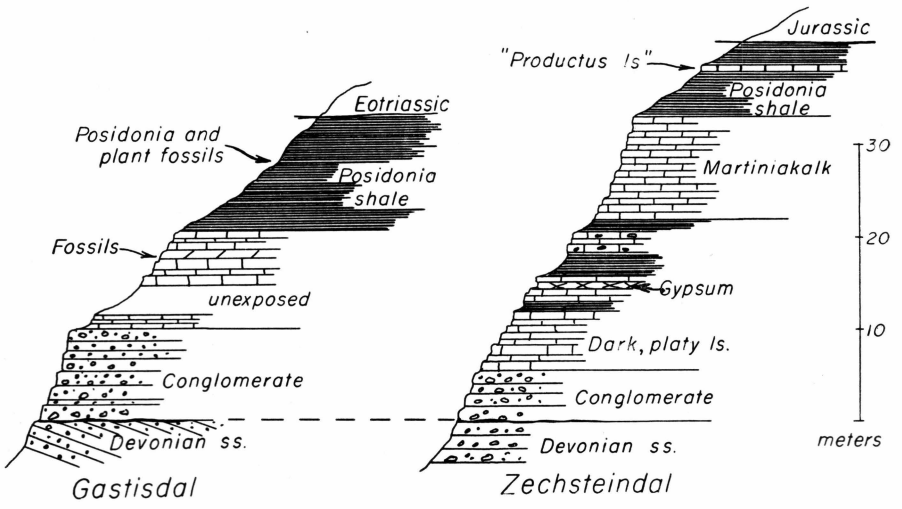

Fig. 9. Profile sections of the Permian strata in the central part of Gauss Halvö. Adapted from MAYNC (1942).

chiefly in that the basal conglomerate is thicker and the black shale makes up a little more of the upper part of the section.

Several rather small collections were made in Gauss Peninsula by MAYNC.

Hold with Hope Land.

The uplands of this area are largely capped by Tertiary basalt, and the lowlands are covered with alluvium, Permian outcrops being limited to the northern margin in the vicinity of Kap Stosch (fig. 7) where the plateau breaks off in a great sea cliff facing Godthaabs Golf.

Kap Stosch area. Permian beds, dipping gently southeastward, crop out as a band along the cliffs for some 10 miles to the east of Kap Stosch and nearly as far to the southwest. Short valleys entrenched into the flanks of the plateau provide the chief access to the Permian exposures. This area has been studied repeatedly by Dr. KOCH and his assistants and has yielded large collections of good fossils. The area has been clearly illustrated by KOCH in 1931 (Meddel. om Grønland, Bd. 83, no. 2, pls. 1 and 2) and by NIELSEN in 1935 *(ibid.*, Bd. 98, no. 1, pl. 1). Valleys crossing the outcrop have been numbered in sequence from River 1 at the southwest to River 16 at the east end of the outcrop, and these serve as the chief landmarks by which fossil collections are located.

From the published accounts, it appears that talus covers a part of the section in most of these small valleys, but MAYNC measured a good profile section at River 14 which is here reproduced as figure 10

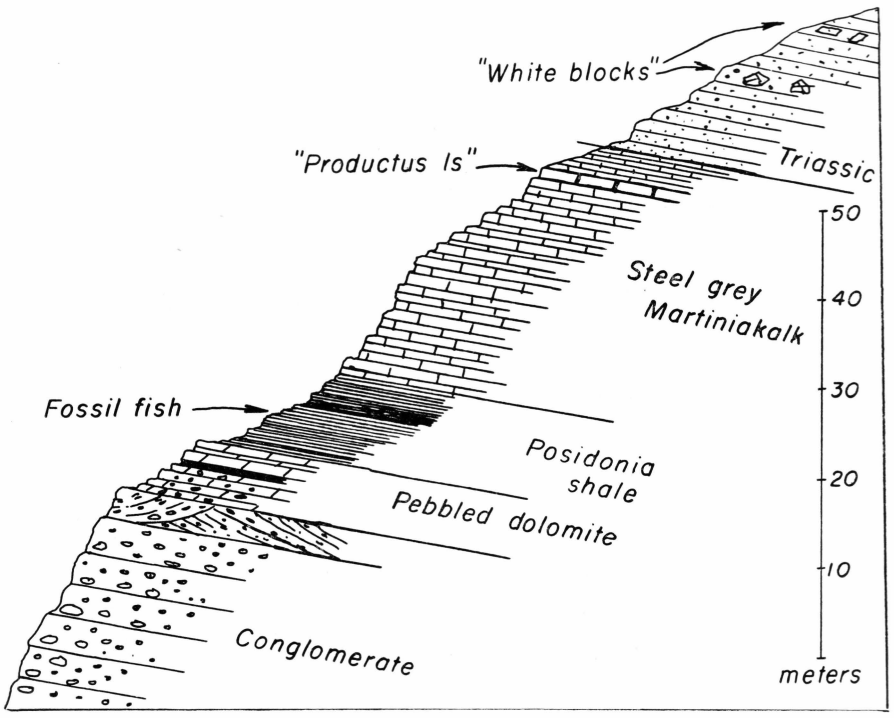

Fig. 10. Profile section of the Permian strata in the valley of River 14, east of Kap Stosch. Adapted from MAYNC (1942).

(MAYNC, 1942, p. 53, fig. 17). This exposure begins with a conglomerate the base of which is not exposed. It is succeeded by about 45 meters of marine strata the lower part of which is dolomite with included pebbles like those in the conglomerate below. This is followed by about 12 meters of black, bituminous *Posidonia* shale from which a fish fauna was secured (NIELSEN, 1932 and 1935; and ALDINGER, 1937). Above the black shale is about 30 meters of bluish-gray Martiniakalk near the top of which there is intercalated a 6-foot bed of "Productus limestone" filled with brachiopods. It evidently is marly, for many of the fossils weather free with surface features well preserved. Nearly all the collections from the Permian beds in the Kap Stosch area appear to have come from this bed or from others like it in the upper part of the section. The numerous collections from this region vary in size from a single specimen to more than a drawerful of free fossils. Dr. KOCH followed the practice of using a single number (e. g. LK 28) for a unit collection, but MAYNC and NIELSEN commonly assigned a separate number to each specimen even though several were from a single spot.

The fauna from the "Productus limestone" of the Kap Stosch area includes 25 species several of which appear in great numbers and are

represented in most collections. In the following table a separate column is used for each of the 7 largest collections in which a star indicates the presence of the species, *c* indicates that it is common, *cc* that it is very abundant, and *r* that the species is rare.

	LK 2	LK 12	LK 28	LK 29	LK 49	Nielsen	Kulling	Others
Streptorhynchus kempei	..	..	..	..	*	*	*	*
Chonetina noe-nygaardi	..	..	..	..	..	*	..	..
Paeckelmannia toulai	..	r	..	*	..	*	..	*
Cancrinella bolchovitinovae	..	..	..	..	..	*	..	..
Liosotella hemispherica	..	*	r	*	..	*	..	..
Liosotella spitzbergiana	..	..	..	..	*	*	..	..
Liosotella vadosisinuata	..	c	*	..	..	*	..	..
Marginifera cf. *septentrionalis*	..	*	..	..	..	*	..	..
Strophalosia pulchella	..	..	..	..	..	..	..	*
Krotovia nielseni	..	*	*	*	..	*	..	*
Waagenoconcha payeri	..	*	*	..	..	*	..	*
Pleurohorridonia scoresbyensis	..	..	..	..	..	*	..	..
Sowerbina maynci	*	..	..	..	..	..	..	*
Sowerbina rudis	*	c	*	*	..	..	..	*
Muirwoodia greenlandica	*	c	cc	*	..	*	*	*
Kochiproductus plexicostatus	*	cc	c	*	..	*	*	*
Dielasma stoschensis	..	..	..	..	..	*	..	..
Camerophoria kochi	..	..	*	*	..	*	..	*
Camerophoria multiplicata	..	..	*	*	..	*	..	..
Cleiothyridina nielseni	..	*	..	*	*	..	..	..
Cleiothyridina maynci	..	*	*	..	..	..	..	*
Cleiothyridina pectinifera	..	*	*	..	..	..	..	..
Spirifer striato-paradoxus	..	..	*	..	..	*	*	*
Spiriferella keilhavii	*	*	cc	*	*	*	c	..
Martinia greenlandica	*	..	*	*	..	*	r	*

"White blocks" in Triassic conglomerates. In the Kap Stosch area the Permian is overlain disconformably by some 500 meters of marine Early Triassic shales and sandstones with thin beds of limestone bearing a succession of ammonite faunas. Interbedded within this sequence are 5 thick conglomerates that include fossiliferous blocks of white Permian limestone.

These conglomerates were studied by Frebold (1933) who concluded that they are limited to the Kap Stosch area and the southern part of Clavering Ø, and that the limestone blocks came from the west. These blocks of very white limestone are lithologically unlike any of the Permian beds that are in place in the Kap Stosch area. Accordingly the composition of their faunas is of particular interest. Nielsen made

an extensive collection from the "white blocks" in 1937 and ROSENKRANTZ made another in 1929. Altogether more than 200 blocks were studied. Each was numbered and its fauna was collected as a unit, and has been studied and preserved as such. For the most part each block has yielded a small collection including a few species; but as a group they appear to represent a single, rather distinctive fauna as follows:

Crania sp.
Streptorhynchus stoschensis (ccc)
Chonetina noe-nygaardi (r)
Liosotella hemispherica (r)
Liosotella spitzbergiana (r)
Pleurohorridonia scoresbyensis (ccc)
Cancrinella bolchovitinovae (r)
Rhynchopora kochi (cc)
Cleiothyridina pectinifera
Cleiothyridina maynci
Hustedia troelseni (r)
Spiriferina multiplicata (cc)
Odontospirifer mirabilis (r)
Dielasma elongatum (ccc)

A very large part of the fauna of these "white blocks" consists of small pelecypods of which Dr. NEWELL has identified the following:

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

In contrast to the great abundance of pelecypods in the "white blocks" of this area, Dr. NEWELL found only 2 species, both pectinoids, in the "Productus limestone" from which we have a prolific brachiopod

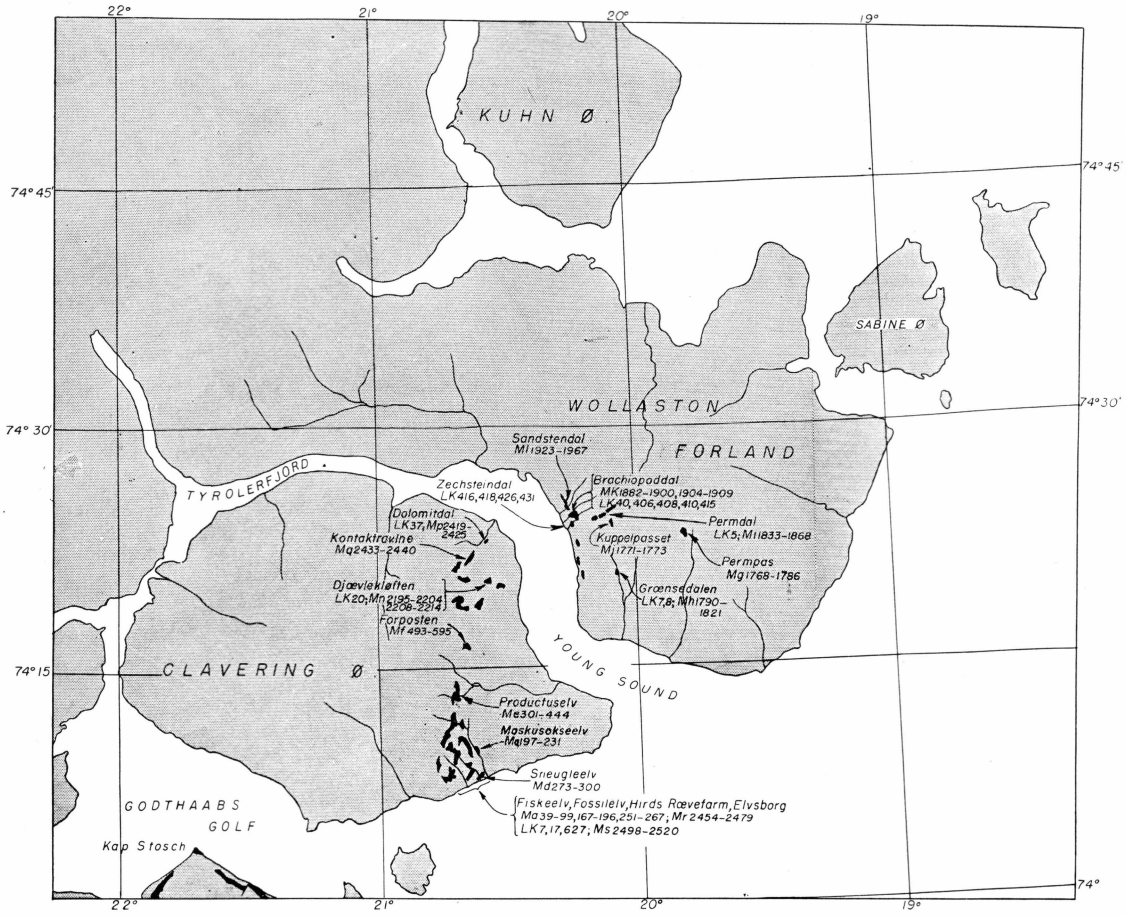

Fig. 11. Map showing outcrops of Permian strata in Clavering Ø and Wollaston Forland. Adapted from KOCH (1950).

fauna. The two clams are *Posidonia permica* NEWELL and *Streblochondria*? *maynci* NEWELL.

Stilles Ø. This small island lying to the east of, but nearly on the strike of, the outcrops east of Kap Stosch is formed of Permian beds from which MAYNC made a small collection. The matrix is a light gray, granular limestone, and the fauna includes:

Chonetina noe-nygaardi
Cleiothyridina nielseni
Spiriferella keilhavii
Spirifer striato-paradoxus

This is clearly the horizon of the richly fossiliferous "Productus limestone" of the Kap Stosch area.

Clavering Ø.

The high central part of Clavering Ø is formed of crystalline rocks, but its eastern margin is formed of fault blocks containing relatively flat-lying Permian strata overlain by Mesozoic formations. In valleys cut into the margins of these blocks there are numerous Permian outcrops along a north-south belt about 10 miles wide (fig. 11).

In this area the Permian beds range in thickness from 120 to about 180 meters of which the lower part, and in most sections more than

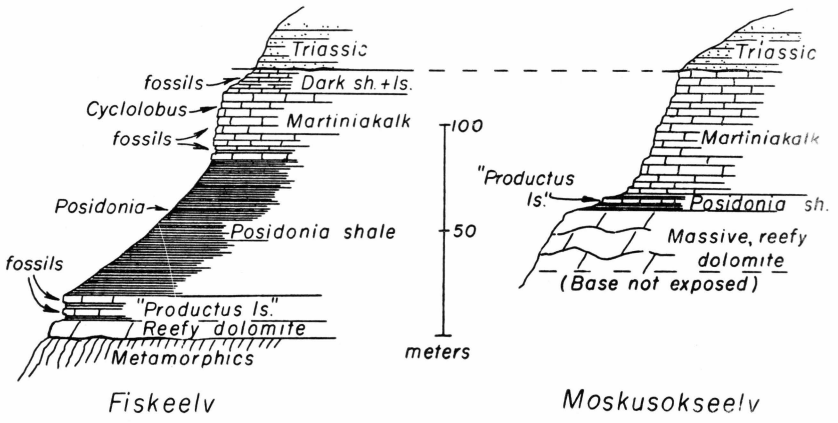

Fig. 12. Profile sections of the Permian strata near the southern coast of Clavering Ø. Adapted from MAYNC (1942).

half the thickness, consists of massive and reefy light gray dolomite resting directly on a pre-Caledonian crystalline floor.

Southern Coast. As indicated in figure 11, MAYNC made numerous collections from small valleys along the south coast of the island. For these, MAYNC's section in Fiskeelv will be useful (fig. 12). At the base is about 7 meters of massive, reefy dolomite with some included gypsum. This is followed by 10 meters of interbedded black shale and gray limestone, the latter bearing the "Productus limestone" fauna. There follows some 70 meters of *Posidonia* shale, succeeded by 31 meters of greenish-gray Martiniakalk, the upper part of which becomes shaly and weak.

From the Martiniakalk at Fiskeelv MAYNC collected the following:

Paeckelmannia toulai
Liosotella vadosisinuata (c)
Krotovia nielseni
Waagenoconcha sp.
Cancrinella germanicus
Martinia greenlandica (c)

In addition these beds yielded the ammonites *Cyclolobus kullingi* and *Medlicottia primas*. One chunk of yellowish-weathering limestone from Fiskeelv, presumably the "Productus limestone," yielded

Streptorhynchus kempei
Kochiproductus plexicostatus
Spirifer striato-paradoxus

Malmquists Plateau. From the margins of nearby Malmquists Plateau MAYNC made 3 collections each with a distinctive matrix.

From a dark gray limestone of the Martiniakalk facies we identify

Packelmannia toulai
Chonetina noe-nygaardi
Waagenoconcha sp.

From a yellowish-weathering shelly limestone ("Productus limestone" facies) we recognize

Liosotella vadosisinuata (c)
Kochiproductus plexicostatus
Camerophoria cf. *multiplicata*
Cleiothyridina pectinifera

and from a gray crinoidal limestone in the same section we identify

Streptorhynchus stoschensis
Liosotella spitzbergiana (c)
Kochiproductus plexicostatus
Martinia greenlandica

In nearby Sneugleelv, MAYNC collected from the Martiniakalk which yielded only *Paeckelmannia toulai* and *Martinia greenlandica*. Another lot from an argillaceous bryozoan limestone included

Liosotella grandicosta
Kochiproductus plexicostatus
Cleiothyridina pectinifera

Moskusokseelv to Productuselv. Within a few miles north of Fiskeelv, the black *Posidonia* shale has largely disappeared, grading laterally into Martiniakalk. The section at Moskusokseelv (MAYNC, 1942, p. 30, fig. 6) is reproduced here in figure 12. At the base there is at least 30 meters of reefy, non-bedded dolomite with poorly preserved productids and horn corals. This is followed by a few meters of black, *Posidonia* shale and that, in turn, by a single bed of shelly limestone that is a veritable coquinite of brachiopods and bryozoans. This is the normal "Productus

limestone" fauna. Above this is about 60 meters of platy, thin-bedded, steel gray Martiniakalk, overlain disconformably by Early Triassic sandstone.

Productuselv, some 10 miles farther north, reveals a good section (fig. 13) which was measured by MAYNC in 1936. It begins with approximately 100 meters of massive, reefy and recrystallized dolomite resting directly on a crystalline floor. Within the massive dolomite are lenses or "nests" of white organic limestone filled with small lamellibranchs.

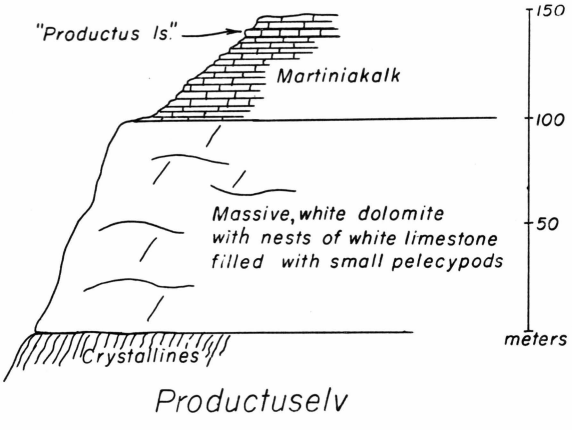

Fig. 13. Profile section of the Permian strata in Productuselv, central-eastern Clavering Ø. Adapted from MAYNC (1942).

MAYNC says these masses are lithologically identical with the "white blocks" in the Triassic conglomerates of the Kap Stosch area.

Above the massive white dolomite is about 45 meters of yellowish-brown well-bedded limestone varying from thin-bedded to thick-bedded. Near the very top of this is a bed about 1 meter thick of dark brown, very fossiliferous limestone, the typical "Productus limestone" of MAYNC.

MAYNC's collections 301—444 are not labeled as to position in the section, but several of them are in thin, platy yellowish-brown limestone, and these are especially rich in species of *Liosotella*. The larger brachiopods probably came mostly from the "Productus limestone" bed near the top of the section. Together these have yielded the following fauna:

Streptorhynchus kempei
Liosotella vadosisinuata
Liosotella delicatula
Liosotella hemispherica
Liosotella spitzbergiana
Kochiproductus plexicostatus

Muirwoodia greenlandica
Pleurohorridonia scoresbyensis
Sowerbina maynci
Sowerbina rudis
Krotovia nielseni
Cancrinella bolchovitinovae
Cancrinella germanicus
Strophalosia pulchella
Camerophoria kochi
Cleiothyridina nielseni
Cleiothyridina maynci
Spiriferella keilhavii
Spirifer striato-paradoxus
Martinia greenlandica

Forposten ("Avantpost" Bjerg). Here in the central eastern part of Clavering Ø the section resembles that of Productuselv, the massive, reefy, white dolomite reaching a thickness of 100 meters and resting directly on a crystalline floor. The upper part of the section is well bedded and largely thin-bedded, yellowish-weathering limestone, some beds of which are rich in bryozoa, in species of the brachiopod *Liosotella* and in *Strophalosia pulchella.* In the upper part MAYNC recognizes a "Productus limestone" unit 2 to 3 meters thick. The fauna from this section, mostly from thin-bedded, light gray, dun-weathering, fine-grained limestone, includes the following:

Liosotella spitzbergiana
Liosotella vadosisinuata
Liosotella delicatula
Muirwoodia greenlandica (c)
Pleurohorridonia scoresbyensis (c)
Sowerbina maynci
Sowerbina rudis
Krotovia nielseni
Dielasma elongatum
Rhynchopora kochi
Rhynchopora abnormalis
Camerophoria kochi
Cleiothyridina maynci
Cleiothyridina pectinifera
Spirifer striato-paradoxus
Spiriferella keilhavii
Punctospirifer cristata
Martinia greenlandica

Djævlekløften. At this locality in the northeastern part of Clavering Ø the Permian beds are not exposed *in situ*, but fossiliferous blocks occur in the Jurassic conglomerates. From these blocks MAYNC collected the following fauna:

Streptorhynchus kempei
Derbyia sp.
Liosotella hemispherica
Liosotella vadosisinuata
Kochiproductus plexicostatus
Muirwoodia greenlandica
Waagenoconcha sp.
Sowerbina maynci
Cleiothyridina neilseni
Cleiothyridina pectinifera
Punctospirifer cristatus
Spirifer striato-paradoxus

Cirkusdal. MAYNC made numerous collections in Cirkusdal from light gray, tan-weathering, thin-bedded magnesian limestone. Both lithology and fauna are similar to those about Forposten. The fauna includes the following:

Streptorhynchus kempei
Liosotella hemispherica
Liosotella vadosisinuata
Strophalosia pulchella
Kochiproductus plexicostatus
Waagenoconcha sp.
Pleurohorridonia scoresbyensis
Sowerbina maynci
Cancrinella germanicus
Rhynchopora kochi
Cleiothyridina pectinifera
Spirifer striato-paradoxus
Punctospirifer cristata

Koralbjerg. In the flanks of Koralbjerg, above the Djævlekløften, MAYNC measured a section about 150 meters thick of which the lower 100 meters consists of massive and in part brecciated dolomite resting on a crystalline floor. This is followed by 12 meters of thin-bedded platy to shaly dolomitic limestone with numerous fossils. This is succeeded by 4 to 5 meters of brownish-weathering "Productus limestone" filled with brachiopods and bryozoans, and that in turn by 7 to 8 meters of reddish and yellowish, bedded sandstone with great numbers of *Can-*

crinella bolchovitinovae and of *Spirifer striato-paradoxus*. The section is completed by 25 meters of somewhat shaly and platy reddish-gray weathering sandstone including 3 separate interbeds of brownish "Productus limestone," all richly fossiliferous. This reddish sandy facies is unknown south of Koralbjerg, but is well developed in Wollaston Forland where it was termed the "Red Series" by FREBOLD and, for a time, was thought by him to be separate from, and younger than, the other Permian strata in East Greenland. Its interbedding here with several layers of typical "Productus limestone" indicates that it is only a facies.

The sections farther north in Clavering Ø, in Kontactravine and Dolomitdal, are much thinner than those previously discussed, partly because the non-bedded dolomite at the base has thinned greatly, and partly because the section is incomplete at the top, being disconformably overlapped by the Jurassic. However, the "Productus limestone," 3 to 4 meters thick, is typically developed and richly fossiliferous and is overlain by about 4 meters of the "Spirifer sandstone."

From Basalt Haven, opposite Kap Herschel on the north shore of Clavering Ø, Buckland, in 1929, collected pieces of black limestone that are filled with *Strophalosia pulchella* and also include *Kochiproductus plexicostatus*.

From Dolomitdal we have the following fauna:

Streptorhynchus kempei
Liosotella vadosisinuata
Strophalosia pulchella
Kochiproductus plexicostatus
Camerophoria kochi
Spiriferella keilhavii

Wollaston Forland.

Along the southwestern border of Wollaston Forland the Permian beds are well developed and are closely comparable to those in Clavering Ø, except for the fact that the upper part grades over more and more into a reddish and brownish sandstone facies toward the north. This sandy facies was termed the "Red Series" by FREBOLD (1932, p. 8) who thought it might be separated by an important hiatus from the rest of the Permian (1932, p. 73). MAYNC (1942, p. 47) found it to intertongue with the normal Permian limestone toward the south (as at Koralbjerg on Clavering Ø) and he concluded that the "Red Series" is only a facies, a conclusion fully supported by our faunal study.

Permdal. Profile sections in Permdal and Brachiopoddal (fig. 14) well represent the Permian succession in this, the northernmost part

of the Permian basin in East Greenland. The section in Permdal (MAYNC, 1942, p. 46, fig. 14) begins with about 25 meters of non-bedded, reefy, light gray to yellowish dolomite, resting on pre-Caledonian metamorphics. This is followed by some 5 meters of typical "Productus limestone," a coquinite of brachiopods and bryozoa. From this unit MAYNC collected *Streptorhynchus kempei*, *Sowerbina rudis*, *Strophalosia pulchella*, *Waagenoconcha* sp., and *Cancrinella bolchovitinovae*, and he noted also *Derbyia* sp. and spirifers.

Platy reddish sandstone some 6 meters thick succeeds the "Productus limestone," and this basal part of the "Red Series" carries a fauna

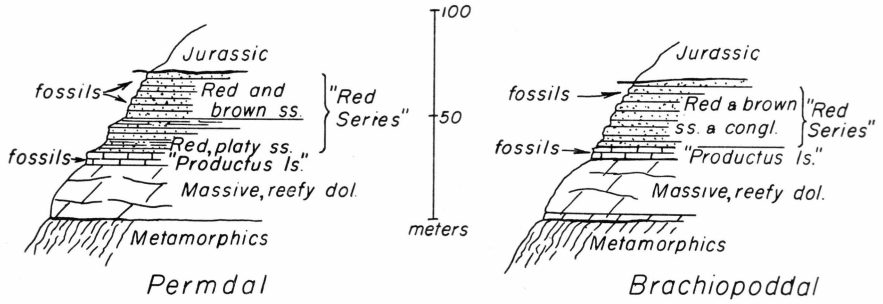

Fig. 14. Profile sections of the Permian strata in Wollaston Forland. Adapted from MAYNC (1942).

of pelecypods along with numerous brachiopods of the "Productus limestone" fauna. MAYNC mentions particularly *Productus weyprechti* [=*Muirwoodia greenlandica*] and *Productus konincki* and *P. cancriniformis* [=*Cancrinella bolchovitinovae*].

The succeeding 5 meters of bright red sandstone seems unfossiliferous here but corresponds with similar layers in adjacent sections (e. g. Permpasset) that bear *Spirifer striato-paradoxus*.

There follows 3 to 5 meters of interbedded red shale and red limestone, and then some 30 meters of brownish or light red calcareous sandstone, in part shaly and weak and in part thick-bedded. It is overlain by Jurassic sandstone and conglomerate.

From yellowish sandstone layers somewhere in the "Red Series" MAYNC collected blocks filled with *Cancrinella bolchovitinovae* and *C. germanicus*.

Brachiopoddal. This locality provides the most northerly good section of Permian strata in East Greenland. It was measured by MAYNC (1942, p. 43, fig. 12) and is shown in our figure 14. At the base, resting on pre-Caledonian metamorphics lies about 3 meters of platy, thin-bedded dolomite, and above this is 25 to 30 meters of reefy, non-bedded dolomite showing varied autogenic structures. In the lower part poorly preserved specimens of productids, bryozoa, and corals were seen. Above the

massive dolomite lies about 3 meters of typical "Productus limestone," a coquinite of brachiopods and bryozoa. From this bed MAYNC collected the following:

Streptorhynchus kempei
Strophalosia pulchella
Waagenoconcha payeri
Cancrinella germanicus
Spirifer striato-paradoxus

Above the "Productus limestone" there is about 30 meters of reddish and brownish, coarse-grained sandstone with some interbedded conglomerate. This upper sandy unit constitutes the "Red Series" of FREBOLD (1932, p. 8). Due to unfavorable weather and residual snow, MAYNC did not find fossils in the sandstones at this locality. However, on a previous occasion KOCH collected three lots "from the upper red sandstone just under the Jurassic" (LK 417, 418, and 426) in nearby Zechsteindal. The first of these is a crumbly drab sandstone, probably calcareous before weathering, bearing *Cancrinella bolchovitinovae* and *Euphemites* and other small gastropods. The second lot bears *Spiriferella keilhavii*, along with small clams and gastropods; and the last lot bears abundant *Cancrinella bolchovitinovae* and both small pelecypods and gastropods.

From nearby Sandstendal MAYNC collected from the "Productus limestone" beds the following fauna:

Streptorhynchus kempei
Strophalosia pulchella
Waagenoconcha payeri
Cancrinella bolchovitinovae
Cancrinella germanicus
Spirifer striato-paradoxus

Grænsedalen. This section, a few miles south of Permdal, was described by MAYNC (1942, p. 50, fig. 15) who made a number of collections from the "Productus limestone" which, as elsewhere, is rich in bryozoa and brachiopods. From these collections we identify the following:

Streptorhynchus kempei (cc)
Liosotella vadosisinuata
Krotovia nielseni
Waagenoconcha payeri
Kochiproductus plexicostatus
Sowerbina rudis
Cancrinella bolchovitinovae
Camerophoria kochi
Spirifer striato-paradoxus (c)

FACIES RELATIONS

From the preceding discussion it is evident that the Permian rocks of Central East Greenland include several strongly contrasting lithotopes each of which is marked by a distinct facies fauna.

Basal conglomerate. At the base of most of the western sections there is a reddish conglomerate that may be at least largely nonmarine. It has not yielded fossils, is commonly poorly bedded, and contains boulders of metamorphic and crystalline rocks evidently derived from the west. This basal conglomerate locally attains a thickness of possibly 100 meters in the Kap Stosch area but is generally not over 30 meters thick in the western sections and thins rapidly to the east and is completely lacking in the Nathorsts Fjord area and in Clavering Ø and Wollaston Forland. It rests generally on an old erosion surface of slight relief.

Massive and reefy dolomite banks. A second lithotope is a light gray to almost white dolomite that occurs chiefly in the lower half of the Permian sequence and in places abruptly succeeds the basal conglomerate, but where the latter is lacking it rests directly on the pre-Permian erosion surface of much older rocks. This dolomite commonly is poorly bedded and has been described as reefy or massive, and in places shows evidence of penecontemporaneous brecciation. Corals and brachiopods have been recognized in it locally but are commonly described as poorly preserved or obscure. The corals are small and solitary, and it is evident that this is not in any sense a coral reef deposit. It appears rather to represent calcareous reefy banks like those that are so prominent in the Permian of the Guadalupe Basin in Texas and New Mexico and have recently been so well described by NEWELL (1953). In places this massive and reefy dolomite includes "nests" or lenses of very pure white limestone like those noted by MAYNC on Productuselv in Clavering Ø, and such must have been the source of the "white blocks" in the Triassic conglomerates that overlie the Permian in the Kap Stosch area and in the southern part of Clavering Ø. Indeed, in the Productuselv exposures MAYNC found (1942, p. 32) that such lenses

of white limestone are filled with small pelecypods identical with those in the "white blocks" at Kap Stosch. The richly fossiliferous ledge of white limestone in the midst of the thick dolomite west of Schucherts Flod is probably another such lens, and its fauna is more closely identical with that of the "white blocks" than any other known.

The massive dolomite varies in thickness from section to section ranging from a maximum of about 100 meters west of Schucherts Flod, and in the Nathorsts Fjord area, to zero in many places. This facies is not represented in the north of Scoresby Land, in Traill Ø, and in the Kap Stosch area. It is thin at the southern edge of Clavering Ø but is locally nearly 100 meters thick in Productuselv in the east-central part of the Island. The relations about Schucherts Flod are illuminating. Here the basal red conglomerate is succeeded by about 100 meters of massive dolomite along the west side of the valley and by an equal thickness of gypsiferous shale on the east side only about 5 miles away. Here also along the bluffs west of the river the lower part of the dolomite grades laterally into lenses of white gypsum as much as 30 meters thick.

It is evident that this massive dolomite was deposited in reefy banks of rather local extent, probably standing somewhat above the adjacent seafloor and flanked by sediments of other types, the lateral change of facies being commonly abrupt. Where typically developed the bedding is obscure, but in some places (for example, in the Nathorsts Fjord area) equivalent deposits are described as light gray, well-bedded dolomitic limestone.

Gypsum. A third lithotope consists of thick lenses of massive white gypsum that lie in the lower part of the Permian sequence. These are quite local in extent, but reach thicknesses up to 30 meters and are associated with the massive and commonly brecciated "reefy" dolomite. Such a thick lens of gypsum occurs in the lower part of the dolomite west of Schucherts Flod and evidently graded eastward into the gypsiferous shale. Another thick lens was described by Maync (1942, p. 73) at the southern margin of Gauss Halvö in Koralkløft where it is underlain by gypsiferous shale and overlain by massive brecciated dolomite; and in very nearby exposures this part of the section is formed of interbedded yellowish platy limestone and "banks" of darker, porous dolomite (see fig 8). The gypsum was, of course, deposited as a result of evaporation in temporarily barred basins, and it may be inferred that these were very shallow embayments associated with the calcareous reefy banks.

Posidonia shale. A fourth lithotope consists of the so-called Posidonomyaschiefer, for which we shall use the name *Posidonia shale.* This platy, bituminous shale varies from dark gray to black. Much of

it is unfossiliferous but certain layers are full of fossils. The fauna, however, is a very restricted and specialized one. The byssiferous clam, *Posidonia permica* NEWELL, occurs locally in great abundance plastered over certain of the bedding planes, and elsewhere appears as scattered specimens; plant fragments are present at several places; and fossil fish and fish scales are abundant locally. The fish fauna described by NIELSEN (1932 and 1935) and by ALDINGER (1937) was secured largely from certain layers in this shale in a zone about 35 meters below the top of the Permian in the Kap Stosch area (fig. 10). The belemnite, *Dictyoconites greenlandica* FISCHER, was found also in abundance in certain limy layers in this black shale in the Kap Stosch area and in several localities in the southern part of Clavering Ø (FISCHER, 1947).

It may be noted that this fauna includes no benthonic organisms. The belemnites and the fishes were free swimmers and the byssiferous clam may have lived attached to seaweeds. The scattered plant fragments, of course, had drifted. The large residue of carbonaceous material in the sediment must reflect a deficiency of oxygen at the bottom, as does the absence of benthonic animals. It is inferred that these black shales formed in the deeper parts of the Permian basin in which density stratification prevented aeration of the bottom water.

Martiniakalk. A fifth lithotope is the so-called *Martiniakalk*, a steel-gray to dark gray well-bedded, fine-grained limestone that is commonly associated with the Posidonia shale. Its fauna is limited and specialized but is quite distinct from that of the black shale. Its commonest and most widely distributed fossil is the brachiopod *Martinia greenlandica*, but it also carries the smooth chonetid, *Paeckelmannia toulai.* In the typical Martiniakalk no other brachiopods are commonly found and no bryozoans are present. Both nautiloids and ammonites have been found in a few places but they are generally rare and poorly preserved. It was in this facies, in the slopes of Brinkley Bjerg near the southern margin of Clavering Ø that *Cyclolobus kullingi* (FREBOLD) was found associated with *Medlicottia malmquisti* FREBOLD. Pelecypods and gastropods are both lacking or very rare. In short, this dark, carbonaceous limestone has a very limited benthonic fauna suggesting that it was laid down in areas deficient in oxygen. It commonly intertongues with and laterally replaces Posidonia shale and was apparently deposited where the bottom conditions were only a little less inhospitable than where the black shale formed.

"*Productus limestone.*" A sixth lithotope is the so-called *Productus limestone* which occurs normally as a bed or a group of beds not more than 4 or 5 meters thick, but of considerable areal extent, intercalated in one of the other facies. It is a medium gray, well-bedded limestone

commonly more or less argillaceous and with shaly partings. It tends to weather light gray. These beds are a virtual coquinite made of the shells of brachiopods and bryozoans. The brachiopod fauna is a relatively large and varied one with several genera of productids and of spiriferoids. The most characteristic forms are the large productids, *Kochiproductus plexicostatus*, *Sowerbina maynci*, and *Sowerbina rudis*, the smaller productid *Muirwoodia greenlandica*, and the spiriferoids, *Spiriferella keilhavii* and *Spirifer striato-paradoxus*. The large fauna collected about Kap Stosch is from this facies.

The "Productus limestone" commonly occurs as a thin unit intercalated in the midst of the Posidonia shale, or in the Martiniakalk. In many localities a single unit of this fossiliferous limestone is present, but in some places it is low in the section (e. g. fig. 12) and in others high (e. g. fig. 9). In a few places MAYNC found two zones of "Productus limestone," one low and another high in the same section (see MAYNC, 1942, p. 6). The occurrence of such richly fossiliferous beds in the midst of the relatively barren Martiniakalk and Posidonia shale suggests that it was formed during a relatively short episode when the stagnant bottoms had become "sweetened" and well aerated, so that brachiopods and bryozoans could thrive luxuriantly. Such a temporary change in bottom conditions probably cannot be attributed to a change in depth of water but rather to some alteration of the threshold of the Permian basin which allowed bottom circulation. A good many features of the Permian deposits indicate that they were formed in a nearly landlocked epeiric sea rather than on an open shelf. We suggest that the concentration of fossils on certain bedding planes in the Posidonia shale is the result of some catastrophe that killed large numbers of the organisms living in the water above the bottom. This may have resulted from a temporary upset of the density stratification and the rise of toxic water from the bottom.

"*Red Series.*" A seventh lithotope is the "Red Series" of reddish and brownish sandstone that forms the upper part of the Permian section in Wollaston Forland (fig. 14). It includes calcareous sandstone beds that are richly fossiliferous, but its fauna differs largely from that of any of the other facies. The one extremely abundant brachiopod is the small productid, *Cancrinella bolchovitinovae* MIRCHINK. Small gastropods and pelecypods are abundant locally. Some layers carry large numbers of *Spirifer striato-paradoxus*.

Although FREBOLD (1932, p. 16) for a time thought this to be a distinct series, younger than the rest of the Permian in East Greenland, MAYNC (1942, p. 47) showed that it intertongues southward with the upper half of the normal Permian sections in Clavering Ø. We

have found also that the brachiopod, *Cancrinella bolchovitinovae* is abundant at many other localities and at various horizons in the Permian sequence in East Greenland.

Mixed lithologies. Besides these well-defined lithotopes there are some places where beds of an intermediate character occur. In the Nathorsts Fjord area, for example, the upper half of the Permian sequence is dark and shaly but with numerous calcareous interbeds, and apparently both shale and limy beds are fossiliferous. The fossils from both types of lithology represent a modified "Productus limestone" fauna. The shale is more calcareous than is normal for the Posidonia shale, and the limestone beds are darker than is normal for the "Productus limestone" and they are repeated at intervals through a considerable thickness of the shale. A comparable situation appears from STAUBER's notes (personal communication) to exist in northern Scoresby Land (fig. 4) where somewhat more than 100 meters of the upper part of the section consists of dark but sandy and marly shale with beds of black limestone that are rich in brachiopods, especially of species of *Liosotella.* This unit rests upon a thick bed of typical Posidonia shale. Apparently in these areas the bottom ecology hovered about a critical condition that led to the accumulation of much carbonaceous matter yet repeatedly permitted an influx of benthonic organisms and the deposition of calcareous mud.

"White blocks" in the Triassic conglomerates. The "white blocks" that occur in the Triassic conglomerates in the Kap Stosch area have a distinctive lithology and fauna, neither of which is represented in the underlying Permian section. They have undoubtedly come out of the reefy dolomite facies, and were derived from the west. The fauna consists almost entirely of brachiopods and small pelecypods. Distinctive features of the brachiopod fauna are: the predominance of *Pleurohorridonia scoresbyensis*, *Dielasma elongatum*, *Spiriferina multiplicata*, and *Rhynchopora kochi;* and the presence of *Odontospirifer mirabilis.* The most closely similar fauna found elsewhere is that in the midst of the massive dolomite west of Schucherts Flod. There also, *Pleurohorridonia scoresbyensis* occurs in amazing abundance along with the other species mentioned above. Save for the "white blocks" this is the only known occurrence of *Odontospirifer. Streptorhynchus stoschensis* is abundant here and rare or absent in other localities. The faunal resemblance is strengthened also by the absence in the "white blocks" and in the white limestone at Schucherts Flod of many of the productids that are ubiquitous in the "Productus limestone."

On the contrary, no pelecypods were found in the large collection from Schucherts Flod. MAYNC records the fact, however, that in a white

limestone in the thick massive dolomite on Productuselv in Clavering Ø there are lenses of white limestone bearing pelecypods identical with those in the "white blocks." These are obviously facies faunas indigenous to the big dolomite banks. The "white blocks" could not have come either from the south or the northeast, but almost certainly were transported from an area of post-Permian uplift west of Kap Stosch. It may be inferred that a fringing reef extended northward along the western shore zone from the locality west of Schucherts Flod to some point north of the latitude of Kap Stosch, or that an independent reefy bank developed west of Kap Stosch and Clavering Ø, in which this particular biotope found a hospitable environment.

Summary. These several facies of the Permian deposits of Central East Greenland are lateral equivalents one of another, and they intertongue and are interbedded in such a complex fashion as to prove that neither has any distinctive time relations. The "Productus limestone" fauna which includes nearly all the brachiopods of the region occurs at various horizons in different sections, indicating that this fauna thrived wherever and whenever the bottom ecology was favorable. Both the stratigraphy and the faunal study indicate that all the Permian beds of this area are closely related in age and represent but a small part of the Permian System.

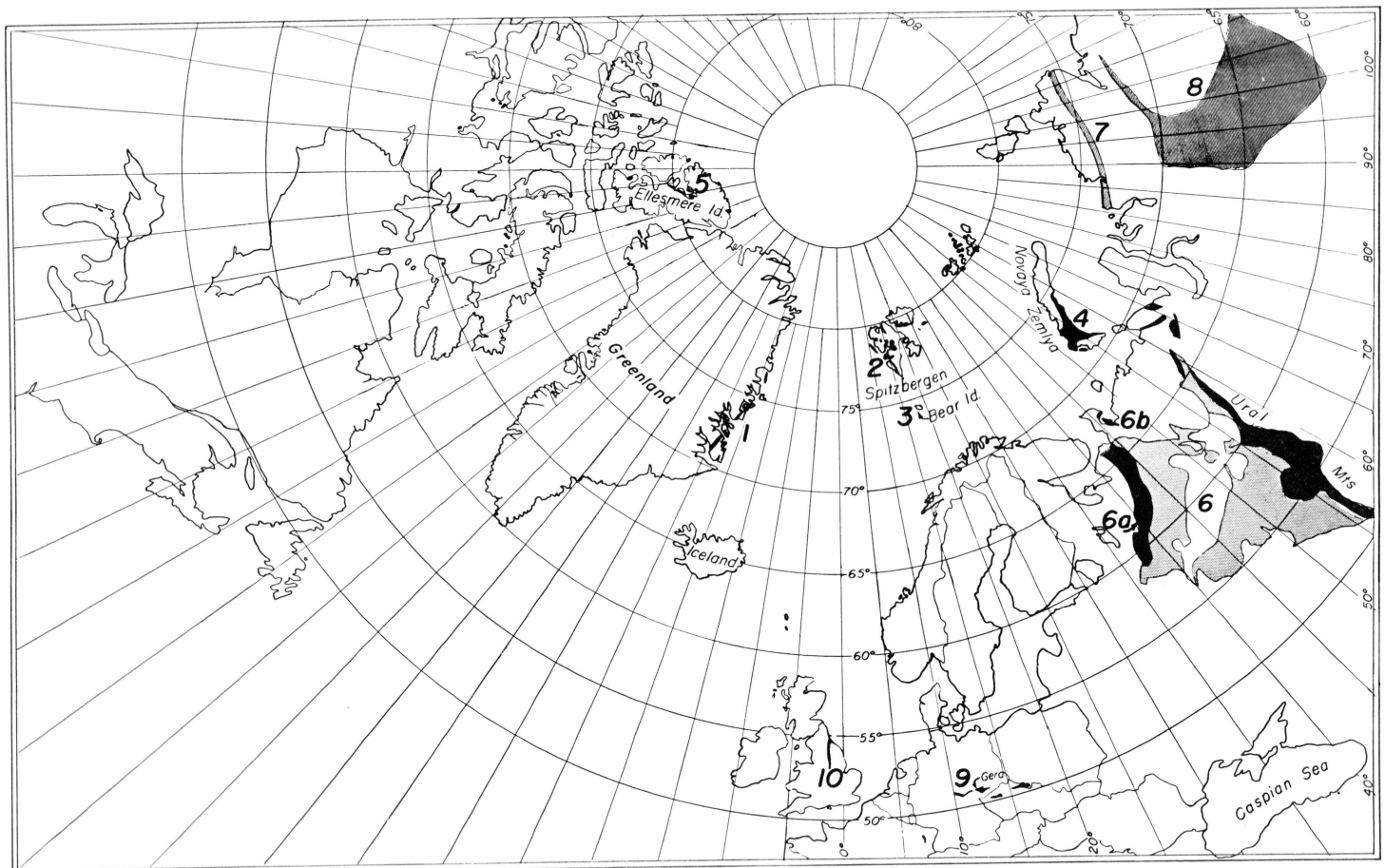

Fig. 15. Map showing the chief outcrops of Permian rocks in the Arctic Region and Europe. 1, Central East Greenland; 2, Spitzbergen; 3, Bear Island; 4, Novaya Zemlya; 5, Ellesmere Island; 6, the great Permian Basin of European Russia; 6a, Zechstein outcrops (solid black) of the Pinega Valley; 6b, Zechstein outcrops in Kanin Peninsula; 7, Taimyr Peninsula; 8, Central Siberia; 9, East Central Germany (Roth-liegendes and Zechstein deposits); 10, Midlands of England (Magnesian limestone).

AGE AND CORRELATION

Historical. As shown in figure 15, Permian rocks are widely distributed in the Arctic Region. Most of these areas were visited by early explorers who brought back small collections, and several of them have been visited repeatedly during the present century. The earliest to yield fossils was Bear Island which was discovered by BERENTZ in 1596 and was visited repeatedly during the 17th century by hunters in search of walrus. In 1827 one of these expeditions was accompanied by the naturalist KEILHAU, who collected a few fossils that were described in 1846 by VON BUCH as *Spirifer keilhavii.* The first fossils from Spitzbergen were described by KONINCK in 1847 and were correctly stated to be Permian. In 1873 RICHARD VON DRASCHE brought back collections from the southern point of Spitzbergen and from a locality farther north on the west coast, and these were placed in the hands of FRANZ TOULA at Vienna who named and described several species (TOULA, 1873, 1874, 1875).

BELCHER picked up a loose block of white limestone at "Depot Island, Albert Land" from which SALTER, in 1855, described the large mid-Permian species, *Fusulina hyperborea* [*Schwagerina hyperborea*].

In 1856 HAUGHTON described a small collection from the north coast of Bathurst Island also far to the west of Ellesmere Island. It had been secured by MCCLINTOCK during his search for the ill-fated ship of Sir JOHN FRANKLIN. This lot included the types of the oft-cited *Productus borealis* HAUGHTON.

Important studies were made in Novaya Zemlya as early as 1895 when TSCHERNYSCHEW recognized a considerable development of "Kohlenkalk," now regarded as, at least in part, Permian rather than Carboniferous.

Central East Greenalnd was the last of the important areas of Permian rocks in the Arctic to be discovered. Marine beds, believed at the time to be Upper Carboniferous or Lower Permian, were observed somewhat farther north (in Amsdrup Land and Holm Land) during the Danish Expedition of 1906—08, when J. P. KOCH and A. WEGENER found beds they thought to be equivalent to the "*Omphalotrochus-Cora-*

Schwagerina beds" of Russia. These were named the Mallemuk formation by GRÖNWALL in 1917 when he described from them a fauna of 26 species.

It was not until 1926 that LAUGE KOCH began his discoveries of the Permian strata of Central East Greenland that form the basis of the present study. During the following years, 1926—1939, these beds were studied by Dr. KOCH and numerous field assistants who mapped the scattered outcrops along a 250-mile belt of rugged terrain, measured many profile sections, and made large collections of fossils. Results of the field work were published piece by piece as the work progressed, but as knowledge grew rapidly and ideas were changing frequently, especially with respect to age and correlation, many of these reports required revision. A very excellent summary by MAYNC (1942) covered the stratigraphy of about half the area but did not include Scoresby Land or the Nathorsts Fjord area.

Many of the fossils were studied by FREBOLD as they were brought in, and most of the species were described by him (FREBOLD, 1931, 1932, 1933). However, his work was largely in the form of progress reports based on limited collections, and they, too, reflect rapidly changing conceptions of age relations.

Since Dr. KOCH has transmitted to me for a more comprehensive monographic study all the collections, totaling over 130 drawers of fossils, it is not surprising that FREBOLD's work has required extensive taxonomonic revision. No other area of the Arctic Permian has yet received so much field study or has yielded such extensive collections of well-located fossils as Central East Greenland. It is hoped that with completion of this faunal study the region may serve as a useful standard for Permian correlation in the Arctic.

Inherited difficulties. Studies of the Arctic Permian faunas have been plagued by three things. First is the inevitable result of the pioneer work in a region so difficult of access. A number of species were described by the early writers on the basis of small, fragmentary collections, in part poorly preserved, brought back by explorers who were not geologists, who had no opportunity to study the stratigraphic relations, and who were content to pick up hurriedly a few pieces of fossiliferous rock. At the time these early descriptions were published the Permian faunas were still largely unknown and neither the taxonomic work or the facilities for illustrating the fossils were acceptable according to modern standards. Thus, for example, *Productus borealis* of HAUGHTON was based on a poor internal mold of a large productid and was illustrated by very crude figures. In the writer's opinion it is quite impossible to be certain of the genus represented, and attempts to recognize

the species amount to futile guesswork. The originals of some of TOULA's species, likewise, are subject to great uncertainty. Yet later workers seem to have felt obligated to recognize all these early and controversial names. The result has been the use of the same name by different workers for quite different fossils and attempts at correlation based on names that have no certain meaning.

Above all else, study of the Arctic Permian faunas continued to be handicapped by inadequate descriptions and illustrations. With very few exceptions, new species have been named on the basis of inadequate material, descriptions have consisted of brief descriptive notes, and the original illustrations have been too few and too poor. Even most of the recent literature is inadequate and in much of it the illustrations are so poor as to be almost useless. As a result, critical evaluation of much of the literature is really hopeless. One writer after another has tried to interpret the species named by others and the result in many instances has been to compound confusion. The urgent need is for monographs with adequate descriptions and good illustrations, and fewer inadequate redescriptions.

A second obstacle has been that for many years following publication of TSCHERNYSCHEW's magnificent work, "Die Oberkarbonischen Brachiopoden des Urals und des Timans," it was the one great comprehensive monograph available for comparison of the Arctic brachiopod faunas, and most students identified their fossils as TSCHERNYSCHEW's species and made their correlations accordingly.

It should be noted that TSCHERNYSCHEW *assumed* that his fossils were Upper Carboniferous rather than Permian. Nowhere in his great work did he attempt an evaluation of the data as did KARPINSKY (1889) when he shifted the Artinsk beds to the Permian on the basis of their ammonite faunas. Following KARPINSKY, Russian geologists as well as those of other countries, almost without exception, accepted the Permian age of the Artinsk, but for nearly a quarter of a century the limestones of the Ufa Plateau continued to be regarded as Upper Carboniferous, following TSCHERNYSCHEW. But between 1920 and 1940 various Soviet geologists were persuaded that the limestones of the Ufa Plateau were, at least in large part, equivalent in age to the Artinsk, but in a different facies. Meanwhile the lower part of the original Artinsk—the zone of *Pseudoschwagerina*—was separated by RUZENCEV as the Sakmarian Stage. It is now widely (but not unanimously) accepted as the basal unit of the Permian. The matter was reviewed by DUNBAR (1940) following the Permian field trip and Symposium of the 17th International Congress. Meanwhile the influence of TSCHERNYSCHEW's work led to the assignment of the Permian beds of East Greenland to the Upper Carboniferous until after 1930.

Yet a third factor has delayed a correct evaluation of the Greenland faunas. It is but natural that comparison should be sought with the faunas of the classic Permian section west of the Urals; but unfortunately the lower part, only, of that sequence (Sakmarian and Artinskian) bears a normal marine fauna. In its type region, the Kungurian is a great salt-bearing series, essentially barren of fossils; the Kazanian bears a restricted fauna (without fusulines or ammonites or any great variety of brachiopods) in the area about Kazan and grades eastward into nonmarine deposits about Perm; and the higher part of the section (Tartarian) in the great Permian Basin consists of nonmarine redbeds. As a result of this circumstance, almost any normal marine Permian fauna of the Arctic region would necessarily show more resemblances to the Lower Permian (Sakmarian and Artinskian) than to the higher part of the type Permian. This impression was strengthened when various workers identified fossils from the Arctic region with TSCHERNYSCHEW's species, purely on the basis of a general (commonly generic) resemblance that does not stand up under critical modern scrutiny.

For these varied reasons we have found that most of the names previously used for the Greenland species are not valid, and the majority of them are described below as new, the reasons being given in each case in the taxonomic discussion. It is hoped that by thus clearing away the incubus of taxonomic uncertainty and confusion, the fauna has been identified and described with sufficient clarity so that others working in other areas may judge with confidence whether they are dealing with species that occur in Greenland.

It is unfortunately true that the faunas in Central East Greenland include no fusulines and but very few ammonites, and that they completely lack such specialized Permian genera as *Aulosteges*, *Leptodus*, *Scaccihnella*, and *Richthofenia*. For some unknown reason they also completely lack such productid genera as *Linoproductus* and *Dictyoclostus* both of which are otherwise so widely distributed throughout both the Upper Carboniferous and Permian of the world.

Zechstein age of the Greenland faunas. The Zechstein formation of Central East Germany (especially near Gera), like its equivalent, the Magnesian limestone of the eastern Midlands in England, has a marine fauna of brachiopods, bryozoans, and pelecypods, and has also yielded a considerable fish fauna. All of these groups of fossils are represented in the Permian beds of Greenland.

The rather rich fish fauna collected from the Posidonia shale in the Kap Stosch area and adjacent parts of Clavering Ø, has been studied by NIELSEN and by ALDINGER. NIELSEN's taxonomic study of 1932 described 5 species, representing as many genera, of bradyodonts, plus

fragmentary paleoniscid remains. And in 1935 (p. 106) he compared the fauna with that recently described by E. B. BRANSON from the Posphoria of Wyoming. His final conclusion (p. 108) that the fish beds in Greenland are overlain "by an immense zone of *Martinia* limestone, in the upper part of which Artinsk ammonites occur" needs correction. These ammonites were restudied by MILLER and FURNISH (1940) who recognized one of the 2 species involved as belonging to the genus *Cyclolobus* otherwise known only in the highest marine zone in the Salt Range section of India. MILLER and FURNISH concluded that the Greenland beds in question belong very high in the Permian. ALDINGER (1937) described the ganoid fishes of the Posidonia shale, of which he recognized 7 species representing as many genera and 7 families. Some of these are rather large and are well preserved. In a discussion of the correlation of the Posidonia shale ALDINGER (1935) noted that none of the genera from the German Zechstein occur in Greenland yet in view of all the evidence he concludes (p. 18) "Zusammenfassend ist also zu sagen, dass die Ganoidfauna der Posidonomyaschiefer eine Zechsteinfauna ist." And in 1937 he stated (p. 11) "Die unten beschriebene Fischfauna ist ihrer Zusammensetzung nach eine typische Zechsteinfauna."

Although FREBOLD's early studies of the Greenland faunas (1931a) proceeded on the assumption that they were Upper Carboniferous, ROSENKRANTZ, in 1929, had argued that a brachiopod fauna he had studied from the "white blocks" in the Triassic conglomerate near Kap Stosch were of Zechstein age, and he listed as Zechstein species

Streptorhynchus pelargonatus SCHLOTHEIM
[= *S. stoschensis* n. sp.]
Dielasma cf. *elongatum* SCHLOTHEIM
Spiriferina cristata SCHLOTHEIM

In 1931, FREBOLD studied a pelecypod fauna from certain of the "white blocks" from the same area (1931b) and indicated that they were of Zechstein age, closely related to the Magnesian limestone fauna of England and the type Zechstein of Germany. As evidence he cited the following species:

Schizodus cf. *obscurus* SOWERBY
Schizodus schlotheimi GEINITZ
Schizodus planus GOLOWK [KAZANIAN]
Pseudomonotis speluncarea SCHLOTHEIM
Pseudomonotis cf. *speluncarea* SCHLOTHEIM
Liebea hausmanni GOLDFUSS
Bakevellia antiqua MÜNSTER
Bakevellia cf. *ceratophaga* SCHLOTHEIM
Solemya aff. *normalis* HOWSE

Yet in this study FREBOLD expressed doubt of the Permian age of ROSENKRANTZ's brachiopods which he believed came from different blocks and were Upper Carboniferous.

However, in the same year (1931 c) FREBOLD published again on fossils from the "white blocks" and in this paper accepted the Zechstein age of both pelecypods and brachiopods. He then recognized from the "white blocks" the following Zechstein species:

Productus horridus SOWERBY
Spirifer cf. *alatus* SCHLOTHEIM
Spiriferina multiplicata KING
Dielasma elongatum SCHLOTHEIM
Athyris pectinifera SOWERBY
Streptorhynchus pelargonatus SCHLOTHEIM
Astartella tunstallensis KING
Schizodus aff. *truncatus* KING
Macrodon striatum SCHLOTHEIM
Clidophorus cf. *pallasi* DE VERNEUIL
Pleurophorus costatus BROWN
Pseudomonotis radialis PHILLIPS
Bakevellia ceratophaga SCHLOTHEIM
Lima permiana KING
Polytropis helicina KING
Macrochilina symmetrica KING

About half of the listed forms were originally described from the Zechstein of Germany and the rest from the Magnesian limestone of England. It may be noted that NEWELL's recent restudy of all the pelecypods from Greenland changes some of these identifications but fully confirms the Zechstein age.

In a stratigraphic section of this paper (p. 19—24) FREBOLD tried to group the fauna of individual "white blocks," some of which he regarded as of Lower Zechstein age, some as Middle, and some as Upper Zechstein. We are convinced that all the "white blocks" are of one faunal assemblage and cannot be so separated.

FREBOLD then gave brief attention (p. 24—26) to the Depot Island formation of the Nathorsts Fjord area from which fossils had become available, and indicated that it, too, was of Zechstein age.

The next year, FREBOLD (1932 a) published on faunas from the reddish sandy beds that comprise the upper part of the Permian sections in Wollaston Forland. These beds he concluded (p. 73) constitute a separate stratigraphic unit of Permian age, for which he introduced the term, the "Red Series," and which he stated is sharply separated from

the underlying "Brachiopodenkalk and Kalkdolomit" which he still regarded as Upper Carboniferous. (For relations see our fig. 14.)

In 1932, also, FREBOLD published on the discovery of two specimens of ammonites from the upper part of the Martiniakalk on the slope of Brinkley Bjerg in the southern part of Clavering Ø (see our fig. 12). These he named *Medlicottia malmquisti* and *Godthabites kullingi* respectively. The former was a very large species of *Medlicottia*, and on the basis of this genus he considered the age to be Artinskian. The second species was based on a juvenile specimen which he recognized as belonging to the family Cyclolobidae and which in the stage of its septal evolution compared most closely with *Perrinites* of Texas (also of Artinskian age). Subsequently more specimens of this species were collected by MAYNC and by NIELSEN, and MILLER and FURNISH (1940) found among these adult specimens of *G. kullingi* which prove it to be more advanced than the juvenile whorls of the holotype suggested and show it to belong to the genus *Cyclolobus* which is otherwise known only from the highest marine zone of the Permian in the Salt Range of India. MILLER and FURNISH therefore concluded that the age of these beds in the Martiniakalk is Late Permian and far younger than the Artinskian.

In 1933 FREBOLD published again on the fauna of the "white blocks" in the Triassic conglomerates of the Kap Stosch area and indicated that their source must have been in an area of uplift directly west of Kap Stosch. But he continued to attempt to distinguish among these blocks 3 faunal groups, one of Upper Carboniferous age ("or of Lower Permian in the sense of Schuchert and others") and two of Upper Permian age (one Early Zechstein, and one Early Middle Zechstein). To the first of these (Upper Carboniferous or Lower Permian) he referred *Productus porrectus* [= *Kochiproductus plexicostatus* DUNBAR], *Streptorhynchus kempei* ANDERSSON, *Productus* aff. *konincki*, and *P. cancriniformis* [*Cancrinella bolchovitinovae* MIRCHINK], and *Spirifer* "*cameratus* MORTON—*condor* D'ORBIGNY" [=*Spirifer striato-paradoxus* TOULA].

To the Lower Zechstein fauna he referred *Productus horridus* var. *initialis* EISEL var. *granuliferous* TOULA [both = *Pleurohorridonia scoresbyensis* DUNBAR], *Athyris pectinifera* [= *Cleiothyridina pectinifera* D'ORBIGNY], *Streptorhynchus* cf. *pelargonatus* SCHLOTHEIM [= *S. stoschensis* DUNBAR], *Dielasma elongatum* SCHLOTHEIM, *Pleurophorus costatus* BROWN, *Lithodomus permianus* FREBOLD, and *Pseudomonotis sparsicostata* FREBOLD.

To the Early Middle Zechstein fauna he referred *Productus horridus* var. *hoppieanus* EISEL [= *Pleurohorridonia scoresbyensis* DUNBAR].

Our restudy of these specimens, along with all the other collections from the Permian beds of the region, has convinced us that no such

separation is permissible. These are all parts of one faunal complex and all these species may be found associated in various parts of the section in East Greenland.

In this work FREBOLD was undoubtedly influenced by EISEL's study (1906) of the evolution of *Productus horridus* in the region about Gera. In that paper EISEL recognized a series of faunal zones in the Zechstein, based on 7 varieties of this protean species (see our discussion of *Pleurohorridonia scoresbyensis).* FREBOLD recognized 2 of these, var. *initialis* and var. *hoppeianus*, in the "white blocks" of Greenland and assumed that they indicated distinct parts of the Zechstein. Fortunately I have before me hundreds of specimens from a single bed in the section west of Schucherts Flod in which the varied forms recognized by FREBOLD are represented; and I also have before me in the collections in Peabody Museum at Yale several suites of fossils made by GEINITZ in the Zechstein section about Gera. In these German collections it is easy to recognize the several varieties named by EISEL, but none of them is identical with the Greenland forms.

MAYNC *(1942) has shown that the Permian deposits of Central East Greenland form a single stratigraphic group or series, differentiated into several distinct lithofacies that intertongue and interlock in such a complex fashion as to prove that they are all closely related in age, and our faunal study completely confirms this interpretation. The faunal differences from place to place and from bed to bed are due to facies and not to age differences. Except for a few rare forms such as Crania and Orbiluloidea, every species of the brachiopods studied is associated with every other species in the fauna in one place or another.*

Equivalence of the Greenland Permian beds with the Zechstein is indicated by such general faunal characteristics as the dominance of the productid tribe of the horridonias *(Sowerbina* and *Pleurohorridonia)* and by the presence of several specific identities. Not all the Zechstein species mentioned by ROSENKRANTZ and by FREBOLD have been confirmed by the present study. The form they identified as *Streptorhynchus pelargonatus* SCHLOTHEIM, for example, is certainly distinct from the German species and is herein described as *S. stoschensis* n. sp. And the forms identified by FREBOLD as *Horridonia horridus* var. *initialis* and var. *hoppeianus* are included in our new species *Pleurohorridonia scoresbyensis.* Since the outcrops of the Magnesian limestone of England are at least 1000 miles from East Greenland, and the Zechstein outcrops in Germany are more than 1500 miles away, it is not surprising that the faunas differ considerably in specific composition even if they are contemporaneous. But there are several species that appear to be identical when compared directly with specimens from the type Zechstein. Of these, one of the most significant is *Spirifer* [*Pterospirifer*] *alatus* SCHLOT-

HEIM, a highly specialized and delicately ornamented species in which distinctions should be easily detected but in which shells from Greenland and Germany appear to be indistinguishable. It may be noted that this species was found in abundance only in the Nathorsts Fjord area, but that it is present also in the *Pleurohorridonia* bed west of Schucherts Flod and about 40 miles west of Nathorsts Fjord. It was identified also by FREBOLD in one of the "white blocks" in the Triassic conglomerate near Kap Stosch.

Another Zechstein species is *Spiriferina multiplicata* KING found in abundance in the "white blocks" and in the *Pleurohorridonia* bed west of Schucherts Flod and, less abundantly, elsewhere. In both the "white blocks" and the bed west of Schucherts Flod it is associated with another Zechstein species, *Dielasma elongatum* SCHLOTHEIM, which is less common elsewhere. *Punctospirifer cristata* (SCHLOTHEIM) is another Zechstein species that occurs also in Greenland but is generally rather scarce. *Cleiothyridina pectinifera* D'ORBIGNY is abundant in the Nathorsts Fjord area and is fairly common in some other areas.

Finally it must be noted that several of the species that have commonly been identified with forms described from the Sakmarian or Artinskian of Russia are generically related but are clearly not specifically identical and do not justify correlation with those horizons. Such, for example, are *Kochiproductus plexicostatus* (distinct from "*Productus*" *porrectus* KUTORGA), *Muirwoodia greenlandica* (distinct from "*Productus*" *mammatus* von KEYSERLING), and *Sowerbina rudis* (distinct from "*Productus*" *timanicus* STUCKENBERG).

Relations to other northern areas.

Spitzbergen and Bear Island lie less than 800 miles to the east-northeast, and both have yielded faunas closely allied to those of Greenland.

Spitzbergen. This island has a thick Late Paleozoic section that has been studied by NATHORST (1910), HOLTEDAHL (1913), ORVIN (1940), and FREBOLD (1951), and its faunas have been described by WIMAN (1914), FREBOLD (1937), and STEPANOV (1937).

Although the island was probably completely covered by Late Paleozoic strata, subsequent deformation and erosion, plus an extensive cover of Mesozoic deposits, has reduced their outcrops to irregular and, in part, disconnected areas. These are well shown on the geologic map of ORVIN. The section is thicker and probably more complete in Spitzbergen than elsewhere in the Arctic region, probably exceeding 1000 meters. The sequence varies in thickness and in lithology in different

parts of the islands. Thick sections have been measured at the Festungsprofil at the entrance to Isfjord, near the middle of the west coast, and in Billen Bay at the head of Isfjord which is about 80 km east of the Festungsprofil and near the center of the island. HOLTEDAHL recognized 4 major divisions of these beds in Spitzbergen, as follows:

4. Productus-bearing siliceous shale
3. Spirifer limestone
2. Cyathophyllum limestone
1. Basal conglomerate

In Billen Bay where the base is well exposed, WIMAN measured a basal unit of red sandstone about 96 meters thick. He found the Cyathophyllum limestone to be 440 meters thick with gypsum lenses in the upper part as thick as 30 meters. This limestone may have a considerable stratigraphic range and its faunas are still not adequately known. HOLTEDAHL (1911) described a fauna of 21 species from the lower part which he believed to be Middle Carboniferous (Moscovian) and from which he cited *Choristites mosquensis*. However, FREBOLD (1951, p. 60) thinks this is not the Middle Carboniferous species, but a younger one.

About 400 feet above the base of the Cyathophyllum limestone there is intercalated a thin zone of fusulines from which WEDEKIND and VON STAFF in 1910 described 4 species as follows:

Schubertella transitoria WEDEKIND and STAFF
Schellwienia [= *Schwagerina*] *andersoni* SCHELLWIEN
Schellwienia [= *Triticites*] *nathorsti* n. sp.
Schellwienia [= *Triticites*(?)] *arctica* SCHELLWIEN

They recognized that this horizon would fall low in the "Schwagerina" horizon of the Russian section, which then was considered Upper Carboniferous but is now commonly placed at the base of the Permian. These fusulines certainly indicate correlation with the basal part of the Sakmarian stage of the Permian Basin of the U.S.S.R. and of the Wolfcamp series in America. This zone could not possibly be as old as Middle Carboniferous. HOLTEDAHL believed that the fusulines are not confined to a constant horizon in the Cyathophyllum limestone. FREBOLD (1951, p. 60) recognized a Cora limestone overlying the Cyathophyllum limestone locally along the west coast of Spitzbergen and from this zone he cited several species that were described by TSCHERNYSCHEW from the "Schwagerina" horizon of the Ufa Plateau. It appears possible that all the Cyathophyllum limestone would now be placed in the basal Permian. In any event, its faunas have nothing in common with Central East Greenland.

The Spirifer limestone, on the contrary, shows a striking faunal resemblance to the Greenland Permian. WIMAN described and illustrated the following fauna in 1914:

Streptorhynchus macrocardinalis TOULA
Streptorhynchus triangularis WIMAN
**Streptorhynchus kempei* ANDERSSON
Chonetes capitolinus TOULA
Chonetes mølleri TSCHERNYSCHEW
Productus weyprechti TOULA
Productus inflatus MCCHESNEY
**Productus purdoni* DAVIDSON [= *Waagenoconcha payeri* TOULA]
Productus aagardi TOULA
Productus konincki DE VERNEUIL
Productus loveni WIMAN
Productus fasciatus KUTORGA
Productus elegans MCCOY
**Productus porrectus* KUTORGA [= *Kochiproductus plexicostatus* n. sp.]
Productus pseudohorridus WIMAN
**Productus timanicus* STUCKENBERG [= *Sowerbina maynci* n. sp.]
x*Productus impressus* TOULA
Dielasma plica KUTORGA
Hemiptychina sublævis WAAGEN
Rhynchopora nikitini TSCHERNYSCHEW
Camerophoria crumena MARTIN
Athyris royssiana TSCHERNYSCHEW
x*Spiriferina expansa* TSCHERNYSCHEW
x*Spiriferina saranae* DE VERNEUIL
**Spiriferina keilhavii* VON BUCH [= *Spiriferella*]
x*Spiriferina draschei* TOULA
x*Spiriferina polaris* WIMAN
Spirifer fasciger KEYSERLING
**Spirifer ravana* DIENER [= *S. striatoparadoxus* TOULA]
x*Spirifer loveni* WIMAN
Reticularia lineata MARTIN

The starred species occur also in Greenland. On the other hand there are a number of very distinctive species in this fauna that have not been seen in Greenland. Notable among these are the species marked

with a cross, any one of which could not have been overlooked if it were in our collections.

FREBOLD (1951, p. 60) listed 10 species from the "Spirifer limestone" on the south side of Horn Sound and of these half occur also in Greenland. These are the ones starred in the list above with the exception of *Spiriferella keilhavii* that was not recorded.

STEPANOV (1937) also described a collection from the Isfjord area that was made by KOTLUKOV and LUTKEVICH in 1932, largely from the "Spirifer limestone" and the "Siliceous shales," but his illustrations are in large part inadequate and some of his identifications difficult to accept. He concluded, however, that these beds are younger than Artinskian and should correlate with the Kungurian and Kazanian as well as with the "Productus limestone" and the Martiniakalk of Greenland.

HOEL and ORVIN (1937) gave a detailed section of the siliceous beds at the mouth of Isfjord where they have a thickness of some 200 meters and consist largely of siliceous shale but with intercalated limestones at various horizons. One of these they identify as the "Spirifer limestone," though it is not at the base of the shale but within it and nearly 100 meters above the top of the "Cyathophyllum limestone." From the limy beds in the upper part of the shale they identified, among other things, *Productus porrectus* [probably = *Kochiproductus plexicostatus*], *Spiriferella keilhavii*, and *Spirifer* cf. *alatus* [probably *Pterospirifer alatus* (SCHLOTHEIM)].

It was clearly from the "Spirifer limestone" or from one of these limy beds in the "Siliceous shales" that TOULA described so many species in 1873—75.

In summary, it now appears evident that the "Spirifer limestone" and the "Siliceous shales" of Spitzbergen may be contemporaneous facies and that they correlate approximately with the Permian beds of Greenland, and with the Zechstein of Germany. It is also clear that the *Cyathophyllum* limestone is older and is not related to any part of the Permian of Central East Greenland.

Bear Island. The late Paleozoic strata on Bear Island have been described by HOLTEDAHL (1919) and by HORN and ORVIN (1928). The lower part of the section seems to correspond to the *Cyathophyllum* limestone of Spitzbergen and the upper part of the Spirifer limestone. The latter is exposed in the slopes of Mt. Misery and carries a rich brachiopod fauna. It was here that KEILHAU collected specimens in 1827 that were made the types of *Spirifer keilhavii* by VON BUCH. Here also was secured the fauna described by WIMAN in 1914 and from which he identified the following:

Streptorhynchus kempei Andersson
Productus weyprechti Toula [= *Muirwoodia greenlandica* n. sp.]
Productus inflatus McChesney [? = *Pleurohorridonia scoresbyensis* n. sp.]
Productus purdoni Davidson [= *Waagenoconcha payeri* Toula]
Productus konincki de Verneuil
Productus timanicus Stuckenberg [= *Sowerbina maynci* n. sp.]
Productus impressus Toula
Spiriferina keilhavii von Buch [= *Spiriferella keilhavii* (von Buch)]
Spirifer fasciger Keyserling
Spirifer ravana Diener [= *S. striatoparadoxus* Toula]
Spirifer marcoui Waagen [= *S. striatoparadoxus* Toula]
Reticularia lineata Martin

Wiman's rather good illustrations show all these species to be decidedly larger than their counterparts in Greenland, some of them 20 % to 50 % larger. The difference in size is so striking that we were at first dubious of the identity of the species from Bear Island. We also considered the possibility that by some inadvertence the original plates were not correctly reduced by the engraver, but this proved to be untenable, for not only does the explanation of the plates state that all figures are natural size, but in the few instances where measurements are cited in the text they agree with the figures. It appears likely, therefore, that because of some ecological factor this fauna reached larger size in the shallow waters of Bear Island than in either Greenland or Spitzbergen.

Novaya Zemlya. The Late Paleozoic rocks of this large island have been studied by a number of geologists, but the most important works are by Holtedahl (1924), Samvilovich (1935), Miloradovich (1935), Licharew (1937), and Licharew and Einor (1939).

Miloradovich described the collections made by Samvilovich from various parts of the island during his expeditions of 1927—31. He concluded that the several faunas represented range in age from Lower Carboniferous to Lower Permian. His illustrations indicate nothing in common with the Permian faunas of Central East Greenland.

The faunal study by Licharew and Einor covered a large number of collections from both the west and the east coasts of both Northern

Island and Southern Island. They expressed difficulty in distinguishing Late Carboniferous from Early Permian faunas and explained that the structure of the region is complex and the stratigraphy not yet well known. They concluded, however, that the many collections studied were either Late Carboniferous or Early Permian. Examination of their faunal lists and of their many plates of illustrations of the faunas indicates nothing in common with our Greenland faunas with the exception of one locality, their outcrop No. 86, from the west coast of Northern Island. From this they identified only a single species which they described as *Productus (Horridonia) borealis* (HAUGHTON). It must be abundant at that locality for they illustrate it with two plates of figures. It is almost certainly the form we have described as *Pleurohorridonia scoresbyensis*, and recalls the occurrence of this species in such abundance in the outcrops west of Schucherts Flod in Scoresby Land. We infer that this single locality includes strata that will correlate with the Permian of Greenland.

Pinega Valley, U.S.S.R. Along the western border of the Permian Basin of the U.S.S.R. there is a belt of strata of Kazanian-Zechstein age (6a in fig. 15) from which the faunas were studied by MIRCHINK (1938). It runs south along the Pinega Valley and beyond to Kirillov, and includes a lower unit of dark gray, sandy and platy marls and an upper one of light gray marl and limestone. The fauna of some 55 species of brachiopods is more varied than that of the type Kazanian which lies farther to the south and east in the Permian Basin. This, MIRCHINK believes, is due to the fact that the Pinega region had "a closer connection with the open arctic Upper Permian sea."

To judge by the faunal list (MIRCHINK, 1938, p. 333) the fauna of these beds is largely different from that of Greenland. Only a few of the species are illustrated or described. However, the new species, *Productus* [= *Cancrinella*] *bolchovitinovae* MIRCHINK, appears to be identical with the one that is so common in certain facies in Greenland, and the form illustrated as "*Productus* sp. undt no. 1" appears to be *Cancrinella germanicus* (FREBOLD). A few of the other species resemble forms from Greenland and might prove to be identical on close comparison, but many of the distinctive species of the Pinega region are quite unlike anything in our faunas.

The fauna of the type Kazanian is even less like the Greenland faunas, probably because it lived far within an interior seaway in which a normal marine fauna was severely restricted.

Kanin Peninsula. Up the strike to the north of Pinega Valley, Permian beds crop out along the southern coast of Kanin Peninsula (6b of fig. 15). Brachiopods collected from this area by EDEMSKY in

1929 were studied by FREDERICKS and the pelecypods by REVUNOVA (FREDERICKS, 1934). FREDERICKS listed 42 species and varieties of pelecypods and brachiopods, and concluded that the age is Upper Permian, probably Kungurian. His taxonomy and terminology is frustrating, but his illustrations indicate the presence of a *Sowerbina* much like our *S. maynci* (which he identifies as *Ruthenia granulifera typica* FREDERICKS) and another form much like our *S. rudis* (which he identifies as *Ruthenia granulifera* morpha *gibbosa* FREDERICKS). It is possible that these will prove to be identical to our species, but the illustrations are too crude and the descriptions inadequate to justify a decision.

In this paper FREDERICKS commented on FREBOLD's paper of 1931 in which 26 species were described from Central East Greenland, suggested different identifications for most of the species (table on his page 33)—most of which we cannot accept—, and concluded that the Greenland fauna was Permian (Kungurian) rather than Carboniferous and was closely related to the fauna in the Kanin Peninsula.

Taimyr Peninsula. In this region (7 of fig. 15) EINOR (1939) has estimated that there is a thickness of about 150 meters of Late Paleozoic strata, all Lower Permian. His monograph on the fauna of some 45 species of brachiopods indicates nothing in common with the Greenland faunas.

Ellesmere Land. Ellesmere Island was visited by PER SHEI while a member of the Second Norwegian Polar Expedition of the "Fram" in 1898—1902. He brought back important collections of Late Paleozoic fossils from two localities, Great Bear Cape in the southwest coast and a locality near the north tip of Heibergs Island. These were described by TSCHERNYSCHEW and STEPANOV in 1919. In 1950 JOHN TROELSEN made a more extended study of the stratigraphy, especially in the Greely Fjord area of the west-central part of Ellesmere Land, and published a geologic map of the entire area. In the Greely Fjord area he found Middle Carboniferous (Moscovian) beds about 160 meters thick overlain disconformably by some 700 meters of Early Permian beds, mostly impure limestones alternating with shales, but with biostromes of brachiopods and bryozoans, and conglomerates including fragments of chert, sandstone and limestone. These faunas have not yet been described but TROELSEN characterizes them as being Early Permian (Wolfcampian).

The fauna described by TSCHERNYSCHEW and STEPANOV included sponges, corals, bryozoans, and brachiopods plus a few pelecypods. Forty species of brachiopods were described and figured and almost all of them were identified with forms previously described by TSCHERNYSCHEW from the Lower Permian of Russia ("Omphalotrochus, Cora

and Schwagerina" beds and Artinskian). For the most part they are unlike anything in the Greenland faunas. Two species were identified—mistakenly, I believe—with forms that occur in East Greenland. These were "*Spiriferella keilhavii*" and "*Spiriferella parryana.*" In my judgment the real *Spirifer parryana* TOULA, from Spitzbergen is a junior synonym of *Spirifer keilhavii* VON BUCH from Bear Island. (The name is also a junior homonym of *Spirifer parryana* HALL and is therefore invalid.) The specimen shown by TSCHERNYSCHEW and STEPANOV as figures 4a—c of their plate 11 is quite unlike the species described by TOULA. The ones shown as figures 1—3 of their plate 12 is probably generically but not specifically related to the true *S. parryana* TOULA [= *S. keilhavii* VON BUCH].

We conclude that the known faunas from Ellesmere Land are Lower Permian and distinctly older than those of Central East Greenland.

Relations to other regions.

Alaska. Permian deposits are known to occur in many places in Alaska, and extensive collections made by the U. S. Geological Survey over a period of many years are now under monographic study, but, as yet, these faunas are almost wholly undescribed. The Alaskan Permian formations were probably formed in the seaway that extended southward through Northwest Territories and British Columbia to the state of Washington and in which the Cache Creek group was formed. Fusulines studied by DUNBAR (unpublished) indicate a stratigraphic range for the Cache Creek group from basal Permian (with *Pseudoschwagerina*) to high Permian (with *Yabeina*). Part of these fusulines have been described by DUNBAR (1932), by THOMPSON and VERVILLE (1950), and by THOMPSON, WHEELER, and DANNER (1950). DUNBAR (1946) also described *Parafusulina alaskensis*, of Artinskian age, from Kuiu Island in the Panhandle of Alaska. The brachiopods, however, have never been described though GIRTY in several places has made tentative identifications involving comparisons with species described by TSCHERNYSCHEW. Since the brachiopods of Alaska and Western Canada are undescribed, and the Permian deposits of Central East Greenland have yielded no fusulines, we have, as yet, no basis for correlation between these regions.

Western United States. The well-known section of the Guadalupe Basin in Trans-Pecos Texas and New Mexico serves as a standard Permian section for this region and has probably the most complete marine sequence known anywhere. Its brachiopod faunas are relatively well known through the works of GIRTY (1909) and of ROBERT E. KING

(1932) and are familiar to the writer who has in his care large collections from this region. However, this region belongs to a faunal province that must have been completely cut off from the Arctic seaways and its faunas are totally unrelated to those of East Greenland. Since the generic compositions of these faunas in the Western United States is so different from that of the East Greenland faunas it is doubtful whether the few specific resemblances have much signifiance in correlation. It may be noted, however, that *Productus guadalupensis* GIRTY from the Capitan limestone is a *Muirwoodia* very similar to *M. greenlandica*, as is also *Productus multistriatus* MEEK of the Phosphoria formation in Utah and Wyoming. *Productus popei* SCHUMARD, also of Capitan age, rather closely resembles our *Liosotella grandicosta.*

On the basis of the general character of its faunas, and of correlation through other parts of the world, it is believed that the Permian formations of Central East Greenland are not older than the Word formation of the Guadalupe Basin and may be as young as the higher part of the Guadalupian Series.

The Permian Basin, U.S.S.R. As indicated in the discussion of the Arctic outcrops the closest faunal ties with the type section of the Permian are with the Kazanian, earlier correlation with the "Uralian" by many workers notwithstanding.

India. The identification of the large spirifers of East Greenland with *Spirifer marcoui* WAAGEN of the Lower "Productus limestone" of the Salt Range, and with *Spirifer ravana* DIENER from the high Himalaya would seem to imply close faunal relations of Greenland with this remote region 4000 miles or more away. The writer has had the opportunity of making direct comparison with a large and finely preserved collection from the Salt Range, and is convinced that *Spirifer marcoui* WAAGEN has only a superficial resemblance to *S. striato-paradoxus* TOULA from Greenland, and it is difficult to see any basis whatever for mistaking any of the Greenland specimens for *S. ravana* DIENER. Such identifications with remote forms, based on superficial resemblance, serve no useful purpose and only confuse the problem of correlation.

If there is any basis for a correlation with India it would be the presence in the upper part of the Greenland sequence of a species of the ammonite genus *Cyclolobus* which is otherwise known only in the highest marine zone of the Salt Range. The Greenland species is distinct from this one in the Salt Range, however, and does not imply a precise correlation though, since it is based on an advanced stage in the septal evolution in a well-known family of ammonites, it strongly indicates that the Greenland Permian is high in the system.

SYSTEMATIC PALEONTOLOGY

Crania sp. A.

Plate 32, figure 1.

A single small dorsal valve of this species was found in White Block No. 6 in the Triassic conglomerate near Kap Stosch. Its size and shape are illustrated in figure 1 of plate 32. The surface is sculptured by very fine radiating lirae each of which is nodose and which in part appears to be rather a row of nodes instead of a rib.

Collected by NIELSEN (N 6).

Crania sp. B.

Plate 32, figures 2, 3.

A single specimen of a second species is shown by figures 2 and 3 of plate 32. The exterior of the dorsal valve is well preserved (but not illustrated) and is smooth except for faint growth lines. The dorsal valve parted from the matrix and the interior is well preserved (fig. 2), revealing the characteristic muscle scars of the genus *Crania*. Since this is a unique specimen there is no assurance that it is mature.

It differs from Sp. A in being subquadrate in outline and in having a smooth surface.

Collected by NIELSEN from a "white block" in the Triassic conglomerate near Kap Stosch (N d).

Orbiculoidea sp. A.

Plate 32, figures 4, 5.

From a single "white block" in the Triassic conglomerate near Kap Stosch, KOCH collected several specimens of this species all of which occur as natural molds. Two of the best are illustrated on plate 32 at natural size and enlarged 2 diameters. Figure 5 shows traces of the characteristic muscle scars and of the vascular sinuses. Bits of the shell indicate a lamellar structure and external molds show a concentric ornamentation on the dorsal valve consisting of sharply raised lirae separated by flat interspaces.

Genus **Streptorhynchus** KING, 1850.

Streptorhynchus KING, Paleontographical Soc., Mem. 3, 1850, p. 107.

Diagnosis. Orthotetids having a twisted or deformed ventral beak resulting from early attachment. Hinge teeth strong but without dental lamellae or a median septum.

Generotype, *Terebratulites pelargonatus* SCHLOTHEIM.

Streptorhynchus kempei ANDERSSON.

Plate 1, figures 1—13; plate 32, figures 9, 10.

Streptorhynchus kempei ANDERSSON, in Wiman, Nova Acta Reg. Soc. Sci. Upsala, ser. IV, v. 3, no. 8, 1914, p. 58, pl. 10, figs. 22—27; pl. 11; pl. 12, figs. 1-8; pl. 13, figs. 11—13.

FREBOLD, Meddel. om Grønland, Bd. 84, no. 2, 1931, p. 19, 41, pl. 6, figs. 1—3.

Description. The following description is based upon about 50 specimens, mostly incomplete, from a score of collections in East Greenland. Comments on the types described by ANDERSSON from Spitzbergen and Bear Island are reserved for the discussion.

Individual variation is so great in this fine species that it is difficult to write a definitive description. As a result of attachment during early growth, the ventral beak is commonly distorted and, while normally neatly pointed, may be bluntly truncated. In most shells the greatest width is near the mid-length and slightly exceeds the width at the hinge line. In such shells the cardinal extremities form an obtuse angle, but one may be angular and the other rounded or both may be rounded. Few of the shells show perfect bilateral symmetry. In our best specimens the cardinal area is 3 to 4 times as wide as high and is apsicline and nearly flat. The dorsal valve is rather strongly convex and a little deeper than the ventral (fig. 10 of pl. 32). The specimens shown as figures 3, 4, 12, and 13 of plate 1 have the dorsal valve displaced at the hinge line and flattened by crushing.

The surface is marked by closely crowded costellae that multiply by intercalation and increase in size very gradually so that fine and coarse costellae of several generations alternate. The costellae are bold but rounded and are separated by flat striae. About 20 costellae occur in a space of 1 cm. Sharp varices of growth are common but are irregularly spaced.

In the collection are several specimens that were worn and abraded before burial, and in these the surface appearance has been greatly altered, giving the impression that the costellae were finer and more equal in size than those of well-preserved shells.

Internally the appearance of the ventral valve changes greatly with age. Young shells (fig. 2 of pl. 1) are thin, have the muscles lightly

impressed, and show vascular markings outside the muscle field. These young shells also show stout hinge teeth which leave a blunt ridge under each side of the deltidium, but dental lamellae are lacking, even at a very early stage. Before reaching half adult size the posterior part of this valve begins to thicken (fig. 10 of pl. 1), and at maturity the space under the hinge plate is almost entirely filled and the muscle scars are deeply impressed (figs. 9 and 11 of pl. 1). Although the anterior half of such a valve remains normally thin, the posterior part may attain a thickness of at least 1 cm. In young shells the adductor scars are clearly distinguishable as a slender impression arising close to the beak and extending forward between the diductors, tapering to a point at the front margin of the latter. In older shells the adductor scars are scarcely distinguishable, and the diductors are large and strongly lobed. In these, however, there is much individual variation in size and shape and in the details of lobation.

The dorsal valve remains normally thin even when mature. It possesses a relatively large orthotetinoid cardinal process that projects back under the ventral cardinal area (figs. 7, 8 of pl. 1). The adductor scars occupy a cardiform area in front of the crural lamellae of the cardinal process (figs. 6, 7 of pl. 1).

The range of size and shape is indicated by the figures on plate 1 and on plate 32.

Discussion. The identification of this Greenland species with ANDERSSON's *S. kempei* from the "Spirifer limestone" of Spitzbergen and Bear Island needs confirmation. Our shells agree with the latter in size, which is exceptional for the genus, and in the excessive thickness of the ventral valve. In both regions the much thinner dorsal valve is known chiefly from fragments, and the ventral valves show an exceptional amount of variability. In such a case the details of surface sculpture might be expected to offer the best check on specific identity. Unfortunately, however, only one of the many specimens figured by ANDERSSON shows the surface, the rest being mostly interiors of ventral valves, and the one showing the exterior was rather obviously deeply corroded and poorly preserved as to surface details. Description of the surface was limited to two sentences to the effect that the external sculpture consists of fine angular [schärfruckigen] striae of which 13 occupy a space of 1 cm over the middle of the shell, and that they increase by interpolation. In our beautifully preserved shells the costellae are rough but not angular, and at least 20 occupy a space of 1 cm over most of the surface. This would seem to be a significant difference. On the other hand, although the surface appears poorly preserved in ANDERSSONS' figure 24, fine costellae are clearly indicated and more than

13 per cm can be recognized. It appears likely, therefore, that, because of poor preservation, the surface sculpture was misinterpreted by ANDERSSON. This seems the more probable because some of our shells that had been abraded before burial resemble the one figured by ANDERSSON.

Distribution. Found near Kap Stosch, Hold with Hope Land (LK 4, 10); from River 9 east of Kap Stosch (N 38); between Rivers 13 and 14 east of Kap Stosch (N 48); from Djævlekløften (LK 7, 20) and Dolomitdal (LK 37) on Clavering Ø; and from Brachiopoddal (LK 410, 606), from Grænsedalen (LK 8), Carbon River (LK 8a, 601), and from Breccia River (ROSENKRANTZ coll., LK 622) on Wollaston Forland. Also found in White Blocks no. 92 and no. 93 in the Triassic conglomerate east of Kap Stosch.

The species was described from the "Spirifer limestone" in Bear Island and in Spitzbergen.

Streptorhynchus stoschensis DUNBAR, n. sp.

Plate 2, figures 1—15; plate 32, figures 6—8.

Streptorhynchus pelargonatus FREBOLD [*non* SCHLOTHEIM], Meddel. om Grønland, Bd. 84, no. 3, 1931, p. 11, pl. 1, figs. 5—11.

This small species occurs in abundance in the "white blocks" of Permian limestone in the Triassic conglomerates.

The adult size and shape are well represented by figures 6 and 10 to 15 of plate 2. Figures 1 to 4 are enlarged views (X2) of two young specimens (also shown at natural size). These enlargements show well the character of the sculpture, but exaggerate its coarseness.

The ventral beaks normally are extended and acutely pointed, the cardinal area being at least as high as wide; but they are almost invariably distorted and unsymmetrical. The lack of symmetry generally affects the whole of the ventral valve or even the whole shell. The dorsal valve is gently convex and neither valve displays a fold or sulcus. The hinge line is straight and somewhat less than the greatest breadth of the shell.

The deltidium is highly convex and bears a median groove. It is bordered by a perideltidial area somewhat broader than the remainder of the cardinal area.

Surface sculpture consists of fine and narrowly rounded costellae separated by narrow striae. The costellae increase by intercalation, and upon reaching normal size continue without further enlargement. As a result the costellae appear more even than is common in this genus (e. g. figs. 5 and 11 of pl. 2).

Inside the ventral valve the hinge teeth are stout but dental lamellae are lacking (pl. 32, fig. 7). Muscle scars are so lightly impressed that they cannot be clearly delineated in any of several silicified and etched specimens available for study.

The cardinalia of the dorsal valve are shown in figure 8 of plate 32. The myophores of the cardinal process are slender and slightly divergent. The crural lamellae curl around under the sockets, attaching to the side of the valve.

Discussion. Although FREBOLD identified some of the Greenland shells as *S. pelargonatum* SCHLOTHEIM (1931, p. 11, pl. 1, figs. 5—11), comparison with abundant material from the Zechstein limestone of Germany shows that they are quite distinct. SCHLOTHEIM's species has a distinct ventral fold and dorsal sulcus, both of which are lacking in our species, its dorsal valve is more strongly arched, and its costellae are distinctly coarser and more unequal.

The form figured by TSCHERNYSCHEW (1902, pl. 26, figs. 6, 7) as *S. pelargonatus* resembles ours rather closely but was neither described nor illustrated sufficiently to permit critical comparison.

Distribution. This is one of the common species in the "white blocks" in the Triassic conglomerates of the Kap Stosch area whence more than 100 specimens were collected. It is common also in the fossiliferous limestone in the midst of the massive dolomite west of Schucherts Flod. It was collected in the Nathorsts Fjord area by STAUBER (coll. II, 326) whence a partly silicified chunk of limestone yielded some 50 free specimens, and in the southern part of Clavering Ø where it is rather rare. It was not found in the collections taken *in situ* in the outcrops about Kap Stosch.

Genus **Derbyia** WAAGEN, 1884.

Derbyia sp. A.

Plate 2, figures 16—20.

?*Streptorhynchus crenistria* TOULA [*non* Phillips], k. Akad. der Wiss. zu Wien, Sitzungsber., Math.—Naturw. Cl., Bd. 68, 1873, p. 274, pl. 3, figs. a, b.

Description. This species is represented in our collections by only a half-dozen specimens divided among three localities. Its size and shape are indicated by the figures on plate 2. The ventral valve was nearly flat or even slightly concave toward the front, and its cardinal area was low. The deltidium was moderately convex and without a median groove.

The dorsal valve was apparently rather gently and evenly convex with a low and ill-defined umbo, but each of our specimens is either

somewhat crushed or otherwise defective so that the amount of convexity cannot be accurately determined.

The surface is sculptured by costellae that multiply by intercalation and increase gradually in size so that finer and larger ones of several generations alternate. Distinct varices of growth are irregularly distributed, being more common on the mature part of the shell.

Inside the ventral valve the muscle field is divided by a rather thick median septum and is bounded at the front and sides by a raised rim (figs. 16 and 17 of pl. 2). Dental lamellae are lacking.

The interior of the dorsal valve is not fully known. A single internal mold of this valve, somewhat imperfect at the hinge line, indicates that the muscle scars are too lightly impressed to be distinguishable and that the crural lamellae supporting the cardinal process are low and widely divergent.

Discussion. In a superficial way these shells resemble *Derbyia buchi* d'Orbigny from the Lower Permian of Bolivia, *Derbyia regularis* Waagen from the Middle Productus limestone of the Salt Range, *Derbyia altestriata* Waagen from the Upper Productus limestone, and young specimens of *Derbyia grandis* Waagen. It is improbable that the Greenland form is identical with either of these but our material is inadequate to justify a critical comparison.

Distribution. Found along Grænsedalen, in Wollaston Forland, by Koch (LK 8) and at "basalt hook" on the north coast of Clavering Ø (LK 1028). Our best specimen was received without a label but in association with material of similar lithology from Djævlekløften on Clavering Ø (LK 7?).

Genus **Chonetina** Krotow, 1888.

Chonetina Krotow, Comité Géol., Mem., v. 5, 1888, p. 500.

Diagnosis. Chonetids with a strongly arched ventral valve bearing a deep, narrow, median sulcus which is matched on the dorsal valve by a narrow median fold. Surface radially lirate.

Generotype *Chonetina artiensis* Krotow.

Chonetina noe-nygaardi Dunbar, n. sp.

Plate 31, figures 1—3.

Description. The size and shape of this very small species are indicated by the smaller photographs in figures 1 to 3 of plate 31, the enlargements being added to show details.

The ventral valve is strongly arched, its umbo rather full but the posterolateral wings nearly flat, and its middle bearing a narrow and moderately deep sulcus. Three or 4 minute cardinal spines appear on each half of the posterior margin.

The dorsal valve follows the contour of the ventral, but the substance of each valve is relatively thick for a shell of such small size. The inner surface of the shell is abundantly pustulose and the outer surface is radially lirate, the lirae appearing rather coarse and rough for a shell of this size.

Discussion. This species is comparable in size to *C. spitzbergiana* (TOULA) (TOULA, 1874, p. 149, pl. 1, fig. 10) and may possibly prove to be the same. Unfortunately TOULA's specimens were exfoliated and, as he states, show only a trace of radial striae. His specimens are more transverse than ours and the sulcus of the ventral valve widens more toward the front so that the lateral humps of the shell diverge at an angle of about 40° whereas in our shells they appear to be almost parallel.

It is inferred that the figured types are mature rather than juvenile, first of all because the largest ones are subequal in size, and second because the shell substance of each valve is relatively quite thick.

Distribution. In our collections this appears as a rare species represented at only 10 localities. Its rarity may, however, be more apparent than real, for it would be easily overlooked in the field. It was found in the "Productus limestone" in the Kap Stosch area (LK 28, 273, 631; N 45a) and in the area west of Schucherts Flod in southern Scoresby Land (STAUBER) and in northern Scoresby Land by BERTHIER (his profile 1, bed 8, and profile 4, bed 8). A fine specimen was found also in White Block no. 5 in the Triassic conglomerate 3 miles east of Kap Stosch.

Genus **Paeckelmannia** LICHAREW, 1936.

Tornquistia PAECKELMANN [*non* Reed, 1896], Abh. Preuss. Geol. Landesaustalt, n. s., v. 122, 1930, p. 218.

Paeckelmannia LICHAREW, Zittel's Grundzüge der Palaeontologie (Russian Ed.), 1936, p. 509, footnote.

Diagnosis. Chonetids of normal contour but with a smooth rather than a striate surface.

Generotype, *Leptaena (Chonetes) polita* MCCOY.

Discussion. In proposing *Tornquistia* as a subgenus of *Chonetes*, PAECKELMANN recognized that the smooth surface is a specialized rather than a primitive feature. He further noted that WAAGEN had proposed to separate smooth species of *Chonetes* into 2 groups: (a) the group of *Chonetes politus* MCCOY, having normal chonetid proportions, and (b) the group of *Chonetes geinitzianus* WAAGEN having a broad ventral sulcus and a corresponding dorsal fold. The former makes its appearance in the late Devonian and is more common in the Lower Carboniferous but ranges up into the Permian; the latter appears later and is especially

characteristic of the high Upper Carboniferous and the Permian. DUNBAR and CONDRA (1932, p. 168) concluded that the two groups are independent in their origin, the later one probably having developed out of *Mesolobus*. They therefore emended *Tornquistia* to include only species of the group of *C. politus*. LICHAREW later noted that REED had previously used the name *Tornquistia* for a trilobite and proposed the new name, *Paeckelmannia*, for the chonetid.

It should be noted that in discussing the genus, PAECKELMANN considered the shell to be punctate.

As DUNBAR and CONDRA later explained, the pseudopunctae which he observed are only the result of internal papillae.

Paeckelmannia toulai DUNBAR, n. sp.

Plate 3, figures 1—8.

?*Chonetes capitolinus* TOULA, Neues Jahrbuch für Min., 1875, p. 26, pl. 8, figs. 9a, b.

Description. Representative specimens of this small smooth species are shown on plate 3 at natural size and at enlargement of 2 diameters. The maximum width is about 12 mm and the length 7 to 8 mm. In the majority of specimens the cardinal extremities form almost right angles (e. g. figs. 1 and 2), but in some (e. g. figs. 5 and 6) the sides converge gently forward and the cardinal extremities are acute. The shell is thin and the curvature rather low. The middle of the ventral valve normally bears a very shallow sulcus (as in fig. 5), but in some well-preserved specimens the sulcus is very faint or lacking (fig. 2), and in a single one of many (fig. 3) a low fold occupies the middle of the valve. The latter is believed to be an individual abnormality. The cardinal spines are very small and are directed laterally and backward at a low angle (20°—30°) from the hinge margin.

In the surface ornamention there is a strange disharmony, the surface of the dorsal valve bearing distinct though faint radial lirae, whereas that of the ventral valve is perfectly smooth except for occasional fine varices of growth. The inside of each valve is studded with radial rows of fine papillae, as is common in the chonetids, and in some of our best preserved specimens the shell is translucent so that these internal papillae can be seen from the exterior. In exfoliated shells the pseudopunctae resulting from these papillae give the impression of a faint radial sculpture, but many well-preserved specimens show clearly that the ventral surface was quite smooth.

The interior of the ventral valve is shown in figure 8 and of the dorsal in figure 7.

Discussion. This species resembles *Chonetes capitolinus* TOULA in shape and in its smooth surface, and may prove to be the same. How-

ever, TOULA's species is very imperfectly known and his types were more than twice as large as any of the Greenland shells. We have well over 100 specimens derived from varied lithotopes and from many localities, and none are larger than the figured specimens. TOULA's types were from the white "Spirifer limestone" in western Spitzbergen. One of these has a width of 29 mm and the other of 24 mm. The description is very brief and gives no information as to the dorsal valve or the interior. WIMAN (1914, p. 62) mentioned seeing the species in a collection in the Reichsmuseum at Stockholm, but he did not describe or figure it.

Chonetes morahensis WAAGEN is similar in size to our species and is smooth, but its ventral sulcus is much more prominent than in the Greenland shells. *C. ambiensis* WAAGEN is narrower, more strongly arched, and is without a trace of a ventral sulcus. *P. novozemliaensis* LICHAREW is also proportionately narrower than our species, and is evenly arched with no trace of a fold and sulcus.

Distribution. This species is especially at home in the Martiniakalk where it occurs locally in abundance, especially in the southern part of Clavering Ø (MAYNC's collections from Brinkley Bjerg, Sneugleelv, and Fiskeelv). It occurs in abundance also in the calcareous shales and in the "Productus limestone," as in KOCH's collections LK 17, 18, 29, 70, 273 and NIELSEN's collections 22 and 24 in the Kap Stosch area.

Genus **Cancrinella** FREDERICKS, 1928.

Cancrinella FREDERICKS, Comité Géol., Bull., v. 46, no. 7, 1928, p. 784, 791.

Diagnosis. Generally small productids with small, thin, and commonly wrinkled auricles. The surface is covered by fine radial lirae. The ventral valve bears many small spines that arise out of the shell at a low angle but may become erect after emerging. There are no large or specialized cardinal spines. The dorsal valve is spineless. The ventral valve is commonly strongly arched, but is not geniculate.

Generotype, *Productus cancrini* DE VERNEUIL.

Discussion. FREDERICKS proposed this genus for striato-spinose productids of the type of *P. cancrini* DE VERNEUIL, *P. koninckianus* KEYSERLING, *P. villiersi* D'ORBIGNY, and *P. cancriniformis* TSCHERNYSCHEW. In the same paper FREDERICKS proposed the genus *Cora* with the generotype *Productus cora* D'ORBIGNY. It also has an ornamentation of radial lirae or very fine costellae but has relatively few, long, erect spines on the ventral valve. Earlier in the same year CHAO had proposed the genus *Linoproductus* with the same generotype, *Productus cora*

D'ORBIGNY. Subsequent workers have, therefore, rejected *Cora* as a synonym of *Linoproductus*, and many have also considered *Cancrinella* to be a synonym of *Linoproductus*. We believe, however, that, although closely allied, there are two distinct generic groups involved. Species of the genus *Cancrinella* are always small, and have very thin and delicate shells. They have very numerous but very slender spines on the ventral valve, and these run along for some distance in the substance of the valve and then leave it tangentially before turning out. There are no specialized cardinal spines.

In *Linoproductus*, on the contrary, the species are usually larger and commonly much larger, the substance of the shell is thicker and the spines are sparsely scattered, they arise at right angles to the surface, and are relatively long. Furthermore, there is a row of relatively large cardinal spines on the ventral valve.

If this distinction be granted generic value, the two species described next fall unquestionably into *Cancrinella*.

Cancrinella bolchovitinovae (MIRCHINK).

Plate 3, figures 9—20.

Productus bolchovitinovae MIRCHINK, Akad. Nauk. Studies of the Geol. Inst., v. 7, 1938, p. 322, 340, pl. 2, figs. 10—12.

Productus (Linoproductus) cf. *konincki* FREBOLD [*non* de Verneuil], Meddel. om Grønland, Bd. 94, no. 8, 1931, p. 18, pl. 1, figs. 1—5; FREBOLD, Skr. om Svalbard og Ishavet, no. 69, 1937, p. 34, pl. 11, figs. 12, 12a, 13.

? *Productus (Linoproductus) cancrini* STEPANOV [*non* de Verneuil], Trans. Arctic Inst., U.S.S.R., v. 76, 1936, pl. 3, figs. 4—6.

Description. A small species with a thin and delicate shell, ornamented by very fine costellae and a large number of slender spines. In the majority of our shells the ventral valve appears almost hemispherical, being strongly and evenly arched, having small auricles and lacking any trace of a sulcus. However, some specimens, presumably fully grown, have continued to grow forward after reaching their normal width (e. g. figs. 12 and 20 of pl. 3) and appear long and slender. The added length constitutes a trail, for the dorsal valve is nearly flat over the visceral disc (fig. 11) and is rather sharply geniculate where it meets the curvature of the ventral valve. It is noteworthy that the trail grew long without increasing appreciably in width.

Concentric rugae are variably developed, appearing chiefly about the margin of the visceral disc of the dorsal valve and on the posterolateral slopes of the ventral umbo and the auricles, dying out over the ventral surface. Spines are thickly scattered over the entire surface of the ventral valve, but are especially concentrated on the lateral slopes over the auricles. The spines arise from the summits of the costellae

and the latter are commonly enlarged for a short distance in front of the spine base so that at first glance it might be inferred that the spines are tangential to the surface. Partly exfoliated shells show that the spines were embedded within the shell for some distance before turning abruptly outward to leave it at approximately a right angle. There were no specialized cardinal spines, and the dorsal valve was spineless. The spines were probably between 5 and 10 mm in length.

Discussion. MIRCHINK's description of this species is brief and his figured specimens were somewhat imperfect, but in every respect with which we can make comparisons our shells seem to agree fully with his.

Distribution. The species was described from strata of Zechstein age in the Pinega River basin. In Greenland it was found by MAYNC in the "Red Series" at Permpas in Wollaston Forland (M 1783—1786), by KOCH and his party on Carbon River in the same region (LK 622), by STAUBER in the Nathorsts Fjord area (S II—318), and by KOCH at Kap Brown in the same area (LK 6, 7).

Cancrinella germanicus (FREBOLD)

Plate 3, figures 21—29

Productus cancrini germanicus FREBOLD, Meddel. om Grønland, Bd. 84, no. 7, 1933, p. 50, pl. 6, figs. 1—4 and IIa and b.

?*Productus* sp. MIRCHINK, Akad. Nauk, Studies of the Geol. Inst., v. 7, 1938, p. 338, 340, pl. 2, figs. 3—5.

Description. FREBOLD did not give a formal description of this species, but his plate of figures with their legend suffice to establish the name legally. His illustrations leave much to be desired and are all somewhat enlarged; but, fortunately, I have his types before me.

All the specimens available have been broken out of an impure limestone matrix and are more or less incomplete. The largest, and most complete, specimen is illustrated as figures 21 to 23 on plate 3. It is well supplemented by the holotype (figs. 24, 25) which is from the same locality and shows the surface of the dorsal valve, except for the trail which is broken away. As shown in figures 21 and 22, the beak is neatly pointed but expands gradually into a strongly convex umbo. Figure 23 shows the strong curvature of the ventral valve which is not in any degree geniculate. The auricles are small and thin. The dorsal valve is slightly concave near the beak and nearly flat over the rest of the visceral disc but is sharply flexed to join the curvature of the ventral valve in the trail.

The surface is ornamented by fine radial costellae of which about 10 occupy a space of 5 mm. Concentric rugae appear on the ears of the

dorsal valve and about the margins of its visceral disc but are generally lacking on the ventral valve. Spines are rather thickly scattered over the surface of the ventral valve, each arising from one of the costellae, and the latter is elevated and enlarged for a distance of a few millimeters in front of each spine base. These elevated and elongate nodes are conspicuous on the surface of the shell or on internal molds. Partly exfoliated shells show that the lumen of each spine runs a considerable distance backward in the shell. There was a concentration of spines on the posterolateral slope, over the auricles. These are unfortunately broken away in each of the figured types. The dorsal valve bears no spines but has dimples corresponding in position to each spine on the ventral valve.

Discussion. FREBOLD stated that he had compared his specimens with others from the Zechstein of Germany and found them identical in every detail. This species differs conspicuously from *L. bolchovitinovae* in being larger and coarser, its spines fewer and much more widely spaced.

L. cancriniformis TSCHERNYSCHEW differs in having much fewer spines and having strong rugae over the entire ventral valve, and in lacking the elongate nodes before the spine bases.

L. cancrini of authors has probably included a variety of distinct forms. In proposing the species, DE VERNEUIL was describing the faunas he then knew from all of Russia and he cited numerous localities, but unfortunately he did not identify the locality of his figured specimens and the two he illustrated now appear not to be conspecific. It is impossible without critical restudy of his material to be certain what form should be recognized as *L. cancrini.*

Distribution. In Greenland this species is known chiefly from the Nathorsts Fjord area whence all of FREBOLD's types were derived. FREBOLD states that shells he figured from the Zechstein conglomerate in Germany are identical with those in Greenland. This is very probably the form from the Zechstein beds of Pinega Valley figured by MIRCHINK as *Productus* sp. indet.

Genus **Liosotella** COOPER, 1953.

Liosotella COOPER, Smithsonian Misc. Coll., v. 119, no. 2, 1953, p. 35.

Diagnosis. Shells of small to medium size, strongly concavo-convex; cardinal extremities auriculate. Pedicle sulcus shallow to deep, dorsal fold low and obscure. Juvenile parts of the shell smooth, and bearing a few small scattered spines; the rest of the shell bearing strong costae. A row of strong spines is born on each side of the ventral valve

at the base of the steep umbonal slope, overarching the auricles which are smooth and spineless. A few stout erect spines are scattered over the anterior slope, generally arising from the costae. No spines appear on the dorsal valve.

Ventral interior with a strong median elevation on which the adductor scars are located; diductor scars large and flabellate. The dorsal interior has a short cardinal process; low curved ridges wall off the visceral area from the auricles; brachial impressions are conspicuous.

Generotype, *Liosotella angustata* COOPER.

Liosotella (?) hemispherica DUNBAR, n. sp.

Plate 4, figures 1—21.

Description. In the Greenland collections there are numerous specimens of this minute species which is mature at a breadth and length of about 1.5 cm. That they are not the young of some larger form is indicated by their distinctive shape, their strong convexity, and their close agreement in size.

Since it is difficult to illustrate the distinctive features of such small shells at natural size, we have added an enlargement of each figure. Each number refers therefore to a pair of figures, one X1 and the other X2.

If we disregard the small, thin and gently arched auricles, the ventral valve is almost hemispherical, generally without a trace of a sinus. In a few of the shells, however, the anterior slope is slightly flattened along the middle. Costae appear obscurely about 7 or 8 mm in front of the apex of the beak and gradually become prominent over the middle and front of the shell, leaving the auricles and the posterior part of the umbo and the lateral margins smooth. The costae are rather few and coarse for shells of such small size, and they are commonly low and rounded so that it is difficult to count them all with assurance.

The auricles and cardinal margin are spineless, but a row of 5 or 6 stout spines follows the base of the umbonal slope on each side (see spine bases in figs. 1 and 6). These spines extended laterally arching over the auricles. In addition, erect spines are scattered over the body of the ventral valve, being most abundant toward the front.

The dorsal valve is gently concave and is spineless.

Discussion. This species resembles *Avonia* in lacking a ventral sulcus and in the late appearance of its costae. However, its spines are strongly differentiated as in *Liosotella* with the large ones aligned in a row between the umbonal slopes and the auricles, a feature not present in *Avonia*. While it lacks the ventral sulcus that is characteristic of *Liosotella*, it bears all the other characters of that genus. It may be

noted that the sulcus only begins to appear some distance from the beak in the larger species of *Liosotella*.

The shell described by GRÖNWALL (1917, p. 576, pl. 28, figs. 10—14) as *Chonetella nasuta* WAAGEN, from Northeast Greenland, resembles this species superficially, being similar in size and shape; but the beak of that shell is costellate and the umbonal area is rugose. Also, GRÖNWALL indicates that cardinal spines were present. It appears to be generically distinct from our species.

Distribution. A few specimens were found near the south shore of Gauss Halvö along Margrethedal (M 2737). The species is abundant in certain beds along Productus River in southeastern Clavering Ø (M 318, 346, 352, 354, 368, 379, 384, 429) and in Permian boulders in Cretaceous conglomerate along Djævlekløften in the northeast part of the island (M 2172, 2174, 2292, 2299). It was also found north of Cirkusdal in the northeastern part of the island (M 2290, 2323, 2365) and on Fiskeelv along its southern coast (M 71). It was found east of Kap Stosch (N 51) on Hold with Hope, and at Grænsedalen in Wollaston Forland (M 1790).

It is also common at MAYNC's localities 2174, 2178, 2181, 2182, 2183, 2184; also abundant in blocks of white limestone in the Triassic conglomerate east of Kap Stosch (Ni; LK 564).

Liosotella spitzbergiana (TOULA).

Plate 5, figures 1—4, 7—13.

Productus spitzbergianus TOULA, k. Akad. der Wiss. zu Wien, Sitzungsber., Math.-Naturw. Cl., Bd. 70, 1874, p. 144, pl. 1, figs. 8a—d.

Marginifera typica var. *septentrionalis* FREBOLD, Meddel. om Grønland, Bd. 84, 1931, p. 25, pl. 3, fig. 2.

Description. The size and shape of this species are well shown on plate 5. The majority of specimens appear wider than long, but when the trail is fully developed, and preserved, as in figure 12, the length may exceed the width. The hinge line normally exceeds the greatest width of the shell before it, and the cardinal extremities form small gently arched, smooth auricles (e. g. figs. 9 and 10).

The surface is smooth for about 8 mm in front of the ventral beak where the costae begin to appear faintly. The latter remain rather subdued and low over the umbo and the anterior slope where 5 or 6 occupy a space of 5 mm. The ventral sulcus begins about 5 mm from the apex of the beak and runs forward without widening appreciably to the front margin.

Spines are limited to the ventral valve. On each side of the umbo there is a single row of 5 or 6 slender, tubular spines along the base of

the umbonal slope directed laterally over the auricles which with rare exceptions are spineless, smooth, and gently arched. With the exception of one specimen (figs. 8—10) which has a single cardinal spine on each auricle, no spines have been observed along the cardinal margin or on the auricles of this species. Slender, erect spines are scattered over the body of the ventral valve, especially over the anterior part of, and the lateral slopes of, the visceral area. There is evidence that some of these spines exceeded 1 cm in length.

None of the specimens available are preserved so as to permit study of the interior of the shell.

Discussion. TOULA's original description leaves something to be desired, but our shells agree closely with his type in size and shape and all characters that he illustrated, and since other elements of the Greenland fauna are associated there seems little reason to doubt their identity.

The resemblance of some of our specimens to TSCHERNYCHEW's figures of *Marginifera typica* var. *septentrionalis* is very close, and it would be impossible from the literature alone to be certain of a distinction.

I also have before me 2 lots of *Marginifera typica* WAAGEN from the Salt Range, and it is evident that TSCHERNYSCHEW's "variety" is not so closely allied to *M. typica* as he supposed and is not even congeneric. It completely lacks the marginal flange, so distinctive of *Marginifera*, on the inside of the dorsal valve between the visceral chamber and the trail. Also the ventral beak is smooth whereas that of *M. typica* bears intersecting costae and rugae. MUIR-WOOD examined our specimens from Orenburg in 1950 and referred them to *Eomarginifera* [personal communication]. However, that Carboniferous genus is costate throughout and has rugae over the posterior part of the umbonal region so that the shell is semireticulate. The Permian species, like the one under consideration, lack rugae completely and were entirely smooth during early growth. They agree much better with COOPER's new genus *Liosotella*.

Distribution. This species appears in collections ranging from Gauss Halvö to the southern part of Wollaston Forland, but at each locality is represented by only a few specimens. In Gauss Halvö it was found along Margrethedal on the southern coast (M 2764, 2767, 2780) and at Ladderbjerg far to the north (M 2990). On Clavering Ø it was found along Productuselv (M 323, 346, 352, 360, 368, 374), about Forposten (M 568—571) and on Malmquists Plateau (M 198).

Liosotella vadosisinuata DUNBAR, n. sp.

Plate 5, figures 14—22.

Description. This species resembles *L. spitzbergiana* in many respects, but its ventral sulcus is very shallow and the umbo more evenly convex. The distinction is well shown in figures 3 and 15 of plate 5.

Like *L. spitzbergiana* it bears a row of slender spines along the base of the umbonal slopes (bases shown in fig. 16) and somewhat more slender spines are scattered over the anterior part of the shell. The auricles are small, gently arched, and spineless. The costae begin very obscurely about 1 cm in front of the apex of the beak.

Distribution. This is the most common and widespread species of the genus in East Greenland. It was found near the south coast of Gauss Halvö at Margrethedal (M 2749), along the south coast of Clavering Ø on Fiskeelv (M 42, 53, 64, 65, 66, 68, 72, 73, 74, 75, 78, 79, 80, 81, 82, 84, 85, 615, 2502, 2503) and on Malmquists Plateau (M 198, 200, 201, 202, 215, 218, 219). It is common along Productuselv in central Clavering Ø (M 307, 308, 321, 325, 330, 361, 379, 435), about Forposten (M 561, 571, 590). It was found in northeastern Clavering Ø on Dolomitdal (M 2434, 2435) and to the north of Cirkusdal (M 2354, 2364) and in boulders in the Cretaceous conglomerate at Djævlekløften (M 2208, 2347). On the south coast of Wollaston Forland it was found along Grænsedalen (M 1795, 1797).

Throughout this range it is generally found in the Martiniakalk facies.

Liosotella delicatula DUNBAR, n. sp.

Plate 5, figures 23—31.

Description. This tiny species resembles *L. spitzbergiana* but is mature at half the size, and its strong curvature and trail show that it could not be the young of that species. In the illustrations on plate 5 each number refers to a pair of photographs, one at natural size and the other X2.

Except for the trail, present in some specimens, the shell appears transversely subquadrate in outline. The auricles are small, forming nearly a right angle at the cardinal extremity, and the anterior part of the shell bears a broad and somewhat indistinct sulcus. Small and rather obscure costae appear about 7 mm in front of the apex of the beak, leaving the posterior part of the umbo and the auricles smooth.

As in the larger species, the auricles and the cardinal margin are spineless but a row of erect spines follows the base of the umbonal slope and extends out over the auricles. Other erect spines are scattered over the body of the valve. The dorsal valve is spineless.

Distribution. Found at Margrethedal on the south coast of Gauss Halvö (M 2182); abundant on Productuselv, central Clavering Ø (M 352, 359, 363, 369, 379, 382, 401); and about Forposten on Clavering Ø (M 562, 584, 585, 590).

Liosotella grandicosta DUNBAR, n. sp.

Plate 6, figures 1—33.

Description. This fine species is represented by a large number of free specimens from two localities in Canning Land. These reveal considerable variation in shape and in the number and coarseness of the ribs, the chief of which are shown on plate 6, all at natural size.

The surface is smooth for about 5 mm in front of the apex of the ventral beak, and the costae arise obscurely at first and gradually become strong and rounded. In some shells the ribs do not increase in number but become very large and coarse for shells of this size; but in many specimens a few to several of the ribs split on the anterior part of the visceral area (e. g. figs. 6, 8, 13 of pl. 6). The number and the coarseness of the costae vary inversely with the number of those that split. The variation in this regard is so great that if one had to deal with isolated specimens he would be tempted to recognize numerous species or variations. The auricles are small and gently arched. They may be slightly extended (figs. 21, 28) or gently rounded (figs. 1, 3), but commonly form nearly a right angle (fig. 24).

Spines are few and highly differentiated. On the ventral valve a single row of 5 or 6 erect tubular spines follows the break in slope between the posterolateral umbonal slope and each auricle, and in addition several similar spines are sparsely distributed over the visceral humps and the anterior slope, arising generally from the summit of the costae. No spines are born along the cardinal margin or on the auricles, and none whatever appear on the dorsal valve.

The interior of the dorsal valve is shown by figures 32 and 33 of plate 6. The cardinal process is short and broad extending but little behind the hinge line; the adductor scars are divided into two pairs of cuneiform outline. Of these the posterior pair is deeply impressed, especially at their posterior end, but the anterior pair is rather elevated on a convex surface. A median groove runs forward from the base of the cardinal process between the adductor scars, and then out of it rises a low median septum that extends forward to a point even with the front margin of the nephriform impressions of the lophophore. On the outer and front borders of the latter there are several blunt tubercles. The visceral disc of this valve is separated from the auricles by a curving ridge.

In the ventral valve the sulcus appears as a ridge between the visceral humps. The adductor scars occupy a subquadrate bulge on its posterior part, close in front of the hinge line. The diductor scars lie in the deep visceral cavities on each side of the median ridge.

Discussion. This species is distinguished by the extraordinary coarseness of its costae, by an unusual degree of variation in their number, and by the fact that occasional ribs fork.

The latter feature recalls *Productus wilczeki* TOULA (1874, p. 141, pl. 1, figs. 6a—d), but the types of that species were much smaller and, more important, their ribs extend to the beak. Furthermore, it has a row of cardinal spines which are lacking in our species.

Distribution. This appears to be one of the commonest species in the dark calcareous shales of the Nathorsts Fjord region. Elsewhere it was found in only one locality, Permpas in Wollaston Forland, where MAYNC secured several typical specimens (M 1768—72).

Genus **Marginifera** WAAGEN, 1884.

Marginifera WAAGEN, Paleontologica Indica, Ser. 13, v. 1, 1884, p. 713.

Diagnosis. Small productids with a strongly convex ventral valve bearing a median sulcus, and with a deeply concave dorsal valve. The surface is costellate and the costellae extend over the umbo to the beak. Relatively large erect spines are sparsely scattered over the ventral valve, and a row of cardinal spines is present along the posterior margin of the ventral valve. The dorsal valve is spineless.

Inside the dorsal valve a flange-like ridge borders the visceral disc.

Generotype, *Marginifera typica* WAAGEN.

Marginifera nathorstfjordensis DUNBAR, n. sp.

Plate 7, figures 1—10.

Description. The size and shape of this species are well shown on plate 7. The ventral valve is strongly arched and moderately geniculate, the curvature decreasing in the rather long trail. Although the umbo of a grown shell projects well back of the hinge, the ventral beak is small and does not overarch the dorsal. A shallow ventral sulcus begins about 6 mm in front of the beak, reaches its greatest depth between the visceral humps and tends to become shallow toward the front of the shell. The dorsal valve is strongly concave and bears a low median fold.

The entire surface is finely costellate. About 7 or 8 costellae occupy a space of 5 mm. They increase occasionally by bifurcation, and tend

to be a little finer toward the front margin than over the visceral humps. The auricles are small and not clearly set off from the sides of the shell.

A row of cardinal spines is borne along the posterior margin of the ventral valve, of which the outermost spine, borne on the auricle, is relatively strong and the rest very small. A few erect spines are scattered over the ventral valve, the chief of which appear in a row down the center of each visceral hump, and of which the pair near the front of the visceral area is much the largest. The dorsal valve is spineless.

The inside of the dorsal valve has strong relief for a shell of such small size. A strong marginal ridge bounds the visceral disc from the tips of the auricles to the front of the shell. The loop-like brachial impressions are strongly elevated and the median septum, which extends slightly farther forward, rises to a blunt spine at its tip. The adductor scars are flabellate and rather deeply impressed. The anterior part of the visceral disc is studded with low blunt spines. No shells have been found which showed a free interior, but a slice into the front of the shell shown as figure 7, plate 7, proves that there is no ridge or diaphragm in the ventral valve.

Distribution. This distinctive species occurs abundantly in two collections from the Nathorsts Fjord area, one made by KOCH and his sailors from the talus on Kollen, and the other made by SÄVE-SÖDERBERG in 1936 from the east profile of Kollen. It does not appear in any other collections.

Marginifera cf. *septentrionalis* TSCHERNYSCHEW.

Plate 5, figures 5 and 6.

Marginifera cf. *typica* var. *septentrionalis* FREBOLD, Meddel. om Grønland, Bd. 84, no. 2, 1931, p. 25, pl. 3, figs. 2a—b.

This species superficially resembles *Liosotella spitzbergiana*, as shown by the figures on plate 5. It has about the same size and shape and a similar ventral sulcus. However, its ribs are sharper and they extend over the umbo to the beak. It differs further from *Liosotella* in having a row of specialized cardinal spines and lacking them at the base of the posterolateral slope.

Only 2 specimens have been seen, both from the "Productus" beds near Kap Stosch. Both are shown on plate 5.

Genus **Strophalosia** KING, 1844.

Strophalosia KING, Annales and Mag. of Nat. Hist., v. 5, 1844, p. 28.

Diagnosis. This genus includes productids with a short hinge line and a narrow ventral beak that commonly is distorted and marked

with a cicatrix where attached to some solid support. This initial attachment is reinforced during early growth by a holdfast of ventral spines. The ventral valve bears a distinct cardinal area in which the delthyrium is closed by a nearly flat deltidium. Ventral valve is gently to strongly convex and dorsal nearly flat or gently concave.

A pair of stout hinge teeth in the ventral valve fit into deep dental sockets of the dorsal valve, close beside the cardinal process. The cardinal process extends but little back of the hinge line but is elevated above the level of the inside of the dorsal valve as though supported by a flange or septum. At the front it tapers to a low median ridge or septum.

In the dorsal valve the adductor muscle scars are roughened by granulations but do not bear the dendritic pattern so common among other productids. In the ventral valve the adductor scars are rather small, lie close together and only a little in front of the hinge; the diductor scars are large, occupying much of the valve in front of the adductors, and bear numerous longitudinal ridges indicating that the muscle was subdivided into slender lobes. Spines are borne abundantly over the surface of the ventral valve and may be present or lacking on the dorsal.

Although resembling *Aulosteges* in attachment by the ventral beak (either by cementation or by a cluster of spines) and by the possession of a ventral cardinal area, there are important differences. Chief of these is the short hinge line and the pointed beak of *Strophalosia*, the presence of strong hinge teeth, and the shape of the cardinal process.

Generotype, *Orthis excavata* GEINITZ.

Strophalosia pulchella DUNBAR, n. sp.

Plate 7, figures 11—22.

Description. In the Arctic faunas *Strophalosia* has been recorded occasionally, but usually without specific identification because of the fragmentary nature of the material. The present species is represented in the East Greenland collections from numerous localities on Clavering Ø and on Wollaston Forland, and in some of these by several specimens. Of these the most notable are two from Brachiopoddal on Wollaston Forland in which the shells are silicified and could be freed by etching with HCl to reveal the spines and internal characters in exceptional preservation.

The size and shape are well represented in plate 7. Normally the hinge is less than half the greatest width of the shell which falls well in front of the mid-length, and the ventral beak is erect and narrow. The ventral valve is gently convex like the bowl of a spoon and the dorsal valve almost flat. Fixation commonly interfered with early growth

so that many of the shells are not strictly bilaterally symmetrical, the ventral beak shows considerable variation in shape, and the hinge line varies from less than one-third to fully half the maximum width of the shell. Normally, however, the ventral beak is erect and rather narrow, and the profile of the valves subtriangular. The ventral cardinal area is narrow and high, and the deltidium almost flat and smooth, the delthyrium having been completely obliterated.

The surface of the ventral valve is thickly studded with slender tubular spines of two sorts (pl. 7, figs. 15, 16, 18). About half of these emerge at a tangent to the surface and are only 4 to 5 mm long. These are essentially straight and lie close to the surface. About an equal number of the spines curl up at right angles to the surface and then curve back more or less strongly toward the beak. These erect spines are about $^1/_3$ mm in diameter and reach a length of 8 to 10 mm or more. The tangential and the erect spines alternate in distribution but show no evident pattern of arrangement. The dorsal valve has a conspicuously lamellose surface and bears no spines. Earliest attachment appears to have been by direct cementation for the beak commonly bears a small cicatrix, but with further growth ventral spines converged toward the beak and anchored and supported the shell.

Internally the ventral valve possesses a pair of stout hinge teeth that fit into deep sockets at each side of the cardinal process in the opposite valve. The adductor scars occupy an ovoid area just in front of the hinge line, and the diductor scars, lying mostly in front of the adductors, are very large and longitudinally lobed, covering a very large share of the anterior part of the valve.

In the dorsal valve the cardinal process extends but little back of the hinge line but is elevated on a high flange above the surface of the valve (pl. 7, fig. 19). The adductor scars, as well shown in figures 21 and 22 of plate 7, are located in the posterior part of the valve and are elevated. They are roughened by minute rounded granules that at high magnification look like cobbles in a stone pavement. They do not show the dendroid pattern that is so common among other productids.

Exfoliated shells broken out of solid matrix give an appearance of indistinct radial ornamentation. This is due to the bases of the tangential spines which are embedded in the shell; well-preserved surfaces show no trace of radial sculpture.

Discussion. This species shows considerable resemblance to *S. excavata* GEINITZ from the Zechstein of Germany, but with both GEINITZ's copious illustrations and a good collection of topotypes before me it is evident that they are distinct. *S. pulchella* is somewhat larger and its ventral beak is in general considerably more extended; but

the most obvious difference is that the spines are much finer and more numerous in *S. excavata* and that spines are borne on both valves in that species and only on the ventral of *S. pulchella.*

In the latter respect our species closely resembles *S. lamellosa* GEINITZ of the Lower Zechstein, but that species has a much thicker shell and its ventral beak is normally much blunter and more arched than in *S. pulchella.* Furthermore, the spines in *S. lamellosa* are both coarser and longer than in our species and are more abruptly turned back close to the shell toward the beak. There is a notable difference in the interior of the dorsal valve since the median septum is very short in *S. lamellosa*, scarcely extending beyond the front of the adductor scars, and the latter are smaller and closer to the hinge line than in *S. pulchella* and are less elevated.

The form described by FREBOLD (1937) from Spitzbergen as *Strophalosia (Aulostegas?)* sp. indet. resembles ours in size and shape and may prove to be identical, but the material described was too poorly preserved to justify specific identification.

Distribution. Found widely distributed on Clavering Ø and in Wollaston Forland. On Clavering Ø it was collected in Grænsedalen (M 1794), in Dolomitdal (LK 37), on Productuselv (M 391) and at Diabase Haven opposite Herschell Bjerg (LK 1030); in Wollaston Forland in Sandstensdal (M 1925, 1929, 1932, 1962), in Brachiopoddal (LK 410, M 1885, 1886, 1890), in Permdal (M 1864) and in Kuppelpasset (M 1871).

Also found at MAYNC's localities 2174, 2350, 2353, 2355, for which we have no data.

Genus **Krotovia** FREDERICKS, 1928.

Krotovia FREDERICKS, Comité Géol., Bull., v. 46, 1928, p. 779, 790.

Diagnosis. FREDERICKS introduced this genus to include productids having "an oval configuration and a plain surface" in which "the ornamentation consists of spines only." Some of the species he cited are now referred to *Waagenoconcha* CHAO, which was proposed during the preceding year and was unknown to FREDERICKS at the time.

There are, however, fundamental differences between *Productus humboldti* D'ORBIGNY, the generotype of *Waagenoconcha*, and *Productus spinulosus* SOWERBY, the type of *Krotovia.* The former is large, has a thick visceral cavity, has a prominent sulcus on the ventral valve, and is covered with small spines that tend to be arranged in quincunx and leave the shell at a tangent and lie close to it. This typifies the genus *Waagenoconcha.*

On the contrary there is a group of species closely allied to *P. spinulosus* all of which are very small, have low curvature and a very

thin visceral cavity, have no ventral sinus, and are covered with minute tubular spines arranged at random and standing erect from the surface. These constitute the genus *Krotovia*.

Generotype, *Productus spinulosus* SOWERBY.

Krotovia nielseni DUNBAR, n. sp.

Plate 8, figures 1—6.

Description. The size and shape are shown by the small photographs in figures 1 to 5 of plate 8. The hinge line is a little shorter than the maximum width of the shell, and the cardinal extremities are rounded. The ventral umbo is rather narrow and moderately convex, the beak overarching the hinge line. There is no trace of a sulcus. The auricles are low, nearly flat, and not clearly delimited from the posterolateral slopes. The dorsal valve is gently concave.

The surface of both valves is very thickly studded with minute erect spines. Only the bases of the spines are preserved in the specimens before us but they indicate (fig. 6, pl. 8) that the spines were not tangential to the surface as is common in the pustulose productids, but arose abruptly and nearly at right angles to the surface. They are so closely spaced that on the average 2 or 3 spines occur within each square millimeter of surface. They are evenly distributed over the entire surface of both valves and show no distinct pattern of arrangement except near the front where varices of growth cause a tendency for them to group in concentric rows.

Interior characters have not been observed.

Discussion. Of this rare little species we have only a few specimens from each of several localities. They are subequal in size and probably are mature. Their very distinctive spines prove, at least, that they are not the young of any of the other species in the fauna.

It is difficult to show the characteristics of such small productids at natural size, and we have therefore illustrated each specimen by 2 photographs, one natural size and the other enlarged 2 diameters. Neither of these specimens is quite complete, but the specific characters are clearly shown.

There has been considerable confusion over species of this genus, most of which are very small and difficult to illustrate adequately. DERBY described an early Permian species from Brazil in 1874 under the name *Productus wallaceianus*. It shows only generic resemblance to our species from Greenland. TSCHERNYSCHEW (1902, p. 617, pl. 30, fig. 8, pl. 60, figs. 19—23) described a form from the Schwagerinakalk of the Urals that he believed to be identical with that of DERBY, but he inadvertently called it *Productus wallacei* DERBY. He expressed some

doubt of the identity, and we consider that there is only a generic resemblance. The Russian species is clearly distinct from ours, having only about half as many spines and developing an obscure radial ornamentation over the front part of the shell that is completely lacking in ours. MILORADOVICH (1935, p. 139) recognized that TSCHERNYSCHEW'S species was distinct from that of DERBY, and proposed to rename it *Productus barenzi*. However, since TSCHERNYSCHEW did not use DERBY'S specific name *wallaceianus* but called his species *wallacei*, the latter name is valid even though the change was due to inadvertence on his part. The correct name of the Russian species is therefore *Krotovia wallacei* (TSCHERNYSCHEW), and the name *Productus barenzi* MILORADOVICH is a straight synonym.

GRÖNWALL (1917, p. 583, pl. 29, figs. 1—4) described 2 specimens from Eskimoures in northeast Greenland under the name *Productus wallaceianus*. These are closely similar to ours if not identical.

Our species is named in honor of EIGEL NIELSEN who collected many of the specimens studied.

Distribution. This species is represented in 5 collections made along the outcrop of the "Productus limestone" east of Kap Stosch. From River 2 east of Kap Stosch (N 46); from River 8 (N 22 and 35), and from Rivers 13—14 (N 48 and 53). It was found also in the Martinia-Productus beds in Margrethedal near the southern margin of Clavering Ø.

Genus **Waagenochoncha** CHAO, 1927.

Waagenoconcha CHAO, Paleontologia Sinica, Ser. B, v. 5, fasc. 2, 1927, p. 85.

Generotype, *Productus humboldti* D'ORBIGNY.
(See discussion of *Krotovia*).

Waagenoconcha payeri (TOULA).

Plate 9, figures 1—8; plate 10, figures 1—8.

Productus payeri, TOULA, k. Akad. der Wiss. zu Wien, Sitzungsber., Math.-Naturw. Cl., Bd. 68, 1873, p. 277, pl. 4, figs. 1—3; FREBOLD, Norges Svalbard- og Ishavs-Undersøkelser, Skr. om Svalbard og Ishavet, no. 69, 1937, p. 19—21, pl. 2, fig. 1; pl. 3, figs. 1—3; pl. 4; figs. 1—3.

Productus purdoni FREBOLD [*non* Davidson, 1862; *non* Waagen, 1882; *non* Wiman, 1914], Meddel. om Grønland, Bd. 84, no. 2, 1931, p. 25, pl. 3, fig. 1,

Productus (Waagenoconcha) wimani FREDERICKS, Trans. Arctic Inst., U.S.S.R., v. 13, 1934, p. 28;
STEPANOV, *ibid.*, v. 76, 1936, p. 126, pl. 6, figs. 1a—c.

Description. The size and shape of this striking species are well shown in plates 9 and 10. The shells are strongly arched but not genic-

ulate, and in late maturity develop a long trail in which the curvature gradually decreases. A ventral fold begins within about 1 cm of the beak and runs forward without increasing appreciably in width. In most shells the hinge line is about equal to the greatest breadth of the shell, and the auricles are extremely small. As in figure 1 of plate 9, the lateral slopes of the umbonal region are normally very steep and the margins almost straight for some distance in front of the hinge line, the cardinal extremities forming almost a right angle; but in several of our specimens (e. g. fig. 2 of pl. 9) the posterolateral slopes are more gentle and the greatest width is in the auricles which, however, are rounded. The dorsal valve is nearly flat over the visceral disc but curves up to the auricles and into the trail.

The distinctive ornamentation is well shown in figures 1, 3, and 6 of plate 9 and in enlarged detail (X4) in figures 7 and 8 of plate 9 and in figure 7 of plate 10. The entire surface was covered by minute slender spines that emerged at a tangent to the surface and lay close to it. In addition the entire surface was ornamented by fine, sharp, regularly spaced growth lirae (see fig. 7 of pl. 10). The spines are largest over the umbonal region and decrease rather regularly in size toward the margins of the trail (figs. 5 and 6 of pl. 9). There is no appreciable pattern in their arrangement (e. g. figs. 7 and 8 of pl. 9) except at occasional varices of growth where there is a degree of concentric zoning (fig. 1 of pl. 9).

Several of the shells show on the anterolateral slopes a few irregular and subangular plications (figs. 2 and 8 of pl. 10, and fig. 6 of pl. 9).

The ventral interior is exceptionally well shown by an internal mold represented in figure 3 of plate 10. The diductor scars are large and radially striated, lying within the visceral humps where they are separated by the long and distinctively shaped adductor scars that lie upon the ventral sulcus (text fig. 16). The beak was lined with a thick callous back of the muscle scars which is reflected in the internal mold as a glossy smooth apex posterior to the muscle scars. The interior of the front part of the valve was studded with low blunt pustules.

The interior of the dorsal valve is not shown in any of our specimens.

Discussion. The shells described above are somewhat tentatively referred to TOULA's species which was based on internal molds, only, from the south tip of Spitzbergen. FREBOLD (1937) studied more extensive collections from this and other localities in Spitzbergen, and figured several specimens with more or less of the shell preserved. Unfortunately the surface ornamentation is very poorly preserved even in the best of these, and, until it is known, some uncertainty will exist as to the real specific characters. However, the faunas of Spitzbergen and

East Greenland have much in common and were probably contemporaneous and represent a single faunal province. Furthermore, FREBOLD's specimens agree well with the Greenland shells in size and shape and in the rather distinctive internal features of the ventral valve.

WIMAN (1914) described a very much larger species from Bear Island which he identified as *Productus purdoni* DAVIDSON, and FREBOLD (1931, p. 25, pl. 3, figs. 1a and b) identified a shell from East Greenland with the same species. In 1933 (p. 21) he expressed doubt

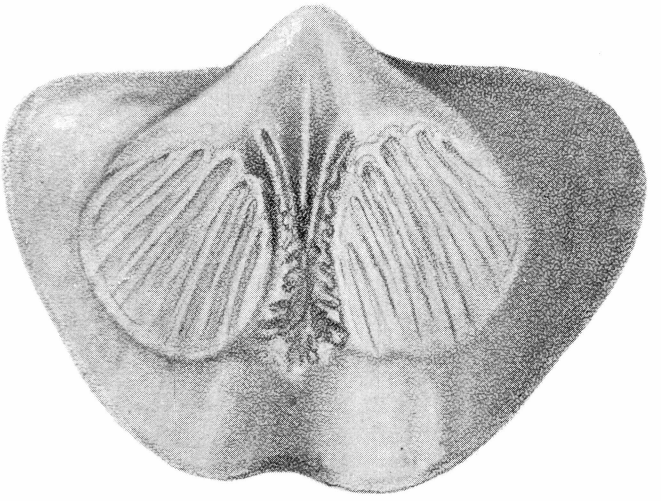

Fig. 16. Interior mold of the ventral valve of *Waagenononcha payeri* (TOULA) showing the position and shape of the muscle scars.

of this identification and indicated that the specimen from Greenland might belong to *P. payeri*. Having studied specimens of *Productus purdoni* from its type region, the Salt Range of India, as well as the shell figured by FREBOLD, I am convinced that there is no close resemblance or relationship between Greenland shells and *Productus purdoni*. DAVIDSON's original description was brief and his illustration, it must be confessed, indicates spines similar to that of our shells in size and arrangement. However, the hinge line of his shell is only about half the maximum width of the shell which lies far forward. WAAGEN's great monograph on the Salt Range fossils (1883) redescribed the species with numerous illustrations that agree closely with specimens before me from that area. If we may accept his interpretation of the species, DAVIDSON's illustration was rather poorly drawn. WAAGEN emphasized the fact that the spine bases in the Salt Range species are arranged in a conspicuous quincunxial pattern. In size and shape this species closely resembles the shells illustrated by DIENER (1897, pl. 2, figs. 1, 2) from

the "Productus shales" near Niti Pass in the Himalaya range north of Nepal, and identified by him as *Productus purdoni* DAVIDSON. Unfortunately, his shells were exfoliated so that the details of surface ornamentation were not shown. In the Indian species the ventral sulcus is not nearly as pronounced as in the Greenland shells, and the longitudinal curvature is different. Furthermore, unless the ventral muscle scars were misinterpreted by DIENER, they differ considerably from those in the Greenland species.

Distribution. This is one of the less common productids in Greenland, and our collections include only a dozen specimens. Fortunately the preservation in several of these is remarkably good.

The species was found in the "Productus limestone" near Kap Stosch in Hold with Hope (LK 11, 12, and 28; N 45a), and in Brachiopoddal (LK 429) and Sandstensdal (M 1945) in Wollaston Forland.

Waagenoconcha sp.

Plate 8, figures 7—16.

?*Productus humboldti* TOULA [*non* D'Orbigny], k. Akad. der Wiss. zu Wien, Sitzungsber., Math.-Naturw. Cl., Bd. 86, 1873, p. 282, pl. 2, figs. 3a—c.

Productus humboldti FREBOLD [*non* D'Orbigny], Meddel. om Grønland, Bd. 84, no. 2, 1931, p. 39, pl. 3, figs. 8a, b.

Productus (*Waagenoconcha*?) *irginae* var. *irginaeformis* FREBOLD [*non* Stepanov], Meddel. om Grønland, Bd. 126, no. 3, 1950, p. 45, pl. 2, figs. 5, 5a, 7, 7a).

Description. This small species is represented in our collections by numerous specimens, all somewhat imperfect. It cannot be identified with any of the numerous described species, but the available material does not permit the satisfactory description of a new species.

The normal size and shape are indicated by figures 10 to 12 of plate 8. The outline is subquadrate, the hinge being a little less than the maximum width, and the cardinal extremities obtusely rounded. The ventral valve is rather strongly arched and bears a rather shallow median sulcus that arises some distance in front of the beak and runs forward with little increase in width. The posterolateral slopes are steep and the ears inconspicuous.

The dorsal valve is nearly flat but bears an inconspicuous median fold.

The surface of both valves is marked by closely spaced needle-like spines that leave the shell at a tangent to its surface. All our specimens are partly exfoliated and the appearance varies accordingly. Where well preserved (fig. 16), the spine bases appear as slender welts, and the entire surface is marked by very fine lines of growth. Where slightly exfoliated, as in figures 13 and 14, the detail is less clear, and where

deeply exfoliated, the spine bases appear as tubes running approximately parallel to the surface as in figure 15.

Discussion. Because of the subquadrate outline and steep sides, this species superficially resembles the genus *Juresania*, but its surface ornamentation belies that appearance. It is not to be mistaken for young specimens of *W. payeri* which at corresponding size has a thicker beak and a wider ventral sulcus, and larger spines. (Compare fig. 16 of pl. 8 and fig. 7 of pl. 9.)

This is the species identified by FREBOLD in 1950 as *Productus* (*Waagenoconcha*?) *irginae* var. *irginaeformis*, but STEPANOV's illustrations indicate a broader shell with spines finer and much more closely spaced than in the Greenland shells.

Our form is similar in general shape and size to the one from Spitzbergen identified by STEPANOV and TSCHERNYSCHEW (1916, p. 36, pl. 6, fig. 5) as *Productus humboldti* D'ORBIGNY, but we cannot confirm that identification. The South American species has its spines much more thickly spaced and differently arranged.

The form from Spitzbergen that FREBOLD (1937, p. 17, pl. 5, figs. 6, 7) identified as *Productus (Waagenoconcha) humboldti* resembles the Greenland form and may prove to be the same, but it is larger and apparently more transverse. FREBOLD's figured specimens, like ours, are more or less incomplete and partially exfoliated so that critical identification is impossible.

Distribution. This form occurs sparsely in the Greenland faunas. It was found in the "Productus limestone" of the Kap Stosch area (LK 28), in Grænsedalen in Wollaston Forland (M 1790, 1793, 1798), and in Permdal (M 1845, 1852).

Genus **Pleurohorridonia** DUNBAR, n. gen.

(Ety. Gr. *pleuron*, rib + *Horridonia*).

Diagnosis. Derived out of *Horridonia* which it resembles in its youth when it possesses a smooth surface, a narrow ventral sinus, a single row of cardinal spines on each valve and scattered erect spines on the surface of the ventral valve; but when less than halfgrown it begins to develop irregular radial corrugations that become strong and more regular ribs over the anterior part of the visceral area and the long trail. A single large spine (or less commonly a pair) is born on the middle of the dorsal auricle, well in front of the outermost cardinal spine and is directed laterally.

The type of this genus is clearly derived from *Horridonia*, but it has specialized so far in developing a ribbed surface that if the apical

part of the shell were lacking or poorly preserved, its relation to that genus would be very obscure. It tends to develop a narrower shell and a much longer trail than is normal in *Horridonia*.

Besides the generotype, it will include *Productus horridus* var. *hoppeianus* EISEL of the Zechstein of Germany.

Generotype, *Pleurohorridonia scoresbyensis*, n. sp.

Pleurohorridonia scoresbyensis DUNBAR, n. sp.

Plate 11, figures 1—10; plate 12, figures 1—13; text figures 17—19.

?*Productus timanicus* GRÖNWALL [*non* Stuckenberg], Meddel. om Grønland, v. 43, 1917, p. 586, pl, 29, figs. 11—16.

Productus horridus var. *initialis* FREBOLD [*non* Eisel], *ibid.*, v. 84, no. 7, 1933, p. 20, pl. 2, figs. 10—12.

Productus horridus var. *granuliferus* FREBOLD [*non* TOULA], *ibid.*, v. 84, no. 7, 1933, p. 21, pl. 2, fig. 13.

Productus horridus var. *hoppeianus* FREBOLD [*non* Eisel] *ibid.*, v. 84, no. 7, 1933, p. 18, pl. 3, figs. 9a—d.

Productus (Horridonia) borealis LICHAREW and EINOR [*non* Haughton, *non* Stepanov], Trans. Arctic Inst., U.S.S.R., v. 127, 1939, p. 55 and 206, pl. 10, figs. 6—11; pl. 11, figs. 1—5.

Description. This, the most abundant of all productids in our collections, is a shell of medium size reaching a breadth of 4 to 4.5 cm, not counting the more extended auricles, and developing a strong and regular curvature and a long trail so that when fully grown it is appreciably longer than wide. In adult shells the ventral umbo appears greatly inflated, extending far back of the hinge line which is overarched by the rather small beak (pl. 11, figs. 5 and 6); but the shell is not geniculated (pl. 11, fig. 7), the radius of curvature increasing very gradually from the beak to the front. The lateral slopes are very steep all the way to the margin. The hinge line is extended to form prominent but relatively small auricles. A median sulcus appears within about 5 mm of the ventral beak and becomes deep but narrow over the umbo, beyond which it varies considerably; in most specimens it persists to the edge of the trail gradually becoming shallower toward the front, but in others it disappears earlier and scarcely affects the anterior slope (pl. 11, fig. 5, and pl. 12, fig. 13).

Surface ornamentation shows a striking series of ontogenetic changes. The young shells have a very smooth, glossy surface with no trace of radial sculpture. Low magnification, however, shows very fine concentric growth lines. When the shell had reached a length of 2 to 3 cm, minute welts began to appear (pl. 11, fig. 9) as tiny pustules, commonly elongated as if about to become prostrate spines. Before the shell had a length of 4 cm, small but uneven striae and ribs began to appear; these gradually increase in size so that the anterior slope and the long

trail appear costate (pl. 11, figs. 5, 7, and 10; pl. 12, figs. 12 and 13). These are not regular, rounded costae, however, as in many other productids. The pustules become sharper and more elevated on this part of the shell where they show some tendency to be arranged in concentric rows (pl. 11, fig. 10). These are not spine bases but, apparently, the

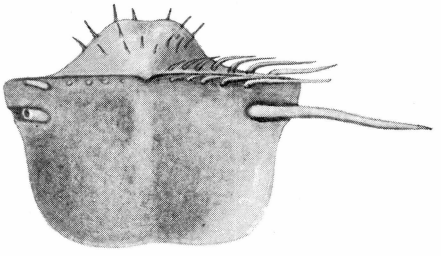

Fig. 17. Dorsal view of *Pleurohorridonia scoresbyensis* showing arrangement of spines.

external expression of stout internal pustules that give a coarsely pseudopunctate appearance to exfoliated shells (pl. 12, figs. 5, 12, and 13). These pustules are somewhat variable in size, shape, and arrangement on different parts of the shell, and they vary also in the position of their first appearance.

True spines appear sparsely and are highly specialized and differentiated (text fig. 17). A single row of tubular cardinal spines is borne near the posterior margin of each valve, of which there are 6 to 8 on each side of the beak, increasing progressively in size toward the cardi-

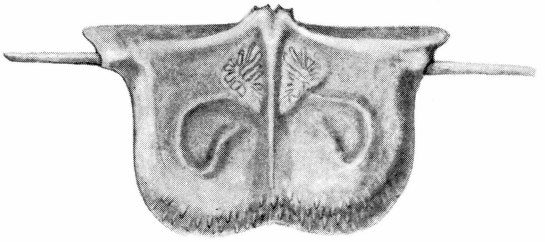

Fig. 18. Interior view of the dorsal valve of *Pleurohorridonia scoresbyensis*.

nal extremity. These were bent strongly outward toward the lateral margin. In addition, a single very much larger spine (or commonly a pair) is borne on the dorsal surface of each auricle. These great auricular spines were formed as the shell approached maturity but before the auricles were complete, and they extended laterally and approximately in the plane of the dorsal surface of the auricle. With further growth the mantle had to accommodate itself by arching over these spines. As a result, each spine appears to lie in a groove across the auricle. This produced a strong welt on the inside of the valve (text fig. 18),

and the auricle of the ventral valve, in turn, is elevated into a conspicuous external welt (pl. 12, figs. 2, 4, 8, and 10).

Smaller but erect tubular spines, some 40 to 50 in number, are sparsely scattered over the surface of the ventral valve, but not the dorsal.

In the ventral valve (text fig. 19) the suboval diductor scars are rather deeply impressed in the umbonal humps and are radially grooved. They are separated by a prominent ridge on which the adductor scars are located. This elevation is widest posteriorly and narrow toward the

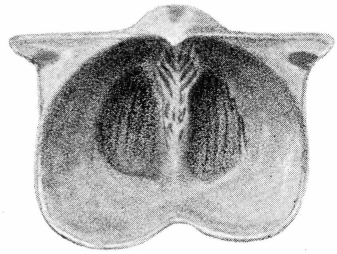

Fig. 19. Interior view of ventral valve of *Pleurohorridonia scoresbyensis*, showing size and shape of the muscle scars, and the grooves on the auricles reflecting the welts in the dorsal valve produced by its great auricular spines.

front of the muscle field. The adductor scars bear an obscure dendritic sculpture.

The interior of the dorsal valve is shown in text figure 18 and in plate 12, figures 9, 10, and 11. The cardinal process is short and broad but projects back of the hinge line, its muscular facets facing posteriorly so as not to show from a direct ventral view. The cardinal process is supported by stout ridges that run laterally to the sides of the visceral disc. The adductor scars and the impression of the lophophore are shown in text figure 18 which also shows the pustulose anterior slope, the steep trail and the welt on the inside of each auricle produced by the great auricular spines.

Discussion. This species is named for Scoresby Land where it occurs in great abundance in the bluffs west of Schucherts Flod. There it forms a veritable coquina from which Dr. STAUBER collected some hundreds of specimens.

The ontogenetic change in shape and surface ornamentation is noteworthy and may cause young shells to be misidentified. Thus, during his early work, FREBOLD (1933) identified young shells as *Productus horridus* var. *initialis* EISEL, and adult shells as *P. horridus* var. *hoppeianus*. With his figured specimens before me and with hundreds of free shells from a single bed for comparison, I have no doubt that they are identical. The resemblance of the Greenland shells to these

forms described by EISEL from the Lower Zechstein beds about Gera in Germany is noteworthy and from the literature alone it would be impossible to be sure of their distinctness. EISEL (1906) recognized a zonal succession of what he considered varieties of *Productus horridus* in the region about Gera where this tribe is not only extremely abundant but highly differentiated. He named the following varieties which he placed in ascending sequence: (1) *Productus horridus* var. *initialis*, (2) var. *hoppeianus*, (3) var. *bufoninus*, (4) var. *auritulus*, (5) var. *laspeanus*, (6) var. *geranus*, and (7) var. *geinitzianus*. The first six of these were proposed as new, the seventh being an old species of DE KONINCK. Unfortunately, EISEL's interesting paper was very brief, his descriptions inadequate, and his illustrations rather poor; but, happily, the Yale collections include a suite of some 30 lots of such material made, in part at least, by GEINITZ about 1860, and in this the several varieties named by EISEL can be readily identified. It is thus possible to be sure that while the Greenland species shows striking resemblances to *P. hoppeianus*, there are important differences. Most obvious of these is in the size and orientation of the cardinal and auricular spines. In *P. hoppeianus* the dorsal cardinal spines are very long and slender, and are directed forward over the dorsal valve almost at right angles to the hinge line. The large auricular spines likewise leave the shell pointing about 45° away from the hinge line and curve farther forward so that their tips are directed almost at right angles to the hinge line. In addition, the umbo is narrower, the ventral valve shallower and the ribs less prominent and more irregular than they are in the Greenland shells. Finally, the surface pustules that ornament the anterior part of the shell in the new species cannot be observed in any of the specimens from Gera. It must be noted, however, that fine surface details are not well preserved in our specimens from Gera, and it is not possible to be certain that pustules were completely absent.

The shells from Bear Island, figured by WIMAN (1914, pl. 14, fig. 2; pl. 15, figs. 3 and 4) as *Productus inflatus*, present a considerable resemblance to our species except that they are much larger. He did not describe the shells but says they agree fully with the forms described by TSCHERNYSCHEW (1902, p. 261, pl. 28, figs. 1—6). The latter shows a fully costate shell of the genus *Dictyoclostus*. WIMAN's specimens were probably worn before burial and poorly preserved.

This species occurs in the Permian beds in Nova Zemlya whence it was described and copiously illustrated by LICHAREW and EINOR under the name of *Productus (Horridonia) borealis* HAUGHTON. In size and shape and the details of surface ornamentation, their shells agree so fully with ours that no doubt can be entertained as to their identity. On the contrary, we cannot accept their identification of the species

with HAUGHTON'S *Productus borealis* which was described from collections brought back by MCCLINTOCK from Hillock Point, Melville Island far to the west of Ellesmere Land. HAUGHTON'S description was brief and his illustrations crude; and they indicate that he embraced two quite different species in his *P. sulcatus* var. *borealis*. Three small specimens (his pl. 7, figs. 2, 3, and 4) which he considered young specimens are altogether too gibbous to be the young of the large form represented by his figures 1 and 7. The large shells should obviously be regarded as the types and were so considered by STEPANOV. They are much larger than our species and relatively broader, and, indeed, show little resemblance to it. In any event the figures are so crude that HAUGHTON'S species can only be recognized when the types, presumably in Dublin, have been restudied. If they belong to either of the Greenland species it is probably our *Sowerbina rudis*.

The shell described from Big Bear Cape, Ellesmere Land, by TSCHERNYSCHEW and STEPANOV (1916, p. 41, pl. 6, figs. 6a—c) under the name of *Productus timanicus* STUCKENBERG, can hardly belong to that species and appears possibly to be our *P. scoresbyensis*, but unfortunately the critical details of surface ornamentation are neither described nor shown in the figures.

The same may be said of the shells from northeast Greenland identified by GRÖNWALL as *Productus timanicus*. His specimens were from limestone boulders at Eskimonæs, Holm Land and Henrik Kröyer Holme off Amdrup Land. He figured only juvenile shells. His figure 14 of plate 29 clearly indicates the presence of cardinal spines on the ventral valve, and his species is therefore generically distinct from *P. timanicus* STUCKENBERG. His figures resemble young specimens of our species in general features and may be identical, but they indicate a somewhat narrower and deeper sinus extending closer to the beak than in our species, and his specimens may well represent a related but distinct species of somewhat different age from ours.

The shell described by TOULA (1875, p. 233, pl. 6, figs. 3a—c, 4) as *Productus horridus* var. *granulifera*, presents a close superficial resemblance to a young specimen of our species. Indeed, FREBOLD (1933, pl. 2, figs. 13a—c) identified one of our specimens (our pl. 12, figs. 1 and 2) with TOULA'S variety. It should be noted, however, that TOULA'S excellent figures of a nearly complete shell show no evidence of cardinal spines or of welts on the ventral auricles, and that the surface ornamentation consists of crinkly pustules. Each of these features indicates that TOULA'S types belong to the genus *Sowerbina* and not to *Pleurohorridonia*. The matter is discussed further under the description of *Sowerbina maynci*.

Distribution. This species occurs in extraordinary abundance in one zone in the limestone about 150 feet above the base of the Permian section along the bluffs west of Schucherts Flod in southern Scoresby Land (S 1—13). Here it forms a coquina and completely dominates the fauna.

Specimens were found also in blocks of white Permian limestone embedded in the Triassic conglomerate in the Kap Stosch area (FREBOLD, 1933). It was found in place on Productuselv, Clavering Ø (M 390) and northeast of Cirkusdal in the northeast of Clavering Ø (M 2345), in the Nathorsts Fjord area and at many other places.

Genus **Sowerbina** FREDERICKS, 1928

Sowerbina FREDERICKS, Comité Géol., Bull., v. 46, no. 7, 1928, p. 778 and 789.

Diagnosis. FREDERICKS defined this genus in Russian with an English summary as follows:

> "1). Glabratae: *Sowerbina* nom. nov. The shell is productiform and has a smooth surface. Sometimes a thin granulation is observed on the surface of the valves. Sometimes are seen marks of a punctate structure.
> Type: *Productus timanicus* STUCKENBERG."

It is evident that he intended the genus to include all the smooth-shelled productids.

Earlier in the same year CHAO had established the genus *Horridonia* to include the same group, and he designated the generotype ambiguously as "*Productus horridus* SOWERBY and *Productus timanicus* STUCKENBERG." Obviously both could not be the generotype, and SCHUCHERT and LEVENE (1929) therefore selected *Productus horridus* SOWERBY and cited SOWERBY's Mineral Conchology, vol. 4, 1823, p. 17, pl. 319, fig. 1, which is the original description of the species. Since both CHAO and FREDERICKS intended to include in a single genus all of the glabrate productids of this general type, it is not surprising that subsequent authors have generally suppressed *Sowerbina* as a synonym of *Horridonia*. Modern trends of refinement, however, would lead to the conception of the *glabratae* as a subfamily rather than a single genus of productids; and there are important differences between the designated generotypes, *P. horridus* and *P. timanicus*, that now seem to necessitate the recognition of both genera.

Productus horridus has a smooth surface marked only by extremely fine growth lines and, on the anterior part of large shells, by irregularly spaced and unequal radial ridges that commonly arise at a spine base and run forward. In this species there is a row of strong cardinal spines

along the posterior margin of *both* dorsal and ventral valves, *those on the ventral valve being the larger.* No other spines are borne on the dorsal valve, but the ventral valve bears numerous, erect, scattered spines among which those on the auricles are conspicuous.

In contrast, *Productus timanicus* STUCKENBERG (like several allied species), has its surface ornamented by a distinctive type of crinkly pustules. Furthermore, the large *cardinal spines are borne only on the dorsal valve* and they lie nearly in the plane of this valve. In addition, a pair of very large spines is borne on the surface of each auricle of the dorsal valve. Spines on the ventral valve, on the contrary, are reduced to a few rows (1 to 3) radiating down over the visceral humps. There are none on the auricles. In all these characteristics of the upper Permian generotype, the two upper Permian species from Greenland agree fully, while at the same time they contrast with the features shown in the coterie of species or varieties that center around *Productus horridus* in the Zechstein of western Europe. We therefore recognize the genus *Sowerbina* FREDERICKS and define it as follows:

Productids of moderate to strong curvature (not geniculate), having a narrow ventral sulcus between strong visceral humps; cardinal extremities extended into conspicuous auricles; surface non-costellate, ornamented by minute crinkly pustules; spines large, specialized and localized as follows: the dorsal valve bears a single row of cardinal spines plus a pair (rarely more or less) of large spines on each auricle, ventral valve without cardinal or auricular spines but having 1 to 3 (rarely more) radial rows of spines on the visceral humps.

Generotype, *Productus timanicus* STUCKENBERG.

Discussion. FREDERICKS (1934, p. 39) erroneously referred the following forms from the Kanin Peninsula to his genus *Ruthenia: Productus granulifera* TOULA, *P. granulifera* var. *typica* FREDERICKS, *P. granulifera* var. *spitzbergensis* FREDERICKS, and *P. granulifera* var. *gibbosa* FREDERICKS. In so doing he stated that they resemble *Sowerbina* in shape and form but differ in having a granulose instead of a smooth surface.

He thus completely misinterpreted the ornamentation, for the type of *Ruthenia* is *Productus irginae* STUCKENBERG which has its surface studded with small tangential spines (like those of *W. payeri;* our pl. 9, figs. 1, 3, 7, and 8) but has no differentiated cardinal spines. Indeed, *Ruthenia* is a synonym of *Waagenoconcha.* The granules that distinguish the surface of *P. granulifera* TOULA and its allies are not in any sense spine bases, and any resemblance of these shells to *Waagenoconcha* is superficial and remote.

FREDERICKS was probably in error, also, in thinking that the surface of *Productus timanicus* is smooth. Unfortunately, neither STUCKEN-

BERG (1875, p. 86) nor TSCHERNYSCHEW (1902, p. 638) described the details of surface ornamentation, but, happily, I have before me a specimen identified by FREDERICKS from the area east of the Timan Plateau and, although it is badly worn, the surface is well preserved on one of the dorsal auricles and it closely resembles that of our species (pl. 13, figs. 6, 7). LICHAREW (LICHAREW and EINOR, 1939, p. 207) states that he has observed the granulation in one of TSCHERNYSCHEW's figured specimens.

Sowerbina maynci DUNBAR, n. sp.
(Ety. Patronymic for Dr. WOLF MAYNC).

Plate 13, figures 1—9; text figure 20.

Productus timanicus FREBOLD [*non* Stuckenberg], Meddel. om Grønland, v. 84, no. 2, 1931, p. 22, pl. 2, figs. 1—5.

?*Ruthenia granulifera typica* FREDERICKS, Trans. Arctic Inst., U.S.S.R., v. 13, 1934, p. 39, pl. 3, figs. 2—6; pl. 4, figs. 1—3, 7, 8.

Productus (Horridonia) timanicus FREBOLD (part) [*non* Stuckenberg], Norges Svalbard- og Ishavs-Undersøkelser, Skr. om Svalbard og Ishavet, no. 69, 1937, p. 21, pl. 7, fig. 2 [not 3; not pl. 6, figs. 1, 2].

?*Productus borealis* var. *granulifera* STEPANOV [*non* Toula], Trans. Arctic Inst., U.S.S.R., v. 76, 1937, p. 175, pl. 5, fig. 1.

?*Productus borealis* STEPANOV (part) [*non* Haughton], *ibid.*, v. 76, 1937, p. 175, pl. 4, fig. 2; pl. 5, fig. 2.

Description. The size and shape of this species are well represented by the figures in plate 13. The shell is about 50 percent wider than long with large but low auricles. The ventral beak is small, extending only a short distance behind the hinge line and scarcely overarching the dorsal valve at all. The ventral umbo is broad and low, and the curvature of the ventral valve is gentle, tending to increase slightly after the shell has attained a length of about 4 cm but not enough to produce geniculation. A narrow sulcus begins within about 5 mm of the apex of the beak and deepens moderately over the visceral area. The lateral slopes of the umbo are gentle, and the auricles are not sharply delimited. The dorsal valve is nearly flat until almost full grown when it curves up steeply around the anterior margin to form a short trail scarcely more than a centimeter in length.

The entire surface is ornamented with minute crinkly pustules (pl. 13, figs. 6, 7) which to the unaided eye appear as fine granules. These are not in any sense spine bases for they are crossed by fine and unbroken growth lines. On the anterior slope and trail of large specimens there is commonly an obscure and very irregular radial corrugation.

Spines are few but large and distinctively placed. The ventral valve has no cardinal spines but bears one or two rows of stout erect spines running from the beak down the axis of each visceral hump

(pl. 13, fig. 5). Two rows seem to be the more common but there is some irregularity in this, and the specimen shown as figure 5 of plate 13 has two distinct rows on one hump and but a single row on the other. On a full-grown shell there are 9 or 10 spines in each row, those nearest the beak being very small. No spines are present on the auricles of this valve.

The dorsal valve bears a row of large cardinal spines that lie nearly in the plane of the valve and curve out and back. In addition, two or three large spines arise on each auricle, lying nearly in the plane of its surface and directed outward and rather strongly forward (pl. 13, fig. 1, and text fig. 20). These large spines were formed at the margin, when the auricles were only partly developed, and with further growth the mantle warped over the spine base. As a result, the spine appears to be impressed into the surface of the auricle and a large welt lies in corresponding position on the ventral surface of the auricle.

Internally, the muscle scars are similar to those of *Pleurohorridonia* except that the ventral diductor scars are relatively shorter and broader and come together for at least half their length in front of the adductors.

Discussion. TOULA based his *Productus horridus* var. *granuliferus* on a small shell from Axel Island, Spitzbergen, that strongly resembles a very young shell of our species. It has the same shape, the same kind of auricles and, like ours, lacks cardinal spines on the ventral valve and the ventral surface of the auricles. Its surface also is covered with fine "granules" apparently comparable to ours, though TOULA's figure suggests a different pattern. But TOULA says of his type that "Spine bases are distributed in greater number on the shell surface," and his figures 3a and 3c of plate 6 indicate 3 regular rows on each lateral hump plus a few others. None of our shells show more than 2 rows. In order to identify our species with his, we should have to assume (1) that his species was based on a juvenile less than one-fourth normal adult dimensions, (2) that it had abnormally numerous spines or that he misrepresented their number and arrangement, and (3) that he did not represent correctly the pattern of the granules. While his shell probably was juvenile, and is certainly generically related to ours, it appears that there is no justification for regarding them as identical.

The Greenland shell which FREBOLD identified as *Productus horridus* var. *granuliferus* TOULA (our pl. 12, figs. 1 and 2) is entirely different and belongs to our *Pleurohorridonia scoresbyensis*. It has a row of stout cardinal spines along the posterior margin of the ventral valve and had a perfectly smooth shell until it was much larger than TOULA's type. Either of these features would disprove its relations to the latter.

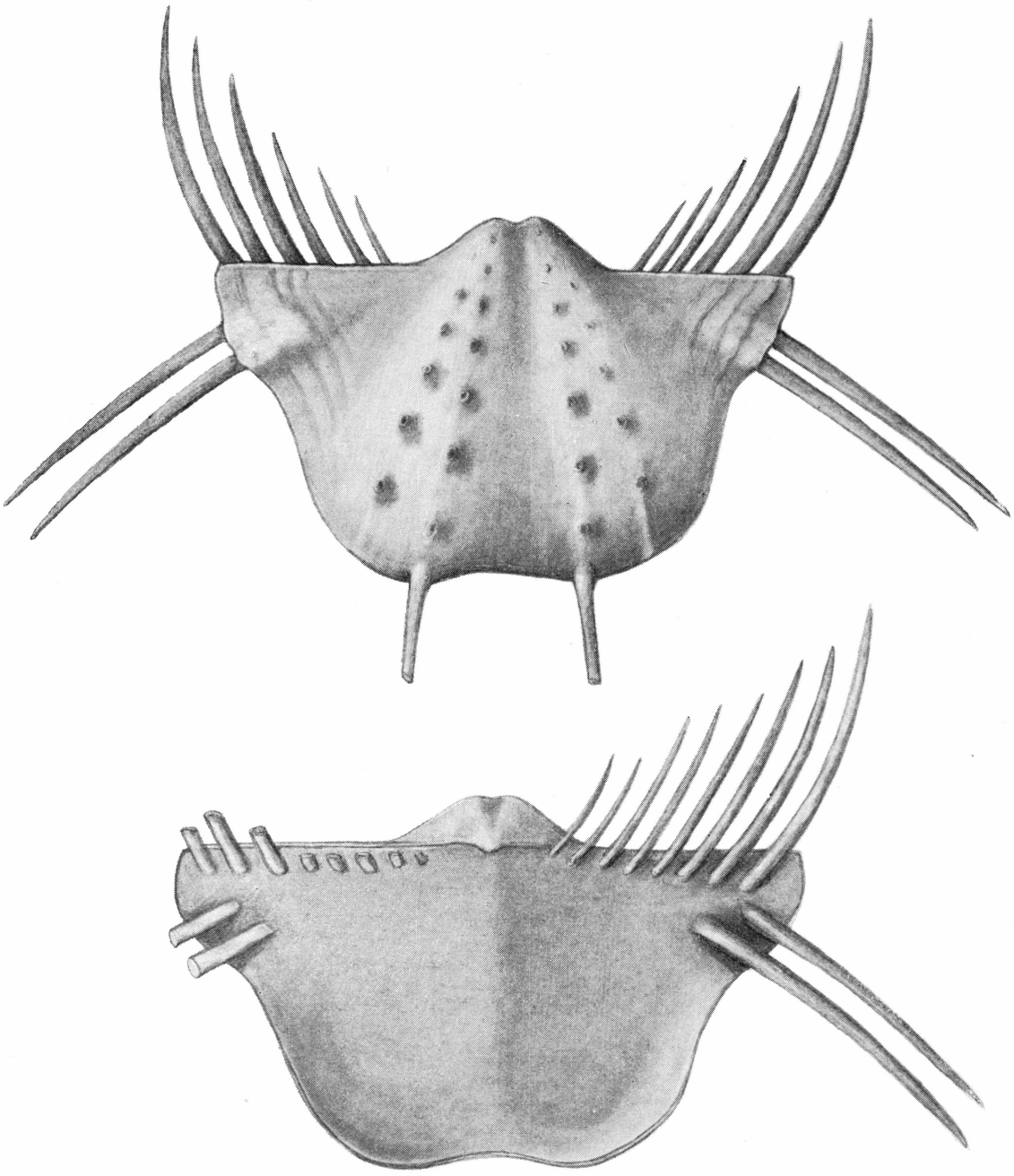

Fig. 20. Ventral and dorsal views of *Sowerbina maynci* showing arrangement of spines.

Productus timanicus STUCKENBERG from the Lower Permian of Russia is proportionately much narrower, has steeper umbonal slopes and is more strongly arched. Furthermore, it has many more spines on the ventral valve and these are arranged in at least 3 main rows down each lateral hump. In addition, the ventral body spines are much larger than those of the dorsal valve whereas the reverse is true of the Greenland shells.

In this interpretation I have depended on the original description by STUCKENBERG and on the extensive illustrations of TSCHERNYSCHEW, plus a specimen in the Yale collections identified by GEORGE FREDERICKS.

The form identified by WIMAN (1914, p. 75, pl. 17, figs. 19—21, and pl. 18, figs. 1—6) as *P. timanicus* appears to be quite different from the Russian species, and the specimens which he figured are for the most part obviously distinct from ours. The one shown as figures 20 and 21 of WIMAN's plate 17 is similar in size and outline to some of ours, but the dorsal valve has a more pronounced median fold than ours and possesses an oblique fold on each side between the visceral disc and the auricles that is not present in our species. The surface of the ventral valve is not shown in any of his figures. The good dorsal exterior shown as figure 2 of his plate 18 shows a large number of auricular spines quite unlike any of ours. On the other hand, the specimen shown as figure 5 of the same plate may possibly belong to our species. The interiors of dorsal valves illustrated belong to the genus *Sowerbina* but cannot be identified specifically. They indicate a much more strongly arched shell than *S. maynci*, one more like *S. rudis* n. sp.

The shell described by TOULA (1875, p. 12, pl. 5, fig. 1) as *Productus impressus* from Spitzbergen bears a superficial resemblance to ours in size and shape, but he showed it to have a finely costellate ornamentation and compared it to *Productus giganteus*. He says that there are traces of spines along the hinge line of his type but does not show them in this figure. WIMAN (1914, p. 76, pl. 18, figs. 7—9, and pl. 19, figs. 22—27) redescribed the species on the basis of collections from Spitzbergen and Bear Island, and he also describes the surface as being striate and says there are about 25 striae per centimeter and that they increase by bifurcation. His figures 7—9 of plate 18 clearly show such ornamentation and do not clearly indicate spines. STUCKENBERG then makes the curious statement that TOULA is said to have observed traces of spines along the cardinal margin but that he, STUCKENBERG, has not seen any, though he admitted that this might be because his material was not "so beautifully" preserved. In any event, the species could not have had large cardinal spines as ours does.

FREDERICKS (1934, p. 39, pl. 3 and 4) identified *Productus granulifera* TOULA in the Kanin Peninsula and proposed 3 varieties, *typica*,

gibbosa, and *spitzbergensis*. His material was apparently not well preserved, and his illustrations are so poor as to be useless for critical comparison. It is possible, if not probable, that the forms in Kanin Peninsula are identical with those in East Greenland. If so, FREDERICKS' *Ruthenia granulifera* var. *gibbosa* has priority over our *Sowerbina rudis*, and his *Ruthenia granulifera* var. *typica* has priority over our *Sowerbina maynci*. We can see no justification for the names *granulifera* var. *spitzbergensis* FREDERICKS and its "aberration" *auriculata* FREDERICKS. The former is based on a badly worn and broken valve with the spines entirely missing and the latter on an equally poorly preserved valve with one auricle partly preserved. It is quite possible that the forms in Kanin Peninsula are no more than generically related to those of East Greenland; to identify them specifically on the basis of FREDERICKS' paper would be sheer guesswork. The faunal studies of the Arctic Permian have long been too much a guessing game, and we have therefore decided to name and describe the Greenland forms so as to establish a firm base for future comparison, even at the risk of creating synonyms.

In his monograph of the Permian brachiopods of Spitzbergen, STEPANOV (1937) considered *Productus granulifera* TOULA to be a variety of *P. borealis* HAUGHTON and to belong to *Horridonia*. He corrected FREDERICKS' mistake in thinking its shell is punctate and in referring it to *Ruthenia* [= *Waagenoconcha*]. But in our judgment he erred in recognizing the species *P. borealis* HAUGHTON which was based on a badly exfoliated specimen so crudely illustrated that it cannot be even generically identified.

Distribution. Found in the "Productus limestone" at Kap Stosch and eastward in Hold with Hope (LK 2, 6, 7, 50; N 45, 45a, 49, 53, 58, 65); along Productuselv in southeastern Clavering Ø (M 316, 381, 385, 388, 395, 401, 444); at Forposten in central eastern Clavering Ø (M 558); in Djævlekløften in northeastern Clavering Ø (LK 20); at Forposten (Avantpostbjerg) in Clavering Ø (M 588); north of Cirkusdal in northeastern Clavering Ø (M 2360); and in the Martinia-Productus limestone in Margrethedal on the south coast of Gauss Halvö.

Sowerbina rudis DUNBAR, n. sp.
(Ety. L. *rudis*, rough).

Plate 14, figures 1—7; plate 15, figures 1—6; text fig. 21.

?*Ruthenia granulifera* var. *gibbosa* FREDERICKS, Trans. Arctic Inst., U.S.S.R., v. 13, 1934, p. 19, 39, pl. 4, figs. 5, 6.

Productus (Horridonia) borealis borealis STEPANOV [*non* Haughton, Trans. Arctic Inst., U.S.S.R. v. 76, 1936, p. 175, pl. 4, figs. 1a—c.

Description. This species is much more strongly arched than *S. maynci*, its lateral slopes are steeper and at maturity it develops

a much longer trail (text fig. 21). The auricles are relatively larger and more distinct from the lateral slopes, and they are strongly arched or rolled in the longitudinal direction. The ventral valve normally has only a single row of spines down the axis of each lateral hump, and these are relatively coarser than in *S. maynci*. The anterior slope is ornamented by strong but uneven ribs that appear gradually over the front

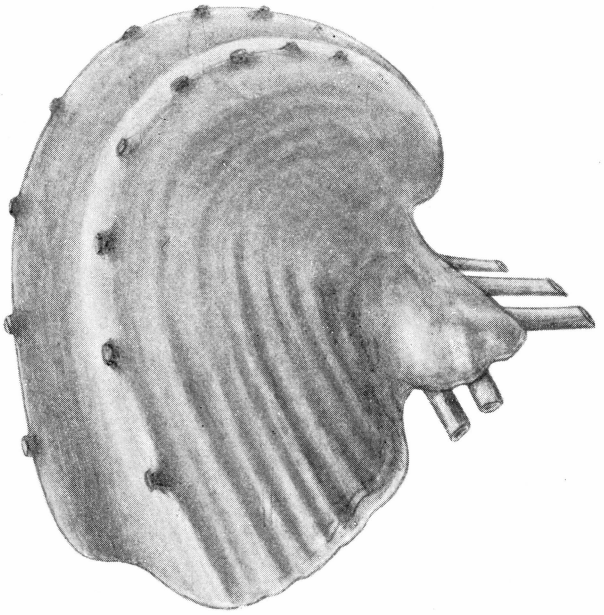

Fig. 21. Oblique lateral view of *Sowerbina rudis*, showing the strong convexity, the single pair of rows of ventral spines, the spineless ventral auricles, and the welts on the latter reflecting the great auricular spines of the dorsal valve.

part of the visceral area. As a result of the steep lateral slopes, the body of the shell (apart from the auricles) appears elongate in contrast to that of *S. maynci* which is transverse. As in the latter species, the spines on the dorsal valve are limited to a single row of cardinal spines and a pair of very large spines on each auricle. These produce conspicuous welts on the ventral surface of the auricles. The general appearance is that of a large, strongly arcuate (but not geniculate) shell with large rolled auricles, great spines, and a rough, radially ribbed anterior. The specific name alludes to this rough, rugged appearance. The substance of each valve is uncommonly thick for a productid.

The surface is covered by crinkly pustules similar in structure to those of *S. maynci*.

Discussion. Although *S. maynci* and *S. rudis* are evidently closely allied and in some localities occur together, they were for the most part

found in different places; they are readily separated (except for very young shells) and probably were adapted to rather different environments.

Sowerbina rudis resembles *S. timanicus* STUCKENBERG from the Lower Permian of Russia in generic features and in its strongly arched form, but it is a much larger species and has only 2 rows of large ventral spines instead of 6 or more.

It is impossible to determine whether any of the shells figured from Spitzbergen and Bear Island by WIMAN (1914, p. 75, pl. 17, figs. 19—21, and pl. 18, figs. 1—6) belong to our species. None of them shows the ventral spines. Figure 2 of his plate 18 shows a shell with numerous auricular spines on the dorsal valve quite unlike any of the Greenland shells. The interiors figured show generic characters only.

Ruthenia granulifera var. *gibbosa* FREDERICKS from Kanin Peninsula may be the same as our *S. rudis* but, as explained in the discussion of the previous species, it was too poorly described to be recognizable.

Distribution. Found in the "Productus limestone" about Kap Stosch, Hold with Hope (LK 2, 6, 7, 12, 29, 49, 50), east of Kap Stosch at River 9 (N 65), and between Rivers 13 and 14 (N 45a, 47, 54, 55, and 57); at Fossilelv in southeastern Clavering Ø (M 2438), at Grænsedalen in southern Wollaston Forland (M 1813, 1817), and on Carbon River (LK 604); at Kap Brown in Nathorsts Fjord, Canning Land (LK 6, 7). It was found also at MAYNC's localities 2338 and 2341.

Genus **Muirwoodia** LICHAREW, 1947.

Muirwoodia LICHAREW, Doklady, Akad. Nauk, U.S.S.R., n. s., v. 57, no. 2, 1947, p. 187—190.

Diagnosis. Productids of medium or small size, strongly arcuate, with a pronounced and rather narrow ventral sulcus and a finely costellate surface. The hinge line is slightly extended, and the auricles small and not sharply set off from the umbonal slopes. A single row of rather small spines is borne along the cardinal margin of the ventral valve, and a few larger and erect spines are scattered over the body of the ventral valve. The dorsal valve is spineless.

Generotype, *Productus mammatus* KEYSERLING.

Muirwoodia greenlandica DUNBAR, n. sp.

Plate 16, figures 1—17.

Productus weyprechti TOULA, k. Akad. der Wiss. zu Wien, Sitzungsber., Math.-Naturw. Cl., Bd. 70, 1874, p. 138, pl. 1, figs. 4 a—c, [not *Productus weyprechti* TOULA, 1873]; *ibid.*, Bd. 70, 1875, p. 10, pl. 6, figs. 2 a—c.

Productus weyprechti TSCHERNYSCHEW and STEPANOV, Second Norwegian Arctic Expedition in the Fram, Rept., v. 4, no. 34, 1916, p. 39, pl. 7, figs. 5, 6.

Productus weyprechti FREBOLD, Meddel. om Grønland, Bd. 84, no. 2, 1931, p. 23, pl. 3, figs. 3—5.

Productus (Thomasina) weyprechti STEPANOV, Trans. Arctic Inst., U.S.S.R., v. 76, 1936, p. 177, pl. 2, figs. 8, 9.

Productus (Thomasina) mammatus STEPANOV [*non* Keyserling], Trans. Arctic Inst., U.S.S.R., v. 76, 1936, p. 177, pl. 2, figs. 5—7.

Description. The normal size and shape are well shown on plate 16. Shells usually are distinctly wider than long, but old ones with the trail fully preserved are nearly as long as wide. A rather narrow sulcus begins about 5 mm in front of the beak and increases to a maximum depth between the inflated visceral humps and tends to become shallower on the trail. The hinge line is slightly extended into small, neat auricles that are not sharply set off from the umbonal slopes. In longitudinal profile the shell is strongly arcuate rather than geniculate but the curvature decreases progressively on the trail. The beak is small and does not overhang the hinge line.

The surface is covered by low, rounded costellae separated by rounded striae. About 15 costellae occupy a space of 1 cm on the body of the shell. They increase by intercalation on the ventral valve and by bifurcation on the dorsal. A faint trace of rugae can be seen on the posterior part of the visceral disc of many well-preserved shells (e. g. pl. 16, fig. 2), but in most shells they are absent or can be seen only in oblique light.

Spines are few. The ventral valve bears a single row of 10 or 12 cardinal spines, all of which are directed laterally and lie close to the shell. Those nearest the beak are minute and easily overlooked; the outer ones increase progressively and the last spine, borne on the auricle, is commonly the only one large enough to be noticed. A single row of body spines radiated from the beak along the crest of each of the visceral humps. The first of these, nearest the beak, were very small and commonly are not preserved, but apparently there were usually 5 or 6 spines in each row increasing progressively to the last, which is near the front of the visceral area. These body spines were erect, tubular and slender. Even well-preserved shells commonly appear to have only 4 spines, one on each auricle and one on each visceral hump, but the bases of the others can be detected with care. Besides these, many shells have a few additional body spines more irregularly spaced along the visceral humps, but none have been observed on the lateral slopes and, with a single exception, none have been seen in the sulcus or on the trail. The exception is a shell bearing a single stout spine in the sulcus near the edge of the trail. The dorsal valve is spineless.

The interior surface of both valves is thickly pustulose, and the texture of the shell is conspicuously pseudopunctate. In the ventral

valve (pl. 16, figs. 9 and 10) the diductor scars are each subtriangular, are about 10 or 11 mm long in adult shells, and are radially striated. They are separated at their posterior ends by a pair of small deeply impressed, elliptical adductor scars. In front of the adductors a conspicuous, raised welt separates the diductor scars. The latter are slightly elevated above the floor of the valve at their front margin and more strongly so along their posterolateral edge. No pallial markings can be observed in this valve.

The interior of the dorsal valve is illustrated by figures 11 and 17 of plate 16. The cardinal process is short and neat with its paired myophores facing posteriorly. It is buttressed by a low ridge on each side running nearly parallel to the hinge line and separating the visceral disc from a narrow posterior zone that is inclined steeply down to the hinge line. This ridge bears a row of rather coarse, low pustules, and the inclined space behind it bears along its middle a series of blunt nodes that interlocked with similar ones in the opposite valve. Although these are not true denticles like those of the *Rafinesquinidae*, but are probably modified internal pustules, they apparently served to aid in keeping the valves in place at the hinge line. Articulation was further strengthened by a comb-like row of short ridges and grooves at the lateral margins, extending from the hinge line fully halfway to the front of the shell. These structures meshed with a corresponding structure in the opposite valve when the shell was closed. The adductor scars are roughly triangular and bear a dendritic sculpture, and the brachial impressions are conspicuous. A very slender and low septal ridge runs along the midline to a point even with the front edge of the brachial impressions where it ends in a blunt spine. The anterior part of the visceral area is conspicuously studded with relatively coarse, blunt spines.

Discussion. This species has been commonly identified as *Productus weyprechti* Toula, probably not on the basis of the original types but of later publications by Toula. Toula based his species on internal molds from the southern tip of Spitzbergen, illustrating one very large specimen (his pl. 5, fig. 1) and 3 much smaller ones (his pl. 5, figs. 2a, b, and 3). It is now clear that the large specimen is not related to the smaller and may not be congeneric. Toula evidently realized his mistake soon, for in redescribing the species in 1874 and again in 1875, he omitted figure 1 in citing the original publication.

In 1873 Toula stated that none of his specimens showed the shell, but that the internal molds were good; and his figures show considerable detail in 3 different specimens, all of which are closely alike. Two of these were together in his figure 2, which is reproduced as figure 18

of our plate 16. These specimens show quite clearly that the ventral umbo bore a conspicuous, weltlike, median ridge some 3 or 4 mm wide that arose near the beak and ran forward between the large diductor muscle scars. They indicate further that the adductor scars were long and closely parallel and were located along the summit of the ridge.

The structure is quite different in *Muirwoodia* as shown by a comparable view of one of our types (pl. 16, fig. 16). Here the adductor scars are small, elliptical, and deep-set, and they are placed back of the diductors and diverge appreciably toward the front.

The features shown by TOULA's types are more like those of *Horridonia* or of *Sowerbina*, and cannot possibly be reconciled with those of *Muirwoodia*. It appears quite probable that TOULA's types are internal molds of the species which WIMAN later described from Spitzbergen as *Productus pseudohorridus* or possibly the one WIMAN recognized as *P. weyprechti* but which is not a *Muirwoodia*.

In 1874 WIMAN described a fauna from the west coast of Spitzbergen and in this he had specimens with the shell preserved, which he supposed to be *P. weyprechti* (WIMAN, 1874, p. 138, pl. 1, figs. 4a—c). This appears to be the species we have in Greenland. Fortunately, the beak of this figured specimen was sufficiently exfoliated to show clearly the distinctive adductor scars of *Muirwoodia*. It is quite clearly not congeneric with the types of *Productus weyprechti* TOULA. All subsequent identifications, with the exception of WIMAN's, have been based on TOULA's misidentified specimens of 1874.

WIMAN (1914, p. 65, pl. 14, figs. 3, 5, 6, 7 [not 4]) described *Productus duplex* from Bear Island. It is clearly a *Muirwoodia* and is much like our species and is possibly conspecific. However, each of the specimens he figured is almost 50 percent larger than the biggest specimen seen in Greenland, the details shown on the interior of the dorsal valve do not agree closely with our species, and, so far as indicated by WIMAN, the large spines on the body of the ventral valve are smaller and differently arranged.

Productus multistriatus MEEK resembles the Greenland species in its deep ventral sinus, strong visceral humps, small ears and fine costellae, but it is a larger and relatively more elongate form with somewhat finer radial ornamentation. The interior of MEEK's species has never been described.

Productus mammatus KEYSERLING is similar in many respects but is scarcely more than half as large and has finer costellae than our new species.

Distribution. This is one of the common species in the Permian beds of East Greenland. It is abundant along the outcrop at Kap Stosch

and eastward to River 14 (LK 4, 6, 7, 28, 29; N 45, 47, 49, 56, 65). It is also present in numerous collections along Margrethedal on the south coast of Hold with Hope (M 2744, 2754, 2762, 2779, 2784, 2790, 2792, 2802, 2830). It was found along Fiskeelv on the south coast of Clavering Ø (M 42, 90), about Forposten in Central Clavering Ø (M 561, 562, 580, 583, 589), along Productuselv (M 318, 324, 368, 370, 372, 373, 375, 378, 382, 384, 389, 412, 439, 442), and in Djævlekløften (M 2209).

Genus **Kochiproductus** Dunbar, n. gen.

Tschernyschewiella Fredericks [*non* von Toll, 1899], Geol. Com. Russian Far East, Records, v. 28, 1924, p. 20.

Shells of this type were recognized as a genus by Fredericks (1924) but his name, *Tschernyschewiella*, had been preoccupied by von Toll in 1893 for a Lower Devonian trilobite. [Eduard von Toll: *Beitrage zur Kentniss des Siberischen Cambrium.* Mem. Acad. Imp. des Sci. de St. Petersbourg, 8th ser., v. 8, no. 10, 1899, p. 37]. The brachiopod genus is here defined and renamed in honor of Dr. Lauge Koch. In view of the fact that Fredericks' name was a homonym, his genus was stillborn and has no legal status; his designated generotype may therefore be disregarded. This is done and the new species, *Kochiproductus plexicostatus*, is designated generotype because it can be described in full detail whereas many of the characters of the previously described species are unknown or, at least, are controversial.

Diagnosis. The new genus is distinguished by a combination of characteristics of shape and of surface ornamentation. It has a modately convex ventral valve in which the curvature decreases gradually toward the front, without geniculation. A broad but shallow ventral sulcus occupies the middle of this valve giving it a somewhat depressed appearance. The lateral slopes of the visceral region are steep but they round evenly into the auricles which are thin, almost flat, and not arched or rolled. The dorsal valve has a nearly flat visceral disc with a slight and rather narrow median fold. Near the edge of the visceral area this valve is flexed gently up into the trail.

The surface bears strong radial costae except on the auricles where they are weak or obsolete. Over the visceral area strong regular rugae cross the ribs and extend onto the auricles, but over the anterior part of the shell they are weak, and irregularly spaced, or are obsolete. Abundant small erect spines are distributed over both valves, arising from nodes on the costae or the rugae. These are subequal in size, normally not over 1 cm long, and show little differentiation on different parts of the shell except for the fact that they are closely crowded on the auricles and over the anterior part of the trail. They arise abruptly

almost at right angles to the surface. There are no distinct cardinal spines on either valve.

The substance of both valves is thin and muscle scars are slightly impressed.

Generotype, *Kochiproductus plexicostatus* DUNBAR, n. sp.

Discussion. To this genus we refer also *Productus porrectus* KUTORGA and *Productus peruvianus* D'ORBIGNY. In its broad umbo, wide ventral sulcus, its stout costae and the regular rugae over the visceral disc, this genus presents a striking resemblance to *Dictyoclostus*. But in the entire subfamily to which that genus belongs, the auricles tend to be extended and strongly arched and—of more importance—the spines are confined to the ventral valve, are rather sparsely distributed, are long, and tend to be differentiated with a row of large spines along the ventral cardinal margin.

The small and abundant spines distributed over both valves and the absence of a row of cardinal spines suggest that the true relations are with the pustulose productids. From all other genera of that subfamily, however, this one is distinguished by its strong ribs that extend from the beak to the anterior margin. From most of them also it is distinguished by the fact that its spines arise abruptly instead of coming out at a tangent to the surface.

R. E. KING (1930) referred *Productus peruvianus* to the genus *Buxtonia* THOMAS. Unfortunately, THOMAS (1914, p. 259) named and defined that genus without adequate description or discussion. He characterized it as being "more or less strongly geniculate and having the young and adult stages characterized by a costate and spinous ornamentation, while in old age spinosity alone is developed," the ribs becoming obsolete. The generotype is *Productus scabriculus* SOWERBY (*fide* MUIR-WOOD and STUBBLEFIELD, 1951, p. 22). It is a rather small, subquadrate shell with fine costellae. The obsolescence of the ribs near the front margin was not indicated in SOWERBY's type nor is it shown in British shells in the SCHUCHERT collection which have been identified as *Productus scabriculus*. It may be only a gerontic character appearing in very old shells. If so, it is hardly a suitable character for generic discrimination. Nevertheless, this species is representative of a group of Lower Carboniferous forms which, like other *pustulosi* have small spines thickly scattered over the surface of both valves but do not have large spines along the cardinal margin or on the auricles which are low and flattish. It differs from *Pustula*, however, in having distinct and continuous costellae. If THOMAS was justified in believing that its costellae were becoming obsolete at full maturity, it was already too specialized in the Lower Carboniferous to give rise directly to shells like *Kochiproductus*. In any event, however, *Buxtonia* represents a group of species

that were common and widespread during Lower Carboniferous time but declined before its close and are unknown in the American Pennsylvanian rocks. *Kochiproductus*, so far recognized only in the Permian, is probably derived out of some of the less specialized species of *Buxtonia* but is characterized by much larger size, a more elongate visceral area, coarser costae, stronger and more regular rugae which produce a conspicuous semireticulate ornamentation, and by having its costae strongly developed to the margin of the shell.

The anastomosis of the costae in the type species is regarded as only a specific and not a generic character.

Kochiproductus plexicostatus Dunbar, n. sp.

Plate 17, figures 1—6; plate 18, figures 1—6.

Productus porrectus Frebold (*non* Kutorga], Meddel. om Grønland, Bd. 84, no. 2, 1931, p. 38, pl. 1, figs. 1—3; *ibid.*, Bd. 84, no. 7, 1933, p. 13, pl. 1, fig. 1.

?*Productus (Buxtonia) freboldi* Stepanov, Trans. Arctic Inst., U.S.S.R., v. 76, 1937, p. 122, 176, pl. 2, fig. 4.

Description. The size and shape of this large species are well shown in plates 17 and 18. The outline normally appears rounded-subquadrate (pl. 17, figs. 1, 2) and, when mature, somewhat longer than wide (pl. 17, fig. 5). The hinge is commonly a little shorter than the greatest breadth of the shell which may lie only a little before the hinge but is usually near the mid-length of the valve. The auricles are remarkably thin and flat, never rolled, and commonly are imperfectly preserved. That shown at the right side in figure 4 of plate 18 is probably abnormally large.

The ventral beak is small and blunt and the umbo broad and rather low so that the shell appears depressed. A ventral sulcus begins 7 or 8 mm in front of the beak and becomes very broad but shallow over the umbo and the anterior slope. The lateral slopes of the umbo are steep but they curve evenly into the flat auricles. The transverse profile of the shell is thus low and subquadrate (fig. 4 of pl. 17). The curvature of the ventral valve decreases gradually toward the front and is slight on the trail. The dorsal valve is nearly flat over the visceral disc, with a very low and narrow median fold, but it curves up steeply in the trail to lie close to the ventral valve.

The surface appears rough and ragged. Except for the auricles it is covered by rather coarse radial costae that are narrower and more acute than the interspaces. They increase by fission on the ventral valve and by intercalation on the dorsal, and tend to be normal over the umbo and the posterior part of the visceral disc but, toward the front of the shell, they frequently anastomose in groups of 2 or 3 or more and then separate again in an irregular fashion (pl. 17, fig. 1, and

pl. 18, fig. 3). This is a distinctive specific character to which the name refers (L. *plexus*, *a*, *um*, from *plexio* to braid or plait + *costa*, a rib). The ribs are generally irregular and uneven in thickness and in height. Over the umbo and the visceral disc they are crossed by fairly regular rugae about equal in coarseness to the costae. The rugae are strong also on the auricles where ribs are lacking, but over the anterior part of the shell they become weak and irregular or completely obsolete. The semireticulate surface thus mimics that of the genus *Dictyoclostus*.

In addition to the costae and rugae, the entire surface was covered with fine concentric lirae about 20 to the millimeter. These are best preserved, and may have been strongest, in the furrows between the costae.

Small erect spines are rather thickly scattered over both valves. They were apparently fairly uniform in size, being about 0.5 mm in diameter and 5.0 mm long. Over the body of the shell they arise from nodes on the costae, usually where costae and rugae intersect, and over the visceral disc they are so spaced that from 3 to 5 or 6 spines appear within each square centimeter. Near the front margin of adult shells they are more crowded, and on the auricles they are closely spaced. They normally arise at right angles to the surface but on the auricles tend to curve laterally. There are no cardinal spines.

The shell of both valves was very thin throughout and the muscle scars are lightly impressed. In the ventral valve the adductor scars are small and slender, lying upon the ridge formed by the sulcus and being embraced by the anterior tips of the large diductor scars. The latter are radially striated.

The interior of the dorsal valve is well shown in figures 1 and 6 of plate 18. The cardinal process is rather long and is directed almost straight back into the ventral beak. It has a double cleft on the dorsal side (fig. 5 of pl. 18). Its shaft runs forward as a slender septal ridge beyond the middle of the valve. In addition, a strong buttressing ridge runs out close to the hinge margin more than halfway to each extremity. A low ridge bounds the sides of the visceral area separating it from the auricles and from the lateral trail (fig. 6 of pl. 18), dying out about mid-length of the shell. The anterior part of this valve is roughened by coarse, low pustules. The adductor scars are long and slender, lying close against the median septum and bearing a dendritic sculpture. No impression of the lophophore has been observed.

Discussion. FREBOLD (1931, 1933) identified these Greenland shells with *Productus porrectus* KUTORGA which is common in the Sakmarian limestones of Russia. The latter, in turn, was regarded by KOZLOWSKI (1914) as a synonym of *Productus peruvianus* D'ORBIGNY

which was described from the Early Permian about Lake Titicaca in South America. R. E. KING (1930) also identified the latter in the early Permian (Hueco and Hess limestones) of west Texas. It is inherently improbable that a species with such strong characters should have spread unchanged over such vast distances, but the difficulties involved in a critical discrimination based only on the literature are considerable. The shells are large and thin, hence liable to distortion when imbedded in shaly or marly matrix, and to loss of the margins—especially the thin flat auricles—when broken from solid limestone. The rough ornamentation clings to the matrix so that the surface is commonly exfoliated when the shells are broken from solid rock. There probably was considerable individual variation in outline of the shell margin especially the trail and the auricles, but few if any of the illustrated specimens were complete. KUTORGA's original description (1844, p. 96) was rather brief and he illustrated only a single type. Although he gave an excellent appearing dorsal and ventral view of this specimen (1844, pl. 10, figs. 3a and b), it is extremely probable that it was considerably exfoliated and had lost both its auricles. TSCHERNYSCHEW (1902) redescribed the species with better illustrations, but he clearly included specimens of at least two quite distinct forms, and neither of his specimens was complete. Fortunately, the SCHUCHERT collection includes two good specimens collected by GEORGE FREDERICKS from the type locality near Sterlitamak and identified by him as *Productus porrectus*. These agree well with the specimen figured by TSCHERNYSCHEW from the same locality (his pl. 56, figs. 4a—c). Another specimen figured by TSCHERNYSCHEW (his pl. 55, figs. 1a and b) from Tastuba appears to be conspecific. Our interpretation of *Productus porrectus* rests upon this data plus a qualified interpretation of the descriptions given by KUTORGA and by TSCHERNYSCHEW.

KOZLOWSKI's redescription and illustration of the South American form, *Productus peruvianus*, are much more adequate. I also have before me the collections of R. E. KING from west Texas.

The collections from East Greenland include more than 50 rather good specimens most of which have weathered from marly shale and show the surface in excellent preservation. Three specimens were silicified in more solid limestone from which they have been freed by HCl, and in one of these it has been possible to separate the valves and to study the excellently preserved interiors and exteriors of both. In this abundant material a good many of the shells have suffered some distortion during compaction of the sediment, and have some of the trail and part of one or both auricles broken away. Some uncertainty therefore remains as to the constancy of the outline and particularly of the length of the hinge and the size of the auricles, but in other respects,

particularly in the short beak, the broad umbo, the depressed shape and the surface ornamentation, the shells are remarkably alike. It is evident that after the animal had approached maturity the chief growth was along the front of the trail so that fully grown shells appear more elongate than submature ones (cf. figs. 1 and 5 of pl. 17).

Study of all available data indicates that there are at least 3 somewhat closely related species in the suites reviewed above, all of which belong in the new genus *Kochiproductus*. These are (1) *Productus porrectus* KUTORGA, confined to the Lower Permian of Russia, (2) *Productus peruvianus* D'ORBIGNY of the Lower Permian of South America and probably of Texas, and (3) *Kochiproductus plexicostatus* n. sp. from the upper Permian of East Greenland.

If we accept the original description and illustrations of KUTORGA it is obviously different from all of these. He figured a shell without auricles and with the greatest width near the middle and almost twice that at the hinge line. His description emphasizes these features for he wrote, "ohne die mindeste Spur von ohernförmigen Seitenflügen an beiden Ende der Schlosslinie." His figures also indicate a small, narrow and rather acute beak. It seems altogether probable that his type originally possessed auricles that were lost when the shell was broken from the rock and that the beak was incorrectly drawn. TSCHERNYSCHEW'S specimens from Sterlitamak and Tastuba appear to have been correctly portrayed and to represent the Russian species best. If so, *K. porrectus* agrees closely with the new species in size and shape (compare our pl. 17, fig. 5, with his pl. 56, fig. 4, and our pl. 18, fig. 4 with his pl. 55, fig. 1); but there is an important difference in the ornamentation. Both KUTORGA and TSCHERNYSCHEW describe and illustrate the costae as extending unchanged to the front margin of the shell, but in the new species they anastomose and subdivide over the anterior half of the shell so as to resemble a braided fabric. This is an obvious specialization and serves to emphasize that the Greenland species occurs higher stratigraphically than the Russian.

[It may be noted in passing that the shells illustrated in text figs. 75 and 76 by TSCHERNYSCHEW, derived from Kasarmensky Kamen near Simskaya have much finer and more numerous costae and a peculiar frill-like trail, and that this form is almost certainly not *P. porrectus* KUTORGA].

The South American species, *P. peruvianus*, possesses a narrower and somewhat more strongly arched umbonal region than either of the others and from the ventral view appears subtriangular, with the greatest width far forward. Furthermore, the reticulation on the visceral disc is not so strong or so regular as in the other species. Unlike the new species, its costae are regular and unspecialized to the front margin of the shell.

TSCHERNYSCHEW and STEPANOV (1902) had 6 specimens from Big Bear Cape, Ellesmere Land, which they identified as *Productus porrectus*, one of which they figured without description. This specimen had both auricles and the ventral beak broken away, and the surface was rather worn and partly exfoliated. Its costae appear to be simple and normal to the front margin, however, and it appears to belong to the Russian species rather than to ours.

STEPANOV (1937, p. 122, 176, pl. 2, fig. 4) named a species, *Productus (Buxtonia) freboldi* STEPANOV, in a description of a fauna from the Ice-Fjord region, western Spitzbergen. In the English text he stated, "This name is proposed for a form identical with '*Pr. porrectus*' described by FREBOLD from the Brachiopod limestone of eastern Greenland. The difference of the Arctic form from the species of KUTORGA consists in the character of the sculpture, the longer hinge line, and the development of the ears." He did not explain what these differences are, and the single specimen which he figured was an incomplete, rather badly crushed shell in which the cardinal extremities are missing. It does not show spines or any other specific characters. STEPANOV did not indicate what he considered the holotype of his species. Presumably it would be the shell which he illustrated, from Spitzbergen. It is herewith so designated. STEPANOV believed it to be conspecific with the Greenland species, but this is quite uncertain. He neither described nor illustrated any significiant specific characters. The fauna in which it occurs in Spitzbergen has but few species in common with Greenland and, on the contrary, most of its species do not occur in Greenland. In view of the uncertainty and the wholly inadequate description of STEPANOV's species, we are describing the Greenland form as a new species even at the risk of coining a synonym.

Distribution. This species was found in greatest abundance in the Kap Stosch area at the north tip of Hold with Hope where it occurs in a bed of greenish gray marl, somewhat less than 1 meter thick. This is the "Productus limestone," unit 6 of MAYNC's profile section (LK 1, 2, 4, 10, 11, 12, 17, 28, 29; N 45—50, 65). It was found also in the equivalent bed in Dolomitdal (LK 37) and in Djævlekløften (LK 20), both in northeastern Clavering Ø, and on Productuselv in east central Clavering Ø (M 412, 428) and at many other places.

Genus **Rhynchopora** KING, 1865.

Rhyncophora KING, Ann. and Mag. Nat. Hist., ser. 3, v. 16, 1865, p. 124.

Diagnosis. Rhynchonelliform, coarsely punctate shells having well-developed dental lamellae and, in the dorsal valve, an undivided

hinge plate supported by a small cruralium that lies at the top of a median septum.

Generotype, *Terebratula genitiziana* DE VERNEUIL.

Rhynchopora abnormalis DUNBAR, n. sp.

Plate 19, figures 1—6.

Description. This small species has the punctate shell and the internal features of *Rhynchopora* but has diverged rather markedly in shape from the norm of this genus. The ventral beak is narrow and erect, and the posterolateral margins diverge gradually at less than a right angle, the maximum width being well in front of the mid-length of the shell. The fold and sulcus appear late and, as shown in figures 3 and 6 of plate 19, are rather obscurely defined. The front of the shell does not appear truncated as it normally does in *Rhynchopora*. Each valve bears 16 or 18 simple, rounded costae of which 4 are borne on the fold and 3 in the sulcus. The shell is abundantly and rather coarsely punctate.

Internally, the ventral valve bears a pair of rather long and slightly diverging dental lamellae, and the dorsal umbo bears a median septum.

Discussion. We have only a few specimens of this species but they are so much alike and so different from other described species as to be easily recognized. The erect ventral beak, narrowness of the shell in the umbonal region, subtriangular outline, ill-defined fold and sulcus, and the lack of truncation at the front are all distinctive characteristics.

Distribution. One specimen was collected by MAYNC at Forposten (Avantpostbjerg) on Clavering Ø (M 515); the rest were collected by STAUBER from the "Productus ledge" west of Schucherts Flod in Southern Scoresby Land.

Rhynchopora kochi DUNBAR, n. sp.

Plate 19, figures 7—24.

?*Camarophoria crumena* TOULA [*non* Martin], k. Akad. der Wiss. zu Wien, Sitzungsber., Math.-Naturw. Cl., Bd. 70, 1874, p. 137, pl. 1, figs. 3a, b.

Description. Several specimens have been figured to illustrate the range of shape in this somewhat variable species. And, since it is so small, each specimen is shown also enlarged to 2 diameters.

The shell is of subpentagonal outline, somewhat wider than long, commonly truncated at the front, with the posterolateral margins gently curved and the ventral beak small and obtusely angular.

In young shells both valves are convex, but when about half-grown a rather broad dorsal fold began to appear, being matched, of course,

by a ventral sulcus; these gradually increased in prominence to the front where the shell in the sulcus is extended as a high tongue meeting the fold of the dorsal valve.

In most specimens both fold and sulcus are almost flat in cross section and are bounded by steep margins (e. g. figs. 12 and 20 of pl. 19), but in some the fold is more rounded (e. g. fig. 14) and a rib breaks the abrupt slope to the lateral part of the shell. There is some variation also in the number of plications on fold and sulcus. The normal number is 6 on the fold and 5 in the sulcus. In such shells the fold and sulcus appear broad and flat. In others (e. g. fig. 14), the lateral pair of the 6 is appreciably lower than the middle 4, and in these shells the fold appears somewhat rounded and less strongly set apart from the lateral slopes. In a few shells one of these marginal plications appears to have failed, or to have slid off the fold onto the side of the shell (e. g. figs. 22 and 24), and in these there are 5 plications on the fold and 4 in the sulcus.

In adult shells the umbo of the ventral valve is gently convex but the lateral areas bordering the sulcus are almost flat; but the area within the sulcus is strongly geniculated and extends as a high tongue into the dorsal fold. The longitudinal profile of the shell is triangular (e. g. fig. 9).

The ventral beak is short and very slightly incurved. The pedicle foramen is small and narrowly triangular, and the deltidial plates appear to be little more than half as wide as the delthyrium. The cardinal area is narrow and poorly defined.

The surface of the shell is marked by radial plications that in most specimens start at the beak but in a few seem to arise some distance in front of it. These ribs are fine on the beak but expand gradually toward the front. They are normally low and flat with narrow, sharp grooves between them; only near the front of the fold, in some shells, they become higher and somewhat subangular. The ribs number from 6 to 9 on each lateral slope of the shell.

The shell substance is abundantly punctate, the punctae being rather thickly spaced but without a regular pattern.

The internal features have been studied in several silicified specimens from Forposten (Avantpostbjerg) that were freed from the matrix by HCl. In the pedicle valve the dental lamellae diverge from the sides a short distance in front of the beak, reach to the floor of the valve and extend forward about one-third the length of the shell, decreasing in height before the hinge line.

The brachial valve has a flattish, triangular hinge plate, from the front of which spring the short, flat, strongly down-curved crural processes. The plate is perforated at its apex by a tiny hole. The hinge plate is supported by a pair of crural lamellae that converge imme-

diately in front of the perforation to form a median septum and to enclose a very small triangular crural cavity.

Discussion. In most respects this species is very close to *R. geinitziana* (DE VERNEUIL). According to DE VERNEUIL, however, *R. geinitziana* has ribs that are slightly angular *(légèrement aigues au sommet)* while nearly all the specimens from Greenland have broadly rounded or even flat ribs. DE VERNEUIL further states that his species has 4—5 ribs in the sulcus and 8—9 on the sides of the test (an examination of his figure shows that there are 8 ribs on each side of the fold). The specimens from Greenland have 3—5 ribs in the sulcus and 6—9 on each side of the fold. As a general rule, the specimens with the largest number of ribs in the sulcus also have the highest number of ribs on the flanks. In size and general shape of the shell there is good agreement between *R. geinitzianus* and the form from Greenland.

In the shape of the ribs the present species resembles *R. nikitini* TSCHERNYSCHEW. In both species the flat ribs are subdivided close to the anterior border by a fine median line that becomes deeper toward the border. According to TSCHERNYSCHEW this character serves to distinguish *R. nikitini* from *R. geinitziana.* In the shape of the sulcus however, the present species differs considerably from *R. nikitini.* While the latter species has a broad, shallow sulcus, the present species has a relatively narrow sulcus with steep sides.

To recapitulate, in the size and shape of the valves and the fold and sinus, and in the number of ribs, the present species resembles *R. geinitziana*, while in the appearance of the ribs it is closer to *R. nikitini* TSCHERNYSCHEW.

Distribution. This species is common in the "Productus ledge" west of Schucherts Flod in southern Scoresby Land (STAUBER coll.). BIERTHER found it in numerous places in northern Scoresby Land. MAYNC collected it at Ladderbjerg in Gauss Halvö (M 2991). It is also common in the "white blocks" in the Triassic conglomerates about Kap Stosch (LK 582; N 8, 27, 99, 100, o, u, r). It was collected in the Permian beds about Kap Stosch (LK 1, 6, 7, 28, 461). In Clavering Ø it was found by MAYNC along Fiskeelv (M 73, 77) and especially about Forposten (Avantpostbjerg) (M 515) and Cirkusdal (M 2268, 2272, 2275, 2277, 2279, 2281) where it is very abundant.

Rhynchopora sp. A.

Plate 19, figures 25, 26.

At a locality on Fiskeelv, near the southern coast of Clavering Ø, MAYNC collected a well-preserved specimen of *Rhynchopora* that is shown in dorsal and anterior views in figures 25 and 26 of plate 19.

It is unlike *R. kochi* in having but 3 plications on the fold and 2 in the sulcus, and in the fact that the plications are angular instead of rounded. Furthermore, it is less truncated in appearance at the front.

It can hardly be an abnormal individual of *R. kochi* but since we have only a single specimen it will not be named.

Genus **Dielasma** KING, 1859.

Diagnosed by KING under the name *Epithyris*. Mon. of the Permian Fossils. The Paleontographical Soc., London, 1850, p. 146; but the name *Dielasma* was substituted in 1859, Proc. Dublin Univ., zool. and bot. Assoc., v. 1, p. 256, 260.

Diagnosis. Elongate, oval terebratuloids with the ventral valve tending to be flattened or sinuate along the middle. Pedicle foramen epithyrid. Dental lamellae present in ventral valve, and in the dorsal a pair of hinge plates that lie close to the sides of the beak and converge downward toward the mid-line where they are attached to the floor of the valve, thus forming a sessile brachidium. Cardinal process lacking. Loop short.

Generotype, *Terebratulites elongatum* SCHLOTHEIM.

Dielasma elongatum (SCHLOTHEIM).

Plate 20, figures 1—17.

Terebratula elongata SCHLOTHEIM, Akad. Wiss. zu München, Denkschr., Math.-Phys. Cl., v. 6, 1816, p. 27, pl. 7, figs. 7, 8, 9, 13, 14; GEINITZ, Dyas, 1861, p. 82, pl. 15, figs. 14—28.

Epithyris elongata KING, Mon. Permian Fossils of England, 1850, p. 147, pl. 6, figs. 30—45.

Terebratulites elongata DAVIDSON, British Fossil Brachiopoda, v. II, pt. 4, 1858, p. 8, pl. 1, figs. 5—22; pl. 2, fig. 2.

Dielasma elongata FREBOLD, Meddel. om Grønland, Bd. 84, no. 7, 1933, p. 23, pl. 3, figs. 14, 15.

Description. A small species whose size and shape are well shown by the smaller photographs in figures 1—17 (the larger member of each pair being enlarged 2 diameters to show details). The average ratio of breadth to length is about 1 : 1.2 and of thickness to breadth 1 : 1.7. In longitudinal profile the ventral valve is moderately and smoothly curved and that of the dorsal valve is somewhat less convex. The beak is strongly curved but is truncated at the apex by the oval pedicle foramen in front of which may be seen the deltidial plates.

The sulcus of the ventral valve is very shallow and is confined to the anterior fourth of the shell. It arises so gradually and obscurely that its beginning cannot be distinctly located.

The surface is smooth except for occasional varices of growth. Shells preserved in white limestone retain traces of radiating color pattern (see figs. 1, 9, 14). The shell substance is abundantly punctate.

Internal structures are revealed in an etched specimen of which the valves could be separated (figs. 12, 13). They show the normal features for the genus *Dielasma*. The ventral beak has short dental lamellae that diverge from the sides of the beak some distance in front of its apex. Muscle scars are so lightly impressed as to be not clearly distinguishable. In the dorsal beak there is no cardinal process; a pair of hinge plates lie close to the sides of the beak and converge toward the mid-line where they are attached to the floor of the valve, thus forming a sessile brachidium. At their upper margin these plates are separated from the shell margin by narrow dental sockets below which they are anchored to the side of the shell by socket plates. The blade-like crurae arise from the front edge of the hinge plates at the level of the socket plates.

Discussion. *Dielasma elongatum* was described by SCHLOTHEIM from the Zechstein beds in Germany and was redescribed from these by GEINITZ and from the Magnesian limestone in England by KING and by DAVIDSON. Illustrations by these writers indicate a shell comparable in size to ours but with a wider range of variation in shape than the Greenland shells show. Our shells clearly fall within the normal habit of that species and could not be separated therefrom by any criteria now available.

This species has been identified by many workers from diverse horizons and widely separated regions. The citations given above include only a few of the references.

Distribution. This species is common in the "white blocks" in the Triassic conglomerate in the region of Kap Stosch appearing in 32 separate collections. It is also common in BIERTHER'S collections from northern Scoresby Land and in STAUBER'S collections from west of Schucherts Flod in southern Scoresby Land. It was also found on Depot Ø in Nathorsts Fjord (LK 13).

Dielasma stoschensis DUNBAR, n. sp.

Plate 20, figures 18—21.

Description. This rare species in distinguished by its subtriangular cross section. Although the longitudinal curvature is normal for the genus, the ventral valve is nearly flat in cross section. A flattened belt begins at the beak and widens forward to occupy the full width of the valve, and toward the front it becomes a very shallow sulcus. Concomitantly the dorsal valve is high and narrowly convex along its middle,

and its sides slope steeply away to the lateral margins. The slightly concave sides of the ventral beak are separated from the ventral surface by a subacutely rounded angle or ridge.

The size and shape are well represented by figures 18 to 21 of plate 20 in which 4 views of the holotype are shown at natural size and enlarged 2 diameters.

Discussion. We have only 3 specimens of this species, none quite complete, but it is clear that their peculiar shape is not due to abnormal growth or to deformation after burial.

The species most closely resembles *Dielasma timanicum* TSCHERNYSCHEW of the Schwagerinakalk of the Urals, but that species is much larger and has a broad, short ventral beak and a relatively wide hinge, being broader and more subquadrate than our species.

Dielasma itaitubense WAAGEN [*non* Derby] from the Middle Productus limestone of India has similar angular separation of the sides and the ventral surface of the ventral beak, but its ventral valve is convex along the middle.

Distribution. The holotype is from White Block No. 15 in the Triassic conglomerate east of Kap Stosch. A second specimen is from White Block No. 37. A third and well-preserved specimen was found in the "Productus limestone" in the Permian section between Rivers 13 and 14 east of Kap Stosch (N 48).

Genus **Camerophoria** KING, 1844.

Camerophoria KING, Ann. and Mag. Nat. Hist., v. 14, 1844, p. 313; v. 18, 1846, p. 89.

Diagnosis. Rhynchonelliform shells with a small spondylium in the ventral valve and an elongate cruralium in the dorsal, and with long slender cruralia.

Range — Devonian to Permian.

Generotype, *Terebratula schlotheimii* VON BUCH.

Discussion. KING introduced the name *Camerophoria* in 1844 in the following words, "In a Monograph of the Invertebrate Fossils of the Magnesian Limestone of the County of Durham, which I am preparing for publication, I have been compelled to institute six new genera, namely, * * *, *Camerophoria* for a Brachoipod approximating to *Pentamerus* in some points of its internal structure." He did not then cite any species or diagnose the genus; but in 1846 he discussed and defined the genus at length and indicated the generotype in the following way, "Having, by the examination of a large number of specimens of the typical species (*C.* [*Terebratula*] *Schlotheimi*) in various states of pre-

servation, satisfied myself regarding the internal characters of *Camerophoria*, I will now proceed to describe them with reference to their generic value."

Some five years earlier CONRAD (Second Ann. Rept. New York Geol. Survey, 1839, p. 59) had proposed the genus *Stenoscisma* and designated its generotype as *Terebratula schlotheimii* VON BUCH. He was writing on Helderbergian fossils of New York, then considered Silurian, and he defined his genus as follows: "The catalogues of organic remains of the Silurian system, hitherto published in Europe are only calculated to mislead and confound the geological enquirer, as they are far too vague; * * *. The genus *Terebratula* is wholly unknown, and the shells usually referred to that genus I propose to group under the generic name of *Stenoscisma*, derived from two Greek words signifying narrow fissure, a character these shells possess under the imperforate apex of the larger valve, and which serves to connect the genus with *Delthyris*, from which it differs in having no cardinal area. This last character, on the other hand, connects it with *Strygocephalus*. I refer to it the common Silurian bivalve, *Terebratula Schlotheimii* (VON BUCH)."

In discussing the genus *Stenoscisma* in 1867 (Paleont. N. Y., v. IV, p. 334) JAMES HALL quoted these remarks of CONRAD and added, "It was a Lower Helderberg species *(Rhynchonella formosa)* which was referred by Mr. CONRAD to 'the common Silurian bivalve, *T. schlotheimii*.' I have in my possession a lithographed plate of the fossils of the Lower Helderberg group by Mr. CONRAD, with the names, in his own hand, written beneath the figures; the species I have since designated as *R. formosa* having there been identified with *Terebratula schlotheimii*."

This poses the problem whether the generotype of *Stenoscisma* is the named species from the Permian rocks or a misidentified species from the Lower Devonian rocks later described by HALL as *Terebratula formosa*. If the former is true, *Camerophoria* is a synonym of *Stenoscisma* and the latter genus was completely misinterpreted by HALL; if the second alternative is true, *Camerophoria* and *Stenoscisma* are both valid.

Most subsequent workers have followed HALL in accepting the second alternative; but COOPER (in Index Fossils of North America, 1944, p. 315) reverted to the first alternative and threw *Camerophoria* into the synonymy of *Stenoscisma*.

The case clearly falls within the purview of Opinion 168 of the International Commission on Zoological Nomenclature dealing with genera based upon erroneously determined species. This opinion recommended that in cases where there was justification to believe that a genus was based upon a misidentified species it should be presented

to the Commission for plenary action. Since then, Opinions 169, 173, 175, 177, 179, and 181 have dealt with such cases and in each instance the decision has been to accept the intended but misidentified species instead of the named species as generotype. It therefore appears altogether likely that similar action would be taken in the present case which is being presented to the Commission.

Camerophoria kochi Dunbar, n. sp.

Plate 21, figures 1—8.

Description. The size and shape of this medium-sized species are well shown in the figures on plate 21. The outline is subpentagonal, the greatest width being only a little in front of the hinge line, and the beaks extending well back of the hinge. The fold and sulcus arise after the shell is almost half-grown and increase in prominence to the front margin. There are normally 4 plications in the sulcus and 5 on the fold (very rarely 6 in the sulcus and 7 on the fold), and 4 on each lateral slope, decreasing in prominence outward. These begin rather obscurely about 7 or 8 mm in front of the beak on the ventral valve and about 5 mm in front of the beak on the dorsal, leaving the umbones of both valves smooth. The ventral beak is rather narrow and inflated but neatly curved in against the much broader and low dorsal beak.

Although no free valves are available to show the internal characters, a number of the shells are so translucent as to reveal the small spondylium in the ventral beak and the median septum of the dorsal beak supporting the slender spoon-like cruralium. In addition, several of the shells are broken so as to reveal these generic structures.

Discussion. This is the most common and widely distributed species of the genus in East Greenland. It shows considerable resemblance to some of the shells that have been described from the Magnesian limestone of England and the Zechstein of Germany under the name *C. schlotheimii* von Buch. It does not, however, agree well with the type of that species as originally described and figured by von Buch (1834, p. 39, pl. 2, figs. 32a—c). The latter is fully as long as wide whereas the Greenland species is decidedly transverse and less extended in the middle so that the outline is quite different.

The form described by King (1850, p. 118—120, pl. 7, figs. 10—21) from the Magnesian limestone of England as *C. schlotheimii* appears to be specifically distinct from von Buch's type and in some respects resembles our species more closely, but King's numerous figures show a wide variation in the number of plications ranging from one with no plications to another with 5 plications in the sulcus and 6 on the fold, the more normal form having but 2 or 3 on fold and sulcus. The number

is much more constant in the species before us, and we have seen none with so few plications. The outline of KING's specimens tends to be subtriangular rather than subpentagonal, the greatest width being farther forward than in our species.

The form described by GEINITZ from the Zechstein of Germany (1848, p. 12, pl. 4, figs. 43—50) as *C. schlotheimii* appears to be the same as that described by KING and shows a comparably wide range in the number of plications on fold and sulcus. The plications appear to be more sharply angular than in our species and to begin much closer to the beak. GEINITZ's redescription of the Zechstein species in 1861 (p. 84, pl. 15, figs. 33—48) confirms the earlier evidence that the plications are highly variable, and there is a tendency for them to become obsolete.

The genus *Camerophoria* has rarely been recognized in the Permian faunas of the Arctic region. One of the specimens identified by TSCHERNYSCHEW from the Lower Permian of the Urals as *C. crumena* MARTIN (TSCHERNYSCHEW, 1902, pl. 22, fig. 10) resembles our species in shape but is appreciably larger and appears to have more sharply angular plications. It appears not to be conspecific with the other specimens he figured, and none of them belong to MARTIN's Lower Carboniferous species.

C. spitzbergiana STEPANOV from Spitzbergen (STEPANOV, 1937, p. 157, pl. 9, fig. 11) is quite different from ours, being more elongate and slender, and having fewer ribs on fold and sulcus. *C. triplicata* KUTORGA is more elongate and slender, and besides being different in shape from our species is generically different. *C. biplicata* STUCKENBERG, from the Artinsk of Russia, also shows little resemblance to our species, being more elongate and differently shaped, and having fewer ribs on fold and sulcus.

Distribution. This species was found most commonly in the Permian beds near Kap Stosch (LK 6, 7, 28, 29, 50; N 18, 19, 30, 32, 33, 38, 47, 51). It is present in the Martiniakalk in Margrethedal on the south coast of Gauss Halvö (M 2756, 2765, 2773). The figured types are from "white blocks" of Permian limestone in the Jurassic beds in Dolomitdal on Clavering Ø (M 2419, 2420, 2421, 2426). It was found in the Permian strata along Productuselv on Clavering Ø (M 318, 320, 346, 347, 401, 430), and near Forposten (Avantpostbjerg) (M 558, 587). It is rare in STAUBER's collections from west of Schucherts Flod in southern Scoresby Land, and in a collection made by the sailors in Nathorsts Fjord.

Camerophoria sp. B.

Plate 21, figures 9—13.

Description. This species is represented by a few specimens from several localities, all of them more or less incomplete so that there is

hardly enough to justify specific description. Figure 9 of plate 21 shows an excellent juvenile specimen, and figures 10—12 show two of the best adult shells. Both of these indicate a species much narrower and more triangular in outline than *C. kochi;* one of these specimens has 2 plications in the sulcus and 4 on the fold, but the other shows 3 and 4 respectively.

Distribution. The figured specimens are from the Kap Stosch area. Several specimens were found by MAYNC along Productuselv in Clavering Ø (M 379, 353), and a few by BIERTHER in the northern part of Scoresby Land. A single specimen was taken by STAUBER west of Schucherts Flod in southern Scoresby Land.

Camerophoria cf. *C. multiplicata* DAVIDSON.

Plate 21, figures 14—16.

Description. From Scoresby Land we have 3 incomplete shells of a species much larger than *C. kochi*, bearing 4 plications in the sulcus and 5 on the fold, and 6 or 7 on each lateral slope. In both size and shape these shells resemble *C. multiplicata* DAVIDSON from the Magnesian limestone of England, but our material is too fragmentary to permit positive identification or adequate description.

Distribution. Our best specimens (figs. 14, 15 of pl. 21) are from STAUBER's collection from west of Schucherts Flod in southern Scoresby Land. The next best (fig. 16, pl. 21) was found by BIERTHER in the Martiniakalk in northern Scoresby Land. Other, fragmentary specimens were found in the "Productus limestone" near Kap Stosch (LK 28 29; N 30, 32, 34, 45, 46, 53). A specimen was found at Permpas in Wollaston Forland (M 1777).

Genus **Cleiothyridina** BUCKMAN, 1906.

Cleiothyrus KING [*non* Phillips, 1841], Mon. Permian Fossils, 1850, p. 137.
Cleiothyridina BUCKMAN, Ann. and Mag. of Nat. Hist., ser. 7, v. 18, 1906, p. 323, 324.

Diagnosis. Subequally biconvex with outline transversely elliptical to elongate oval with small beak bearing a small circular foramen at its apex, without a cardinal area, surface lamellose with the lamellae bordered by slender flattened spines.

Internally the ventral beak bears short dental lamellae; the dorsal valve bears at its beak a low, transversely lunate cardinal process perforated at the apex and bordered laterally by dental sockets. From the front of this structure arise the blade-like crurae that arch down toward the middle of the ventral valve. From their termini the lamellae of the spiral brachidia run abruptly back, reversing the curvature of the crurae,

and run dorsad and then forward. Near the mid-length of the first coil of the spiral lamellae they are joined by a complex jugum from the posterior end of which arise a pair of slender blades that run back and curve up alongside the crurae and then follow the curvature of the spiralia, ending freely between the first and second coil of the latter.

Generotype, *Athyris royssii* DAVIDSON.

Discussion. PHILLIPS' original definition of *Cleiothyrus* was very inadequate. KING (1850) considered that he had meant it as a substitute for the name *Atrypa*, and this he rejected as improper. But since he recognized another group that needed a generic name, he proposed to reuse PHILLIPS' name in a different sense, designating as its generotype *Atrypa pectinifera* SOWERBY. Curiously, he explained this course in the following words: "Further, as a group of shells hitherto placed in *Atrypa* requires a name, I have made free to adopt Professor PHILLIPS' rather than propose one myself, a step which has one recommendation in its favor, that of using up a synonym." Of course his name was thus a homonym of *Cleiothyrus* PHILLIPS, and by the accepted rule of nomenclature is invalid. BUCKMAN (1906, p. 323) argued that PHILLIPS' genus could be recognized and established, with the generotype *Terebratula concentrica* VON BUCH, and for the group, incorrectly called *Cleiothyris* by KING, he proposed the new name *Cleiothyridina* BUCKMAN with *Athyris royssii* DAVIDSON as generotype.

Cleiothyridina nielseni DUNBAR, n. sp.

Plate 21, figures 11—25.

Description. This small species is well illustrated by the small photographs in figures 18 to 25 of plate 21. It is normally wider than long (figs. 18, 23, 25) with a maximum width of about 18 mm and a corresponding length of 14 mm. The greatest width is a little back of the mid-length from which point the lateral margins converge forward. The valves are subequally but gently convex. The ventral beak is very small and closely appressed against the dorsal beak, its apex being occupied by a small round pedicle foramen. No cardinal area is present on either valve. On the dorsal valve a shallow fold appears at the beak and runs forward to the anterior margin. On the ventral a narrow and shallow sulcus appears at the beak and widens gradually toward the front margin.

The surface is covered with growth lamellae each of which was extended into a frill of low flattened spines as is normal in this genus.

Internal features agree in essential characters with those described in *C. pectinifera*, except that the brachidia have not been observed.

Discussion. This fine little species resembles *C. acutomarginalis* (WAAGEN) but the latter is somewhat larger, more strongly biconvex, and its ventral umbo is evenly convex, whereas in ours a distinct sulcus and fold are present from the earliest growth stage.

Distribution. Of some 20 lots of this species, the majority came from the outcrops near, and to the east of Kap Stosch where the matrix was a light gray, calcareous shale. A single, good specimen was collected by MAYNC (2752) in the "Martinia-Productus limestone" in Margrethedal at the southern margin of Gauss Halvö. Here the matrix is a dark gray, micaceous and silty limestone. Scattered specimens were found in other places.

Cleiothyridina maynci DUNBAR, n. sp.

Plate 22, figures 1—8.

Athyris planosulcata FREBOLD [*non* Phillips], Meddel. om Grønland, Bd. 84, no. 2, 1931, p. 19, pl. 6, figs. 7, 8.

Description. This is a medium small species with a somewhat more prominent beak than is normal for this genus. The shells tend to be thickest in the umbonal region, and the appearance is more like that of *Athyris* than of *Cleiothyridina*. These features are well shown in figures 1 to 8 of plate 22. Nevertheless the distinctive surface sculpture is precisely that of *Cleiothyridina*, and the brachidium (beautifully shown in one of our silicified, etched specimens) agrees precisely with that in *C. pectinifera*. The muscle scars also agree in shape and proportions with that species. Most of our shells are not larger than those figured.

Some of the shells show scarcely a trace of a fold and sulcus, but in others (e. g. fig. 4 of pl. 22) a very obscure fold and sulcus appear near the front.

Discussion. This species occurs in places with *C. pectinifera* from which it is easily separated. It is only about half as large in diameter as the latter and is easily distinguished from young shells of *C. pectinifera* by its shorter hinge, and narrower and more erect ventral beak.

A specimen of this species was illustrated by FREBOLD (1931, pl. 6, figs. 7, 8) as *Athyris planosulcata* PHILLIPS. In view of the fact that PHILLIPS' types were from the Lower Carboniferous of Ireland, this identification can hardly be acceptable. It does closely resemble in size and shape some (only) of the shells so identified by TSCHERNYSCHEW (1902, pl. 43, figs. 8, 9) from the Lower Permian of the Urals.

Distribution. Rather rare in the vicinity of Kap Stosch (LK 10, 28). Our best specimens are from Forposten (Avantpostbjerg) in Clavering Ø (M 548, 551, 555). It also occurs in Djævlekløften, on Clavering

Ø. The most abundant specimens were collected by STAUBER from the "Productus limestone" west of Schucherts Flod in southern Scoresby Land. It was collected by KOCH in the Nathorsts Fjord area.

Cleiothyridina pectinifera (D'ORBIGNY).

Plate 22, figures 9—18.

Atrypa pectinifera SOWERBY, Min. Conch., v. 7, 1840, p. 14, pl. 616.
Cleiothyris pectinifera KING, Mon. British Permian Fossils, 1850, p. 138, pl. 10, figs. 1—10.
Athyris pectinifera DAVIDSON, British Fossils Brachiopods, v. II, pt. 4, 1858, p. 21, pl. 1, figs. 50—56; pl. 2, figs. 1—5.
Athyris pectinifera GEINITZ, Dyas, 1861, p. 86, pl. 15, figs. 49, 50.
Athyris pectinifera FREBOLD, Meddel. om Grønland, Bd. 84, no. 2. 1931, p. 29, pl. 6, figs. 5, 6.

Description. A species of medium size. The shells shown as figures 9, 10, and 13 of plate 22 are average adults of normal shape; figure 16 shows an exceptionally large shell, much larger than any other in our collections. Length and breadth are subequal, the outline varying from slightly longer than wide in some specimens to a little wider than long in others. The shell is thickest near the middle and has almost the form of a biconvex lens, the valves being subequal in depth and almost without a trace of fold or sulcus. The ventral beak is small and tightly appressed against the dorsal, neither having a cardinal area. The apex of the ventral beak is perforated by a round pedicle foramen.

The surface is ornamented by thickly spaced growth lamellae each of which in life bore a frill of rather long, flattened spines. The spines are well shown in specimens preserved in the matrix but are commonly broken away in those freed from limestone.

Inside the ventral valve, the short, stout hinge teeth are supported by dental lamellae. These show well in young shells but in old ones become submerged in secondary shell growth. The space between the dental lamellae is deeply concave, apparently to provide space for a thick pedicular muscle. The muscle scars lie in front of the hinge line and nearly centered in the valve (fig. 17 of pl. 22). The adductor scars form a deeper, elongate oval depression surrounded almost symmetrically by the diductor scars.

In the dorsal valve the cardinalia are small and simple. The margin inside the beak is thickened to form a small lunate hinge plate separated from the shell margin by slender dental sockets and perforated at the apex by a tubular pore. The upper surface of this structure served as a myophore for the diductor muscles, and from the outer edges of its summit arose a pair of long cycle-shaped crurae that arch down into the ventral valve. From the ends of these, the ribbonlike lamellae of

the spiralia arise, each bending back abruptly to parallel the curved crus, curving back up into the dorsal valve which it follows forward along the middle of the shell as it begins a spiral that culminates in an apex at the side of the shell. The spiralia are united by a large and complex jugum as well described and figured by DAVIDSON (1858, p. 22, pl. 2, figs. 2 and 3).

The adductor muscle scars are relatively large and distinctively shaped, but are very lightly impressed. A slender ridge arising under the hinge plate runs forward along the mid-line to the front of the muscle scars.

Discussion. Originally described from the Magnesian limestone in England, this fine species has been repeatedly described from this source and from the Zechstein in Germany. DAVIDSON's excellent description, based on specimens from the Magnesian limestone of Humbleton Hill, has been accepted as definitive by most later workers.

Our shells seem to agree with DAVIDSON's figures so closely that no basis can be found for a specific separation. DAVIDSON says that the species rarely attains a length of 12 lines (one inch) and a breadth of 14 lines. The majority of our shells would fall under these limits, but a few are appreciably larger.

DAVIDSON described the brachidia in detail from a specimen found at Humbleton Hill. We were fortunate in developing a remarkable, silicified specimen from Forposten (Avantpostbjerg) on Clavering Ø by dissolving the matrix in HCl. It confirms DAVIDSON's observations in nearly all details but clarifies one doubtful point. DAVIDSON represented the spiral ribbon of the spiralia as being spinose along its outer margin (his pl. 2, fig. 5) though he stated (p. 22) that "this appearance was considered by Mr. HOUSE to be more deceptive than real, and entirely due to a foreign substance which encrusts the internal portions of the larger number of the specimens." Our remarkably preserved specimen indicates that Mr. HOUSE was right and that the spiral lamellae had a smooth margin.

This species closely resembles *C. stuckenbergi* (NETSCHEV) from the Zechstein horizon in Samara, but that species has a flatter ventral umbo and a distinct, even though shallow, ventral sulcus.

Cleiothyridina capillata var. *sibirica* EINOR is similar in size but is too briefly described and too poorly illustrated to be safely recognized. It appears, however, to have an appreciable fold and sulcus on the anterior part of the shell.

Distribution. This species was found in some abundance in the "Productus limestone" ledge west of Schucherts Flod in southern Scoresby Land (STAUBER coll.); in several of the blocks of white Permian

limestone in the Triassic conglomerates about Kap Stosch; in the Permian beds near Kap Stosch (LK 28); and at several localities in Clavering Ø. The most abundant collections were made by MAYNC in a yellowish gray dolomite north of Cirkusdal (M 2303, 2305, 2310, 2312, 2319, 2337, 2339).

Genus **Pterospirifer** DUNBAR, n. gen.
(Ety. *Pteron*, wing + *Spirifer*)

Diagnosis. Short spiriferoids with a long hinge and alate cardinal extremities, with non-plicated fold and sulcus, and with numerous simple costae on the lateral slopes. Entire surface ornamented by fine and closely crowded concentric lamellae and by fine and closely spaced radial lirae. Sulcus rather shallow, and bearing along its mid-line a narrow and obscure ridge hardly prominent enough to be called a plication.

The ventral cardinal area is broad for shells of this size, and the ventral beak is small and neatly arched over the apex of the delthyrium. The latter is partly covered by a strongly arched deltidial covering (whether a true deltidium or a symphytium has not been determined). Dental lamellae are well developed and reach to the inner surface of the valve for a short distance from the beak, beyond which they are relatively shorter and, near the front of the delthyrium in adult shells, they are reduced to short but thick, rounded flanges. A very low angular ridge arises along the mid-line some distance in front of the beak and runs forward through the muscle scars but does not rise enough to be considered a septum. The apical part of the ventral valve is considerably thickened by fibrous shelly material, and a callous fills more or less of the space between the dental lamellae.

Generotype, *Spirifer alatus* SCHLOTHEIM.

Discussion. The generotype, *S. alatus*, has a very long hinge line and acutely extended cardinal extremities, and SCHLOTHEIM'S specific name, winged, suggested the corresponding Greek root for the generic name.

These shells are probably closely allied to *Paeckelmanella* LICHAREW, to which we were at first inclined to assign them. However, LICHAREW emphasized the fact that in his genus "a median ventral septum is strongly developed in height and in length," and in *Spirifer alatus* there is no septum. I have before me several lots of specimens from the Zechstein in Thuringia, and serial sections of the beaks show that neither in these nor in the material from Greenland is there a septum. Probably *Pterospirifer* bears to *Paeckelmanella* approximately the relation that the Devonian genus *Fimbrospirifer* bears to *Delthyris*. *Paeckelmanella* was based on shells from the basal Permian of the Urals, and *Ptero-*

spirifer on shells from the Zechstein, Upper Permian. It is possible that the latter evolved out of the former with the reduction of the dental lamellae and the disappearance of the median septum. In his original description of *Spirifer dieneri*, the generotype of *Paeckelmanella*, TSCHERNYSCHEW did not mention fine radial lirae and none can be distinguished in his illustrations, nor were they mentioned by LICHAREW. If the imbricating lamellae are smooth in *P. dieneri* as they are in *Fimbrospirifer*, this is an important distinction between *Paeckelmanella* and *Pterospirifer*.

The genus *Tylothyris* NORTH was based on a Lower Carboniferous species, *T. laminosa* MCCOY, which somewhat resembles our genus, but it has a long and well developed median septum, and lacks the fine radial sculpture of *P. alatus*.

Pterospirifer alatus (SCHLOTHEIM).

Plate 22, figures 19—25.

Spirifer alatus SCHOLTHEIM, Leonhards Taschenbuch für Min., v. 7, 1813, p. 58, pl. 2, figs. 1—3; GEINITZ, Dias oder die Zechsteinformation und das Rothliegende, 1861, p. 87, pl. 16, figs. 1—7.

Spirifer cf. *alatus* FREDERICKS, Norges Svalbard- og Ishavs-Undersøkelser, Skr. om Svalbard og Ishavet, no. 69, 1937, p. 49, pl. 2, fig. 2.

Description. Although we have about 50 specimens of this species, each of them is incomplete or deformed or partly covered with matrix. It is impossible therefore to present fully satisfactory illustrations even though the material is satisfactory for study. I have before me 5 small collections of the species from the Lower Zechstein of Germany and one from the Magnesian limestone at Shildon, England, and can find no basis for separating the Greenland shells from the German species.

Our largest specimen (pl. 22, fig. 20) has a length of approximately 25 mm and a breadth at the hinge line of 90 mm. Growth lines indicate the shell had nearly these proportions during most of its growth. At a length of 15 mm, for example, its hinge line measured about 45 mm. Throughout growth the cardinal extremities were very acutely extended. Other shells had similar proportions. The one shown as figure 22 had a breadth at the hinge line of 40 mm when the length was 13 mm.

The cardinal area of the ventral valve is uncommonly high for a shell of this group, and it was sublinear rather than triangular and was nearly flat except near the apex where it curves gently under the small beak. The area shows rather conspicuous vertical striation. The delthyrium was rather narrow, with an apical angle of 45° to 50°, and was overarched by a high delthyrial covering that looks like a deltidium.

Its surface sculpture is not sufficiently well preserved in the specimens seen to indicate it is a true deltidium or a symphytium.

The ventral sulcus is shallow and bears a slender and very low ridge or costa along its mid-line. The dorsal fold is correspondingly low and flat and it, too, bears along its mid-line in some specimens an obscure slender ridge. On each side of the fold and sulcus, the shell bears a dozen or more rounded plications that are separated by furrows of comparable size. In some shells one or two of those next to the fold or sulcus split at an early stage of growth, but this is a variable character. In some shells none of the ribs split; in a few, two on each side split; and commonly when one splits its counterpart on the other side of the shell fails to split. The outer plications decrease progressively in size and appear on the posterior slope during growth, not extending to the beak.

The entire surface is ornamented by closely crowded growth lamellae of which 4 to 6 occur in a space of 1 mm. These in turn are crossed by almost microscopic radial lirae of which a score or more occur within the space of 1 mm. This submicroscopic ornamentation is illustrated at a magnification of 5 diameters in figure 23 of plate 22.

During early growth the dental lamellae reached down to join the shell, but serial sections indicate that from about 5 mm in front of the beak they failed to reach the shell and that they grew progressively shorter but thicker until at maturity they appear as short, rounded flanges under the edge of the delthyrium. A very slight subangualr ridge appears along the mid-line a short distance in front of the beak and extends out into the muscle scars, but it could not at any stage be considered a median septum. The posterior part of this valve is considerably thickened by later shell growth, and a callous partially fills the space between the dental lamellae. The muscle scars are rather deeply impressed in this valve but, unfortunately, their full shape is not revealed in any of the specimens available for study.

Distribution. This species is abundant in a collection made by the sailors with the field party on the north slopes of Kollen, south of Nathorsts Fjord. They are embedded in a bluish gray, yellowish weathering argillaceous calcarenite. A single specimen was found in BIERTHER's collection 9 (71) from the northern part of Scoresby Land, and others are present in BIERTHER's collection X1 (25) and his C1 from the same region. Several specimens were found in STAUBER's collection from the section west of Schucherts Flod in Scoresby Land. A single specimen was found by MAYNC (8a) at Fiskeelv on the south coast of Clavering Ø.

Genus **Spirifer** SOWERBY, 1814 and 1818.

Diagnosis. Spiriferidae of medium to large size, generally wider than long; with a dorsal fold and ventral sulcus; with costate ornamentation over entire surface and not differentiated on fold and sulcus. Costae may be simple or may split occasionally or frequently, especially over the posterior part of the valves, but do not become strongly fasciculate. In addition to the costae, the surface is ornamented by a microscopic grid of concentric and radial lirae (only to be seen on well-preserved surfaces). Ventral cardinal area supported by strong dental lamellae. Cardinal process a low, triangular, longitudinally striated elevation in the dorsal beak.

Generotype, *Anomites striatus* MARTIN.

Discussion. The genus *Spirifer* was based on the discovery by SOWERBY of the spiral brachidia in specimens of *Anomites striatus* MARTIN. He communicated this information to the Linnaean Society in 1814 but his manuscript was not published until 1818. In the meantime he published a description of the genus *Spirifer* (Mineral Conchology, v. 2, p. 42) and inadvertently cited as the type, *Anomites cuspidatus*, instead of *A. striatus*. This later became the source of confusion when the genus *Syringothyris* was created for punctate species having a syrinx, both of which characters were possessed by *A. cuspidatus* but not by *A. striatus*. The relation was clarified in 1928 when the International Commission on Zoological Nomenclature (Opinion 100), under suspension of the rules, fixed the type of *Spirifer* as *Anomia striata* MARTIN.

The genus *Neospirifer* FREDERICKS undoubtedly developed out of *Spirifer* s. s. from which it differs only in having strongly fasciculate ribs. The generotype of *Spirifer*, *S. striatus* (MARTIN), is from the Lower Carboniferous and is one of a group of very large species of the Upper Paleozoic rocks that are closely alike. In these the ribs split frequently during early growth stages until the adult number has appeared. In this multiplication each rib tends to split into two equal branches and thus all remain subequal, whereas in *Neospirifer* they tend to split into three branches of which the middle one is largest and remains higher than the lateral branches, thus producing fasciculation. The distinction is not clean-cut, however, for in *S. striatus* and related species costae occasionally split into three instead of two branches, and a moderate degree of fasciculation is commonly visible near the beaks.

Spirifer striato-paradoxus TOULA.

Plate 23, figures 1—7; plate 24, figures 1—5; plate 28, figures 1—6.

Spirifer striato-paradoxus TOULA, k. Akad. der Wiss. zu Wien, Sitzungsber., v. 68, 1873, p. 271, pl. 1, figs. 2a—c; Neues Jahrbuch für Min., 1875, p. 30, pl. 8, fig. 1.

Spirifer marcoui WIMAN [*non* Waagen], Nova Acta Reg. Soc. Sci. Upsaliensis (Upsala), ser. 4, v. 3, no. 8, 1914, p. 44, pl. 6, figs. 3—7; pl. 7, figs. 9—11.

Spirifer ravana WIMAN [*non* Diener], *ibid.*, 1914, p. 43, pl. 5, figs. 17—19; pl. 6, figs. 1, 2.

Spirifer marcoui TSCHERNYSCHEW and STEPANOV [*non* Waagen], Second Norwegian Expedition of the "Fram" 1898—1902, Rept., v. 4, 1919, p. 47, pl. 9, fig. 4.

Spirifer cf. *marcoui* FREBOLD, Meddel. om Grønland, Bd. 84, no. 2, 1931, p. 16, pl. 4, fig. 2.

Spirifer ravana FREBOLD [*non* Diener], Meddel. om Grønland, Bd. 84, no. 2, 1931, p. 39, pl. 4, figs. 1—1b; pl. 5, fig. 1; Norges Svalbard- og Ishavs-Undersøkelser, Skr. om Svalbard og Ishavet, no. 69, 1937, p. 48, pl. 2, fig. 3.

Spirifer cameratus FREBOLD [*non* Marcou], Meddel. om Grønland, Bd. 84, no. 7, 1933, p. 15, pl. 1, fig. 4; Norges Svalbard- og Ishavs-Undersøkelser, Skr. om Svalbard og Ishavet, no. 69, 1937, p. 48, pl. 2, fig. 3.

Description. The size and shape of this large species are well shown by the illustrations. The shells are wider than long but there is considerable variation in proportions depending on how the cardinal extremities developed as the animal approached maturity. For example, the shell represented in figures 1—3 of plate 23 has rounded cardinal extremities, and the ratio of its breadth to length is 1 : 1.4+; but the growth lines indicate that, until nearly adult, the greatest width was at the hinge line, and the ratio of breadth to length exceeded 1 : 1.44. During later growth there was little increase in breadth and the cardinal extremities became rounded. On the contrary in the specimen shown as figures 5—7 of plate 23, late growth was fully as great at the hinge line as toward the front margin, and the cardinal extremities remained angular, and the ratio of breadth to length is 1 : 1.6+. Figure 5 of plate 24 would suggest a narrower proportion, but growth lines on the outer surface of the same specimen (fig. 4) show that until more than half-grown it had more extended cardinal extremities.

The dorsal fold is narrow and commonly rather acute near the beak but widens gradually and becomes more rounded and less sharply defined toward the front of the shell, subtending an angle of not over 30°. The ventral sulcus is likewise rounded and not sharply defined. The entire surface is costate with no appreciable differentiation of the costae on fold and sulcus as compared with those on the lateral slopes.

When very young, the shell had only 5 or 6 costae on each side of a very narrow fold and sulcus; but as growth proceeded, these lateral ribs each split into three branches of which the center one was usually strongest. Near the beaks the ribs thus appear distinctly fasciculate. But farther forward these ribs tended to become subequal and the fasciculation became obscure or disappeared. Later on, when the shell was nearing half growth many or all of the costae split again, but this time into two instead of three branches, so that the ribs continued to be subequal. In later growth there was a variable amount of splitting,

but in general the costae became gradually coarser without rapid increase in numbers.

At a distance of several millimeters from the beak a single median rib arose in the sulcus. Soon a flanking pair was added, one having split off the admedian flank of each bounding costa. The median costa generally remained simple, but the lateral ones soon split into two and were joined by others that split off the flanking costae until at maturity the sulcus was ornamented with 15 to 25 costae. In the best preserved specimens, the entire surface of the shell is ornamented with a microscopic grid formed by intersecting radial and concentric lirae of exceedingly fine size (pl. 28, fig. 6).

The costae and the intervening furrows are subequal in breadth and are separated by steep slopes. Furthermore, the ribs are not quite uniform in width and are crossed by irregularly spaced varices of growth, the net effect being to give the shell a rough appearance.

The ventral beak is relatively short and blunt, and the cardinal area is only moderately high and is normally arched as suggested in figures 4 and 7 of plate 23 and figure 2 of plate 24.

The ventral interior is well shown in a fine silicified valve, figure 5 of plate 24. The dental lamellae are strong. They converge toward the mid-line for a short distance below the margins of the delthyrium, and at about half the distance to the floor of the valve they diverge again so as to embrace the posterior half of the muscle field. Their basal margin is then confluent with a sharply elevated rim that continues around the anterior margin of the muscle scar. The adductor scars are distinctly defined by a tasselated ornamentation, and they occupy the posterior part of the muscle field. The apex of the ventral beak is occupied by a small callous that forms a triangular platform.

The shell is rather thin over the dorsal beak. The crural bases are supported by flanges that curve down and medially. The dental sockets are deep and slender grooves diverging from the beak at an angle of a little more than 90°. The cardinal process appears as a tiny callous inside the dorsal beak with its summit divided into a score or more of delicate lamellae arising vertically and lying parallel to the sagittal plane of the shell.

One of our etched specimens indicates that each coil of the spiralia included 25 or more volutions.

Discussion. The identification of these fine Greenland shells has been the subject of much confusion. Being large and having a rough surface they have appeared mostly in fragmentary condition in the early collections; and since there is considerable individual variation, several students have recognized more than one species. But with more

than 100 specimens before us representing many localities, we are convinced that they are conspecific. Although such shells occur in great numbers in certain beds, the stratigraphic range represented in Greenland is small.

The first spirifer of this type to be identified from the Arctic province was *Spirifer striato-paradoxus* TOULA which was based on specimens from the southern tip of Spitzbergen, the original description of 1873 having depended on mere fragments of which three were figured. The species was redescribed by TOULA in 1875 and illustrated by a much better specimen from outcrops in the headland between Dickson Bay and Ekman Bay north of Isfjord, central western Spitzbergen. This specimen (reproduced as fig. 1 of our pl. 28) was an internal mold with part of the shell adhering on the left side, preserving the beak and the posterior margin to the cardinal extremity. It clearly indicates a shell closely comparable in size and shape to those in Greenland. Yet neither the brief descriptions nor the illustrations by TOULA would, of themselves, permit a secure specific identification.

In 1902 TSCHERNYSCHEW (p. 532—534, pl. 6, figs. 9a—d; pl. 12, fig. 3; pl. 49, figs. 2, 3) described large spirifers of this general type from the Urals as both *S. marcoui* WAAGEN and *S. ravana* DIENER, and later reports on Arctic faunas from Spitzbergen, Bear Island, and Greenland have commonly recognized both species, but the identifications have probably been based more on TSCHERNYSCHEW's interpretations than on the original sources from India.

WIMAN (1914) later monographed the Permian faunas of Spitzbergen and recognized large spirifers of this type from numerous places along the western coast, some of them very near the sources of TOULA's collections. It is almost inconceivable that WIMAN's material did not include the form which TOULA named, but unfortunately he seems to have completely overlooked, or ignored, TOULA's species and, instead, identified his shells with *S. marcoui* WAAGEN and *S. ravana* DIENER. We are convinced that WIMAN had one species instead of two, that it is the one that occurs so abundantly in Greenland, and that it is not to be identified with either of the Indian species. On this basis, we feel justified in recognizing TOULA's species which can be interpreted through WIMAN's work.

Spirifer marcoui WAAGEN was described from the "Productus limestone" of the Salt Range in India, a locality some 4,000 miles from East Greenland by the most direct airline. Furthermore, it occurs in a prolific and well-known fauna but one that has almost nothing in common with that of East Greenland. These facts alone would suggest caution in identifying the Indian species in this province though it must be confessed that WAAGEN's fine illustrations (1887, pl. 47, figs. 1—3a)

show a striking resemblance to the Greenland shells. These illustrations also indicate that the Indian species showed a range of variation with respect to the shape of the cardinal extremities similar to that described above. Nevertheless, there are recognizable distinctions. *S. marcoui* has a somewhat higher and more acute dorsal fold, and its sulcus is deeper and more acute at the middle. The last feature was emphasized in WAAGEN's description and is well shown in figure 2b of his plate 47. Furthermore, the ventral beak is larger and the cardinal area higher in the Salt Range species. I have before me 4 specimens of WAAGEN's species from the lower "Productus limestone" at Warcha, in the Salt Range, at approximately the horizon from which the figured types were secured at Pail, and they would not be confused with any of our Greenland shells.

Spirifer ravana DIENER was described from shales just under the Triassic beds in the Niti Pass area in the high Himalaya, north of western Nepal, in faunal associations totally unlike those of East Greenland. This locality, like the Salt Range, is some 4000 miles from Greenland, and the probability of specific identities would be slight under any conditions. But in this case there is no justification for identification of any of our shells with DIENER's species. The latter was based upon very incomplete specimens so that its characters are not well known; but the types were of enormous size with a cardinal area at least three or four times as high as it is in the Greenland shells, and with a sulcus much larger and deeper. Indeed, there is nothing more than generic resemblance and large size to suggest close relations. So long as identifications are based on such vague resemblances, fossils will be of little use in correlation.

The shells described and figured by TSCHERNYSCHEW from the Urals as *S. marcoui* and *S. ravana* were almost certainly misidentified and belong neither to the Indian species nor to that from the Arctic.

Indeed, the difficulty of discriminating between the large species of the genus *Spirifer* s. s. in the late Paleozoic has been troublesome to many workers. WAAGEN felt it necessary to compare his species with *S. striatus* MARTIN, notwithstanding the fact that the latter is a Lower Carboniferous species and his was Permian. And he says that he long considered his to be identical with *S. cameratus* MORTON, a North American species from the basal part of the Pennsylvanian (Upper Carboniferous) System. He further expressed confidence that his was conspecific with a form MARCOU had illustrated as *S. striatus* from Pecos village, New Mexico (basal Pennsylvanian), and he pointed to close resemblance of his species to *S. logani* HALL of the Osagian Series in the lower half of the Mississippian System in America.

Spirifer kaninensis LICHAREW, from Kanin Peninsula northeast of the White Sea, is similar to *S. striato-paradoxus* but appears to be smaller and more transverse than the latter. LICHAREW (1943) says that it occurs with *Productus loveni*, *P. (Horridonia) borealis* var. *granulifera* TOULA and *Chonetes (Paeckelmannia) capitolinus* TOULA, all of which occur in Spitzbergen.

Distribution. This fine species is widely spread in East Greenland, occurring in almost every locality that has been collected. It is rather rare west of Schucherts Flod in southern Scoresby Land but is fairly common in the Nathorsts Fjord area (STAUBER II—315, N. F., and SÄVE-SÖDERBERGH). It is abundant in the Kap Stosch area (LK 4, 6, 7, 12, 20, 28, 37, 604, 1030; N 57, 65). On Clavering Ø it was found along Productuselv (M 316, 318, 321, 322, 329), on Forposten (Avantpostbjerg) (M 560, 575), in Cirkusdal (M 2335, 2342, 2364, 2365), near Djævlekløften (LK 20; M 2199, 2200, 2304), and in Dolomitdal (M 2439). It was also found on Wollaston Forland about Permpas (M 1773—1775), in Grænsedalen (M 1803, 1821; LK 7, 8), in Sandstensdal (M 1931, 1937, 1940, 1966), on Carbon River (LK 8a, 80, 606), and in Brachiopoddal (LK 406, 411, 415).

Genus **Spiriferella** TCHERNYSCHEW, 1902.
[*non* Weller, 1914].

Spiriferella TSCHERNYSCHEW [*non* Weller, 1914], Comité Géol., Mem., (Leningrad), v. 16, no. 2, 1902, p. 522—526.

Elivina FREDERICKS, Comité Géol., Bull., (Leningrad), v. 38, 1919, p. 315; Acad. Sci., Bull., U.S.S.R., for 1926, p. 404.

Discussion. Between the years 1918 and 1926 GEORGE FREDERICKS developed a fantastic scheme for a "standard classification" of the Spiriferidae, in which subfamilies were based on internal characters of the ventral beak ("apical apparatus"), and genera on surface ornamentation. He recognized 10 basic types of "apical apparatus." In the first and simplest, for example, there were no internal structures in the ventral beak; in the second, there were short delthyrial flanges; in the third, well-developed dental lamellae; in the fourth, strong dental lamellae plus a median septum; and so on. Each of these defined a subfamily without regard to other considerations.

As a basis for distinguishing genera he recognized 7 primary types of ornamentation: glabrate, plicate, fimbriate, striate, costate, spinose, and lamellose. But since these might also occur in combinations—e. g. plicatocostate, lamellospinose, plicatofimbriate, etc.—he built up a "sculptural grid" with 64 possible types of ornamentation, each the basis of a potential genus. Each of these could occur in any one of the

subfamilies, and so, adding to his sculptural grid a third dimension based on "apical apparatus," he conceived a three dimensional "space lattice," each node of which might represent a genus. He then scanned the literature for examples and, after placing all previously described genera, he named a score of new ones, each very briefly defined by reference to his sculptural grid and the citation of a type species.

Of course this scheme disregarded the fact that both apical structures and surface ornamentation may have undergone change in any genetic line, or that different types may have evolved independently. Indeed, he stated in a manuscript sent to CHARLES SCHUCHERT on March 3, 1927,

> "When applying such a purely morphological or 'standard' classification, the genetic relations between individual groups evidently disappear almost completely. * * * Our classification has been built up according to these considerations, irrespective of the circumstance that some varieties of the same species might prove to be allocated not only in different morphological combinations of the same family, but even be referred to different subfamilies; and so much the more that the problem of clearing up the genetic classification between individual forms does not constitute the main object of a standard classification. * * * I am quite aware of the fact that such a standard classification disunites closely allied forms and unites alien ones."

In short, FREDERICKS' classification is entirely morphologic rather than genetic, and is completely at variance with the accepted principles of all modern taxonomists. Although several of the genera he proposed have been redescribed and made useful for later workers, none of them were originally defined in a useful way and several of them remain as an incubus to plague those who have to deal with the taxonomy of the group, since each is technically a genus with a legally designated generotype, and the names must be accepted under the rules of nomenclature unless shown to be either synonyms or homonyms.

One of the most troublesome and unresolved problems relates to the character and relations of 4 genera based upon apparently closely allied Permian species from Russia. These are *Spiriferella* TSCHERNYSCHEW, 1902, (generotype, *Spirifer saranae* DE VERNEUIL); *Eliva* FREDERICKS, 1919, (generotype, *S. lyra* KUTORGA); *Elivina* FREDERICKS, 1919, (generotype, *S. tibetanus* DIENER); and *Munella* FREDERICKS, 1919, (generotype, *S. nikitini* TSCHERNYSCHEW).

The 4 generotypes cited resemble each other in the following characteristics. The surface is plicatocostate with a tendency for the plications to split into branches; the ventral beak is rather prominent, and the

posterior part of this valve tends to be greatly thickened during growth by a fibrous shelly deposit; the cardinal extremities are commonly more or less rounded and the shells longer than wide; the ventral muscles were deeply impressed in the thickened shell and present a distinctive pattern (see our pl. 26, fig. 4, and pl. 27, fig. 12). These early Permian species resemble in many ways *Choristites* which is so common in the Carboniferous of Russia, and are possibly descended therefrom or related thereto.

Spiriferella has priority over the others by many years. It is said to be distinguished by possessing a median septum in the apical part of the ventral valve, in addition to a pair of thick stout dental lamellae that join the shell. However, the entire apex became filled with a fibrous growth of shell that largely or entirely invests and buries these plates, and although the median septum was pointed out as a distinctive character of *S. saranae* by KEYSERLING in 1846, and was described and illustrated by TSCHERNYSCHEW in 1902, neither of them presented convincing evidence of such a structure. KEYSERLING gave no illustrations of it, and TSCHERNYSCHEW's are limited to two drawings made from shells that had split along the mid-line. KEYSERLING compared the structure with that in *Pentamerous*, but TSCHERNYSCHEW recognized only a rather low septum running forward from the beak to the front edge of the callous that fills the space between the dental lamellae, and he says that from its crest a slender partition extends on up to join the deltidium along its mid-line. This interpretation is difficult to reconcile with the interior views which he gives of unbroken shells.

We follow MILORADOVICH (1936, p. 72—76) in deciding that both KEYSERLING and TSCHERNYSCHEW misinterpreted the apical structure and that *S. saranae* did not possess a median septum. The supposed low septum, as MILORADOVICH states, had nothing in common with the euseptoid of FREDERICKS' conception and was only the low ridge dividing the paired muscles (as seen in our pl. 27, fig. 12); and the supposed partition extending up from the ridge to the "deltidium" is an optical illusion due to the way in which the callous between the dental lamellae formed and, probably in TSCHERNYSCHEW's specimens had been recrystallized.

The secondary shelly growth that so greatly thickened the posterior part of the valve in this group of spirifers had a fibrous structure in which the fibers stand at a high angle to the growing surface. The callous that largely fills the space between the dental lamellae began to form against the dental lamellae, and in young shells it bears a deep V-shaped groove down its middle. The callous was thus largely formed of two elements meeting at the mid-line. The center of this structure is thus a plane of weakness along which the shell tends to split even in

well-preserved material, and, when recrystallized, this plane separates two masses of crystals differently oriented. This is the explanation of TSCHERNYSCHEW's "thin partition that rises to meet the deltidium along its midline."

If it be granted that *S. saranae* had no medium septum, but only strong dental lamellae, then *Elivina* FREDERICKS is a junior homonym.

As MILORADOVICH noted, WELLER (1914) was misled by TSCHERNYSCHEW's observation that the surface of *Spiriferella* bears minute tubercles in regular rows. Weller took this to mean that the shell was punctate and, accordingly, he referred to this genus several Lower Carboniferous, punctate spiriferoids. They have nothing to do with *Spiriferella* which has a fibrous, non-punctate shell and has its dental lamellae and muscle scars quite differently arranged from those of the Lower Carboniferous American species. The "minute tubercles" of *Spiriferella* are purely surface structures as shown in our plate 26, figures 9—11.

The 3 genera proposed by FREDERICKS were not clearly differentiated. *Eliva* was said to be plicatocostate and to have very abbreviated dental lamellae in the form of short flanges under the margins of the delthyrium; *Munella* was described as costate, with fully developed dental lamellae reaching the inner surface of the shell below the hinge plate; and *Elivina* was said to be plicatocostate and to have well-developed dental lamellae like those of *Munella*.

Of these names, *Munella* was preoccupied by *Munella* BONIER, 1896 (Crust.). Apparently *Eliva* and *Elivina* were differentiated solely on the degree to which the dental lamellae are developed, and in 1927 (letter to SCHUCHERT) FREDERICKS, himself, expressed difficulty in separating them. If they should not be accepted as distinct, *Eliva* would have priority because of page precedence.

Although there is considerable resemblance to *Choristites*, the latter has its dental lamellae close together and subparallel, and the ventral muscle field is unlike that of *Spiriferella* in shape or appearance.

Generotype, *Spirifer saranae* KEYSERLING.

Spiriferella keilhavii (VON BUCH).

Plate 25, figures 1—9; plate 26, figures 1—11; plate 27, figures 1—14.

Spirifer keilhavii VON BUCH, k. Akad. der Wiss. zu Wien, Abh., 1846, p. 74, figs. 2a, b.

?*Spirifer arcticus* HAUGHTON, Jour. Royal Dublin Soc., v. 1, 1858, p. 243, pl. 9, fig. 1.

Spirifer parryanus TOULA [*non* Hall, 1858], Neues Jahrbuch für Min. (Stuttgart), 1875, p. 32, pl. 7, figs. 8a—d.

Spirifer loveni DIENER [*non* Wiman, 1914], Paleontologica Indica, ser. 15, v. 1, pt. 2, 1899, p. 68.

Spiriferina keilhavii WIMAN, Nova Acta Reg. Soc. Sci. Upsaliensis (Upsala), ser. 4, v. 3, 1914, p. 36, pl. 2, figs. 25—30; pl. 3, fig. 1; FREBOLD, Norges Svalbard-

og Ishavs-Undersøkelser, Skr. om Svalbard og Ishavet, no. 69, 1937, p. 46, pl. 11, fig. 9.

Spiriferella parryana FREBOLD [*non* Tschernychew and Stepanov, 1916], Meddel. om Grønland, Bd. 84, no. 2, 1931, p. 18, pl. 5, figs. 5—6; Norges Svalbard- og Ishavs-Undersøkelser, Skr. om Svalbard og Ishavet, no. 69, 1937, p. 45, pl. 11, fig. 6.

Spirifer interplicatus var. *bashkirica* FREBOLD [*non* Tschernyschew, 1902], Meddel. om Grønland, Bd. 84, no. 2, 1931, p. 27, pl. 5, figs. 3, 4,

Spirifer rectangulus FREBOLD [*non* Kutorga, 1844], *ibid.*, 1931, p. 27, pl. 5, figs. 2, 10.

Spiriferella parryana MILORADOVICH, Trans. Arctic Inst., U.S.S.R., v. 37, 1936, p. 73, pl. 1, figs. 1—3; pl. 2, figs. 1, 2; pl. 4, figs. 1—9.

Spiriferella keilhavii FREBOLD, Meddel. om Grønland, Bd. 84, no. 2, p. 28, pl. 5, figs. 7—9; Norges Svalbard- og Ishavs-Undersøkelser, Skr. om Svalbard og Ishavet, no. 69, 1937, p. 46, pl. 11, fig. 9.

Spiriferella saranae FREBOLD [*non* de Verneuil, 1845], *ibid.*, 1937, p. 45, pl. 11, figs. 7, 8.

Description. Plates 25 to 27 illustrate the size and general appearance of this protean species, yet with more than 150 free specimens before us it is impossible to give a completely satisfactory description. The difficulties are in part due to preservation and in part to the great range of individual variation. Most of the shells were rolled about on the shallow seafloor after death, and, with few exceptions, the valves were separated before burial, the margins and cardinal extremities being generally broken, leaving only the thickened posterior and umbonal parts well preserved.

Figure 1 of plate 25 shows one of the few complete shells of normal size and shape, and figure 4 shows another, almost complete but with the dorsal valve slightly displaced. Figures 1 and 2 of plate 26 show a third specimen with the valves in place, and indicate well the normal convexity. Growth lines show that young shells were almost semicircular in outline with the greatest width at, or very near, the hinge line and not quite equal to twice the length; but later growth was disproportionate at the front until length and breadth were subequal at maturity. The normal outline was probably like that of figure 1, plate 25, in which the cardinal extremities form right angles and the margin before them is gently concave to the point of maximum width of the shell, which is near the mid-length; but a number of shells have somewhat extended cardinal extremities like figure 2 of plate 25, and others fall between these extremes.

The fold on the dorsal valve is low and commonly rather obscurely defined. The sulcus on the ventral valve is shallow and rounded, but it shows a considerable amount of variation in its details. In a few shells, like figure 1 of plate 25 and figure 1 of plate 27, it is nonplicated and lies between the median pair of primary ribs with a nearly flat bottom and steep sides. It shows these characters at an early growth stage in all shells, but in the majority it later comes to bear 4 plications that arise

during growth in a very definite way. A slender median pair arises gradually from the floor of the sulcus some distance in front of the beak (e. g. pl. 27, figs. 2 to 7); the outer pair appears later and is formed by a branch from the admedian flank of each adjacent primary rib. There is a surprising amount of variation in the time of appearance of these sulcal plications and in the coarseness which they assume. Commonly the first pair appears within about 5 mm of the beak (pl. 27, fig. 2), but in some shells it is delayed for a distance of 10 mm or more, and in a few (e. g. fig. 1 of pl. 27) it fails to appear altogether or remains very obscure. The lateral pair commonly branches off the adjacent primary ribs about 10 mm from the beak, but may be delayed until 20 mm or more, and in a few shells they fail to appear altogether. Furthermore, this outer pair may remain slender or may grow to a size comparable to the primary ribs. Where normally developed, they leave the sulcus appearing shallow and ill-defined. Thus a complete gradation occurs (as shown by figs. 1—7 of pl. 27) from shells in which the sulcus is deep, nonplicated, and sharply defined to those in which it is shallow, ill-defined, and ornamented with 4 plications.

The ribs on the body of the shell also show an amazing range of variation. In a small percentage of the shells there are 10 primary plications on each valve that remain simple and become very broad, almost flat, ribs, with narrow furrows between, as in figure 1 of plate 25. The lateral plications are, of course, progressively smaller than the middle ones and more obscure. Some shells of this type have 12 instead of 10 ribs on each valve, and in some the furrows are almost as wide as the ribs.

In a large percentage, some or all of the primary ribs split into 3 (rarely 2) branches during growth. In some shells the 2 median pairs on each valve split into 3 branches and the next pair into 2, the rest remaining simple; but, in the majority, all of the primary ribs thus subdivide into triads as in figure 4 of plate 25. The front part of such a shell is ornamented by 30 or more plications instead of the 10 primary ribs. Furthermore, there is considerable variation in the growth stage at which the splitting occurs. And, finally, in a small percentage of the shells the middle branch of each triad is elevated above the lateral branches so that the plications are conspicuously fasciculate, as in figure 6 of plate 26. It is not uncommon for a rib on one side of the shell to subdivide while its opposite remains simple. Although the plications normally number 5 or 6 on each half of each valve, a small percentage of shells have more.

In short, the variation in the sulcus and in the size, number, and arrangement of the ribs in so great that scarcely any two shells appear to be exactly alike.

The ventral beak is moderately large and the cardinal area of medium height, as well shown in the illustrations. The ventral cardinal area is fully twice as high as the dorsal and is divided by a large triangular delthyrium having an apical angle of 50° to 60°. A few specimens suggest that the apex of the deltidium may have been closed by an arched symphytium, but if so, it has been broken away in all the shells studied.

In addition to the plications, the surface was ornamented by very fine and closely crowded concentric lirae and by sharp but minute pustules. The latter are well shown at a magnification of 5 diameters in figures 9 to 11 of plate 26. Where the shells have been worn or abraded these delicate structures are commonly lost or are easily overlooked, but even in worn shells they may be preserved in the furrows between ribs. This microscopic ornamentation is a specific if not a generic character.

The dorsal cardinalia are illustrated in figure 3 of plate 26. Stout crural bases diverge strongly and are bordered laterally by deep dental sockets floored by buttress plates. The cardinal process is a small subtriangular elevation lying inside the dorsal beak with its myophore edge frayed out into vertical lamellae as is common in the genus *Spirifer*.

In the ventral valve the hinge teeth are strong and are supported by large dental lamellae that diverge slightly so as to embrace the posterior part of the diductor muscle scars. The umbonal part of this valve was gradually thickened by secondary shell growth that at maturity almost completely invested the dental lamellae, filled the space under the cardinal area, and elevated the region under and around the muscle field. The characteristic shape of the muscle scars is well shown in figure 4 of plate 26, and figure 12 of plate 27. Apparently the adductor muscles occupied the linear ridge that runs full length of the middle of the field. The space under the beak and between the dental lamellae was progressively filled with a callous that encroached on the posterior part of the muscle scars.

The dental lamellae reached to the floor of the valve during early growth but, from about 5 mm in front of the beak, their basal margins rise gradually. However, since the shell was being thickened by a deposit that envelopes the sides and lower edges of the lamellae, it is probable that at all stages of growth they were supported almost, if not quite, to their front tips.

Discussion. In view of the diversity among these shells we made various attempts to separate them into natural groups that might prove to be subspecies, perhaps ecads—each inhabiting a distinct niche in the environment—or possibly varieties of different stratigraphic range.

Eventually we separated them for purposes of study into 4 groups distinguished as follows:

Form A. Shells like figure 1 of plate 25, and figure 1 of plate 27, in which the primary ribs remain simple, are broad and flat, and are separated by narrow interspaces. The median pair on the dorsal valve forms a very low, obscure fold. The median pair on the ventral valve diverges slightly so as to leave between them a sharply defined sulcus that is nonplicated or in which plications appear late and remain very obscure. Faint grooves may appear on one or more of the ribs suggesting a tendency to split.

Form B. Similar to A except that the median pair of ribs and the next adjacent pair subdivide into triads whereas the outer ribs remain simple and are broad and low. The sulcus bears 2 (or more commonly 4) slender plications but these may arise at some distance in front of the beak.

Form C. All the ribs on both valves split into triads as in figure 4 of plate 25, the branches remaining subequal in size and height. The front part of such shells bears 30 or more plications. The sulcus is shallow and ill-defined, bearing 4 plications.

Form D. The ribs split into triads but the fission occurs early in ontogeny, and the middle branch of each triad is more elevated than the others so that the plications appear distinctly fasciculate as in figure 6 of plate 26.

The more these groups were studied, the more evident it became, however, that they completely intergrade. Furthermore, when all their field occurrences were plotted it was found that they occur indiscriminately together, that no form is limited to any distinct lithotope, and that none is restricted more than the rest in stratigraphic range. We are unable, therefore, to find any satisfactory or useful basis for taxonomic subdivision of what appears to be a completely intergrading series in which no two shells are exactly alike. It is possible that if all or most of the shells were complete so that a variety of statistical measurements could be made, some useful subdivision would be possible, but at present it is not.

With small collections the gradation would not be evident and there would be a tendency to recognize several distinct species instead of one. This, indeed, has been done by several workers as explained below.

Spirifer keilhavii was described by VON BUCH in 1846 on the basis of a small collection made in 1827 by the Norwegian naturalist KEILHAU on the slopes of Mt. Misery, Bear Island. It was illustrated by dorsal

and ventral views of a single specimen, reproduced as figures 8 and 9 of our plate 27. The ventral view shows a rather deep flat-bottomed, steep-sided sulcus with only a faint suggestion of plications. It also shows more primary ribs than any of our specimens. The resemblance to the Greenland shells is therefore slight, and we were at first inclined to doubt that any close relation exists. However, in his rather brief and general description, VON BUCH stated that "in the sinus one sees only finer plications, no coarse ones." Evidently, therefore, his figure does not adequately represent the plications in the sulcus. Furthermore, WIMAN, who redescribed the species (1916, p. 36) on the basis of a collection made by ANDERSSON near the type locality on the slopes of Mt. Misery, states that he had seen VON BUCH's types in Vienna and that the latter's figures are composite drawings based upon several specimens, but that they represent the species better than the single specimen which he had labeled "original." Unfortunately WIMAN's redescription tends to confuse rather than to clarify the situation, for the single specimen of which he figured external views (our plate 27, figs. 13 and 14) differs from VON BUCH's illustrations in several respects. The sulcus agrees well with the normal appearance in the Greenland shells, with a median pair of plications arising near the beak and a lateral pair split off, farther forward, from the margins of the adjacent primary ribs. It is shallow and indistinctly defined, just as in our shells, and quite unlike that figured by VON BUCH. But the plications on the lateral slopes appear to be unbranched and to be at least 9 in number on each side. Although these figures are halftone reproductions of what appear to have been rather good photographs, they can hardly be reconciled with the text which may be translated as follows:

> "The sulcus is bounded by two broad flat plications which somewhere in the first third of their course split into 3 branches of which the middle one is broadest. At the sides of these main ones lie 5 to 9 plications which also subdivide into 2 or 3 branches."

Evidently, then, many of his shells had fewer plications than the one he figured, and the more normal condition was to have many or all of the lateral plications subdivided, as they were described by VON BUCH and were clearly shown to be in the original illustrations, especially that of the dorsal view (our fig. 9, pl. 27).

Since VON BUCH's figures were composite drawings it is probable that the lateral margins and cardinal extremities are restored and that the original specimens may not have had so many small plications out near the flanks as he indicated.

We conclude that with these allowances both the shell figured by VON BUCH and by WIMAN would fall within the limits of the highly

varied species before us in Greenland, but that each of these authors selected for illustration a shell near the extreme rather than the normal or average. It must be admitted that the identification of the Greenland species with *S. keilhavii* is still fraught with some uncertainty, but the faunal associations of the species in Bear Island suggest that the two regions were in the same faunal province and that the beds are of approximately the same age.

Spirifer parryanus TOULA was described from western Spitzbergen in 1875 and was evidently based on several incomplete specimens of which two small valves, one dorsal and one ventral, were figured. Although these specimens have a length of only 25 mm, TOULA states that the species attains a breadth of 46 mm and a length of 34 mm. His illustrations are reproduced as figures 10 and 11 of our plate 27. There can hardly be a doubt that this species would include the Greenland shells. However, it is a junior homonym of *Spirifer parryanus* HALL, 1858, from the Devonian of Iowa, and would not be available even if our species were not referred to *S. keilhavii.* DIENER (1899, p. 68) noted that TOULA's name was preoccupied and proposed to rename the species *Spirifer loveni.* In 1916 (p. 49) TSCHERNYSCHEW and STEPANOV used the name *Spiriferella parryana* for the species in Spitzbergen, arguing that by shifting it from the genus *Spirifer* to *Spiriferella* the homonymy was avoided. Of course this is in strict violation of Article 36 of the International Rules of Zoological Nomenclature which provides that a suppressed homonym may never be revived even when the species is placed in a different genus.

Confusion was compounded by TSCHERNYSCHEW and STEPANOV (1916) when they published on a collection made by PER SCHEI in Spitzbergen and, from a single locality (Store Bjornekap) recognized 3 species which they referred to the genus *Spiriferella.* These were *Spirifer saranae* DE VERNEUIL (1845) from the Urals, *Spirifer keilhavii* VON BUCH (1846) from Bear Island, and *Spirifer parryanus* TOULA (1874) from Spitzbergen. As we now know, the first of these was originally described from basal Permian, and the last two from a much higher horizon (probably Kazanian). The first was a narrow, elongate shell quite unlike any known in Greenland, and need not be considered further.

Of the shells they identified as *S. parryana* one was nearly complete and was illustrated from ventral, lateral, and dorsal views (their pl. 11, figs. 4a—c). But it is an elongate narrow species with a very high, subacute dorsal fold bearing 2 narrow and closely adjacent costae. The shell is quite unlike any seen in Greenland, and we can see no possible justification for identifying it with Toula's species. On the contrary, the ventral beaks shown as figures 1 to 3c on their plate 12,

appear conspecific with the types of *S. parryanus* and with our Greenland shells. The shells they identify as *S. keilhavii* (figs. 15, 16 of our pl. 27) can hardly be admitted to VON BUCH's species. Their best specimen (their pl. 11, figs. 3a—c) is a highly arched shell, longer than wide, with a large, deep, and subtriangular sulcus bearing 9 plications. They emphasize (p. 53) that unlike the condition in *S. parryanus*, which has a pair of ribs in the sulcus, this form has a single median plication flanked by others. Unfortunately, the microscopic sculpture was not described by TSCHERNYSCHEW and STEPANOV, but their figure 3b, an excellent halftone from a good photograph, shows a grid of very fine longitudinal lirae and intersecting growth lirae, but no pustules. In short, we cannot accept TSCHERNYSCHEW and STEPANOV's identification of *S. keilhavii* nor the distinction they make between it and *S. parryanus* [= *S. loveni* Diener].

FREBOLD examined and described many of the Greenland shells now before us (1931) and fell into the mistake of identifying different shells with distinct species from widely separate regions and far different stratigraphic horizons. In 1931 he was assuming that the beds in East Greenland were Upper Carboniferous and, like TSCHERNYSCHEW and STEPANOV, sought identifications from TSCHERNYSCHEW's great monograph of 1902, Die Oberkarbonischen Brachiopoden des Ural und des Timan. We now know that the fauna therein described are not younger than basal Permian (Sakmarian) whereas those of East Greenland, Spitzbergen, and Bear Island are much younger (probably Kazanian).

Shells which we place in forms A and B of *S. keilhavii*, FREBOLD identified as *Spirifer rectangulus* KUTORGA (his pl. 5, fig. 2); those like our form C he identified as *S. interplicata* var. *bashkirica* TSCHERNYSCHEW (his pl. 5, figs. 3, 4); those like our form D he referred to *Spiriferella parryana* (TOULA) (his pl. 5, fig. 5); and others which we would refer to form B or C he identified as *Spiriferella keilhavii* (v. BUCH).

The originals of KUTORGA's *S. rectangulus*, refigured by TSCHERNYSCHEW (1902, pl. 8, figs. 1a—d) are from the basal Permian (Sakmarian) of the Urals, and they show no close resemblance to the Greenland shells. *Spirifer interplicata* var. *bashkirica* is also from the basal Permian of the Urals and it, too, shows only the most superficial resemblance to any of our Greenland shells. The relations of *S. parryanus* and *S. keilhavii* have already been discussed.

Distribution. This species is both widely distributed and abundant. It is especially common in collections from the Kap Stosch area (LK 2, 4, 6, 7, 10, 11, 28, 29, 49; N 19, 24, 33, 34, 45, 45a, 47, 50, 51, 55, 58). In northern Scoresby Land it was collected by BIERTHER at

numerous places (B c, g, h, 7a, (8) 16, (8) 30, (10) 25). It is present but less common west of Schucherts Flod in southern Scoresby Land (STAUBER). We seem to have no specimens from Gauss Halvö but it occurs on Clavering Ø along Productuselv (M 320—328, 330, 332—334, 336, 337, 382) and about Avantpostbjerg (M 578, 579) and at Dolomitdal (M 2440). It is also common in the black calcareous shale of the Nathorsts Fjord region (S II — 315, N. F., etc.)

Genus **Spiriferina** D'ORBIGNY, 1847.

Spiriferina D'ORBIGNY, Compte Rendu, Acad. Sci., Paris, v. 25, 1847, p. 268; Ann. Sci. Nat., v. 13, 1850, p. 334.

Spiriferina D'ORBIGNY, emend. NORTH, Quart. Jour. Geol. Soc. (London), v. 76, 1920, p. 208.

Diagnosis. Small spiriferoids with few, simple plications and with a narrow and subangular fold and sulcus which resemble the lateral plications and furrows except for being somewhat larger. The surface is more or less strongly lamellose. The cardinal extremities are rounded, the greatest width of the shell being in front of the hinge line. The ventral cardinal area is arched and is not very sharply set off from the lateral slopes of the beak which curve around to join it at a very broad angle.

Internally, the ventral valve bears well-developed dental lamellae and a high median septum.

The shell substance is fibrous and rather coarsely punctate.

Generotype, *Spiriferina rostrata* SCHLOTHEIM.

Discussion. NORTH proposed to separate the species commonly referred to *Spiriferina* into 2 groups, (1) *Spiriferina* s. s. with a Triassic generotype, *S. rostrata*, and (2) *Punctospirifer* NORTH with a Lower Carboniferous generotype, *P. scabricosta*. The distinction is based on external features, *Punctospirifer* having a more erect ventral beak and a flatter cardinal area that is separated by a sharp angulation from the lateral slopes of the beak. Also it tends to be extended at the hinge line, and its fold and sulcus are relatively much larger than any of the lateral plications. The shell is fibrous and punctate in both genera.

Judged by the criteria cited above, *S. multiplicata* falls decidedly within the genus *Spiriferina*.

Spiriferina multiplicata KING, 1850.

Plate 29, figures 1—9.

Trigonotreta multiplicata KING, Mon. Permian Fossils, 1850, p. 129, pl. 8, figs. 15—18.

Spiriferina multiplicata FREBOLD, Meddel. om Grønland, Bd. 84, no. 3, 1931, p. 10, pl. 1, figs. 12—14.

Description. The size and shape of this small species are well shown by the figures on plate 29. It should be noted that figures 1 to 8 each include a smaller picture at natural size and an enlargement (X2) to show better details. There are 6 or 7 simple plications on each side of each valve. The median fold is shaped much like the bordering plications but is fully twice as large. The ventral sulcus is moderately deep and broadly concave along the middle. The cardinal extremities are rounded. The ventral cardinal area is rather high and triangular and is moderately curved in the longitudinal direction, but is not sharply defined at its lateral margins because the lateral slopes of the beak curve around to join it at a very flat angle.

The surface of the shell is ornamented with rather abundant but irregularly spaced lamellose growth varices. The shell substance is fibrous and abundantly punctate.

Discussion. This species was described by King from the Magnesian limestone at Tunstall Hill where it is rather rare. King's several illustrations agree so fully with our specimens that we can find no basis for separation of ours from his species.

Distribution. In East Greenland it occurs in many of the "white blocks" of Permian limestone in the Triassic conglomerates of the Kap Stosch region (blocks 5, 12, 15, 29, 74, 100, 138, 154, 166, and several others). It has also been found in considerable numbers in STAUBER's large collection from the "Productus limestone" bed in the section west of Schucherts Flod, in southern Scoresby Land. It occurs also in 5 of the collections made by BIERTHER (B (8) 86, (9) 36, V 89, XI 46, XI 63) from northern Scoresby Land.

Spiriferina sp. A.

Plate 29, figures 10—12.

From the "white blocks" of Permian limestone in the Triassic conglomerate near Kap Stosch we have 8 small specimens of a *Spiriferina* quite distinct from *S. multiplicata* with which they are associated, but too fragmentary to permit satisfactory specific description.

Two nearly complete dorsal valves (figs. 10 and 12) are almost twice as wide as long. The fold and sulcus are similar in shape and proportions to those of *S. multiplicata* but are shallower, and the lateral plications are almost obsolete.

Distribution. White Blocks no. 3, no. 21, and no. 96 of NIELSEN's collections from conglomerate No. 2 in the Triassic in the vicinity of Kap Stosch.

Genus **Punctospirifer** North, 1920.

Punctospirifer North, Quart. Jour. Geol. Soc. (London), v. 76, 1920, p. 212.

This genus was separated by North in 1920 from *Spiriferina* of authors. See discussion of the latter genus.

Generotype, *Punctospirifer scabricostata* North.

Punctospirifer cristata (Schlotheim).

Plate 29, figures 13—20.

Terebratulites cristata Schlotheim, Akad. München, v. 6, 1816, p. 28, pl. 1, figs. 3a—c.
Spirifer cristatus King, Mon. Permian Fossils, 1850, p. 127, pl. 8, figs. 9—14.
Spirifer cristatus Geinitz, Dyas, (Leipzig), 1861, p. 88, pl. 16, figs. 8—11.
Spirifer cristatus De Koninck, Acad. Royal de Belg., Bull., v. 12, 1849, p. 11, fig. 6.

Description. The shape and size of this species are shown by the smaller photographs in figures 13—16 of plate 29 (the larger of each pair being twice natural size). The greatest width is at or near the hinge line, and the cardinal extremities are approximately right angles but may be slightly acute or slightly rounded. The cardinal area is sharply defined, being separated from the lateral slopes of the beak by a sharp angulation of about 90°. There are normally only 4 or 5 simple plications on each side of each valve. These are high and are separated by deep, rounded furrows. The median fold and sulcus are similar in shape to the ribs and sulci, and are only a little larger than the latter.

The surface is covered with very fine closely crowded concentric lirae and occasional but irregularly spaced growth varices. In addition it bears rather thickly scattered small pustules that probably were the bases of minute tubular spines. (These are shown at a magnification of X 5 in pl. 29, fig. 20.)

The shell substance is fibrous and rather coarsely punctate.

Internally, the ventral beak bears a median septum that rises to an acute angle a little before the hinge line and then is steeply truncated. Dental lamellae reach to the floor of the valve during early growth but are reduced to rather stout flanges under the front part of the mature cardinal area.

Discussion. Although this species is approximately equal in size to *Spiriferina multiplicata* with which it is associated in some of our collections, it is readily distinguished by several features. Its cardinal extremities are more extended, its cardinal area bounded by a sharp angle from the lateral surface, its ribs are fewer in number and the sulci between them relatively wider and deeper, and it had a spinose surface quite unlike that of *S. multiplicata*. The surface features are contrasted in figures 9 and 20 of plate 29, both of which are enlarged

5 diameters. In addition, the punctae are much coarser in *P. cristata* than in *S. multiplicata*, so that it is possible to distinguish them on the basis of a minute fragment of the shell.

The angular cardinal extremities, sharply defined cardinal area, and the relative narrowness of fold and sulcus combine to indicate that this species must be assigned to *Punctospirifer* rather than to *Spiriferina* s. s.

Distribution. This species was originally described from the Zechstein beds in Germany, and was recognized in the Magnesian limestone of England by KING. Its only recorded occurrence in the Arctic faunas was by DE KONINCK (1847) who identified it in a small collection from Bell Sound in Spitzbergen.

In East Greenland it has been found sparingly in the "white blocks" of Permian limestone in the Triassic beds of the Kap Stosch area (blocks 4, 15, 100, and others). It was found also by BIERTHER (B (8) 2, (8) 6, (8) 8, (8) 9) in northern Scoresby Land, and by STAUBER in the collections from the "Productus limestone" west of Schucherts Flod in southern Scoresby Land, and by MAYNC at Avantpostbjerg in Clavering Ø, and by NOE-NYGAARD in Djævlekløften in the same region. In several of these places it is associated with *Spiriferina multiplicata.*

Genus **Martinia** McCOY, 1844.

Martinia McCOY, Carb. Fossils Ireland, 1844, p. 128, fig. 18, p. 139, fig. 22.
Martinia HALL and CLARKE, Paleont. New York, v. 8, pt. 2, 1892, p. 9.
Martinia BUCKMAN, Quart. Jour. Geol. Soc. (London), v. 64, 1908, p. 30.
Martinia GEORGE, Geol. Mag., v. 64, 1927, p. 110.
Martinia PAECKELMANN, Neues Jahrbuch für Min., Paleont., and Geol., Beil-Bd., v. 67, pt. B, 1931, p. 46.
Pseudomartinia LEIDHOLD, Abh. preuss. geol. Landesanst, n. s., v. 109, 1928, p. 82—84.

Diagnosis. Smooth speriferoids in which the hinge is relatively short and the ventral cardinal area triangular and obscurely defined because the lateral slopes of the beak round over to join it at a very flat angle. The ventral valve bears a very shallow sulcus that appears some distance in front of the beak and is only prominent toward the front of the shell. The dorsal valve bears a low fold that is indistinct over the umbonal area but may become prominent near the front margin. The surface appears smooth to the unaided eye, but under low magnification shows extremely fine growth lines.

Internally, the ventral valve is without dental lamellae and its muscle field is relatively small and largely behind the hinge line. A conspicuous groove occupied the mid-line of the muscle field, tapering

forward; and radiating from the margins of the muscle field are conspicuous grooves corresponding to the main trunks of the pallial sinuses.

The dorsal valve is thin, its muscle scars very lightly impressed, and its cardinalia very simple. Its brachial supports consist of a pair of flange-like structures arising close to the beak and running laterally, parallel with and very close to the hinge margin.

The shell substance is fibrous and impunctate.

Generotype, (lectotype by BUCKMAN, 1908), *Anomites glaber* MARTIN.

Discussion. The real nature of the genus *Martinia* has been a subject of much confusion. McCOY's original diagnosis (1844) reads simply,

> "Martinia, McCOY, or the smooth Spirifers in which the hinge-line is less than the width of the shell, and the area triangular." (p. 128).
>
> "Hinge-line shorter than the width of the shell; dorsal edges of the cardinal area obtusely rounded; surface smooth; spiral appendages small." (p. 139).

McCOY did not designate a type. HALL and CLARKE in 1894 (p. 9) pointed out that *Spirifera decora* PHILLIPS (= *Anomites glaber* MARTIN) was the first species listed by McCOY, and in so doing they implied, but did not specifically state, that this is, therefore, the generotype. BUCKMAN (1908) unequivocally made *Anomites glaber* MARTIN the lectotype, arguing that "McCOY evidently, from using MARTIN's name, intended MARTIN's species *Anomites glaber* to be the type."

BUCKMAN then pointed out that *Anomites glaber*, as commonly understood, actually included two unrelated homeomorphs, one more slender and lacking dental lamellae, and the other broader and flatter and having distinct dental lamellae. He further noted that although MARTIN had figured the more slender form, McCOY had figured the broader one which BUCKMAN believed to be a catagenic descendant of *Reticularia*. He argued, therefore,

> "The case may be regarded as one in which there are two genosyntypes—*Anomites glaber*, MARTIN, indicated by the name, and *Spirifer glaber*, auctt. *non* MARTIN = ? Sp. *latus* BROWN, indicated by the figure [i. e. McCOY's figure]. From these, selection may be made; and *Anomites glaber* becomes the genolectotype."

The distinction which BUCKMAN made is easily verified. I find in the SCHUCHERT collection, for example, several lots of specimens from the Lower Carboniferous of Ireland, and of Belgium, labeled "*Martinia glaber*," in which the two forms are mixed. Actually they are not dif-

ficult to separate for, aside from the presence or absence of dental lamellae, the narrower form is more convex and has a higher cardinal area.

Twenty years later, LEIDHOLD (1928, pp. 82—84) called attention to the fact that these two unrelated forms were present in *Martinia glaber* of authors, but he chose the larger, broader species as generotype of *Martinia* on the ground that MCCOY had figured it in connection with the original diagnosis of the genus.

However, in view of the fact that MCCOY paid no attention to the dental lamellae and obviously was thinking only of the smooth surface, and that he clearly intended to honor MARTIN, we feel that BUCKMAN's choice was correct, and that, having long priority over that of LEIDHOLD, it cannot be reversed.

Having decided that the broad form was the generotype of *Martinia*, LEIDHOLD proposed a new genus *Pseudomartinia* for the slender form (the original *Anomites glaber* of MARTIN). Accepting BUCKMAN's solution, on the contrary, we regard *Pseudomartinia* LEIDHOLD as a straight synonym of *Martinia* MCCOY.

It should be noted in passing that LEIDHOLD regarded a "chagrin-sculpture" (sic) as the most distinctive characteristic of his *Martinia*, and that PAECKELMANN (1931, p. 46) follows him in this regard. This statement is puzzling, but it seems probable that LEIDHOLD meant "shagreen" instead of "chagrin," and that what he observed was a vestige of the ornamentation of the ancestral stock, *Reticularia*, from which BUCKMAN inferred the broad form of *Martinia glaber* auctoris had descended. It may be emphasized that no such ornamentation is present in *Martinia* as BUCKMAN interpreted it.

We are indebted to GEORGE (1927, p. 110) for a critical restudy and description of *Martinia glaber* as restricted by BUCKMAN.

Martinia greenlandica DUNBAR, n. sp.

Plate 30, figures 1—8.

Martinia triquetra FREBOLD, [*non* Gemellaro] Meddel. om Grønland, Bd. 84, no. 2, 1931, p. 37, pl. 4, fig. 5.

Description. The size and shape of this species are well represented by figures 1 to 4 of plate 30. Length and breadth are approximately equal; the maximum breadth is about midway between the hinge line and the front margin. The ventral beak is moderately large but neatly pointed and curved over the triangular cardinal area. The hinge line is short, measuring a little less than half the width of the shell, and the cardinal extremities are broadly rounded.

The lateral slopes of the beak curve around gradually to meet the edges of the cardinal area at a low, but appreciable, angle. The cardinal

area has an apical angle of about 100° and is rather strongly arched in the longitudinal plane. The sulcus on the ventral valve begins obscurely some distance (commonly about 15 mm) in front of the beak and remains very shallow to the front margin where it is carried forward as a linguliform extension. It normally is nearly flat across the middle and toward the front has rather angular borders, but the angles become obsolete farther back. However, there is some variation in the shape of the sulcus. Commonly it first appears as an obscure, flattened belt along the middle of the umbo, but in some shells (e. g. fig. 6 of pl. 30) its sides slope gently toward a faint depression along the mid-line.

The fold on the dorsal valve arises obscurely about the middle of the valve and rises to its maximum height at the front margin where it is still low and rather obscurely bounded.

The apical and umbonal parts of the ventral valve are considerably thickened, but the front and lateral parts of this valve, and all of the dorsal valve, are quite thin. The shell substance is fibrous and impunctate, and its surface is smooth except for microscopic growth lines.

The ventral muscle scars are small and are located mostly within the beak and behind the hinge line. The muscle field is divided by a median groove that is widest at the posterior end and tapers to a point near the middle of the shell. The adductor muscles were inserted in the posterior part of this groove, and the diductor muscles surrounded them, occupying a lozenge-shaped area with its longest axis along the mid-line. Beyond the muscle scars the interior of the valve is marked by numerous prominent radiating grooves that undoubtedly reflect the main trunks of the pallial sulcis.

The inside of the dorsal valve is very simple, the muscle scars being so lightly impressed as to be scarcely distinguishable on excellent internal molds. The cardinalia also are very simple. The cardinal process is not adequately shown on any of our specimens but it must be very small and low. A pair of flange-like ridges run out parallel to the hinge and extends about halfway to the end of the hinge line. These were probably the bases to which the spiralia were attached. The brachidia have not been observed.

Discussion. This is one of the most common species in the Permian faunas of East Greenland, being found chiefly, but not exclusively, in the Martiniakalk facies. We have literally hundreds of specimens and they come from many localities. The majority of these are incomplete or are deformed by compaction of the sediment. Many of them are ventral valves alone, and it is evident that, due to their feeble hinge structures, the valves fell apart readily after death. Thereafter the dorsal valves were so thin and fragile that they were commonly broken up. Many of the ventral valves are well preserved except for the front and lateral

margins which, being very thin, are commonly broken or flattened. Although many of the specimens are thus imperfect, we are of the opinion that only a single species is represented.

In genera so simple in ornamentation as *Martinia*, there are few variables on which species can be discriminated, and there has been a tendency to use a single species name, such as *M. triquetra* GEMELLARO, for specimens representing a wide range in both time and space. Such composite "species" have little value in correlation or paleogeography and are commonly misleading because they are unnatural and yet lead geologists to infer that the widely different faunas have affinities that they do not possess. *M. triquetra* is a good illustration. First described from beds high in the Permian of Sicily, it was later identified by TSCHERNYSCHEW in the Schwagerinakalk of the Ural region, by HUANG in China, by MANSUY in Indochina, by HERITSCH in the Alps, and by FREBOLD in East Greenland. In all these instances there is rather close similarity, but the Martinias occur in very different faunal associations, and, we believe, have appreciable, even though slight, differences.

The Greenland shells differ both from those figured by GEMELLARO (1899, pl. 32, figs. 23—28) and from those figured by TSCHERNYSCHEW (1902, pl. 16, figs. 1—6). The originals by GEMELLARO have a hinge line only about one-fourth the width of the shell, and in ours it is relatively twice as long. Furthermore, the fold and sulcus are both shaped somewhat differently than in ours. In the shells from Sicily there is a slight groove along the mid-line of the fold (figs. 23 and 24 of GEMELLARO) and the sulcus is deepest at the mid-line whence the surface rounds up into the lateral part of the shell. In our species there is no groove whatever on the fold, and the sulcus is flat-bottomed and is well defined by angular slopes toward the front of the shell.

TSCHERNYSCHEW's specimens from the Schwagerinakalk at Simskaya in the Urals represent a much larger species than ours that is broader through the beak, is more nearly circular in outline, and has a sulcus deepest at the mid-line and indistinct at its sides.

Distribution. This is the most nearly ubiquitous species in our faunas. It is especially characteristic of the Martiniakalk and has been found in almost all outcrops of that facies where it commonly occurs in abundance even though other brachiopods are rare. It is not confined to this facies, however, but occurs in the "Productus limestone," along with a variety of other brachiopods, in the Kap Stosch area.

Genus **Odontospirifer** DUNBAR, n. gen.

Diagnosis. Externally resembling *Delthyris*, this small spiriferoid has simple but strong plications and a lamellose surface. The fold is

narrow, high and nonplicated; the ventral sulcus bears a single median costa that arises some distance in front of the beak and rises rapidly in height toward the front where it meets the extension of the dorsal fold to form a narrow keel-like extension over the mid-line of the shell at the front. Commonly the surface of the lamellae appears smooth, but in exceptionally preserved specimens it appears to be ornamented by microscopic radial lirae.

Internally, the ventral valve bears dental lamellae only at a very early stage in ontogeny after which they become obsolete. However, it bears a very high median septum that extends forward a little beyond the hinge line. The hinge line is completely denticulate and traces of the denticles form relatively strong vertical ridges across the cardinal area.

The shell is impunctate.

Generotype, *Odontospirifer mirabilis* DUNBAR, n. sp.

Discussion. These small shells superficially resemble *Punctospirifer* (*Spiriferina* in part of authors) but cannot be closely related thereto since that genus is coarsely punctate and the new genus is completely impunctate. The resemblance to *Delthyris* is also striking and that may be the ancestral stock from which *Odontospirifer* was derived, but the obsolescence of the dental lamellae and the development of a fully denticulate hinge line serve to distinguish the latter. This denticulation is similar to that in the chonetid genus *Eodevonaria* and in the strophomenid genera such as *Stropheodonta* and *Strophonellina*. The generic name refers to this remarkable specialization [Gr. *odons*, tooth + *Spirifer*].

Odontospirifer mirabilis DUNBAR, n. sp.

Plate 30, figures 9—19.

Spirifer cf. *alatus* FREBOLD [*non* Schlotheim], Meddel. om Grønland, Bd. 84, no. 3, 1931, p. 9, pl. 1, figs. 15, 15a.

Description. The size and shape of this small species are well shown on plate 30, but it should be noted that the larger photographs in figures 9 to 16 are all enlarged 2 diameters. There are only 3 ribs on each side of each valve. These are simple and rather high, and are narrower than the furrows between. The ventral valve bears a deep, rather narrow sulcus from the middle of which a single small plication arises some distance in front of the beak. The dorsal valve has a high, narrow fold with a narrow crest. At the front, where this fold meets the median costa of the ventral sulcus, the two are extended to form a flange-like keel in the vertical plane of the shell (figs. 11 and 12 of pl. 30).

The ventral cardinal area is high and moderately arched, and is ornamented with vertical ridges (3 or 4 per mm) that are the trace of

sharp, regularly spaced denticles on the hinge margin (pl. 30, figs. 18, 19). This little spiriferoid has developed a distinctly denticulate hinge line like that of *Eodevonaria* among the chonetids of the Lower Devonian. There is some evidence that the delthyrium was covered by a highly arched deltidial covering, but if so it has been broken away in the specimens before us to such an extent that its details cannot be described.

The entire surface is lamellose so that the shell appears rough and ragged (fig. 17 of pl. 30). The best preserved specimens revealed in addition a very fine radial liration on the surface of the lamellae. The shell substance is fibrous and impunctate.

Serial sections of the ventral beak (text fig. 22) show that a high median septum is present from the very apex and extends forward to a slight distance in front of the hinge line. A pair of dental lamellae

Fig. 22. Serial sections of the ventral beak of *Odontospirifer mirabilis*, made at 2, 5, 7, 8, and 10 mm, respectively, from the apex.

appeared after the shell had a width of more than 2 mm, diverging from the side of the beak but running forward parallel to the median septum. These lamellae are complete for a short distance reaching from the hinge plate to join the inner surface of the valve below, but after the shell had attained a breadth of only about 7 mm they ceased to grow forward and are quickly reduced to slight flanges under the margins of the delthyrium.

Discussion. Although this small shell superficially resembles *Punctospirifer*, it is quite impunctate and can have no close relation to the latter; our material is beautifully preserved and there can be no doubt that these shells are impunctate.

In shape, in its lamellose surface, and especially in the possession of a median costa in the sulcus, this shell resembles the much larger species *Spiriferina panderi* MÖLLER of the Schwagerinakalk (basal Permian) of the Urals; but TSCHERNYSCHEW (1902, p. 518) showed that the latter is abundantly and coarsely punctate.

Spiriferina expansa WIMAN (*non* TSCHERNYSCHEW), 1914 was renamed *S.*(?) *wimani* by STEPANOV (1937, p. 181, pl. 8, figs. 15a, b); but, although several specimens were figured by WIMAN, he said not a word about shell structure, and STEPANOV added nothing to the description. Unfortunately, therefore, we do not know whether the shell was punctate, but the fact that STEPANOV questioned the assignment to

Spiriferina may imply that he could not detect punctation. If the shell is impunctate it is probably congeneric with *O. mirabilis*, even though specifically quite distinct. STEPANOV's species is more than twice as large as ours, is much more transverse and extended at the hinge line, and has fully twice as many plications.

Distribution. This species was first observed in the "white blocks" of Permian limestone in the Eotriassic conglomerate of the Kap Stosch area (LK 1; N a, f, g, o, r, 3), but it was later found in abundance in STAUBER's collections from the "Productus" shell bed west of Schucherts Flod in southern Scoresby Land. There it is associated with the enormously abundant *Pleurohorridonia scoresbyensis*.

Genus **Choristites** FISCHER DE WALDHEIM, 1825.

Choristites FISCHER DE WALDHEIM, Note sur la Choristite, 1825, p. 7, pl. 1, figs. 1—4.
Choristites MILORADOVICH, Trans. Arctic Inst., U.S.S.R., v. 30, 1936, p. 52.
Munella FREDERICKS [*non* Bonnier, 1896], Comité Géol., Bull., v. 38, no. 3, 1919, p. 314.
Purdonella REED, Palaeontologica Indica, n. s., v. 23, Mem. no. 2, 1944, p. 218.

Diagnosis. Spiriferoids of medium to large size having a subcircular or subelliptical outline, the hinge line being shorter than the maximum width of the shell and the cardinal extremities rounded. The ventral beak is prominent and its lateral slopes round over to meet the cardinal area at a very obtuse angle.

The surface of the shell is covered by rather low, rounded costae that increase in number by dichotomy. The ventral valve bears a rather narrow and very shallow and ill-defined sulcus, and the dorsal valve bears a correspondingly low fold.

Internally, the ventral valve has long, stout dental lamellae that extend below the hinge plate to join the shell and extend forward into the muscle field. The posterior part of this valve becomes greatly thickened during growth by a secondary shelly deposit that invests the dental lamellae and lines the area under the hinge plate and largely fills the space between the dental lamellae.

Generotype, *Choristites mosquensis* FISCHER de WALDHEIM.

Discussion. In his scheme for a "standard classification" of the spiriferoids in 1919 (discussed above on p. 137), Fredericks proposed a new genus *Munella* (generotype, *Spirifer nikitini* TSCHERNYSCHEW), which he thought differed from *Choristites* in the structures in the apex of the ventral valve. However, LICHAREW (1934, pp. 443—446) published a critical study of the structure in *S. nikitini* and concluded that there was no basis for separating it from *Choristites*. MILORADOVICH (1936,

p. 13 and p. 52) discussed the matter fully, confirmed LICHAREW's opinion, and rejected *Munella* as a synonym of *Choristites*.

SCHUCHERT and Le VENE had pointed out that *Munella* FREDERICKS is a junior homonym of *Munella* BONNIER (1896), and could not be used for a Spirifer. In 1944 (p. 218) REED proposed a new name *Purdonella* to replace *Munella* FREDERICKS, apparently having overlooked the works of LICHAREW and of MILORADOVICH.

Choristites söderberghi DUNBAR, n. sp.

Plate 31, figures 4—11.

Description. Of this form we have about a dozen specimens, all more or less incomplete. The best of them are figured on plate 31. The largest specimen (fig. 4) indicates that the species attained a length of about 7 cm and at this size was over 8.0 cm wide. Varices of growth in figure 11 indicate that the shell was wider than long during early growth, also, and that the cardinal extremities were rounded. The ventral beak was neatly pointed and rather erect, its apex greatly arched over a high but narrow and obscurely delimited cardinal area (fig. 5). The delthyrium is large, having an apical angle of about 70°, and occupying rather more space than the bordering cardinal area.

The sulcus appears on the ventral beak as a single furrow between the admedian costae, and only a little larger and deeper than the furrows between other ribs. At a centimeter or more in front of the beak, a single costa arises in the middle of this furrow and the adjacent part of the valve gradually becomes slightly impressed to form a very shallow and obscurely defined sulcus that widens gradually to the front of the shell (pl. 28, figs. 7—9). Some or all of the ribs split dichotomously during youthful growth (occasionally during later growth), and at maturity each valve bears 70 or more rather low, rounded ribs with shallow furrows between.

None of our specimens show well the dorsal valve, but the longitudinal curvature of the ventral valve indicates that the shell was only gently biconvex with the umbones less inflated than is usual in *Choristites*.

The species is named in honor of Dr. SÄVE-SÖDERBERGH who collected some of our best specimens during his survey of Canning Land and Wegeners Halvö.

Discussion. *Choristites* is most common in the Middle Carboniferous of Russia but ranges up into the Upper Carboniferous. MILORADOVICH has described several species from the Timan Plateau (1936). It is less common in the Permian, but *C. nikitini* TSCHERNYSCHEW occurs in Sakmarian beds, which we regard as basal Permian, in the Ural

region. The Greenland species is much younger than these and may be the youngest one known. The Carboniferous species are generally more elongate, more convex, and have a more inflated ventral umbo, and have the cardinal area more sharply defined than in our species.

Of the forms described by MILORADOVICH, *C. priscus* EICHWALD (?) most nearly resembles ours, but it has a longer hinge line and its cardinal area is a very broad, low triangle. The shell also is much less transverse than ours.

Our species is larger and more transverse than *C. nikitini* and less strongly convex. Its ribs, also, are appreciably finer and its ventral beak more erect than in the Russian species, and its cardinal area less sharply defined.

Ours is also more transverse than *C. uralicus* LEBEDEW, and its cardinal area is narrower and less sharply defined.

REED described several species from the Salt Range of India under the generic name *Purdonella*. These are wider than long but they all have coarser and stronger ribs, and are not closely similar to ours.

The form which TSCHERNYSCHEW and STEPANOV (1919, pl. 10, figs. 2a, b) described from Store Björnekap in Ellesmere Land and identified as *Spirifer nikitini*, is obviously different from our species, being longer than wide and having much coarser costae.

Choristites anikeevi EINOR from Taimyr appears to resemble our species in general but differs in having a broadly concave sulcus whereas ours has a narrow sulcus sloping into a narrow depression along the mid-line.

Distribution. Most of our specimens came from the slopes of Kollen in Canning Land. SÄVE-SÖDERBERGH collected the species on the eastern side of Kollen where it was associated with *Spirifer striatoparadoxus*, *Spiriferella keilhavii*, and *Liosotella grandicosta*.

It was found by BIERTHER in northern Scoresby Land (C 1) and a few specimens were collected by STAUBER west of Schucherts Flod in southern Scoresby Land. It has not been found in the Kap Stosch area nor in Clavering Ø or Wollaston Forland.

Genus **Hustedia** HALL and CLARKE, 1893.

Hustedia HALL and CLARKE, Paleontology of New York, v. 8, 1893, p. 120.

Diagnosis. Small, rostrate, ribbed; having a short but straight hinge with a high undivided cardinal area (or a symphytium?) on the ventral valve; with an apical pedicle foramen and, inside the shell, an incomplete pedicle collar; without dental lamellae; bearing spirilia with a specialized jugum; shell abundantly punctate.

Generotype, *Terebratula mormoni* MARCOU.

Hustedia troelseni DUNBAR, n. sp.

Plate 32, figures 12—17.

Discription. This species is based upon a few specimens, most of which are somewhat crushed. The one selected as holotype (figs. 12 and 13 of plate 32) is believed to represent these well in both size and shape. The first paratype (figs. 14 and 15) is excellent except that one side is missing, and a second paratype (figs. 16 and 17) appears superficially to be abnormal because it has been somewhat deformed by lateral compression.

This is a small species, as indicated by the several smaller photographs on plate 32 (the larger ones being enlarged $\times 2$). The ventral valve bears 3 plications on each side of the midline, and the intervening furrows are subequal, rather deep, and about equal in breadth to the plications. Outside the last furrow is a flattened or gently concave lateral area along the side of the beak, and the angle between it and the outer furrow might be considered an incipient plication. The median furrow does not differ in size from the adjacent pair. On the dorsal valve there are 3 plications on each side plus a median plication that is somewhat narrower and lower than the others, especially in the umbonal region, and appears to have arisen out of a dorsal sulcus a short distance in front of the beak. The pedicle foramen is round and has been enlarged by resorption of the shell so that the apex of the beak is truncated. Internal characters have not been observed.

Discussion. In the two shells represented by figs. 12—14 of plate 32, as in all but one of the others observed, the plications have rather narrowly rounded crests and somewhat concave sides, and the intervening furrows are relatively deep for shells of such small size. As a result the shells appear gaunt. The one represented by figs. 16 and 17 seems to have rather broader and more rounded ribs and the two median ones have been pressed close together (due to compression after burial). This shell may not be conspecific with those described, but it occurs in a small lot (LK 20) that agree well with the description given above.

A small specimen (figs. 11, 12, of plate 32) from a "white block" in the Triassic conglomerate near Kap Stosch (N—Bs) differs from the described form in having 4 ribs on each side of the ventral valve. From this single specimen it is not certain whether it represents a distinct form or an individual aberration. However, it is associated with an incomplete and somewhat larger specimen having only 3 ribs on each side.

Many of the described species of *Hustedia* are rather closely similar so that significant specific distinctions are difficult in this genus. *Hustedia*

indica WAAGEN, from the Salt Range of India, is more globose and has lower ribs and shallower furrows. The shells so identified by TSCHERNYSCHEW from the Schwagerinakalk in the Ufa Plateau agree with Waagens species rather than with ours. *H. remota* EICHWALD differs from ours in having an extra pair of ribs and especially in that the ribs are more slender and are separated by nearly flat spaces instead of deep, rounded furrows. *H. meekana* Shumard (*fide* GIRTY, 1909) is larger and more inflated than ours. *H. phosphoriensis* BRANSON is more globular and has appreciably more numerous plications. The species is named in honor of Dr. JOHN C. TROELSEN.

Distribution. This small species was found in 6 collections but it is easily overlooked and was probably more common than thus indicated. Three of the lots (LK 551, N—Bs, and LK 518) are from "white blocks" in the Triassic conglomerates near Kap Stosch; and 3 of them (LK 6, 7, LK 29, and LK 28) are from in situ in the Permian sections of the Kap Stosch area.

CATALOGUE OF COLLECTIONS

Lauge Koch collections. Made during a period of many years and from diverse parts of East Greenland.

LK 1—4.	Vicinity of Kap Stosch, Hold with Hope.
LK 5.	Permdal, Wollaston Forland.
LK 7.	North of Hird's Fox Farm, south coast of Clavering Ø.
LK 8.	Graensedalen, Wollaston Forland.
LK 9, 10.	Vicinity of Kap Stosch.
LK 11.	Rivers 14—16, east of Kap Stosch.
LK 12.	Miscellaneous.
LK 13.	Depot Ø.
LK 14.	Vicinity of Kap Stosch.
LK 17.;	Hird's Fox Farm, south coast of Clavering Ø.
LK 18, 19.	"Great Fault River" (River 16?) east of Kap Stosch.
LK 20.	Djaevlekløft, northeastern Clavering Ø.
LK 24, 25.	(Locality unknown).
LK 28, 29.	Vicinity of Kap Stosch.
LK 37.	Dolomitdal, Clavering Ø.
LK 40.	Brachiopoddal, Wollaston Forland.
LK 43.	River 7, east of Kap Stosch.
LK 49, 50.	River 9 (or 8) east of Kap Stosch.
LK 62.	(Locality unknown.)
LK 70.	Kap Stosch.
LK 268.	Spath Plateau east of Kap Stosch.
LK 271.	Spath Plateau east of Kap Stosch.
LK 273.	Spath Plateau east of Kap Stosch.
LK 343.	River 14, east of Kap Stosch.
LK 406.	Brachiopoddal, Wollaston Forland.
LK 408.	Brachiopoddal, Wollaston Forland.
LK 410.	Brachiopoddal, Wollaston Forland.
LK 415.	Brachiopoddal, Wollaston Forland.
LK 416.	East of Brachiopoddal.
LK 418.	East of Brachiopoddal.
LK 426.	Zechsteindal, Wollaston Forland.
LK 431.	East of Brachiopoddal.
LK 432.	Carbondal, Wollaston Forland.
LK 443.	Kap Stosch.
LK 447.	Locality 3 east of Kap Stosch (alt. 240 meters).
LK 459.	Locality 4 east of Kap Stosch (alt. 340 meters).
LK 461.	Vicinity of Kap Stosch.

LK 471.	Vicinity of Kap Stosch.
LK 473.	Locality 3 east of Kap Stosch (alt. 240 meters).
LK 476.	Locality 3 east of Kap Stosch (alt. 240 meters).
LK 478.	Locality 3 east of Kap Stosch (alt. 240 meters).
LK 479.	Locality 3 east of Kap Stosch (alt. 240 meters).
LK 488.	Locality 3 east of Kap Stosch (alt. 240 meters).
LK 498.	Locality 3 east of Kap Stosch (alt. 240 meters).
LK 501.	Locality 3 east of Kap Stosch (alt. 240 meters).
LK 512.	Locality 3 east of Kap Stosch (alt. 240 meters).
LK 517.	Locality 3 east of Kap Stosch (alt. 240 meters).
LK 522, 523.	Locality 3 east of Kap Stosch (alt. 240 meters).
LK 525.	Locality 3 east of Kap Stosch (alt. 240 meters).
LK 528, 529.	Locality 3 east of Kap Stosch (alt. 240 meters).
LK 539.	Locality 3 east of Kap Stosch (alt. 240 meters).
LK 546.	Locality 3 east of Kap Stosch (alt. 240 meters).
LK 551.	Locality 3 east of Kap Stosch (alt. 240 meters).
LK 554.	Locality 3 east of Kap Stosch (alt. 240 meters).
LK 556.	Locality 3 east of Kap Stosch (alt. 240 meters).
LK 558, 559.	Locality 3 east of Kap Stosch (alt. 240 meters).
LK 564—566.	Locality 3 east of Kap Stosch (alt. 240 meters).
LK 582.	Locality 3 east of Kap Stosch (alt. 240 meters).
LK 601.	Carbondal, Wollaston Forland.
LK 604.	Carbondal, Wollaston Forland.
LK 606.	Carbondal, Wollaston Forland.
LK 622.	Breccia River, Wollaston Forland.
LK 622a.	Breccia River, Wollaston Forland.
LK 622b.	Carbondal, Wollaston Forland.
LK 627.	Hird's Fox Farm, southern coast of Clavering Ø.
LK 631.	East of Kap Stosch.
LK 1026.	Basalt Haven opposite Kap Herschele Bjerg, north shore of Clavering Ø.
LK 1028.	Basalt Haven opposite Herschele Bjerg, north shore of Clavering Ø.
LK 1030.	Basalt Haven opposite Herschele Bjerg, north shore of Clavering Ø.
LK 1031.	Basalt Haven opposite Herschele Bjerg, north shore of Clavering Ø.
LK W.	East of Brachiopoddal, Wollaston Forland.
LK WB.	White blocks in Triassic conglomerate near Kap Stosch.
NF.	Talus on north of Kollen in Nathorsts Fjord. (Collected by ship's crew).

Maync collection. Made in Wollaston Forland and Gauss Halvö, 1936—38. (Individual specimens numbered).

Ma 33—99.	Fiskeelv, south coast of Clavering Ø. From the Permian sequence.
Ma 129—166.	East of Brinkley Bjerg above Fiskeelv.
Ma 167—196.	Fiskeelv, south coast of Clavering Ø.
Ma 197—231.	East of Malmquists Plateau, west of Moskusokseelv, southern Clavering Ø.
Ma 251—267.	Fiskeelv, south coast of Clavering Ø.
Ma 273—300.	Sneugleelv, south coast of Clavering Ø.
Me 301—444.	Productuselv, southeastern Clavering Ø.
M 493—595.	"Avantpost Bjerg" (Forposten) east-central Clavering Ø.
Mg 1768—1786.	Permpas, central southern Wollaston Forland.

Mh 1790—1821. Grænsedal, southwestern Wollaston Forland.
Mi 1833—1868. Permdal, above west coast of Wollaston Forland.
Mj 1871—1873. Kuppelpasset, south of Permdal, Wollaston Forland.
Mk 1882—1900. Brachiopoddal, west coast of Wollaston Forland.
Mk 1904—1909. Brachiopoddal, west coast of Wollaston Forland.
Ml 1923—1967. Sandstensdal, west coast of Wollaston Forland.
Mn 2194—2204. Permian boulders in Cretaceous beds in Djaevlekløft, northeastern
2208—2214. Clavering Ø.
Mo 2262—2371. North of Cirkusdal, northeastern Clavering Ø.
Mp 2419—2425. Permian boulders in Jurassic beds at Dolomitdal, northeastern Clavering Ø.
Mq 2433—2440. Permian beds at Kontactravine, Upper Dolomitdal.
Mr 2454—2479. Fossilelv, southern Clavering Ø.
Ms 2498—2520. Fiskeelv, southern coast of Clavering Ø.
Mt 2649. Stilles Ø, off north coast of Hold with Hope.
Mu 2665—2679. River 14, east of Kap Stosch, northern coast of Hold with Hope.
Mv 2706—2715. Koral Creek, Margrethedal, south coast of Gauss Halvö.
2720—2722.
Mw 2733—2735. East of Margrethedal on the south coast of Gauss Halvö.
Mx 2736—2804. Martinia and Productuskalk, Margrethedal.
My 2830. Productus limestone, River "a", east of Margrethedal.
Mz 2834—2835. Posidonomya beds northwest of Franklinfjeld, west of Kap Franklin, southern Gauss Halvö.
Maa 2877—2902. South-central Giesecke Bjerge, Gauss Halvö.
Mbb 2907—2911. Jakobsdal, east-central Giesecke Bjerge, Gauss Halvö.
Mcc 2984—3013. Ladderbjerg, northeastern Giesecke Bjerge, Gauss Halvö.
Mdd 3058—3063. Slopes above Gastisdal, west-central flank of Giesecke Bjerge, Gauss Halvø.

Nielsen collection. Made along the north border of Hold with Hope in 1932—33. (Map in M. O. G., Bd. 98, nr. 1, 1935).

NB 1. River 6, east of Kap Stosch.
NB 3, 4. Fish Plateau, between River 2 and River 4, southwest of Kap Stosch.
NB 6. (no data).
NB 7, 8. Between River 2 and River 4, southwest of Kap Stosch.
NB 10. Vicinity of Kap Stosch.
NB 11, 99, 100. Fish Plateau east of Kap Stosch.
NB 21—24. River 3, southwest of Kap Stosch.
N 11. Rivers 14 and 15, east of Kap Stosch.
N 18—20. River 8, east of Kap Stosch.
N 22—25. River 8, east of Kap Stosch.
N 27. River 8, east of Kap Stosch.
N 30. River 8, east of Kap Stosch.
N 32—35. River 8, east of Kap Stosch.
N 38. River 9, east of Kap Stosch.
N 42, 43, 45. River 2, southwest of Kap Stosch.
N 45a. Float, near N 45.
N 46. River 2 or Rivers 13—14, near Kap Stosch.
N 47—58. Rivers 13 and 14, east of Kap Stosch.

N 54. (no data).
N 63. West of River 8, east of Kap Stosch.
N 65. River 9, East of Kap Stosch.

NB a—g, i, k, m—p, r—v. All from the vicinity of Kap Stosch.

Säve-Söderbergh collection. Made in Wegeners Halvö and Canning Land in summer of 1936. (See M.O.G. Bd. 96, Nr. 5, 1937).

Stauber collections.

A. South border of Traill Ø, 1937.
S 584. South base of Svinhufvuds Bjerge.
S 643. South base of Svinhufvuds Bjerge.
S 730. South base of Svinhufvuds Bjerge.
S 733. South base of Svinhufvuds Bjerge.
S 754. South base of Svinhufvuds Bjerge.

B. Nathorsts Fjord region, 1938.
S 302.
S 305.
S 310.
S 311.
S 312.
S 314.
S 315.
S 317.
S 396.
S 809.
S 827.
These were labeled as "from Ravnefjeld on Wegener Peninsula and also from Depot Island in Nathorstfjord." We have no evidence as to which came from each locality.

C. West of Schucherts Flod, Scoresby Land, 1938 Boxes 1—13, all from a single ledge of shell limestone (a productid coquinite).

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Færdig fra trykkeriet den 3. juni 1955.

PLATES

Plate 1.

Streptorhynchus kempei ANDERSSON . . . . . p. 63

Figs. 1, 2. Exterior and interior views of a young shell from Dolomitdal, Clavering Ø (LK 37).

Figs. 3, 4. Ventral and dorsal views of a young shell of which the dorsal valve was slightly displaced before preservation. From Kap Stosch (LK). Figured by FREBOLD, 1931, pl. 6, figs. 1—3.

Fig. 5. Interior of posterior part of a young ventral valve showing absence of dental lamellae. Brachiopoddal, Wollaston Forland (LK 410).

Fig. 6. Interior view of posterior part of a young dorsal valve from the same lot as the last.

Figs. 7, 8. Interior view of posterior part of a young dorsal valve (X 2) and posterior view of the same (X 2) showing the structure of the cardinal process, the supporting buttresses, and the crural bases. Carbon River, Wollaston Forland (LK 606).

Fig. 9. Interior view of posterior part of a submature shell showing the muscle scars deeply impressed in the greatly thickened shell. Kap Stosch (LK 4).

Fig. 10. Interior view of ventral valve of a halfgrown shell from the same lot as figs. 1 and 2.

Fig. 11. Interior view of adult ventral valve showing the massive thickness of the posterior part and the deeply impressed muscle scars. This specimen was received without a label but is lithologically like others in the same box from Djævlekløften on Clavering Ø (? LK 7).

Figs. 12, 13. Ventral and dorsal views of a fine adult shell from Rivers 13—14 east of Kap Stosch (N 48).

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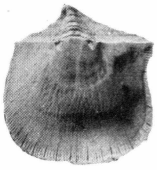

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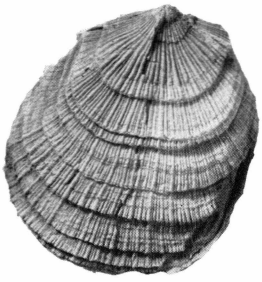

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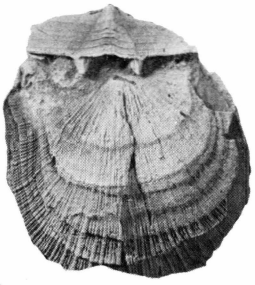

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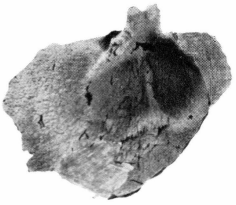

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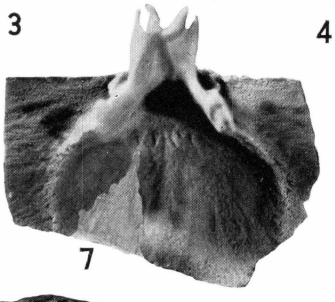

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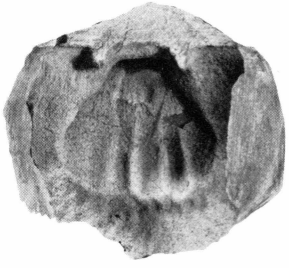

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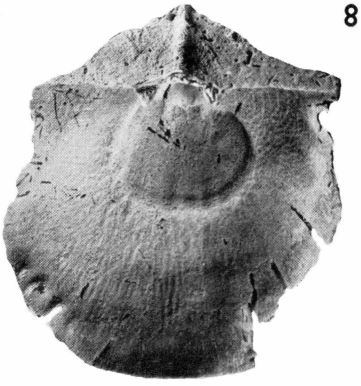

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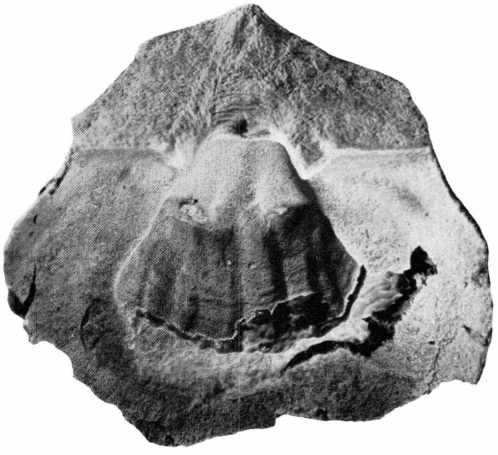

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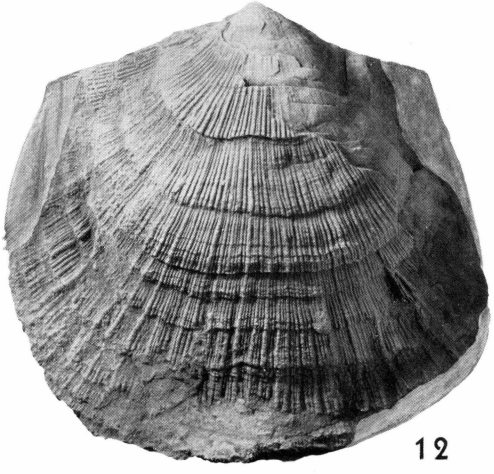

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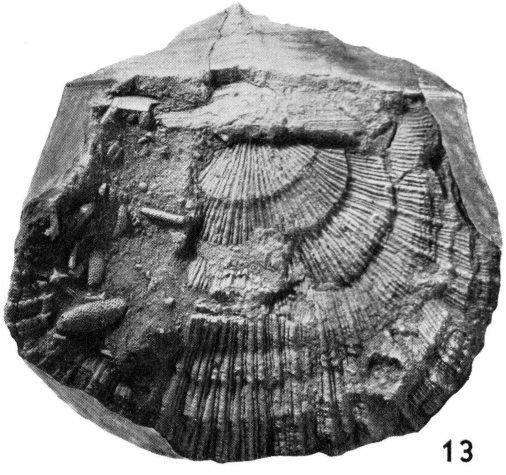

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Plate 2.

Streptorhynchus stoschensis DUNBAR, n. sp. ..... p. 65

Figs. 1—3. Young specimen in dorsal view (X 1 and X 2), lateral view (X 2) and ventral view (X 2). "White block" in the Triassic conglomerate Kap Stosch (Na).

Fig. 4. Young shell in ventral view (X 1 and X 2) from same locality (LK Wb).

Fig. 5. Ventral view (X 1 and X 2) of a mature shell from same locality. Figured by FREBOLD (1931, pl. 1, figs. 9, 9a) as *S. pelargonatus*.

Fig. 6. Dorsal valve (X 1) from same locality (N k).

Figs. 7, 8. Cardinal and ventral views (X 2) of the apical part of a young shell from the same area (LK Wb).

Fig. 9. Cardinal view (X 2) of the specimen shown as fig. 4.

Figs. 10, 13, 14. Cardinal, lateral, and ventral views (X 1) of a broken but mature shell from the same locality.

Figs. 11, 12, 15. Ventral, lateral, and cardinal views (X 1) of a mature ventral valve from the same locality.

Derbyia sp. A ..... p. 66

Fig. 16. Internal mold of a ventral valve showing the septal ridge running through the field of the diductor muscle scars. Grænsedalen, Wollaston Forland (LK 8).

Figs. 17, 18. Ventral and dorsal views of an incomplete internal mold of a shell from the same locality.

Figs. 19, 20. Ventral and dorsal views of a silicified and slightly crushed shell from Djævlekløften, Clavering Ø (LK).

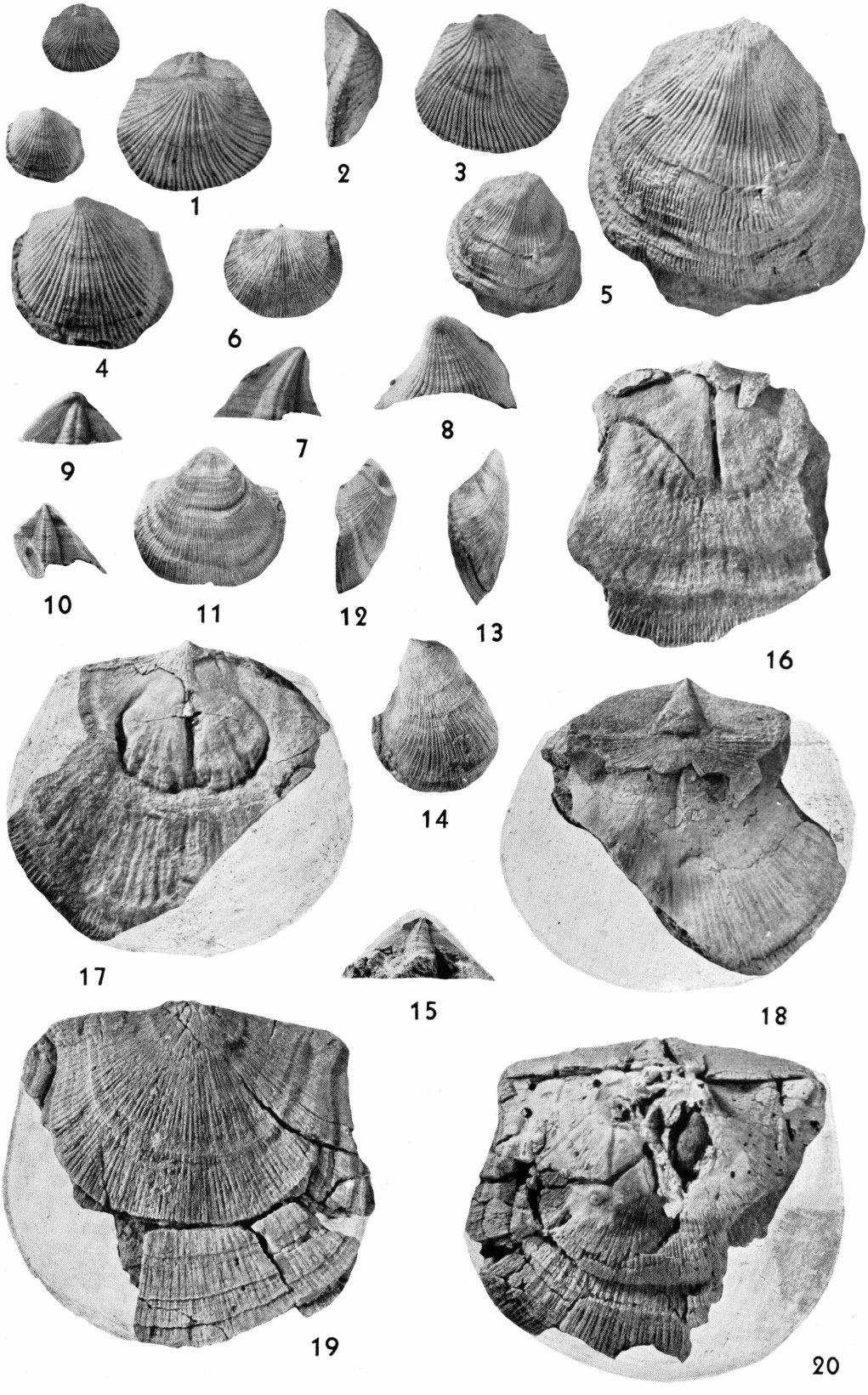
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Plate 3.

Paeckelmannia toulai DUNBAR, n. sp. . . . . p. 69

Figs. 1—3. Three paratypes (X 1 and X 2) from the "Productus limestone" in the vicinity of Kap Stosch (LK 29). The last of the three is abnormal, having a fold on the ventral valve.

Fig. 4. Paratype on a slab of Martiniakalk (X 1 and X 2) from Sneugleelv, southern margin of Clavering Ø (M 281).

Fig. 5. Holotype (X 1 and X 2), from the same lot (M 279).

Fig. 6. External mold of a ventral valve in the rock (X 1 and X 2). Same lot (M 281).

Fig. 7. Interior view of a dorsal valve (X 3) from the same lot as figs. 1—3.

Fig. 8. Interior view of a ventral valve (X 3) from the same lot.

Cancrinella bolchovitinovae (MIRCHINK) . . . . . p. 71

Figs. 9—11. Lateral, ventral, and dorsal views of a specimen from Kumait, Nathorsts Fjord (LK 6, 7).

Figs. 12, 13. Ventral and lateral views of a specimen with fully developed trail. "Productus limestone" west of Schucherts Flod in southern Scoresby Land (STAUBER coll.).

Fig. 14. Lateral view of a young specimen showing the abundant spine bases on the lateral slopes. From the "Red Series" in Permpas, Wollaston Forland (M 1786).

Figs. 15, 16. Ventral and lateral views of a broad specimen from the same lot (M 1784).

Fig. 17. Lateral view showing spines and rugae on the lateral slopes. Same lot (M 1783).

Figs. 18—20. Posterior, lateral, and ventral views of a specimen with a long trail. Same lot (M 1782).

Cancrinella germanicus (FREBOLD) . . . . . p. 72

Figs. 21—23. Posterior, ventral, and lateral views of a specimen from Kumait, Nathorsts Fjord area (LK 6, 7).

Figs. 24, 25. Dorsal and ventral views of one of FREBOLD's types, here designated the holotype (FREBOLD's pl. 6, fig. 3). From Nathorsts Fjord area.

Figs. 26, 27. Dorsal and ventral views of a paratype from the same lot (FREBOLD's pl. 6, fig. 4).

Figs. 28, 29. Ventral and posterior views of a paratype from the same lot (FREBOLD's pl. 6, fig. 2).

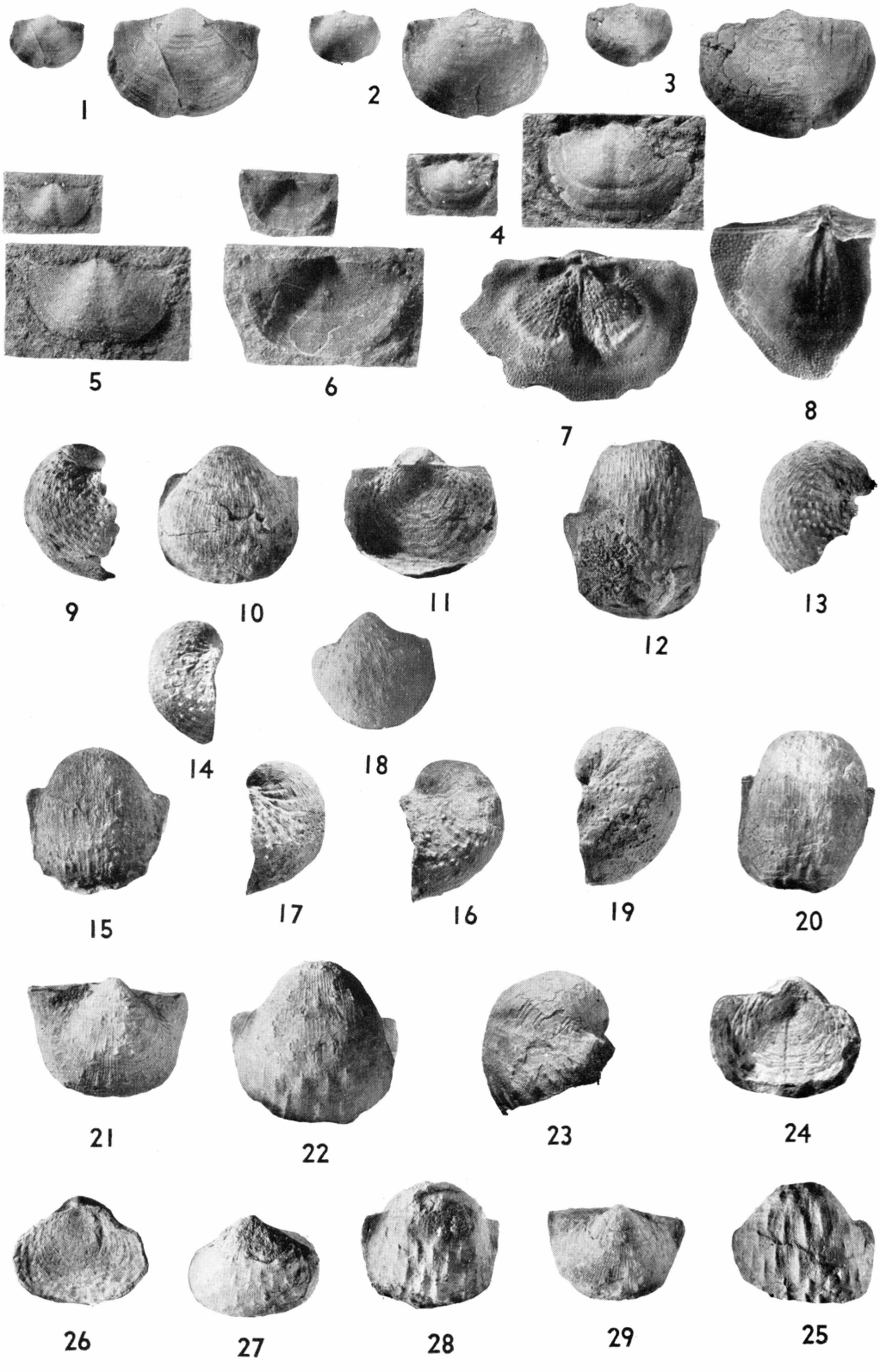
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Plate 4.

Liosotella hemispherica DUNBAR, n. sp. . . . . p. 74

Fig. 1. Posterior view (X 1 and X 2) of a paratype from Grænsedalen, southern Wollaston Forland (M 1790).

Figs. 2, 3. Ventral and lateral views (X 1 and X 2) of a paratype from north of Cirkusdal, northeastern Clavering Ø (M 2308).

Figs. 4—6. Posterior, ventral, and lateral views (X 1 and X 2) of holotype (M 2184).

Fig. 7. Ventral view (X 1 and X 2) of a paratype from Productuselv, Clavering Ø (M 354).

Figs. 8, 9. Ventral and lateral views (X 1 and X 2) of a paratype from Rivers 13—14, east of Kap Stosch, northern Hold with Hope (N 51).

Figs. 10, 11. Ventral and lateral views (X 1 and X 2) of a paratype (M 2184).

Fig. 12. Ventral view (X 1 and X 2) of a paratype from Fiskeelv, south coast of Clavering Ø (M 71).

Figs. 13, 14. Lateral and ventral views (X 1 and X 2) of a paratype from same locality as fig. 2 (M 2307).

Figs. 15, 16. Ventral and lateral views (X 1 and X 2) of a paratype from the same area (M 2365).

Figs. 17, 18. Ventral and lateral views (X 1 and X 2) of another paratype from the same area (M 2307).

Figs. 19—21. Ventral, posterior, and lateral views (X 1 znd X 2) of a paratype showing well the smooth surface of the posterior part of the umbo, the auricles, and the lateral slopes. From the same area (M 2323).

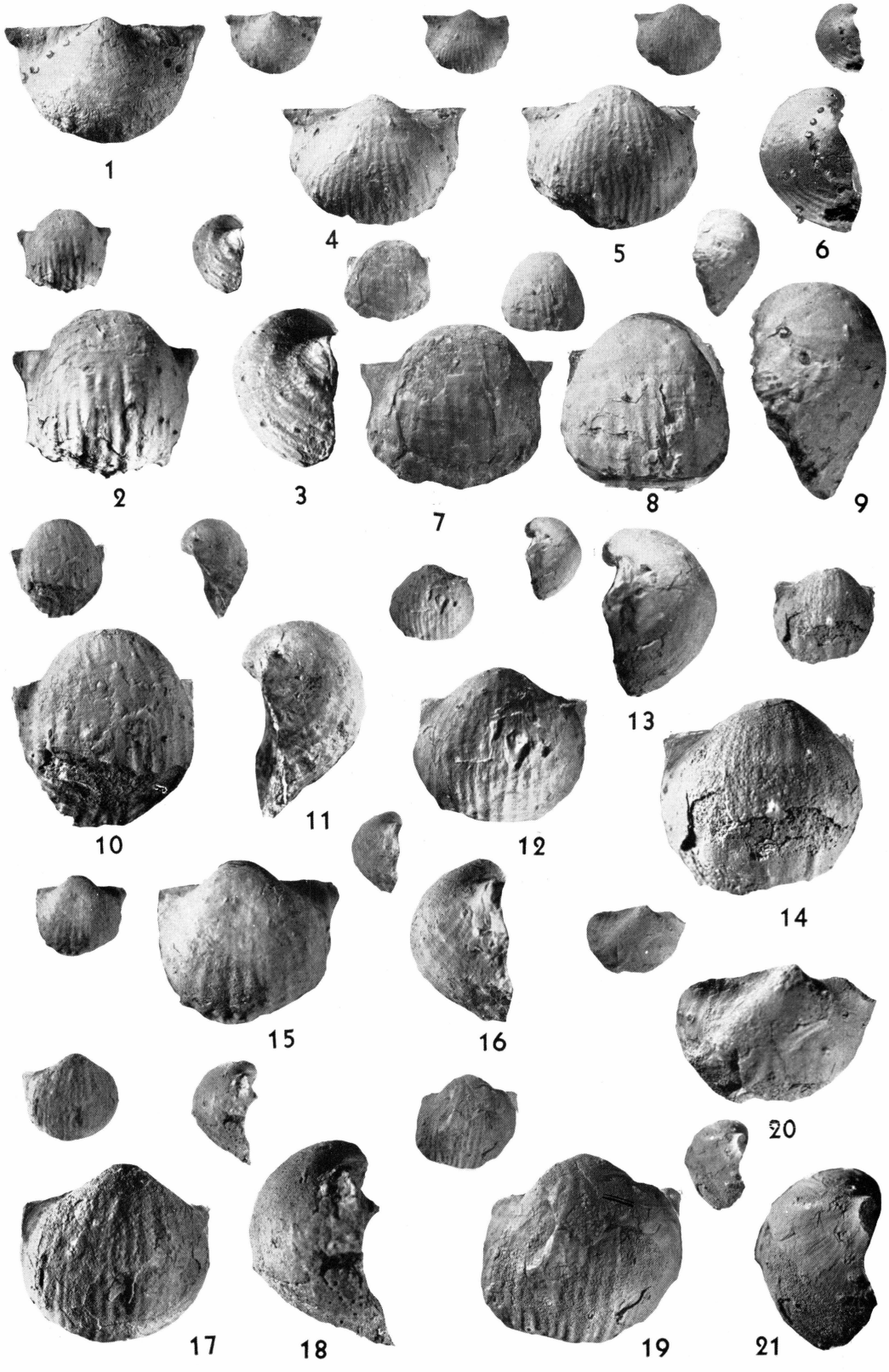
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Plate 5.

Liosotella spitzbergiana (Toula) ..... p. 75

Figs. 1—3. Posterior, lateral, and ventral views of a typical specimen from Productuselv on Clavering Ø (M 374).

Fig. 4. Dorsal view of another specimen from the same lot.

Figs. 7, 11, 12. Posterior, lateral, and ventral views of specimen with fully grown trail. From the Martinia-Productus limestone in Margrethedal, Gauss Halvö (M 2786).

Figs. 8—10. Posterior, ventral, and lateral views of a specimen from Avantpostbjerg, Clavering Ø (M 568).

Fig. 13. Ventral view of a submature shell from the same locality as figs. 7, 11, 12 (M 2764).

Liosotella vadosisinuata Dunbar, n. sp..... p. 77

Figs. 14—16. Posterior, ventral, and lateral views of holotype, from a Permian boulder in the Neocomian conglomerates at Djævlekløften, Clavering Ø (M 2210).

Figs. 17, 20, 21. Posterior, ventral, and lateral views of a specimen from Fiskeelv, southern coast of Clavering Ø (M 78).

Figs. 18, 19. Posterior and ventral views of a specimen from the same locality (M 79).

Fig. 22. Partly exfoliated interior of a dorsal valve from the last locality (M 78).

Liosotella delicatula Dunbar, n. sp..... p. 77

Figs. 23, 24. Ventral and dorsal views of the holotype, from Avantpostbjerg, Clavering Ø (M 590).

Figs. 25, 26. Posterior and ventral views of a paratype from the same locality (M 562).

Figs. 27, 28. Ventral and lateral views of a paratype from northeast of Cirkusdal, northeastern Clavering Ø (M 2311).

Figs. 29—31. Ventral, posterior, and lateral views of a paratype from Productuselv, Clavering Ø (M 382).

Marginifera cf. *septentrionalis* Tschernyschew ..... p. 80

Fig. 5. Ventral view of specimen from River 8 east of Kap Stosch (N 24).

Fig. 6. Ventral view of specimen figured by Frebold as *Marginifera* cf. *typica* var. *septentrionalis* Tschernyschew (1931, pl. 3, figs. 2a—b). From Kap Stosch.

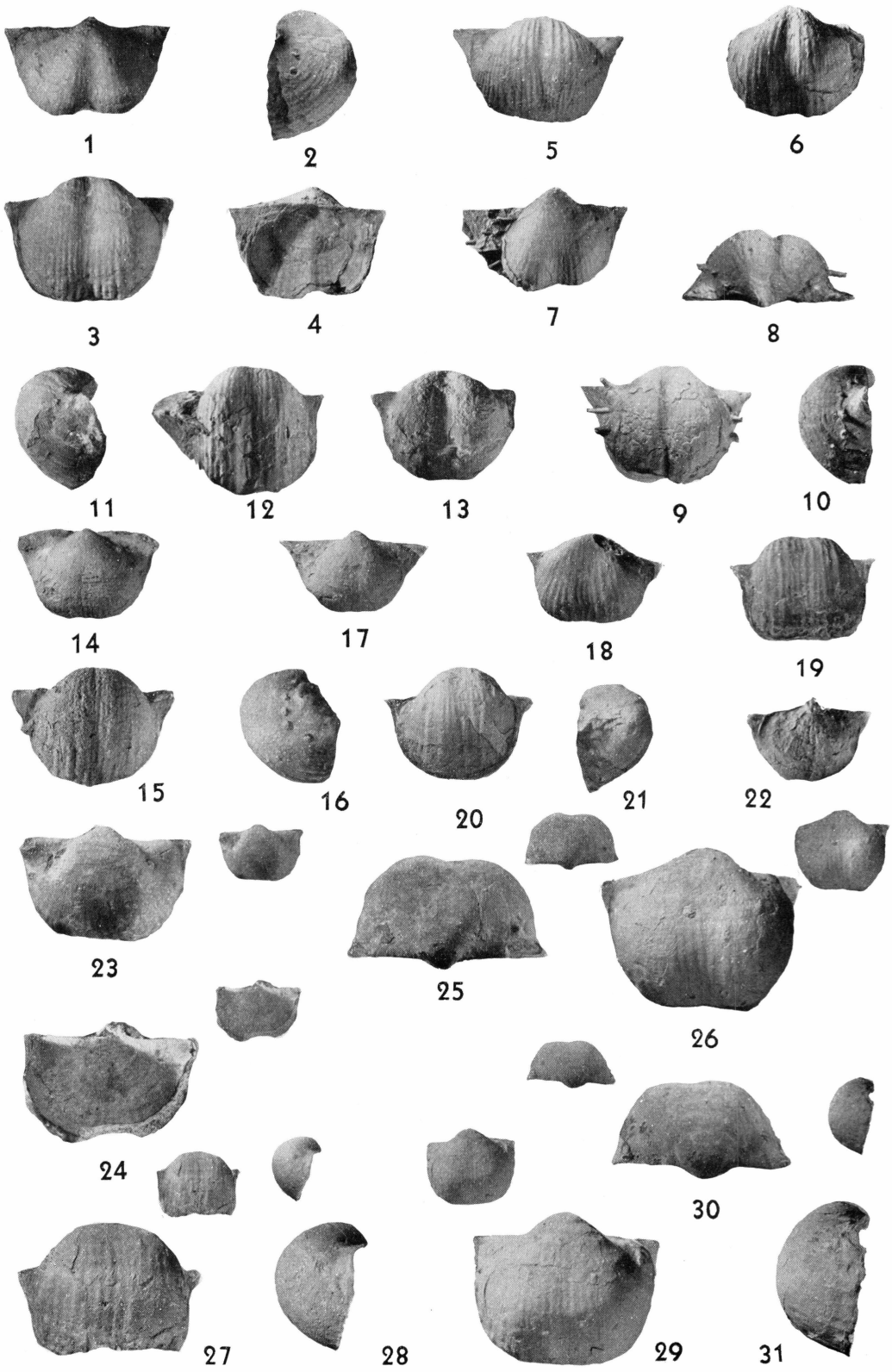
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Plate 6.

Liosotella grandicosta DUNBAR, n. sp. . . . . p. 78

Figs. 1—4. Ventral, lateral, dorsal, and posterior views of a well-preserved young shell from Nathorsts Fjord, Canning Land.

Figs. 5—6. Lateral and ventral views of another young shell. Same locality.

Figs. 7, 8. Lateral and ventral views of a submature shell with more than normally numerous costae. Same locality.

Figs. 9—12. Four views of a small shell with trail. Same locality.

Figs. 13—14. Ventral views of 2 submature shells from Kollen (Profile e of SÄVE-SÖDERBERGH), Canning Land.

Figs. 15—20. Ventral views of 6 normal, adult shells from same locality.

Figs. 21—24. Posterior, lateral, ventral, and dorsal views of the holotype. Nathorsts Fjord.

Figs. 25, 26. Ventral and lateral views of a specimen from Permpas, Wollaston Forland (M 1768).

Figs. 27, 28. Posterior and ventral views of another specimen from the same locality.

Fig. 29. Ventral view of a small and narrow shell with coarse costae, from Nathorsts Fjord.

Figs. 30, 31. Lateral and ventral views of an abnormally narrow, slender specimen with fully developed trail. Nathorsts Fjord.

Fig. 32. Interior of a dorsal valve from Nathorsts Fjord.

Fig. 33. Composite drawing based on the previous specimen and another from the same lot.

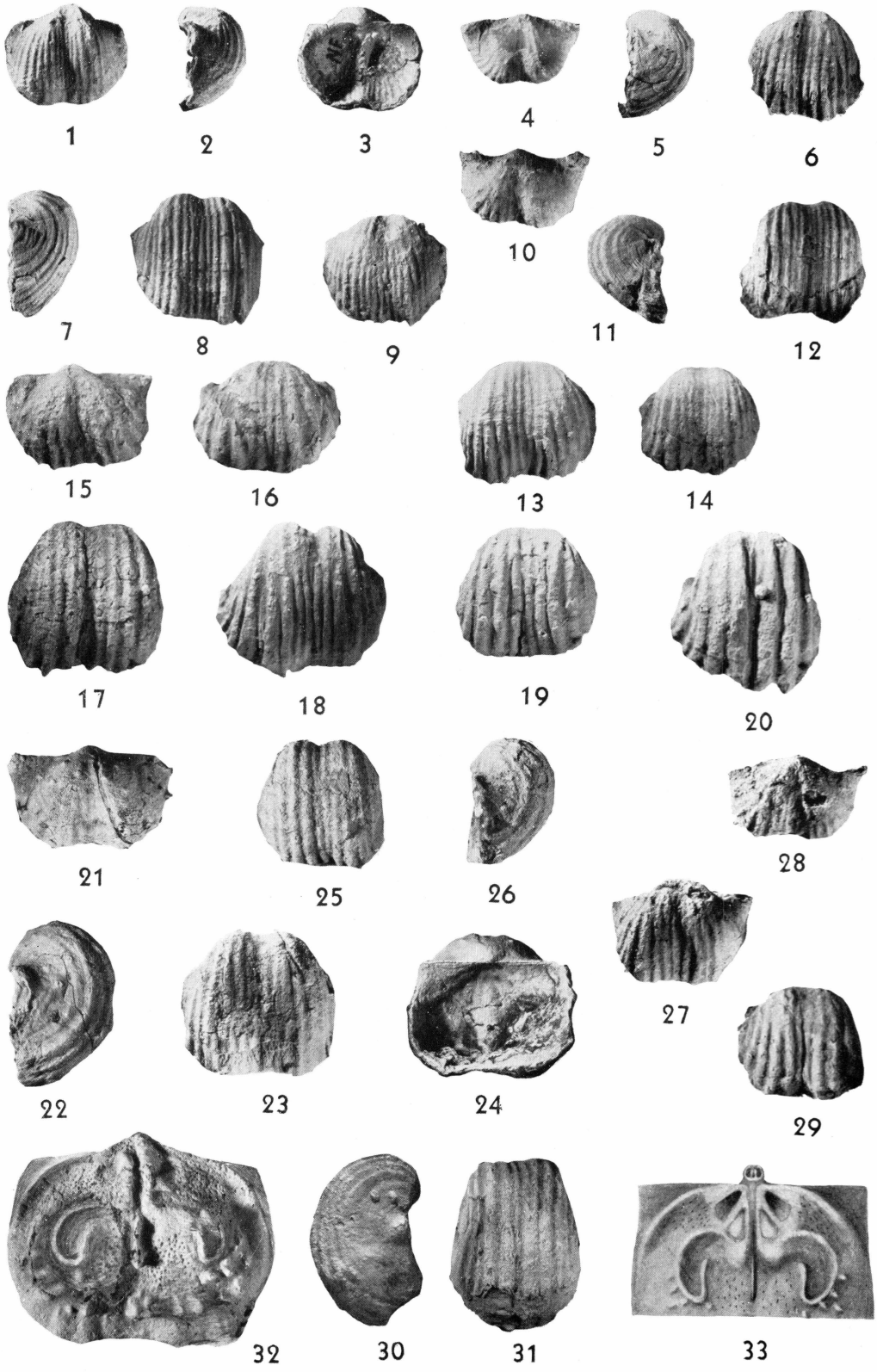
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Plate 7.

Marginifera nathorstfjordensis DUNBAR, n. sp. ..... p. 79

Figs. 1—4. Posterior, lateral, ventral, and dorsal views of the holotype from the talus of Kollen in Nathorsts Fjord, Canning Land.

Fig. 5. Posterior view of a paratype from the same lot.

Fig. 6. Interior of a dorsal valve from the same lot.

Fig. 7. Ventral view of a paratype. Same lot.

Figs. 8—10. Posterior, ventral, and lateral views of a paratype. Same lot.

Strophalosia pulchella DUNBAR, n. sp. ..... p. 81

Figs. 11—13. Dorsal, ventral, and lateral views of an exfoliated specimen broken from limestone matrix at Diabase Haven opposite Hershell Bjerg on the north side of Clavering Ø (LK 1030).

Fig. 14. Internal mold of a ventral valve, lateral view. From Sandstensdal, southern part of Wollaston Forland (M 1962).

Figs. 15, 16. Ventral valve etched from the matrix with HCl (X 1 and X 2) showing spines. From Brachiopoddal, Wollaston Forland (LK 410).

Fig. 17. Interior view of same specimen (X 2) showing the cardinal area, the large hinge teeth, the small adductor scars and the very large diductor scars.

Fig. 18. Ventral view of a young specimen (X 2) from Dolomitdal, Clavering Ø (LK 37) showing the two groups of spines.

Fig. 19. Posterior view of the cardinal margin and the cardinal process of the last specimen.

Figs. 20, 21. Exterior and interior views of an etched dorsal valve from the same lot as figs. 15, 16.

Fig. 22. Interior view of another dorsal valve from the same lot having a shorter hinge line.

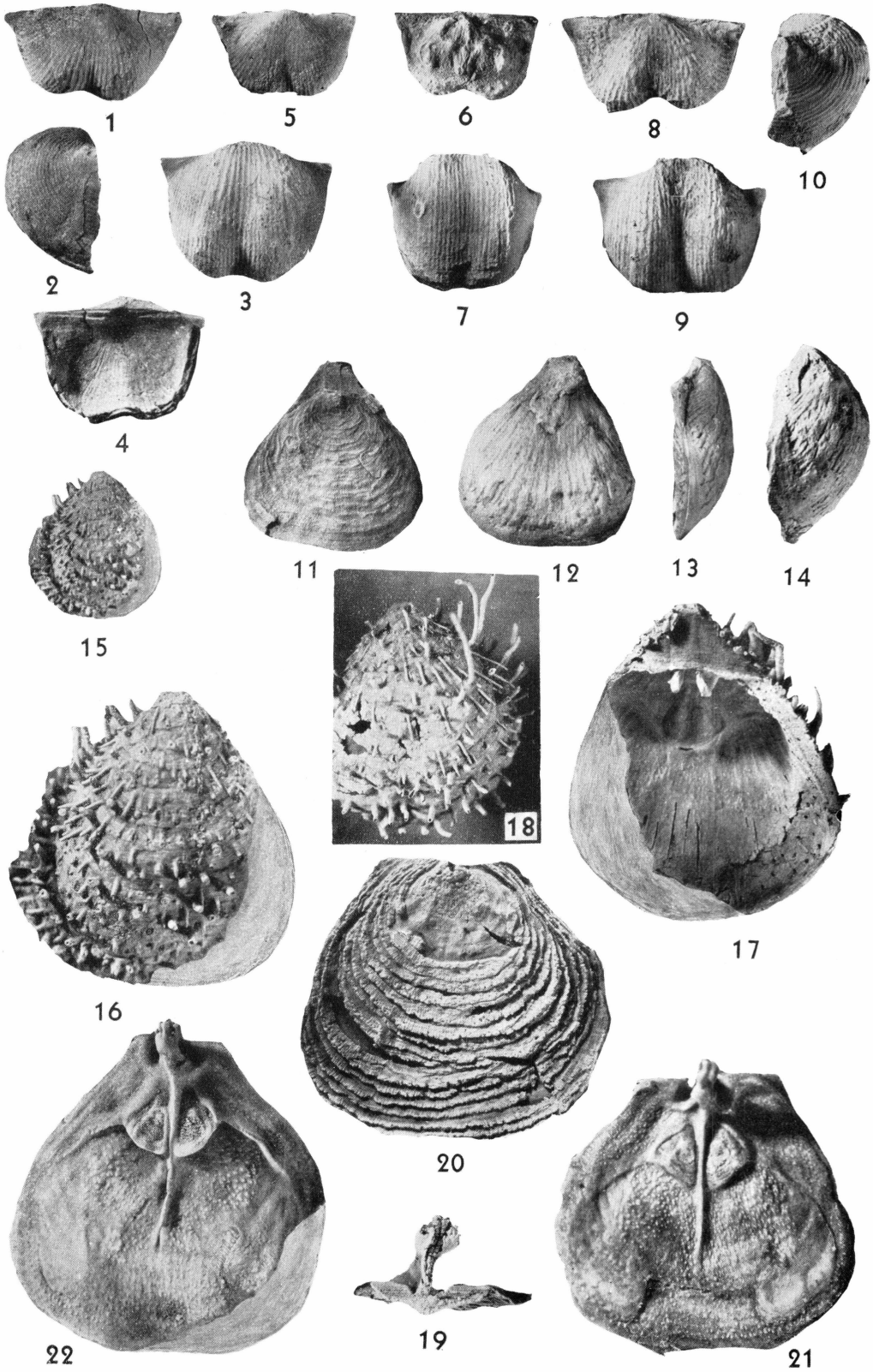
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Plate 8.

Krotovia nielseni DUNBAR, n. sp. ..... p. 84

Fig. 1. Ventral view (X 1 and X 2) of a holotype from the "Productus limestone" on River 2, east of Kap Stosch (N 46).

Fig. 2. Profile view of a paratype from the same horizon between Rivers 13 and 14 east of Kap Stosch (N 53).

Fig. 3. Ventral view of a paratype from River 8 east of Kap Stosch (N 22).

Fig. 4. External mold of a dorsal valve showing evidence of closely spaced spines like those of the ventral valve. Same lot as fig. 3.

Figs. 5, 6. Ventral views (X 1 and X 2) and detail of surface (X 5) of a paratype from the same lot as fig. 1.

Waagenoconcha sp. ..... p. 88

Figs. 7—9. Ventral, dorsal, and lateral views of specimen figured by FREBOLD (1931, pl. 3, figs. 8, 8a) as *Productus humboldti* D'Orbigny. Koch collection from Grænsedalen, Wollaston Forland.

Figs. 10, 11. Ventral and lateral views of another specimen from Grænsedalen collected by MAYNC (M 1790).

Fig. 12. Ventral view of another specimen from the same locality (M 1793).

Figs. 13—16. Surface (X 5) of 4 shells, showing variations in appearance with differing degrees of wear and exfoliation. Fig. 13 is from a slightly exfoliated shell from Permdal (M 1846). Fig. 14 is from the specimen shown as fig. 7. Fig. 15 is from a deeply exfoliated shell showing tubes in the shell that will emerge as spines. This shell is shown as fig. 10. Fig. 16 shows the well-preserved outer surface from which the tangential spines have been broken away. From Grænsedalen (M 1798).

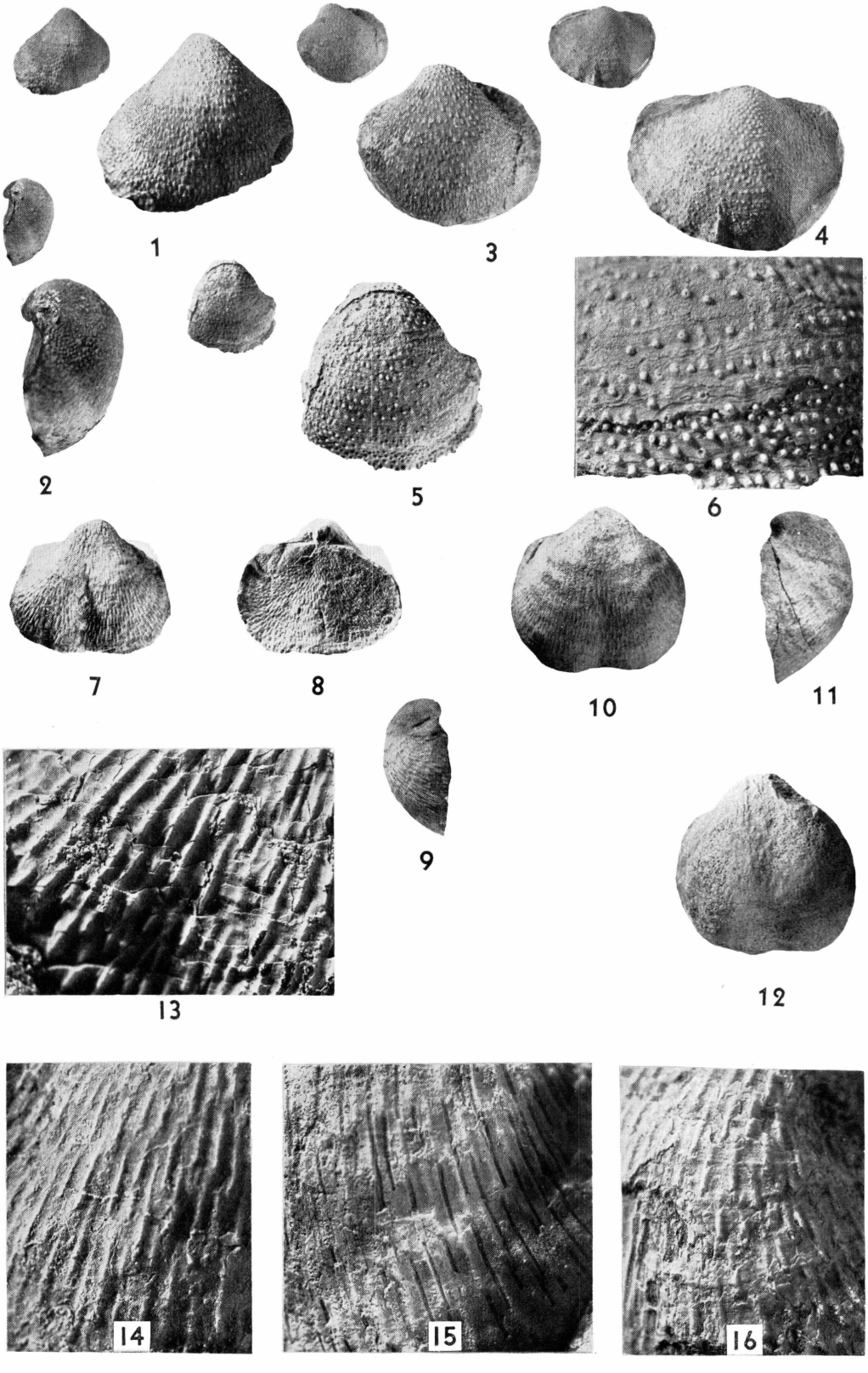
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Plate 9.

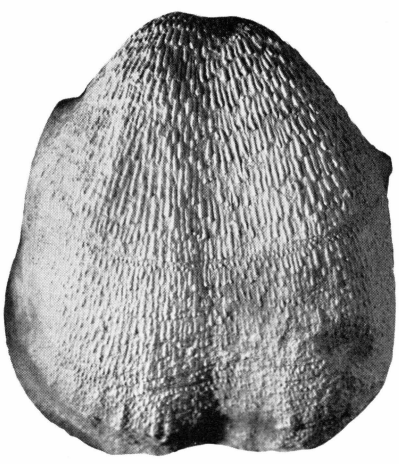
Waagenoconcha payeri (Toula) . . . . . p. 85

Figs. 1, 3, 5. Ventral, posterior, and lateral views of a specimen from the "Productus limestone," River 2, Hold with Hope (N 45a).

Figs. 2, 4. Ventral and posterior views of a broader specimen from the same horizon in Brachiopoddal, Wollaston Forland (LK 429).

Fig. 6. Lateral view of a specimen considerably distorted by compression from the side but showing exceptionally well the decrease in size of the spines and the appearance of irregular radial ridges on the anterior and lateral slopes. From River 9, east of Kap Stosch, Hold with Hope (LK 12).

Figs. 7, 8. Details of surface (X 4) from specimen shown as fig. 1. All but a few of the spines have been broken away.



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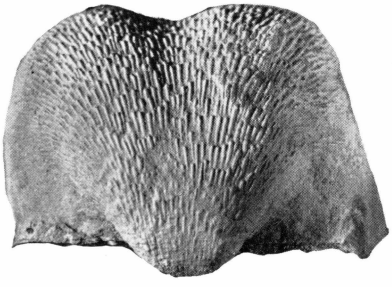

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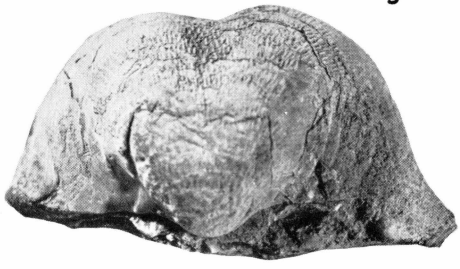

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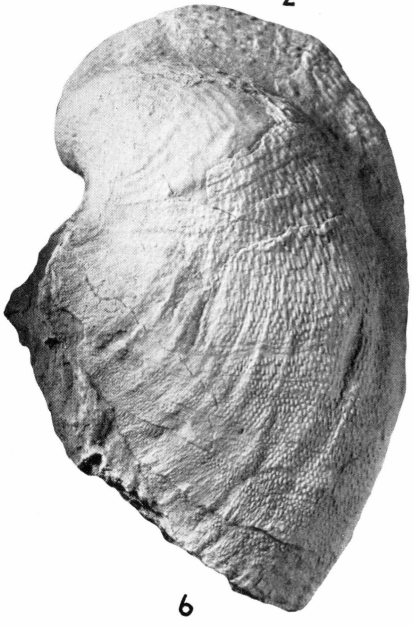

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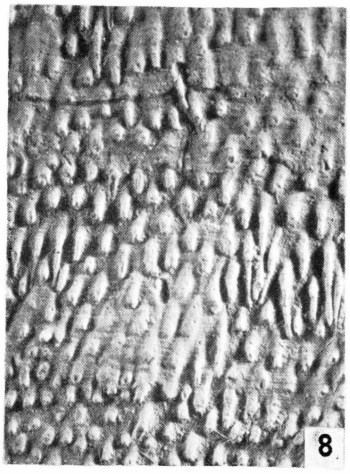

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Plate 10.

Waagenoconcha payeri (TOULA) ..... p. 85

Figs. 1, 2. Ventral and lateral views of immature shell showing irregular radial ribs on anterior lateral slope.

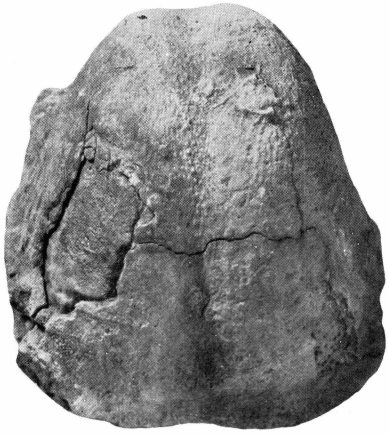
Fig. 3. Posterior view of internal mold of ventral valve showing lightly impressed muscle scars. Specimen a large, broad one from Sandstensdal in Wollaston Forland (M 1945).

Fig. 4. Lateral view of specimen shown as figs. 2 and 4 of plate 9.

Fig. 5. Dorsal view of posterior part of a young specimen showing the neat hinge line. Kap Stosch (LK 28).

Figs. 6, 8. Dorsal and lateral views of a large shell that has been compressed laterally to about half its normal width. This specimen was figured by FREBOLD (1931, pl. 3, fig. 1) as *Productus purdoni.*

Fig. 7. Enlargement (X 4) from the right side of the beak in above specimen, showing character of the spines.



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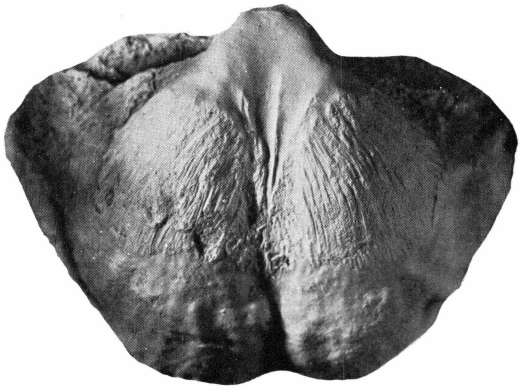

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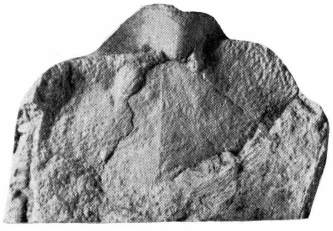

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Plate 11.

Pleurohorridonia scoresbyensis DUNBAR, n. sp. . . . . p. 90

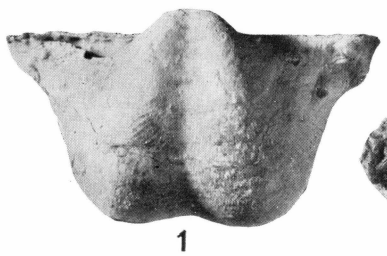
Figs. 1—4. Posterior, ventral, dorsal, and lateral views of a representative specimen from a brachiopod coquina about 150 feet above the base of the Permian section west of Schucherts Flod, Scoresby Land (S 6).

Figs. 5—7. Shell from the same locality showing full development of the trail (S 1).

Fig. 8. Ventral view of internal mold showing muscle impressions. Productuselv, Clavering Ø (M 390).

Fig. 9. Surface (X 5) on the umbonal part of a shell showing the predominance of fine growth lines and the beginning of radial sculpture.

Fig. 10. Surface (X 5) on the lateral part of the trail showing irregular ribs and pustules.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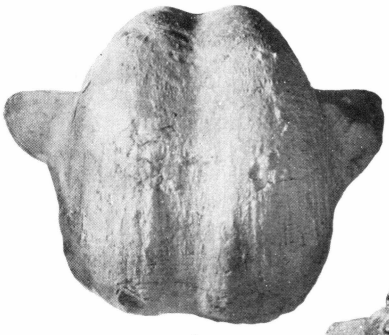
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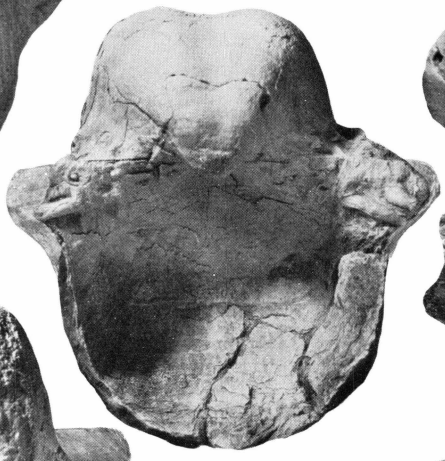
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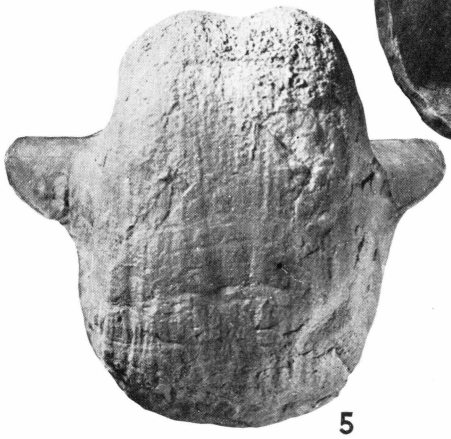
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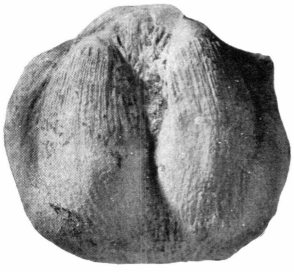
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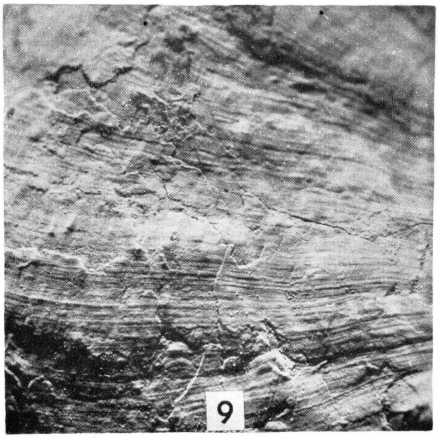
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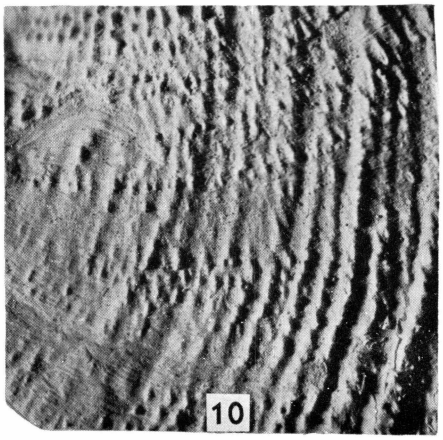
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Plate 12.

Pleurohorridonia scoresbyensis DUNBAR, n. sp. . . . . p. 90

Figs. 1, 2. Specimen with trail broken away, showing well the cardinal spines. This one was figured by FREBOLD (1933, pl. 2, fig. 13) as *Productus horridus* var. *granuliferous* TOULA. From Boulder 7 in the Triassic conglomerate east of Kap Stosch (NOE-NYGAARD coll., LK 468).

Fig. 3. Umbonal view of ventral valve of a young shell showing smooth surface and scattered spines. Figured by FREBOLD (1933, pl. 2, figs. 10a—c) as *Productus horridus* var. *initialis* EISEL. From Boulder 37 in the Triassic conglomerate east of Kap Stosch.

Figs. 4, 5. Dorsal and lateral views of a normal shell, west of Schucherts Flod, Scoresby Land (S 1).

Figs. 6, 7. Young specimen that has only started to form a trail. Same locality as above.

Fig. 8. Dorsal view of auricle of a specimen in the rock to show the large supra-auricular spine.

Fig. 9. Interior view of dorsal valve from a limestone boulder east of Kap Stosch (N 22).

Figs. 10, 11. Interior view of dorsal valve from above and from the side. From west of Schucherts Flod, Scoresby Land (S 6).

Figs. 12, 13. Lateral and ventral views of exfoliated shell with a long trail, showing irregular ribs on the trail. This specimen was figured by FREBOLD (1933, pl. 3, figs. 9a—d) as *Productus horridus* var. *hoppeianus* EISEL. From Boulder 78 in the Triassic conglomerate east of Kap Stosch (ROSENKRANTZ coll. LK 509).

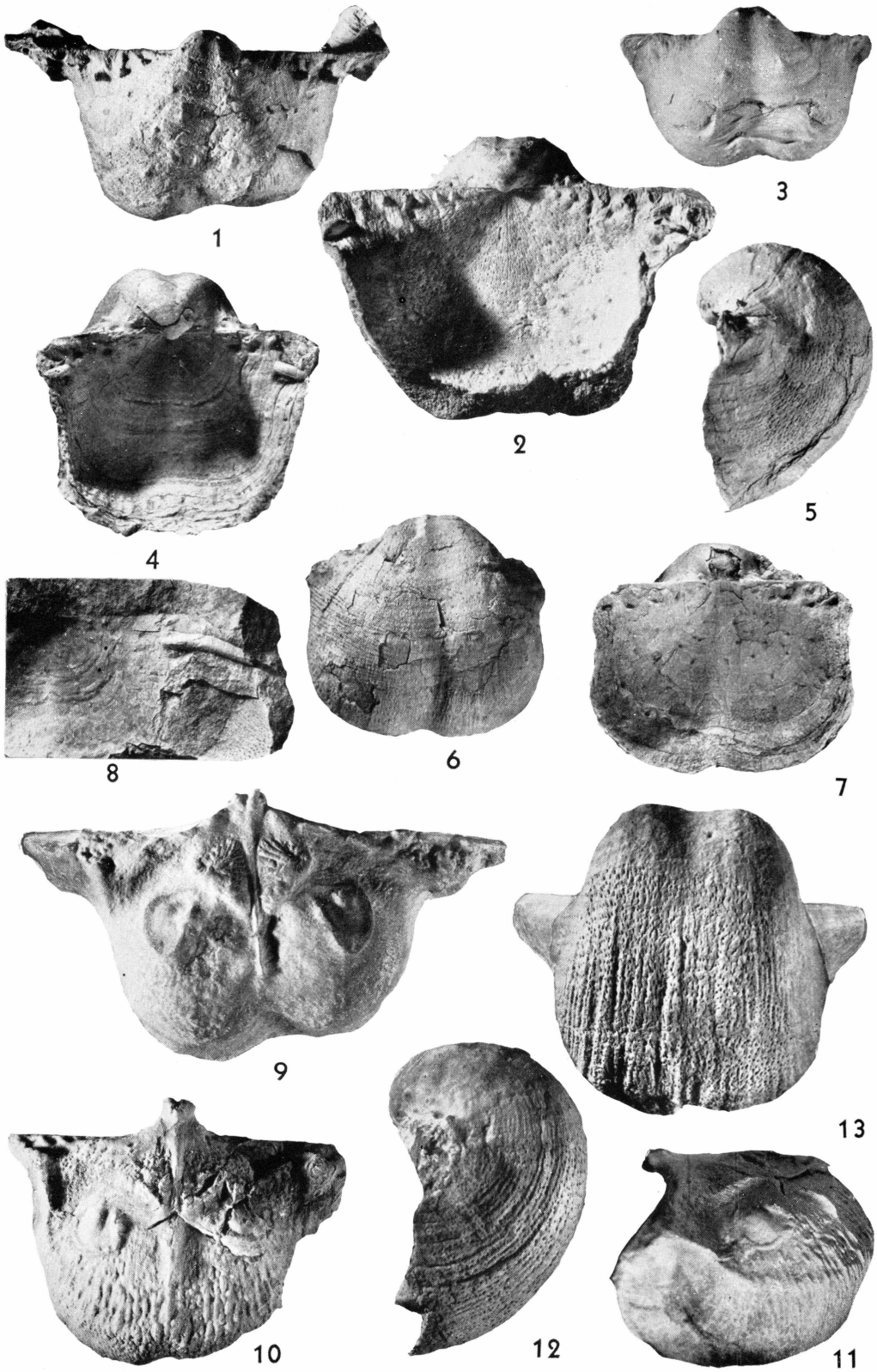
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Plate 13.

Sowerbina maynci DUNBAR, n. sp. . . . . p. 97

Fig. 1. Oblique ventral view of holotype showing part of the large auricular spines. Avantpostbjerg, central Clavering Ø (M 588).

Fig. 2. Ventral view of shell with spines broken away. East of Kap Stosch, northern Hold with Hope (N 45a).

Figs. 3—5. Lateral, posterior, and ventral views of a submature shell. Kap Stosch area (LK 2).

Fig. 6. Surface sculpture (X4) near the front and in the sulcus of a shell from River 9, Vestryggen, east of Kap Stosch (LK 50).

Fig. 7. Surface sculpture (X4) on visceral hump near the middle of a shell like fig. 5 from between Rivers 13 and 14 east of Kap Stosch (N 49).

Figs. 8, 9. Dorsal and ventral views of a juvenile specimen closely similar in size and shape to the type of *Productus horridus* var. *granuliferus* TOULA (1875, pl. 6, figs. 3a—c).

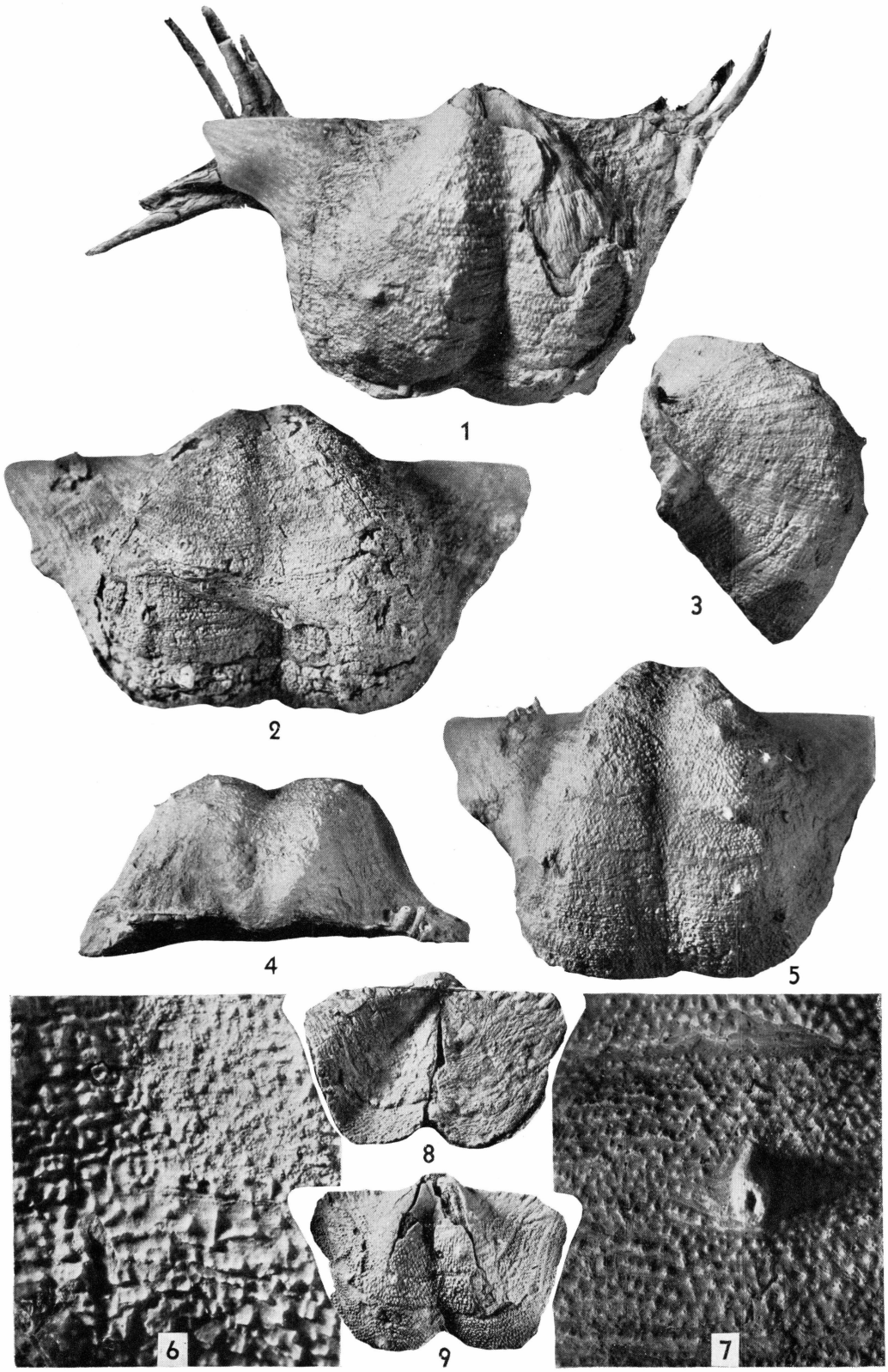
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Plate 14.

Sowerbina rudis DUNBAR, n. sp. . . . . p. 101

Figs. 1—4. Holotype from Kontactravine, Dolomitdal, northeastern Clavering Ø (M 2438).

Figs. 5—7. Posterior, ventral, and dorsal views of an incomplete specimen showing one nearly complete auricle with its heavy spine bases. River 2, east of Kap Stosch (N 45a).

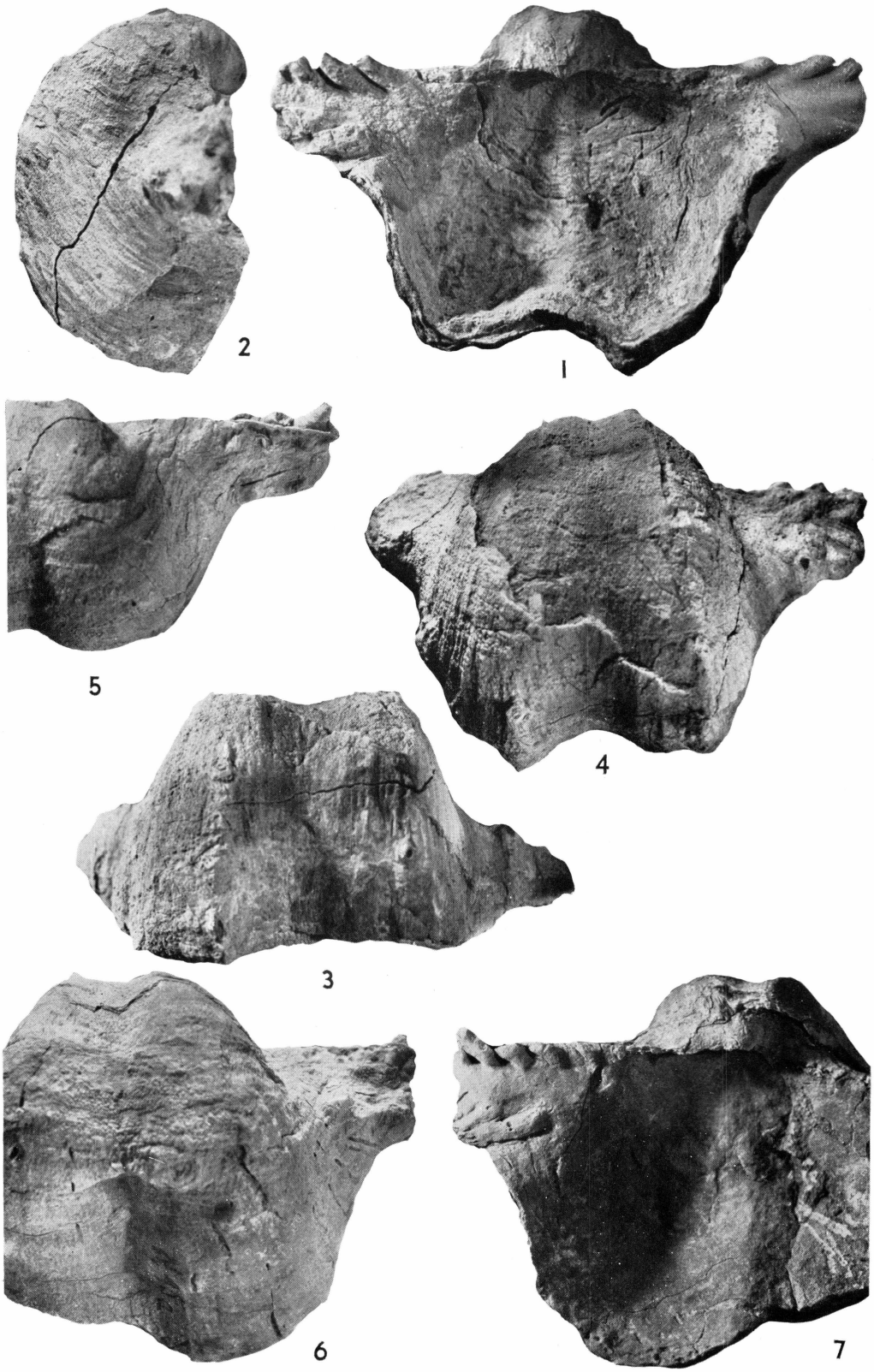
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Plate 15.

Sowerbina rudis DUNBAR, n. sp. . . . . p. 101

Fig. 1. Dorsal interior of a silicified specimen in which, after etching free of the matrix vith HCl, the valves could be freed. Brachiopod limestone, Carbon River, Wollaston Forland (LK 604).

Fig. 2. Ventral view of the cardinal process (X 2.5) of the last specimen.

Fig. 3. Dorsal interior of a shell from the "Productus limestone" on River 5, east of Kap Stosch, Hold with Hope (N 65).

Fig. 4. Anteroventral view of a somewhat crushed and immature specimen showing well the single row of large spines on each visceral hump. Brachiopod limestone at Kap Stosch (LK 2).

Figs. 5, 6. Ventral and lateral views of a mature shell with long trail. Both auricles are broken away but have been restored in outline. Brachiopod limestone on River 9, east of Kap Stosch (LK 50).

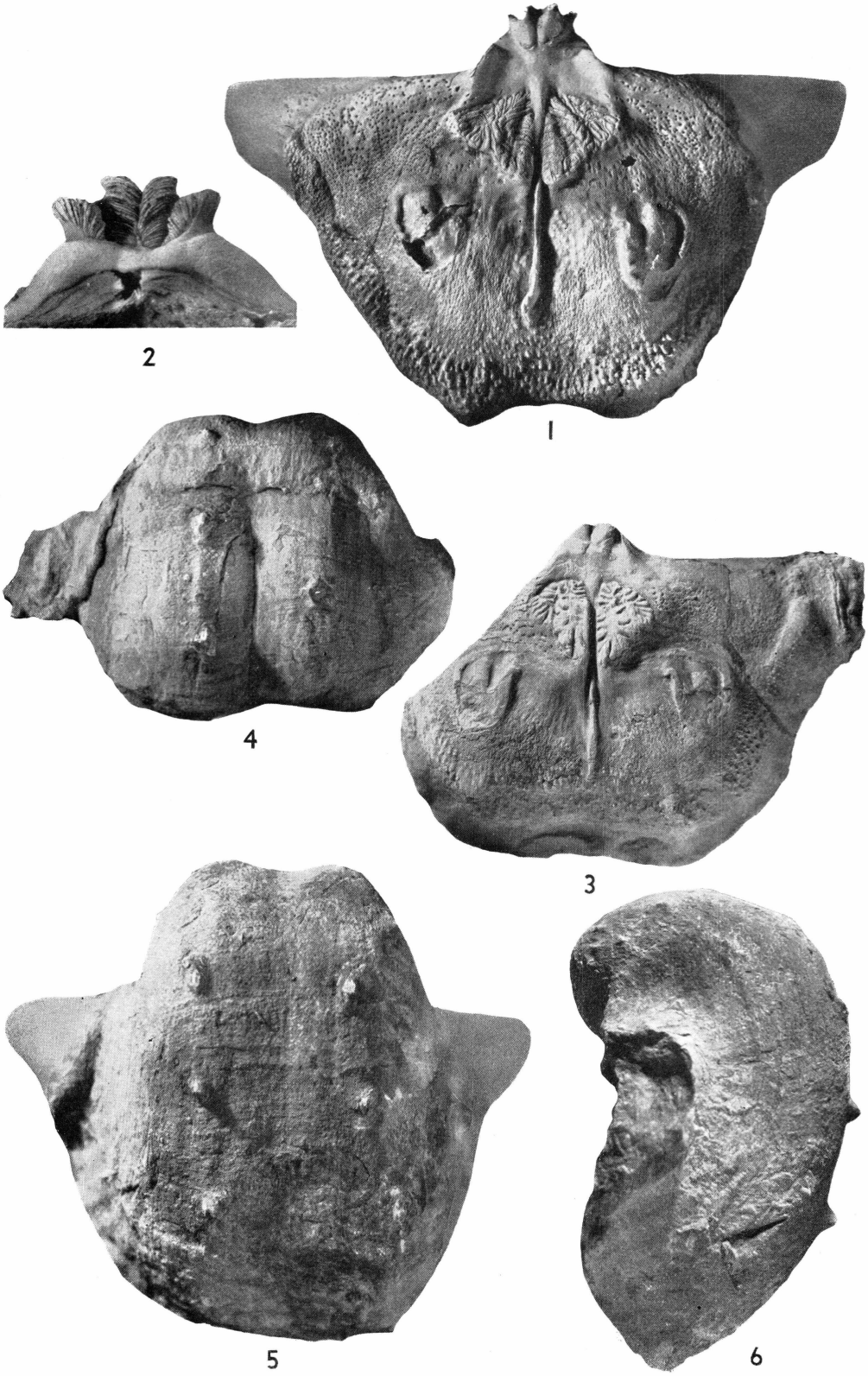
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Plate 16.

Muirwoodia greenlandica DUNBAR, n. sp. . . . . p. 103

(All figures natural size except fig. 17)

Figs. 1—4. Lateral, posterior, ventral, and dorsal views of holotype at Avantpostbjerg (M 589), central Clavering Ø.

Figs. 5, 6. Dorsal and ventral views of a paratype from the same locality.

Fig. 7. Ventral view of a paratype from Djævlekløften (M 2209), northeastern Clavering Ø.

Fig. 8. Lateral view of a paratype from Kap Stosch (LK 1), Clavering Ø.

Figs. 12, 13. Lateral and ventral views of another paratype from the same collection.

Figs. 14, 15. Lateral and ventral views of a third paratype from the same locality. This is an old individual with an uncommonly long trail.

Figs. 9, 16. Ventral and posterior views of an internal mold of a paratype from MAYNC's locality 589.

Fig. 10. Artificial cast from specimen shown in fig. 9, showing appearance of the muscle field in true relief.

Fig. 11. Interior view of dorsal valve of a paratype from near Kap Stosch (LK 28).

Fig. 17. Enlarged drawing from the same specimen, slightly restored, showing internal features.

Fig. 18. Copy of TOULA's original illustration of *Productus weyprechti.*

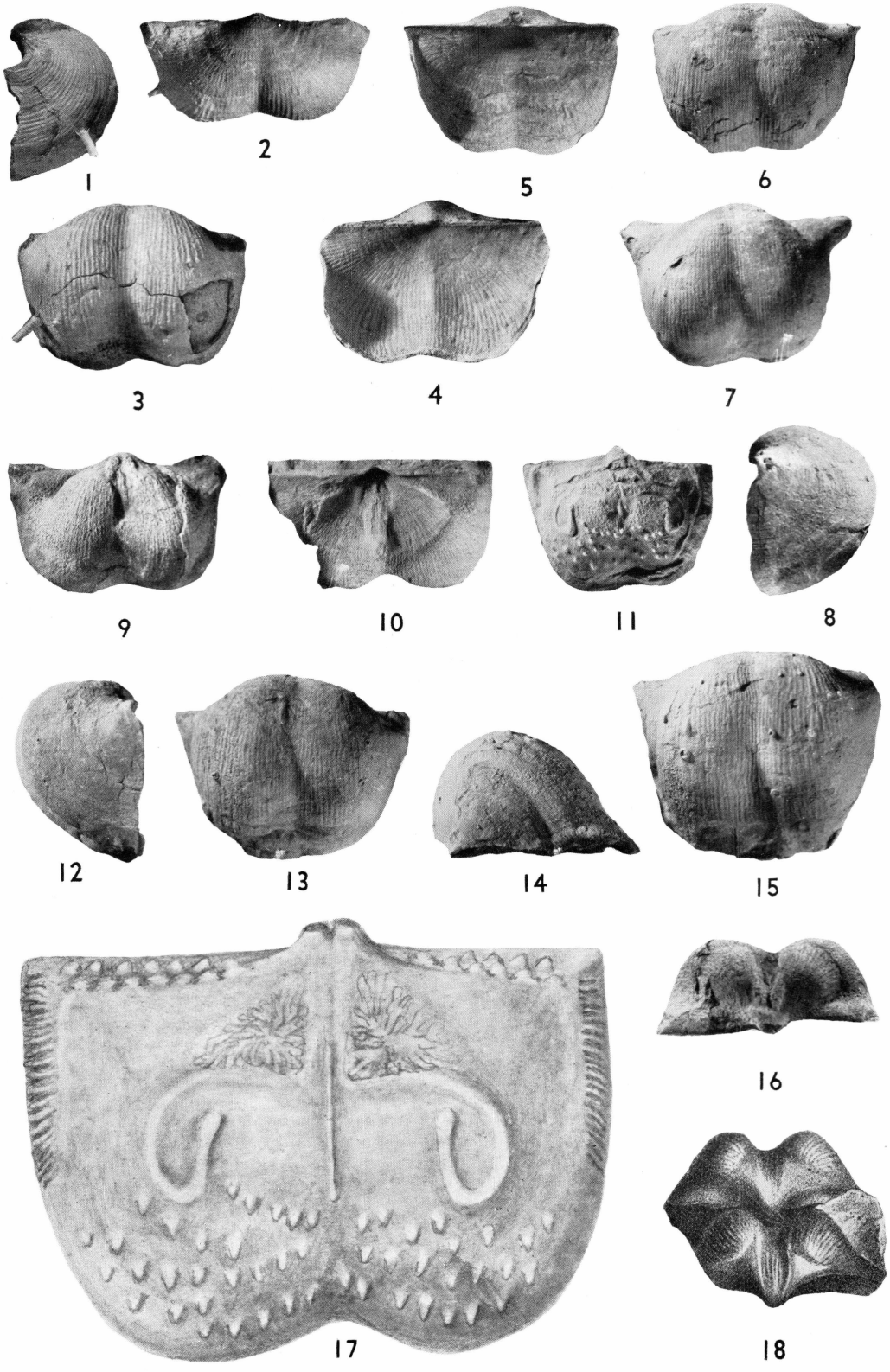
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Plate 17.

Kochiproductus plexicostatus DUNBAR, n. sp. . . . . p. 109

Figs. 1—4. Ventral, dorsal, posterior, and lateral views of a submature, silicified shell freed from a limestone matrix by HCl. It is undistorted and remarkably well preserved, but had not yet developed a long trail. From the Brachiopod limestone in Dolomitdal, northeastern Clavering Ø (LK 37). Holotype.

Figs. 5, 6. Ventral and lateral views of a large and mature shell with normal trail but with auricles partly broken away. River 2, southwest of Kap Stosch, Hold with Hope (N 45a).

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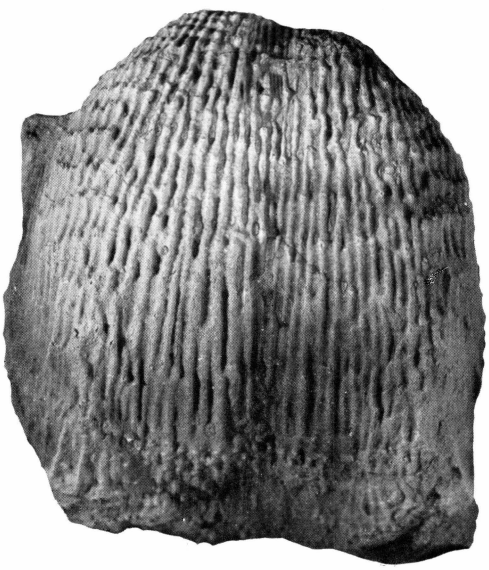

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Plate 18.

Kochiproductus plexicostatus DUNBAR, n. sp. . . . . p. 109

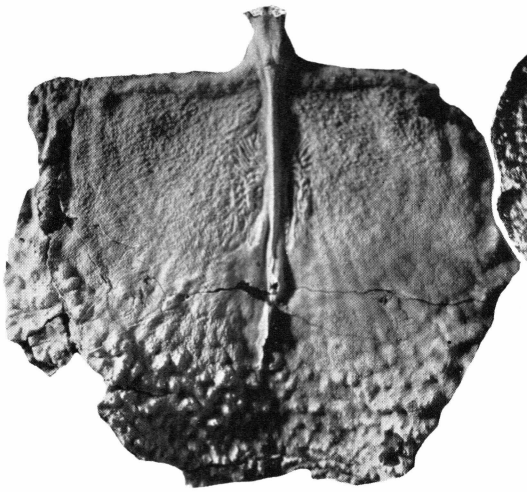
Figs. 1, 5. Interior and exterior of a silicified dorsal valve etched from the matrix and freed from its ventral counterpart by HCl. (Fig. 5, ×2). Brachiopod limestone in Dolomitdal, northeastern Clavering Ø (LK 37).

Fig. 2. Exterior of a dorsal valve. Figured by FREBOLD (1933, pl. 1, fig. 1). Kap Stosch.

Fig. 3. Anterior part of a ventral valve showing the characteristic anastomosis of the costae, and the abundant spines. Brachiopod limestone at Kap Stosch (LK 1).

Fig. 4. Ventral view of large specimen with perhaps uncommonly large auricles of which the right is almost completely preserved and the left broken away. Brachiopod limestone between Rivers 14 and 16, east of Kap Stosch, Hold with Hope (LK 11).

Fig. 6. Interior of silicified dorsal valve. Figured by FREBOLD (1931, pl. 1, fig. 3). Kap Stosch.



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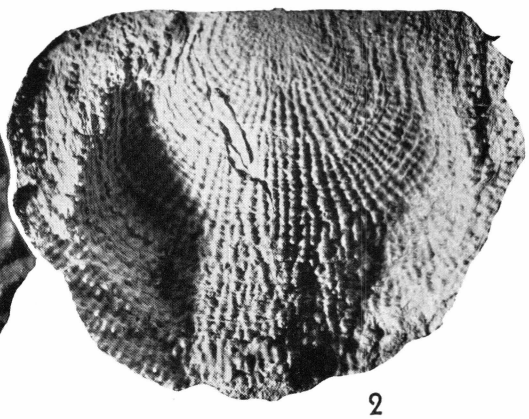

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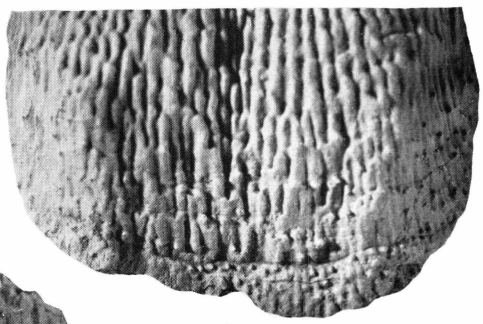

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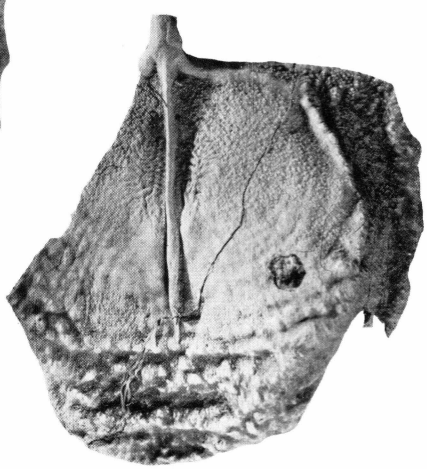

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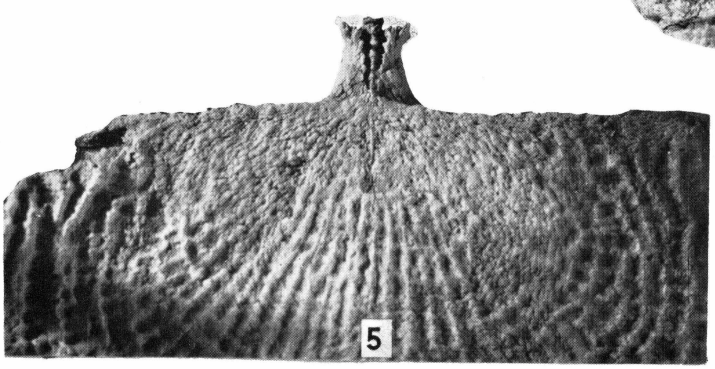

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Plate 19.

Rhynchopora abnormalis DUNBAR, n. sp. ..... p. 114

Figs. 1—3. Dorsal, ventral, and anterior views of the holotype (X 1 and X 2) from the "Productus limestone" west of Schucherts Flod, southern Scoresby Land (STAUBER coll.).

Figs. 4—6. Dorsal, ventral, and anterior views (X 1 and X 2) of a paratype from the same lot.

Rhynchopora kochi DUNBAR, n. sp. ..... p. 114

Fig. 7. Dorsal views (X 1 and X 2) of a specimen from the vicinity of Kap Stosch LK 28).

Figs. 8, 9, 11. Dorsal, lateral, and anterior views (X 1 and X 2) of another specimen from the same lot.

Fig. 10. Ventral views (X 1 and X 2) of a third specimen from the same lot.

Figs. 12—14. Dorsal, posterior, and anterior views (X 1 and X 2) of the holotype, from the "Productus limestone" west of Schucherts Flod, southern Scoresby Land (S 1).

Fig. 15. View inside the beak of an etched specimen, showing the well-developed dental lamellae in the ventral valve (below) and the hinge plate and a supporting median septum in the dorsal umbo. From MAYNC's collection at Avantpostbjerg on Clavering Ø (M 515).

Figs. 16 and 24. Dorsal and anterior views (X 1 and X 2) of a specimen from the "Productus limestone" west of Schucherts Flod, southern Scoresby Land (S 310).

Figs. 17, 18. Dorsal and ventral views of a young shell from White Block no. 208 in the Triassic conglomerate near Kap Stosch. ROSENKRANTZ collection (LK 582).

Figs. 19, 20. Ventral and anterior views (X 1 and X 2) of a young shell from west of Schucherts Flod, Scoresby Land (S 310).

Figs. 21, 22. Ventral and anterior views (X 1 and X 2) of another shell from the same lot.

Fig. 23. Dorsal views (X 1 and X 2) of a specimen.

Rhynochopora sp. A. ..... p. 116

Figs. 25, 26. Dorsal and anterior views of a specimen from Fiskeelv on the southern margin of Clavering Ø (M 73).

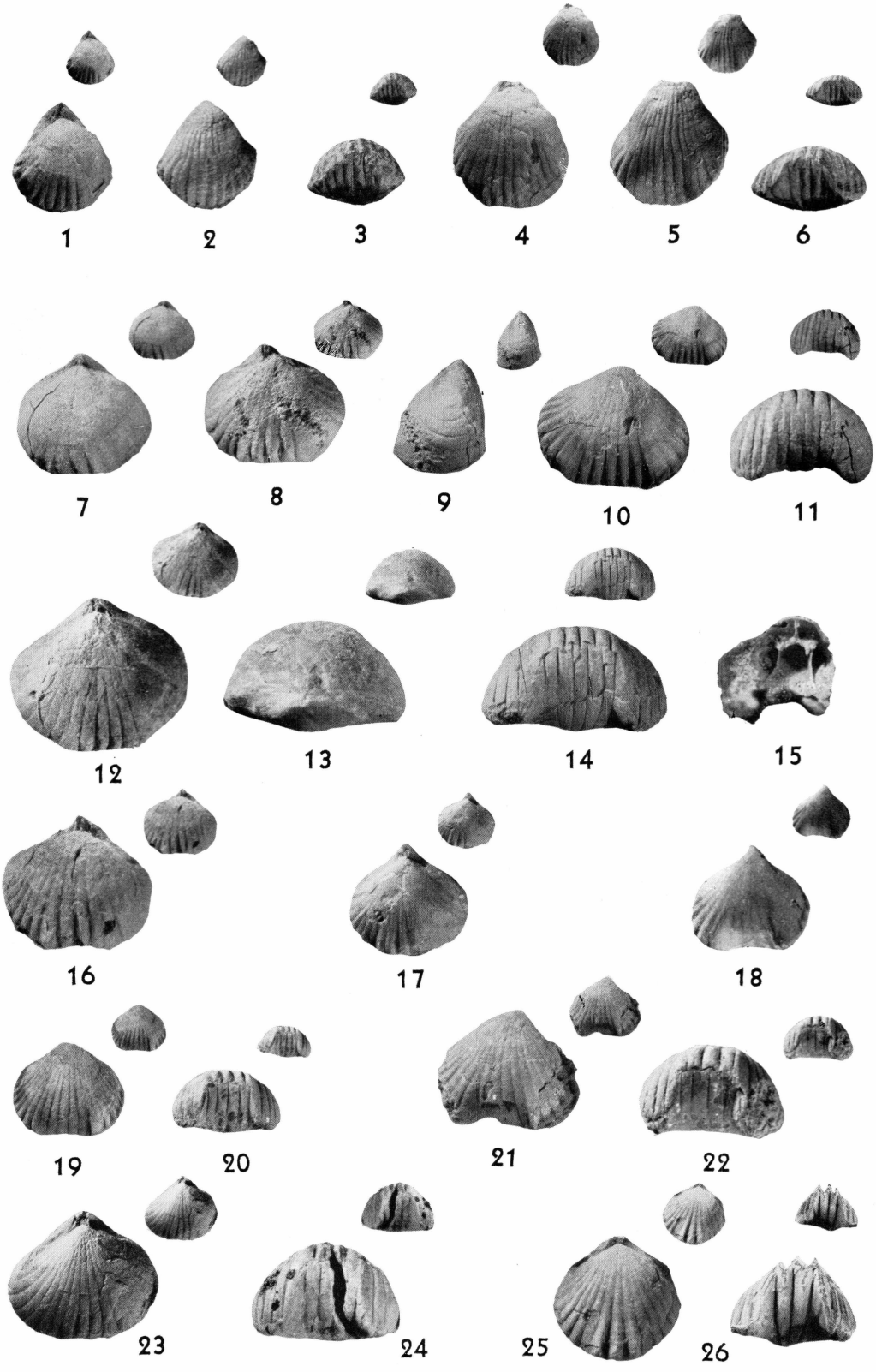
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Plate 20.

Dielasma elongatum SCHLOTHEIM . . . . . p. 117

Figs. 1, 2. A typical specimen, dorsal and anterior views (X 1 and X 2) from White Block no. 100 in the Triassic conglomerate east of Kap Stosch.

Figs. 3, 4. Dorsal and anterior views (X 1 and X 2) of another specimen from the same lot.

Figs. 5, 6. Ventral and dorsal views (X 1 and X 2) of another specimen from the same lot.

Figs. 7, 8. Ventral and dorsal views (X 1 and X 2) of another specimen from the same lot.

Figs. 9—11. Dorsal, ventral, and lateral views (X 1 and X 2) of another specimen from the same lot.

Figs. 12, 13. Interior (X 2) of the ventral and dorsal valves of a single shell from Djævlekløften on Clavering Ø (LK 20).

Figs. 14—17. Dorsal, ventral, lateral, and anterior views (X 1 and X 2) of a shell from White Block no. 100.

Dielasma stoschensis DUNBAR, n. sp. . . . . p. 118

Figs. 18—21. Dorsal, ventral, posterior, and lateral views (X 1 and X 2) of an incomplete specimen from White Block no. 15 in the Triassic conglomerate east of Kap Stosch.

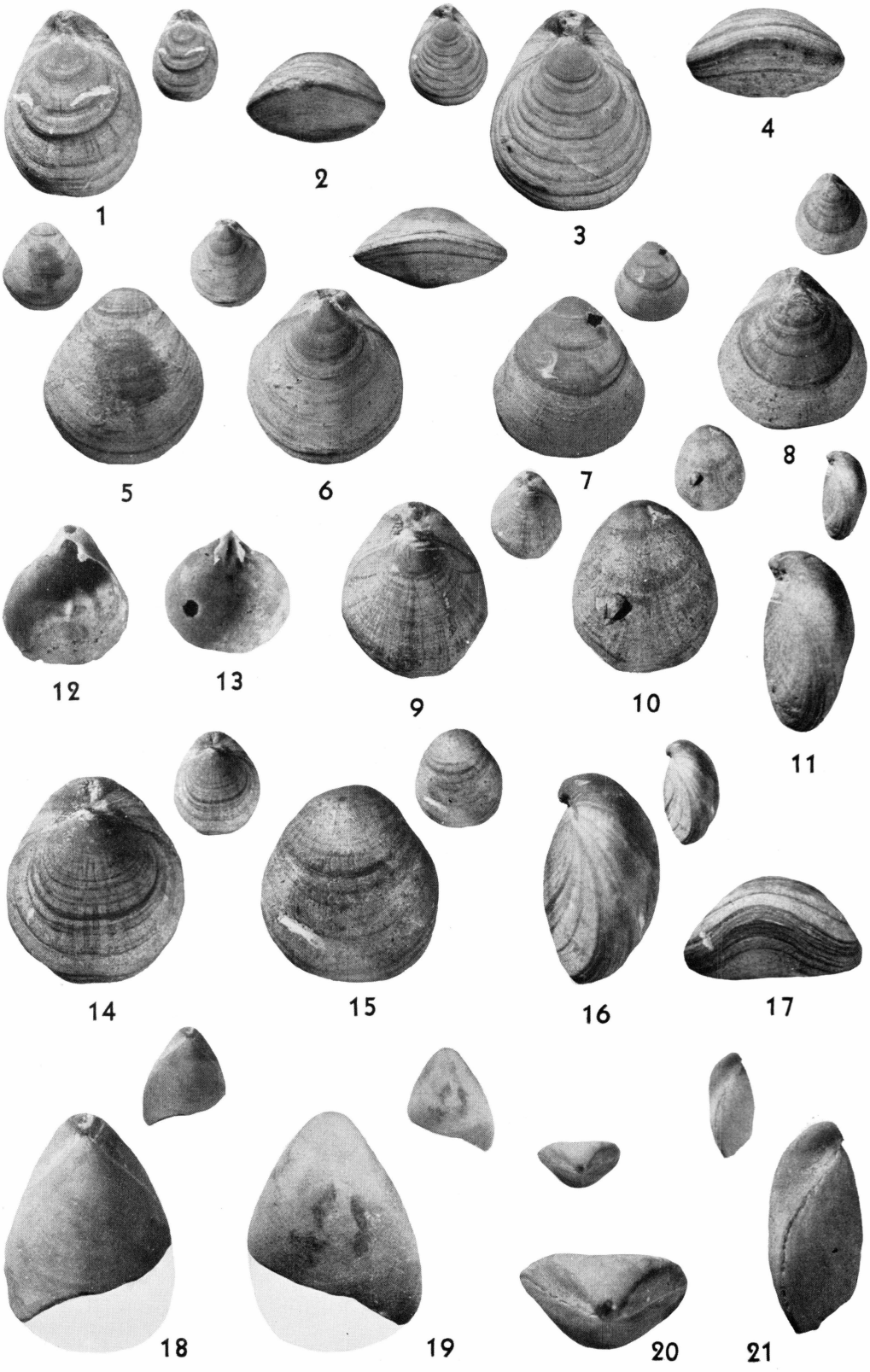
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Plate 21.

Camerophoria kochi DUNBAR, n. sp. ..... p. 121

Figs. 1—4. Specimen from white Permian limestone boulder in Jurassic conglomerate in Dolomitdal, Clavering Ø (M 2419).

Figs. 5—8. Dorsal, lateral, ventral, and anterior views of another specimen from the same lot (M 2422).

Camerophoria sp. B ..... p. 122

Fig. 9. Dorsal view of juvenile specimen from White Block no. 100 in conglomerate II or III on Fish Plateau near Kap Stosch (N 100).

Figs. 10, 11. Dorsal and ventral views of a specimen from Permian beds near Kap Stosch (LK 28).

Figs. 12, 13. Dorsal and ventral views of a specimen from the "Productus limestone" at Rivers 13—14, east of Kap Stosch (N 51).

Camerophoria cf. *C. multiplicata* KING ..... p. 123

Fig. 14. Dorsal view of a broken shell in which the ventral beak has been foreshortened somewhat by pressure after burial. "Productus" ledge west of Schucherts Flod, southern Scoresby Land (STAUBER coll.).

Fig. 15. Incomplete dorsal valve from the same lot.

Fig. 16. Ventral view of a specimen embedded in matrix. From the "Spirifer limestone" on Sieburgerdal, northeastern Scoresby Land (Bh).

Cleiothyridina nielseni DUNBAR, n. sp. ..... p. 124

Fig. 17. Interior of a ventral valve showing the stout hinge teeth, the heavy callous in the posterior of the shell, and the elongate diductor scars which reach almost to the front of the valve (LK 6, 7).

Fig. 18. Ventral view (X1 and X2) of a paratype. Kap Stosch area (LK 6, 7).

Figs. 19, 20. Dorsal and ventral views (X1 and X2) of a paratype from the vicinity of Kap Stosch (LK 28).

Figs. 21, 24. Dorsal and ventral views (X1 and X2) of another paratype from the same lot (LK 28).

Figs. 22, 23. Dorsal and ventral views of another paratype from the same lot (LK 28).

Fig. 25. Dorsal view (X1 and X2) of the holotype. From the Kap Stosch area (LK 6, 7).

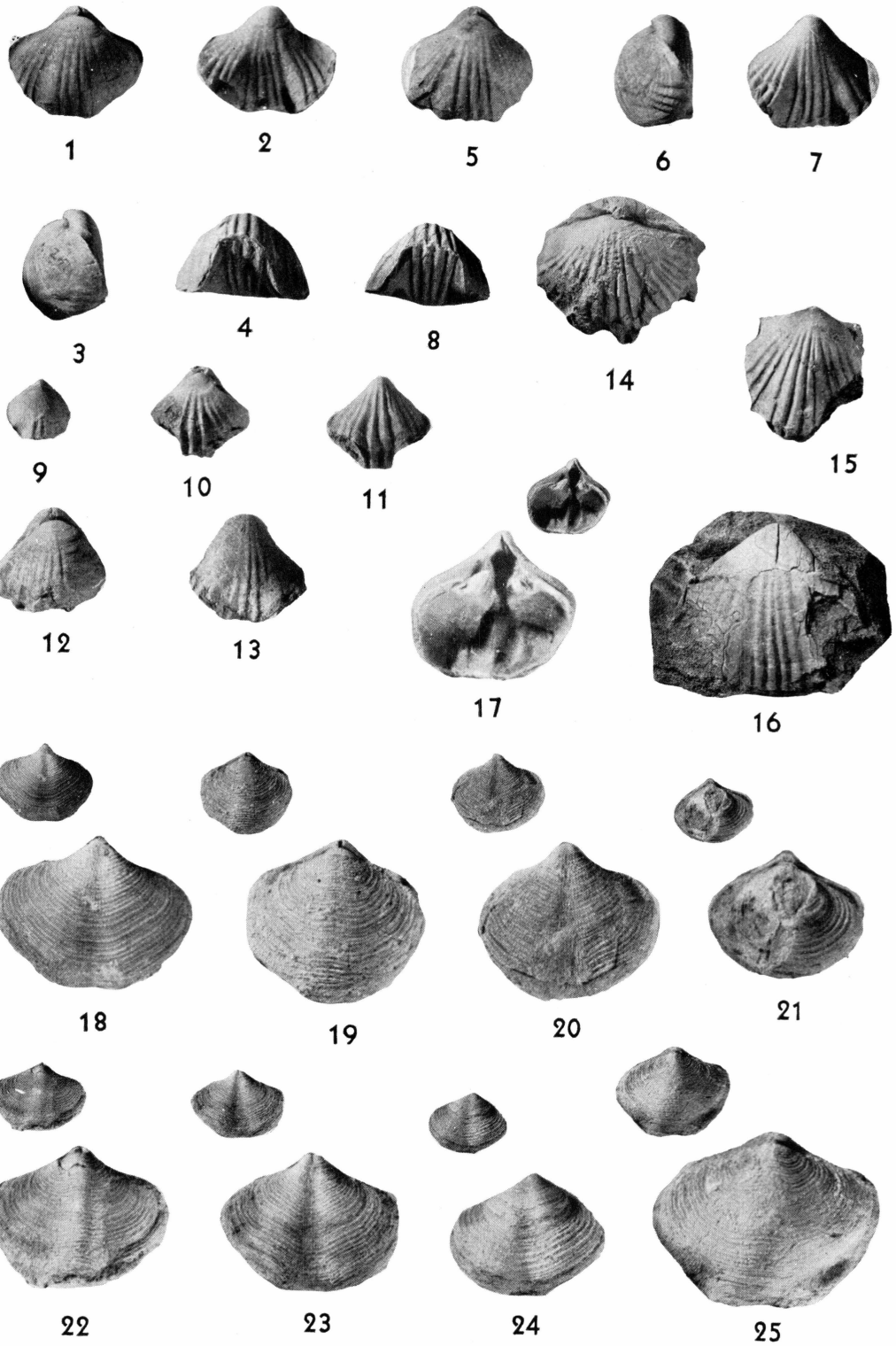
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Plate 22.

Cleiothyridina maynci DUNBAR, n. sp. ..... p. 125

Figs. 1—4. Four views of the holotype from near Kap Stosch (LK 28).

Figs. 5—8. Four views of another specimen from the same lot.

Cleiothyridina pectinifera (D'ORBIGNY) ..... p. 126

Figs. 9, 10. Dorsal and lateral views of a specimen of normal shape and size from Avantpostbjerg, Clavering Ø (M 508).

Figs. 11, 12. Dorsal and ventral views of a specimen with dorsal valve somewhat crushed from near Kap Stosch.

Fig. 13. Dorsal view of a large specimen from Avantpostbjerg, Clavering Ø (M 536).

Figs. 14, 15. Dorsal and lateral views of a young specimen from the "Productus limestone" at Djævlekløften, Clavering Ø. NOE-NYGAARD collection (LK 20).

Fig. 16. Ventral view of an unusually large specimen from near Kap Stosch.

Fig. 17. Interior of incomplete ventral valve, showing muscle scars, from same locality.

Fig. 18. Interior of young dorsal valve showing cardinalia. "Brachiopod limestone" on Carbon River, Wollaston Forland. TEICHERT collection (LK 604).

Pterospirifer alatus (SCHLOTHEIM) ..... p. 129

Fig. 19. Dorsal view of specimen with both extremities broken away. Growth lines on the right side indicate that the cardinal extremities were very acute and extended. Slope of Kollen in Nathorsts Fjord (LK coll.).

Fig. 20. Ventral view of very large, incomplete specimen with acute cardinal extremity on right side preserved in hard matrix. Same locality.

Fig. 21. Dorsal view of incomplete specimen. Same locality.

Fig. 22. Ventral view of crushed specimen showing faint ridge along center of the sulcus. Same locality.

Fig. 23. Enlarged detail (X 5) of the surface sculpture.

Fig. 24. Ventral view of specimen from the Lower Zechstein at Gera, Germany. Yale Peabody Museum catalogue No. 8312.

Fig. 25. Dorsal view of another specimen from the same lot at Gera, Germany, showing the wide and sublinear cardinal area. Yale Peabody Museum catalogue No. 8312.

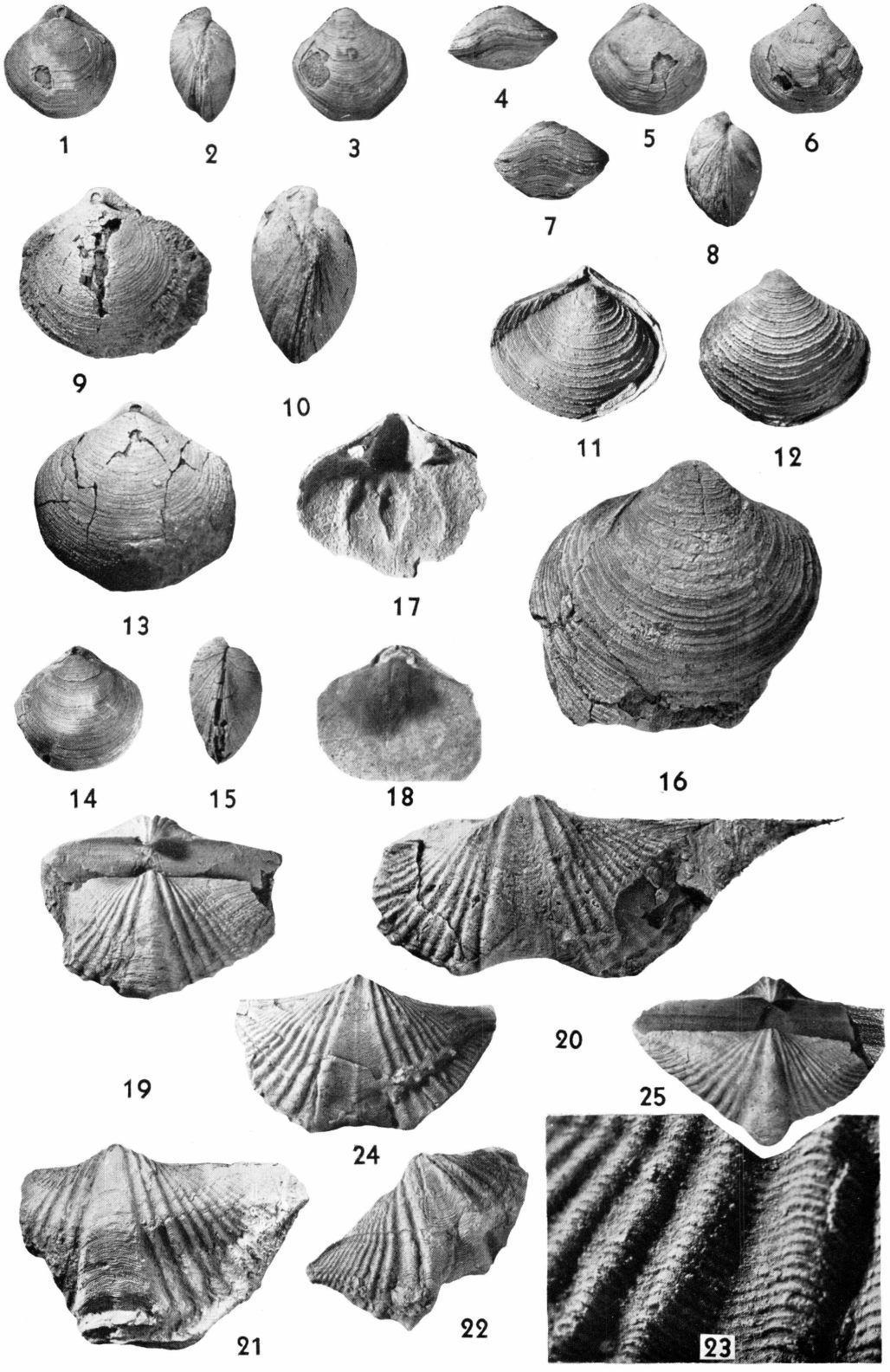
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Plate 23.

Spirifer striato-paradoxus Toula ..... p. 131

Figs. 1—4. Four views of an exceptionally well-preserved specimen with cardinal extremities less extended than the norm for this species. "Productus limestone" on Avantpostbjerg, Clavering Ø (M 560).

Figs. 5—7. Three views of a partly exfoliated specimen (M 2363).

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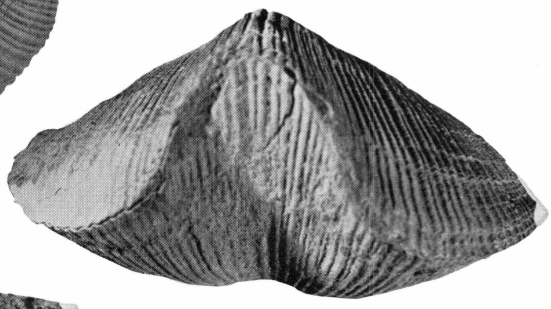

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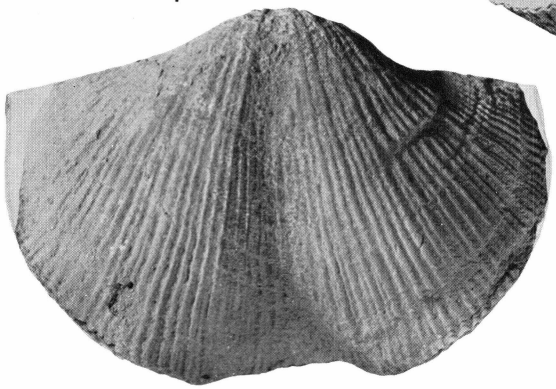

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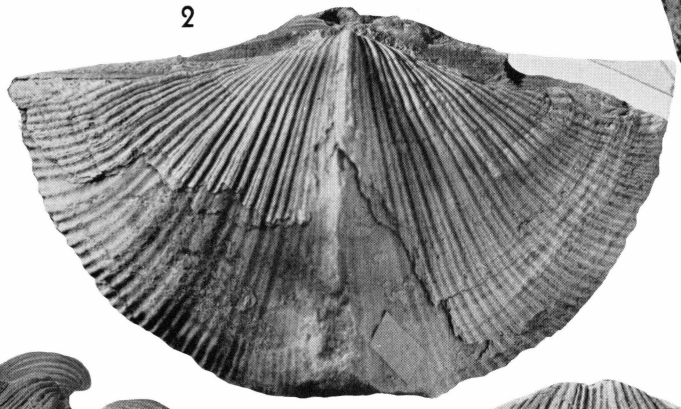

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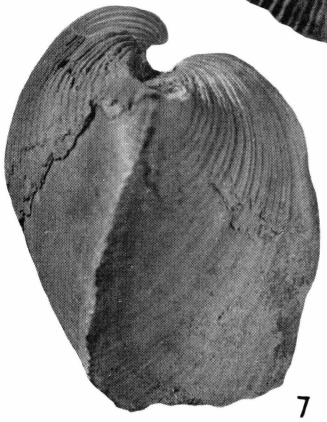

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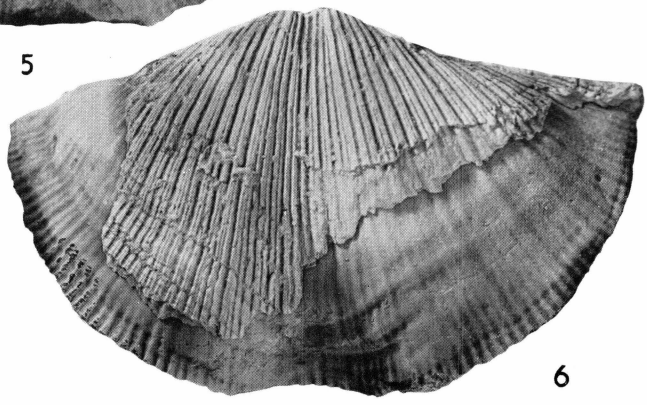

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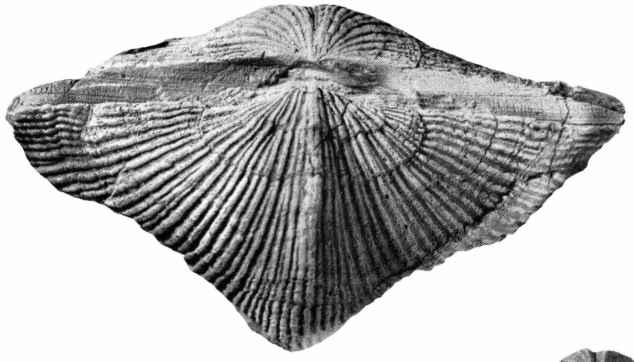
Plate 24.

Spirifer striato-paradoxus TOULA ..... p. 131

Figs. 1, 2. Two views of an immature and somewhat crushed specimen showing well the posterior and cardinal appearance and the ornamentation. This specimen was figured by FREBOLD (1931, pl. 5, fig. 1) as *Spirifer ravana*. "Productus limestone" near Kap Stosch (LK coll.).

Fig. 3. Large specimen of normal shape from MAYNC's locality 2364.

Figs. 4, 5. Exterior and interior views of a silicified ventral valve freed from the matrix by HCl. The cardinal extremities are broken away. "Brachiopod limestone" at Djævlekløften, Clavering Ø. NOE-NYGAARD and SÖDERBERGH collection of 1931 (LK 20).



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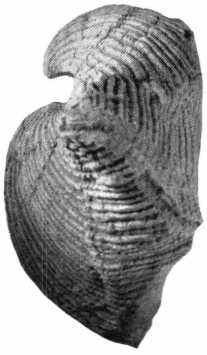

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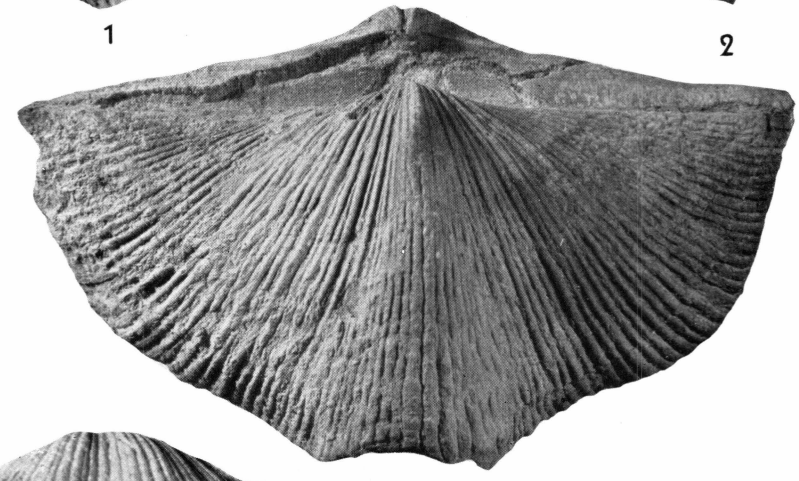

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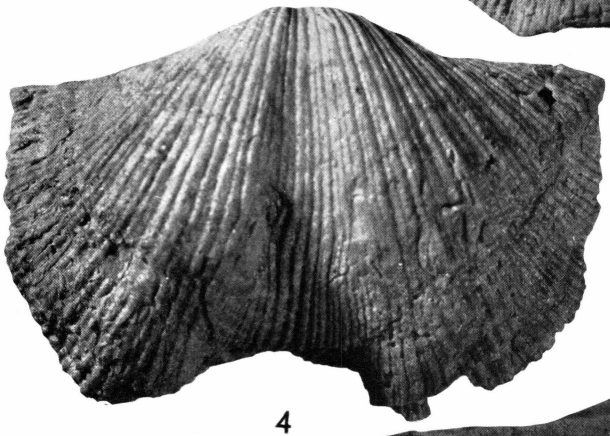

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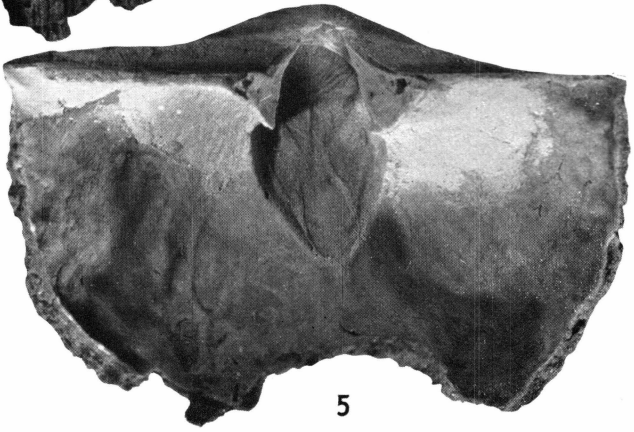

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Plate 25.

Spiriferella keilhavii (VON BUCH) ..... p. 139

Fig. 1. Dorsal view of a specimen with uncommonly broad simple ribs, from Avantpostbjerg, Clavering Ø (M 579).

Figs. 2, 3. Ventral views of 2 specimens from the "Productus limestone" on Productus River, Clavering Ø (M 320, 328).

Figs. 4, 5. Dorsal and ventral views of a specimen from the "Productus limestone" at Kap Stosch (LK 28).

Figs. 6, 7. Posterior and ventral views of another specimen from Kap Stosch (LK 2).

Fig. 8. Ventral view of a specimen from Rivers 13—14, east of Kap Stosch (N 56).

Fig. 9. Another specimen from the same locality (N 58).

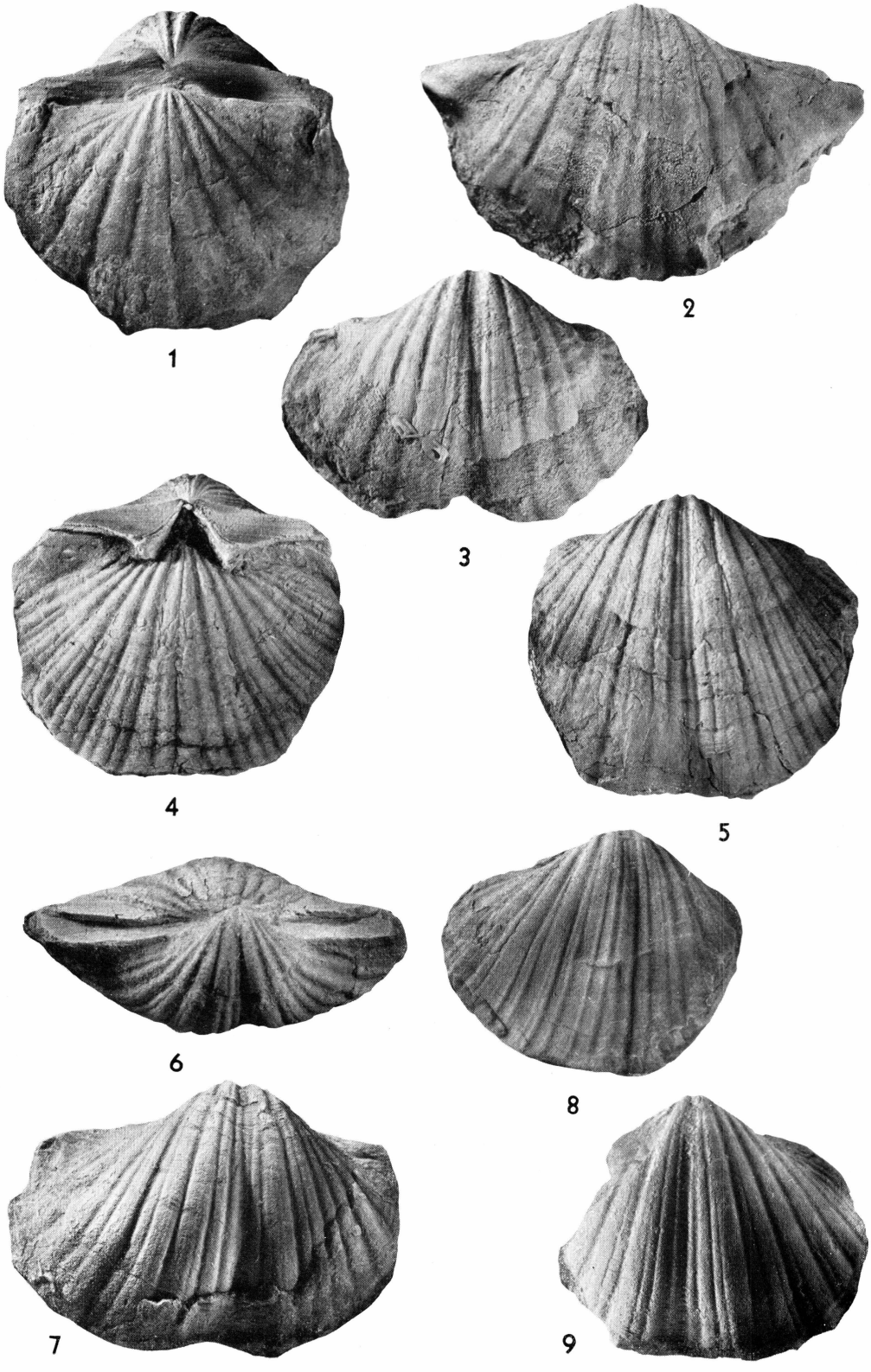
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Plate 26.

Spiriferella keilhavii VON BUCH ..... p. 139

Figs. 1, 2. Dorsal and lateral views of a specimen from Kap Stosch (LK 28).

Fig. 3. Dorsal cardinalia of a specimen from Kap Stosch (LK 29).

Fig. 4. Fragment of ventral interior showing muscle scars. Same locality (LK 6).

Fig. 5. Incomplete ventral valve of maximum size. Kap Stosch (LK 11).

Fig. 6. Incomplete ventral valve with strongly fasciculate ribs. Kap Stosch (LK 2).

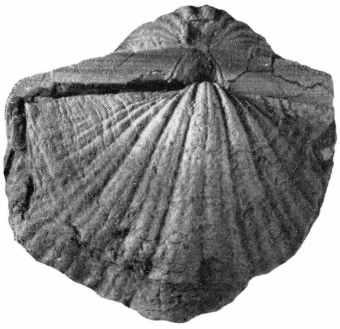
Fig. 7. Incomplete ventral valve from west of River 8, east of Kap Stosch (N 33).

Fig. 8. Incomplete ventral valve from Ravnefjeld, Wegeners Halvö (S 315).

Fig. 9. Surface sculpture (X 5) on a specimen from the "Productus limestone" between Rivers 14 and 16, east of Kap Stosch. NIELSEN collection (LK 11).

Fig. 10. Surface sculpture (X 5) on the specimen shown as fig. 5.

Fig. 11. Surface sculpture (X 5) on a specimen from the slope of the mountains in Nathorsts Fjord.



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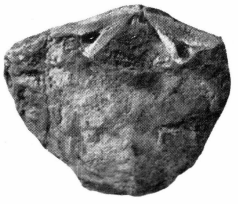

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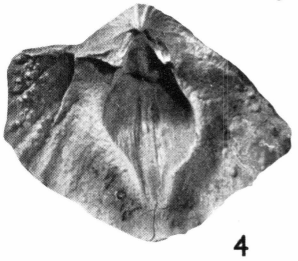

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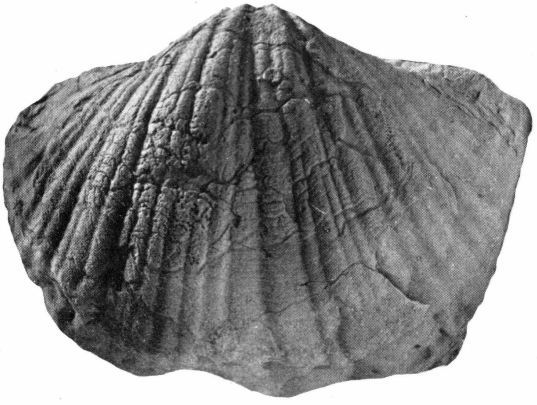

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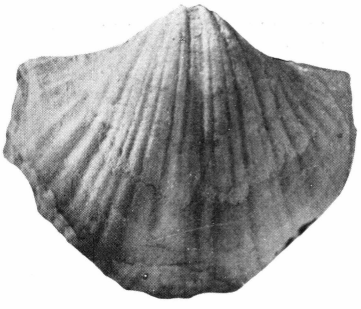

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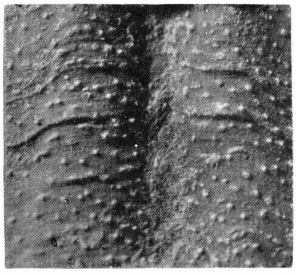

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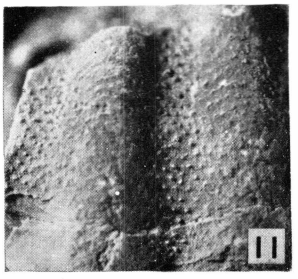

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Plate 27.

Spiriferella keilhavii (VON BUCH) 139

Fig. 1. Fragment of a ventral valve with simple ribs and nonplicated sulcus from "Productus limestone" near Kap Stosch (LK 28).

Fig. 2. Similar fragment from the same lot with 2 slender costae in the sulcus but with simple ribs.

Fig. 3. Another from the same bed (LK 7) with 2 slender costae on the floor of the sulcus and a second pair just beginning to appear as branches of the adjacent ribs.

Fig. 4. Another from lot LK 28 showing the lateral costae in the sulcus more clearly developed.

Fig. 5. Another shell (N 45a).

Fig. 6. Specimen from lot LK 28 showing the 4 plications in the sulcus fully developed, the 2 adjacent primary ribs showing several subdivisions and the outer ones simple.

Fig. 7. Similar specimen from the same bed near Kap Stosch (LK 10).

Figs. 8, 9. Original illustrations by von BUCH.

Figs. 10, 11. Original illustrations of *Spirifer parryanus* Toula *(non* Hall) from Spitzbergen.

Fig. 12. Incomplete ventral interior to show characteristic muscle scars (LK 4).

Figs. 13, 14. Originals of specimen figured by WIMAN as *S. keilhavii*, from Mt. Misery, Bear Island.

Spirifella (?) sp. undt. 146

Figs. 15, 16. Original figures of a specimen identified as *S. keilhavii* by TSCHERNYSCHEW and STEPANOV from Spitzbergen.

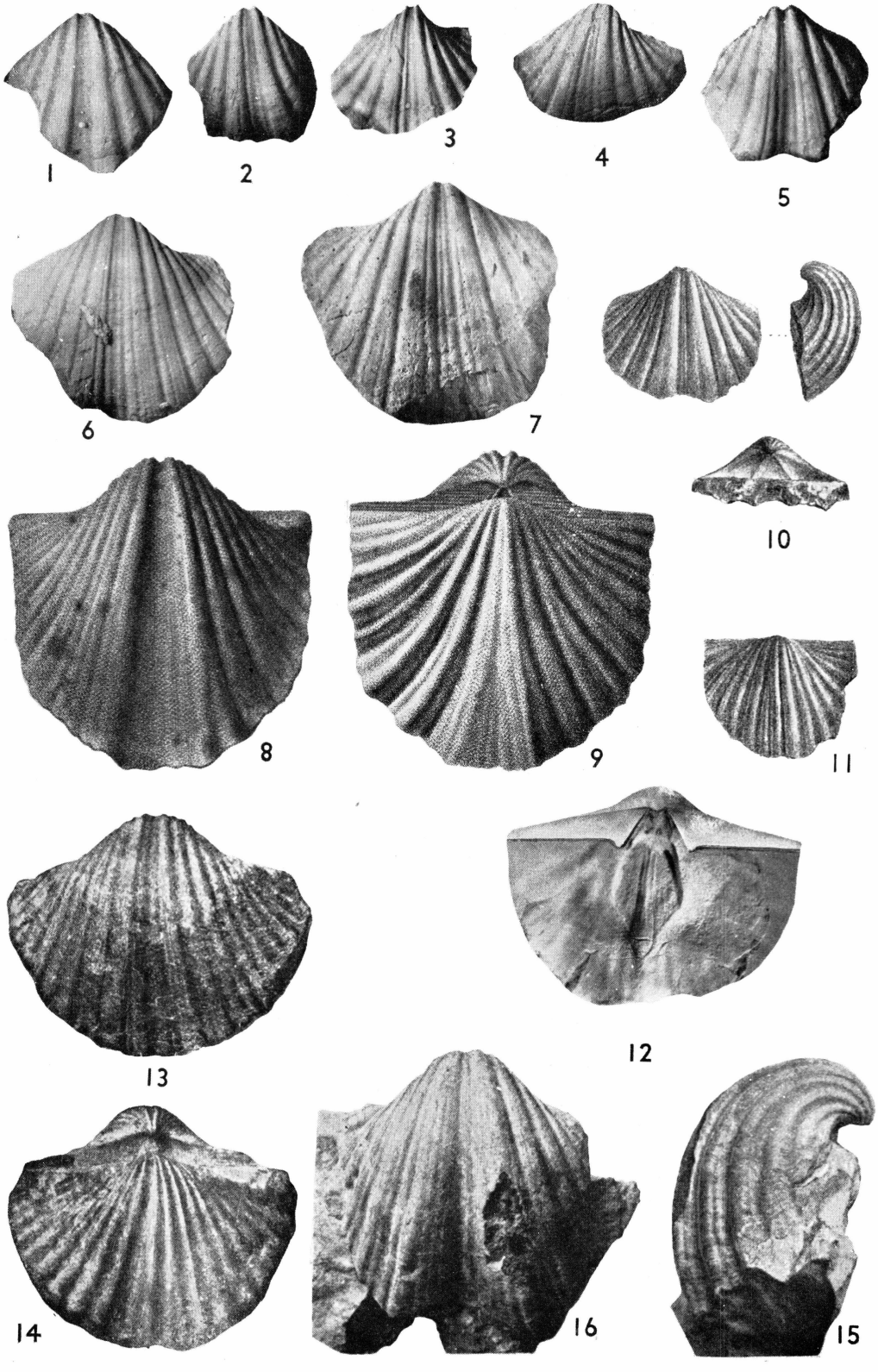
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Plate 28.

Spirifer striato-paradoxus TOULA ..... p. 131

Fig. 1. Copy of Toula's original illustration (TOULA, 1875, pl. 8, fig. 1).

Figs. 2, 3. Anterior and posterior views of the specimen shown in figs. 5—7 of plate 23.

Figs. 4, 5. Dorsal and ventral views of a large specimen from Cirkusdal, Clavering Ø (M 2364).

Fig. 6. Detail of surface ornamentation (X 5) showing the grid of microscopic lirae.

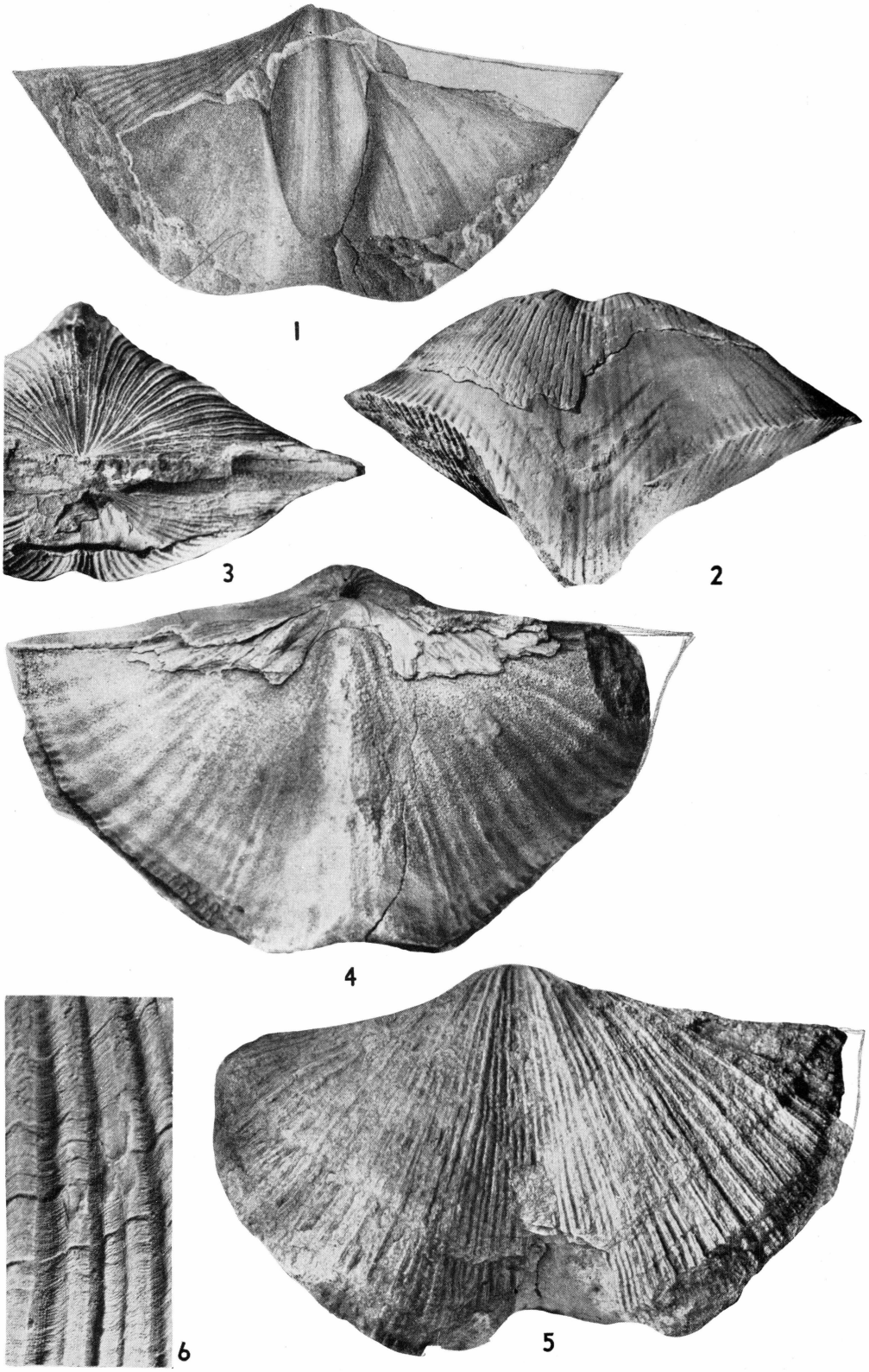
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Plate 29.

Spiriferina multiplicata KING ..... p. 147

Figs. 1—3. Dorsal, lateral, and ventral views of a specimen (X 1 and X 2) from a "white block" of Permian limestone in the Triassic conglomerate east of Kap Stosch (Na).

Figs. 4—6. Dorsal, lateral, and ventral views of a large specimen (X 1 and X 2) from another "white block" (LK 5).

Figs. 7, 8. Ventral and dorsal views (X 1 and X 2) of a specimen from another "white block" near Kap Stosch (No).

Fig. 9. Enlarged view (X 5) of part of the specimen shown in fig. 1.

Spiriferina sp. A ..... p. 148

Figs. 10—12. Three specimens (X 2) from White Block no. 3 of NIELSEN's collection east of Kap Stosch (N 3).

Punctospirifer cristata (SCHLOTHEIM) ..... p. 149

Figs. 13—15. Dorsal, lateral, and ventral views (X 1 and X 2) of a specimen etched from the matrix of the "Productus ledge" west of Schucherts Flod in southern Scoresby Land (STAUBER coll.).

Fig. 16. Dorsal valve (X 1 and X 2) of a specimen from White Block no. 15 of KOCH's collection east of Kap Stosch (LK 10).

Figs. 17—19. Interior of an incomplete dorsal valve and of the ventral valve of the same shell, etched from the matrix. Carbon River, Wollaston Forland. Collected by TEICHERT (LK 604).

Fig. 20. Enlargement (X 5) to show surface details. From "Productus limestone" at a locality near Kap Stosch (LK 28).

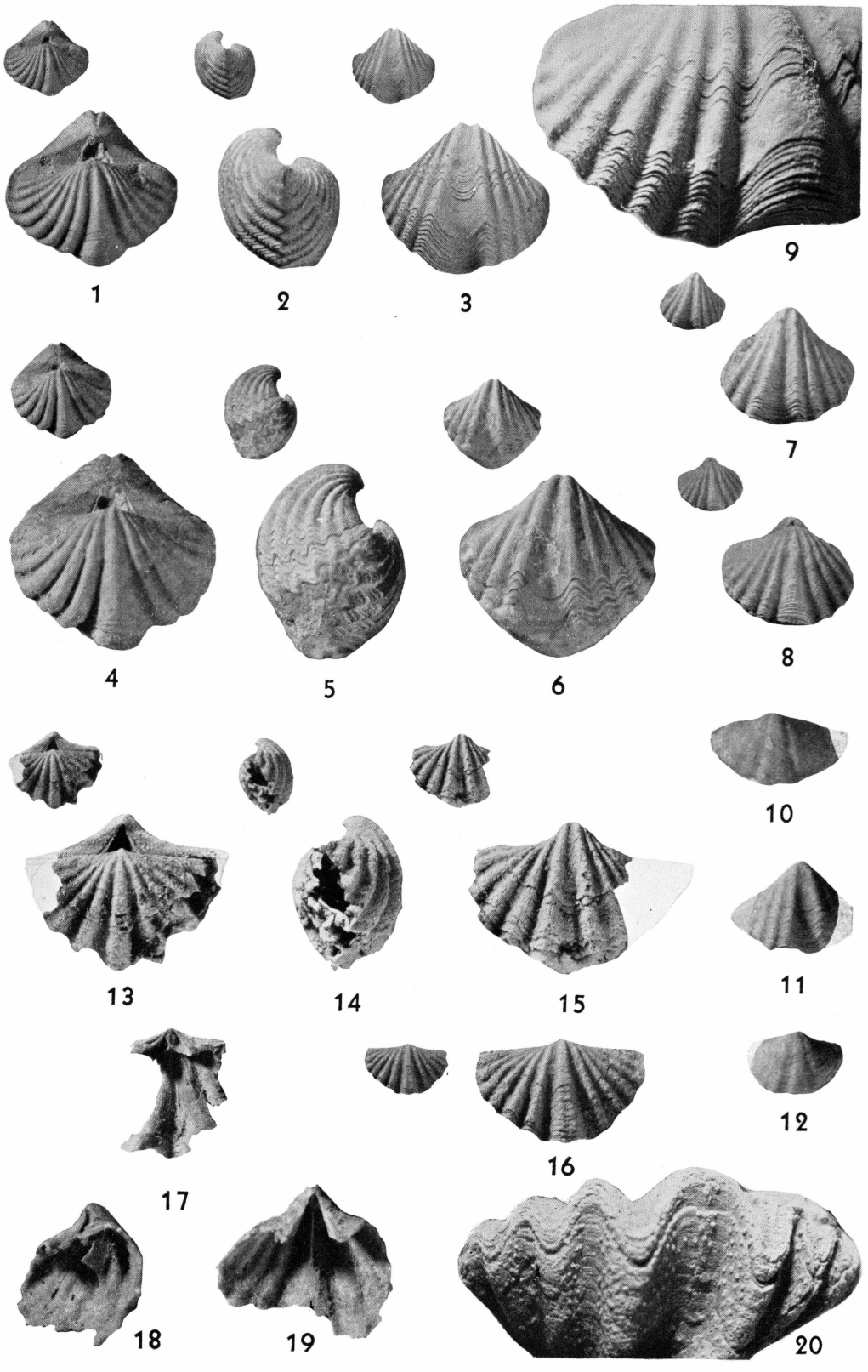
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Plate 30.

Martinia greenlandica DUNBAR, n. sp. ..... p. 152

Figs. 1—4. Dorsal, lateral, ventral, and anterior views of the holotype. From the Martiniakalk at a locality on Productuselv, Clavering Ø (M 312).

Fig. 5. Ventral view of a specimen from Fiskeelv, Clavering Ø (M 257).

Fig. 6. Slightly flattened ventral valve from Sneugleelv, Clavering Ø (M 291).

Fig. 7. Two incomplete ventral valves from the same lot as fig. 6.

Fig. 8. A dental wax squeeze from an internal mold of the ventral valve, showing the median groove and the large diductor scars marked by radiating grooves.

Odontospirifer mirabilis DUNBAR, n. gen., n. sp. ..... p. 155

Figs. 9—12. Dorsal, ventral, lateral, and anterior views of the holotype. From White Block no. 3 east of Kap Stosch (N 3).

Figs. 13, 16. Ventral and posterior views (X 1 and X 2) of a paratype ventral valve from another "white block" (Na).

Fig. 14. Dorsal valve (X 1 and X 2) of a young shell from another "white block" east of Kap Stosch (N g).

Fig. 15. Anterior view of a specimen (X 1 and X 2) showing well the plication in the ventral sulcus. Same lot as fig. 9.

Fig. 17. Enlargement (X 5) part of a young ventral valve to show the strong lamellae. From another "white block" near Kap Stosch (N r).

Fig. 18. Cardinal view (X 5) of the specimen represented by figs. 13 and 16, showing strong denticles along the hinge line and the vertical ridges on the cardinal area produced by growth of the denticles.

Fig. 19. Similar view (X 5) of the specimen represented by fig. 17.

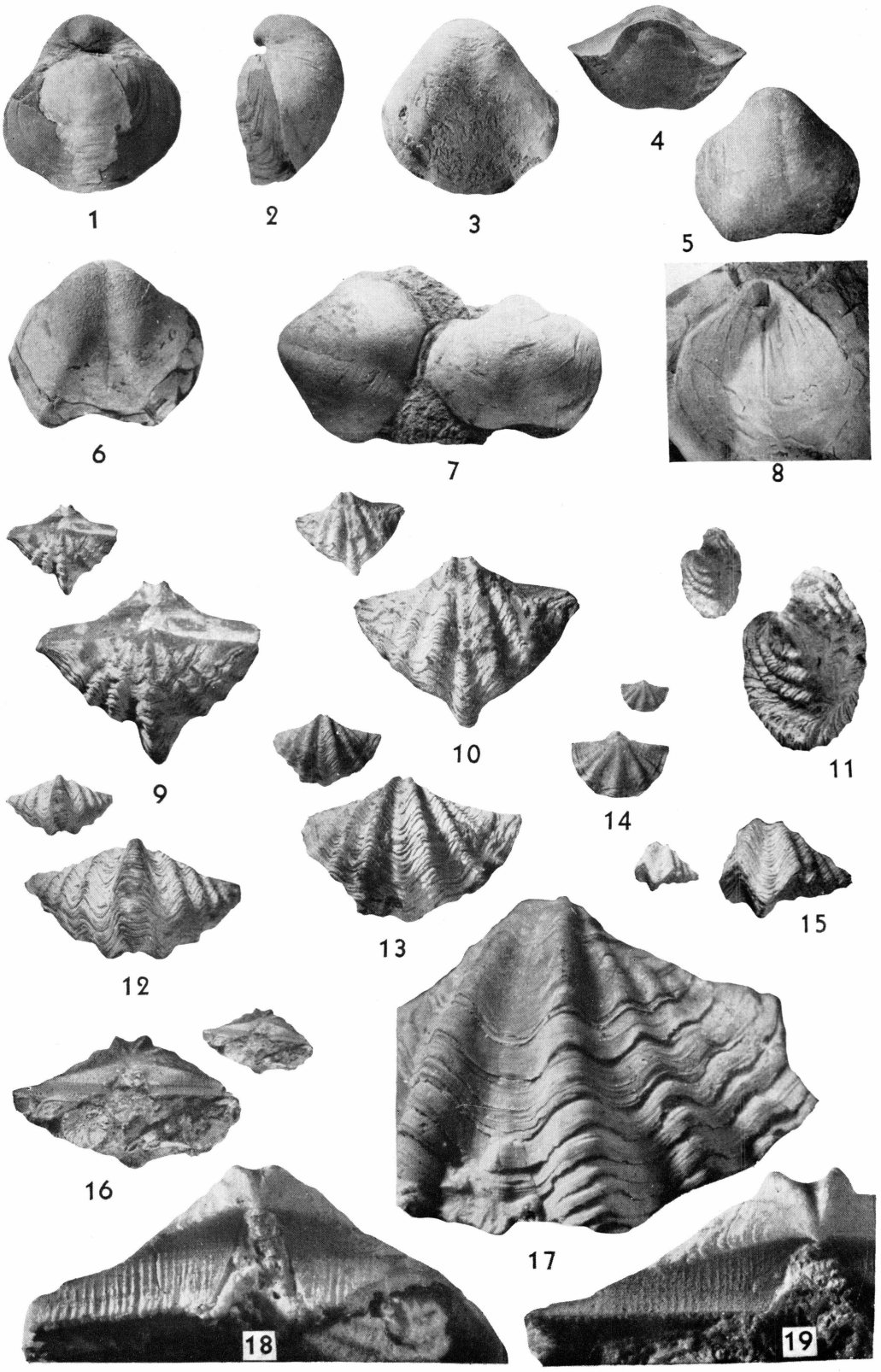
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Plate 31.

Chonetina noe-nygaardi DUNBAR, n. sp. ..... p. 67

Fig. 1. Holotype in ventral view (X 1), and in ventral and posterier views (X 2). Permian beds east of Kap Stosch (LK 28).

Fig. 2. Paratype in ventral and lateral views (X 1 and X 2), from southwest of Kap Stosch (N 45 a).

Fig. 3. Paratype in ventral view (X 1 and X 2), from the "Productus limestone" west of Schucherts Flod, southern Scoresby Land (STAUBER coll.).

Choristites søderberghi DUNBAR, n. sp. ..... p. 158

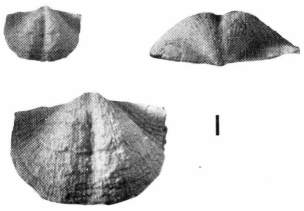
Fig. 4. Holotype ventral valve from the east slope of Kollen, Canning Land (SÄVE-SÖDERBERGH coll.).

Figs. 5, 6, 9. Posterior, lateral, and ventral views of a young ventral valve showing the high, triangular cardinal area. From the slope at Komait southwest of Kap Brown, Wegeners Halvö (LK coll. of 1927).

Figs. 7, 10. Ventral and cardinal views of an incomplete ventral valve from the talus of Kollen, Nathorsts Fjord (SÄVE-SÖDERBERGH coll.).

Fig. 8. Ventral view of an incomplete ventral valve from the same lot as fig. 7.

Fig. 11. Ventral view of the posterior part of a large ventral valve from the same lot as fig. 8.



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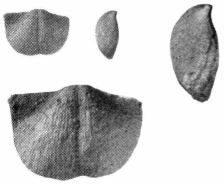

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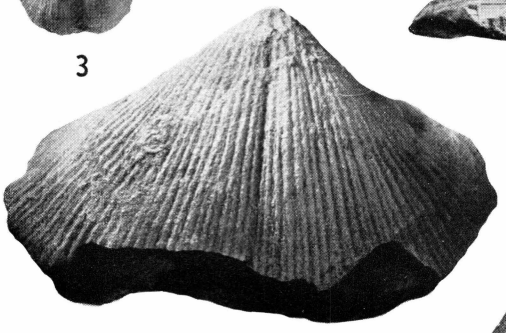

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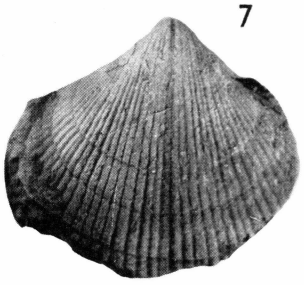

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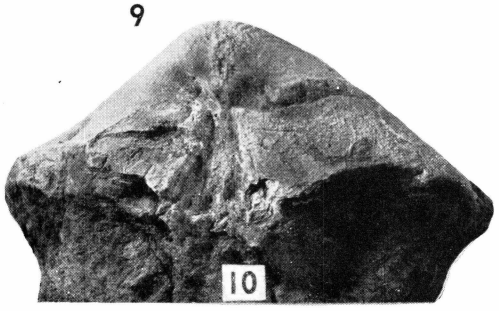

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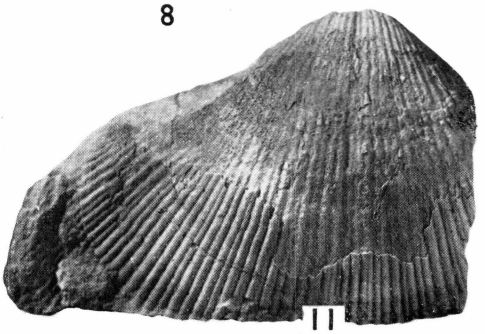

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Plate 32.

Crania sp. A ..... p. 62

Fig. 1. Dorsal view of a unique specimen (X 1 and X 2) from White Block no. 6 in Triassic conglomerate near Kap Stosch. (N 6)

Crania sp. B ..... p. 62

Fig. 2. Interior of incomplete valve (X 5) showing characteristic muscle scars of the genus.

Fig. 3. Internal mold of the last specimen in the rock (X 1 and X 5). From a "white block" in the Triassic conglomerate near Kap Stosch (N d).

Orbiculoidea sp. A ..... p. 62

Fig. 4. Dorsal view of exterior (X 1 and X 2) from a "white block" in the Triassic conglomerate near Kap Stosch (LK WB).

Fig. 5. Internal mold of dorsal valve of another specimen from the same lot (X 1 and X 2).

Streptorhynchus stoschensis DUNBAR, n. sp. ..... p. 65

Figs. 6, 7. Cardinal and interior views of a silicified ventral beak (X 3), the latter showing well the lack of dental lamellae. Nathorsts Fjord area (S II, 326).

Fig. 8. Interior of dorsal valve (X 3) from the same lot.

Streptorhynchus kempei ANDERSSON ..... p. 63

Figs. 9, 10. Dorsal and lateral views of a specimen crushed on the left side but showing well the normal convexity of both valves. Djævlekløft, Clavering Ø (LK 20).

Hustedia sp. ..... p. 161

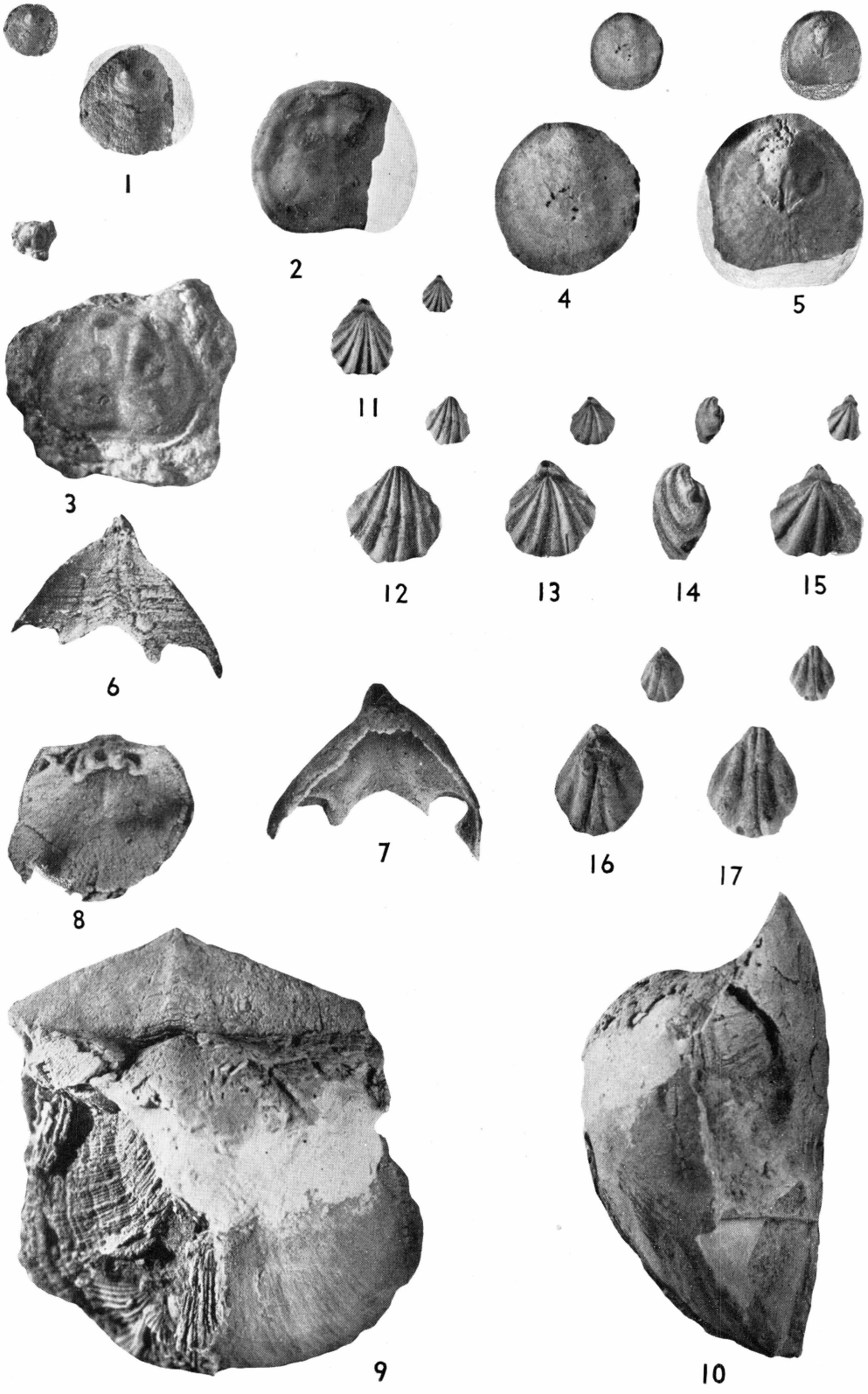
Fig. 11. Dorsal view (X 1 and X 2) of specimen from a "white block" in the Triassic conglomerate near Kap Stosch (N s).

Hustedia troelseni DUNBAR, n. sp. ..... p. 160

Figs. 12, 13. Ventral and dorsal views (X 1 and X 2) of holotype. Kap Stosch area (LK 29).

Figs. 14, 15. Lateral and dorsal views of a paratype from boulder 160 in the Triassic conglomerate east of Kap Stosch (LK 551).

Figs. 16, 17. Dorsal and ventral views of a specimen (X 1 and X 2) that has been somewhat squeezed from the sides. Kap Stosch area (LK 28).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