GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

MEMOIR 309

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P. Harker and R. Thorsteinsson

Price, $2.00

1960

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No. 2557
3,000—1959—1480

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THE QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1960

Price $2.00 Cat. No. M46-309

PREFACE

Fossil collections made by some of the early explorers of Arctic Canada showed that Permian rocks occurred at widely separated localities. Extensive field work in the Arctic islands by the Geological Survey of Canada during recent years has shown that these isolated occurrences belong to a circumpolar belt of Permian and Carboniferous rocks that passes through the northern part of the Arctic islands.

Grinnell Peninsula, which forms the northern part of Devon Island, occupies a central position in this belt. A fortunate combination of geographic position, highly fossiliferous deposits, and simple structure has made the succession of Grinnell Peninsula an important index section for the Permian geology of the Canadian Arctic. This report, which is in three parts, describes the geology and more important faunas of the peninsula, and is based on field investigations by Thorsteinsson and on detailed faunal studies by both authors. It is the first contribution from the Geological Survey on the Permian faunas of the Arctic and provides a standard to which faunas elsewhere in northern Canada may be compared, and a type section that may be related to the standard Permian sections in the United States and Eurasia.

J. M. HARRISON,
Director, Geological Survey of Canada

OTTAWA, March 9, 1959

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Abstract

Marine Permian deposits are widespread in the Canadian Arctic Islands but their faunas and age relationships have received little systematic study. This report describes the Permian rocks and faunas of Grinnell Peninsula, where the section consists of two highly fossiliferous formations.

The older formation, the Belcher Channel, which is mainly limestone, rests with angular unconformity on the Ordovician and contains the fusulinids *Schubertella, Pseudofusulinella, Schwagerina* and *Parafusulina,* corals, and a few brachiopods. The fossils indicate that the formation is mainly of Artinskian age.

The younger formation, the Assistance, consists of weakly consolidated glauconitic sandstones and is transgressive; elsewhere in the Canadian Arctic it rests on rocks ranging in age from Ordovician to Devonian. It contains an abundant and well-preserved fauna with many brachiopods, including species of *Streptorhynchus, Derbyia, Dictyoclostus, Muirwoodia, Kochiproductus, Waagenoconcha, Stenoscisma, Rhynchopora, Pterospirifer,* and *Spiriferella.* The ammonoids *Pseudogastrioceras* and *Metalegoceras* also occur. Similar faunas considered to be approximately contemporaneous occur at many localities in boreal regions and are here referred to as the Arctic Permian fauna. The Arctic Permian fauna cannot readily be assigned to any well-established marine Permian stage and is referred to the Svalbardian, recently proposed for marine equivalents of the Kungurian and lying between the Artinskian and the Kazanian.

Résumé

L'archipel Arctique renferme de nombreux depôts permiens d'origine marine, mais on n'a guère encore étudié leurs faunes et leurs relations chronologiques. Le rapport décrit les roches et faunes permiennes de la presqu'île Grinnell, où la section se compose de deux formations fort riches en fossiles.

La plus ancienne formation, celle du canal Belcher, se compose en grande partie de calcaire et repose en discordance sur l'ordovicien. Elle contient des fusulinidés des genres *Schubertella, Pseudofusulinella, Schwagerina* et *Parafusulina,* ainsi que des coraux et quelques brachiopodes. A en juger par les fossiles, cette formation date en grande partie de l'âge artinskien.

La formation plus récente, l'Assistance, se compose de grès glauconieux peu cohérents; elle est d'origine transgressive; ailleurs dans l'Arctique du Canada, elle repose sur des roches dont l'âge varie de l'ordovicien au dévonien. Parmi sa faune abondante et bien conservée, on rencontre de nombreux brachiopodes, y compris des espèces de *Streptorhyncus, Derbyia, Dictyoclostus, Muirwoodia, Kochiproductus, Waagenoconcha, Stenoscisma, Rhynchopora, Pterospirifer* et *Spiriferella.* On rencontre aussi les ammonoïdes *Pseudogastrioceras* et *Metalegoceras.* Il y a des fossiles semblables qui auraient à peu près le même âge dans de nombreux endroits des regions boréales; l'auteur les englobe sous le nom de faune permienne arctique. Il n'est pas facile de faire remonter cette dernière faune à un âge bien établi de transgression marine du permien; on la rattache au svalbardien, terme qu'on a proposé récemment pour désigner les équivalents marins du kungurien et dont les couches se situent entre l'artinskien et le kazanien.

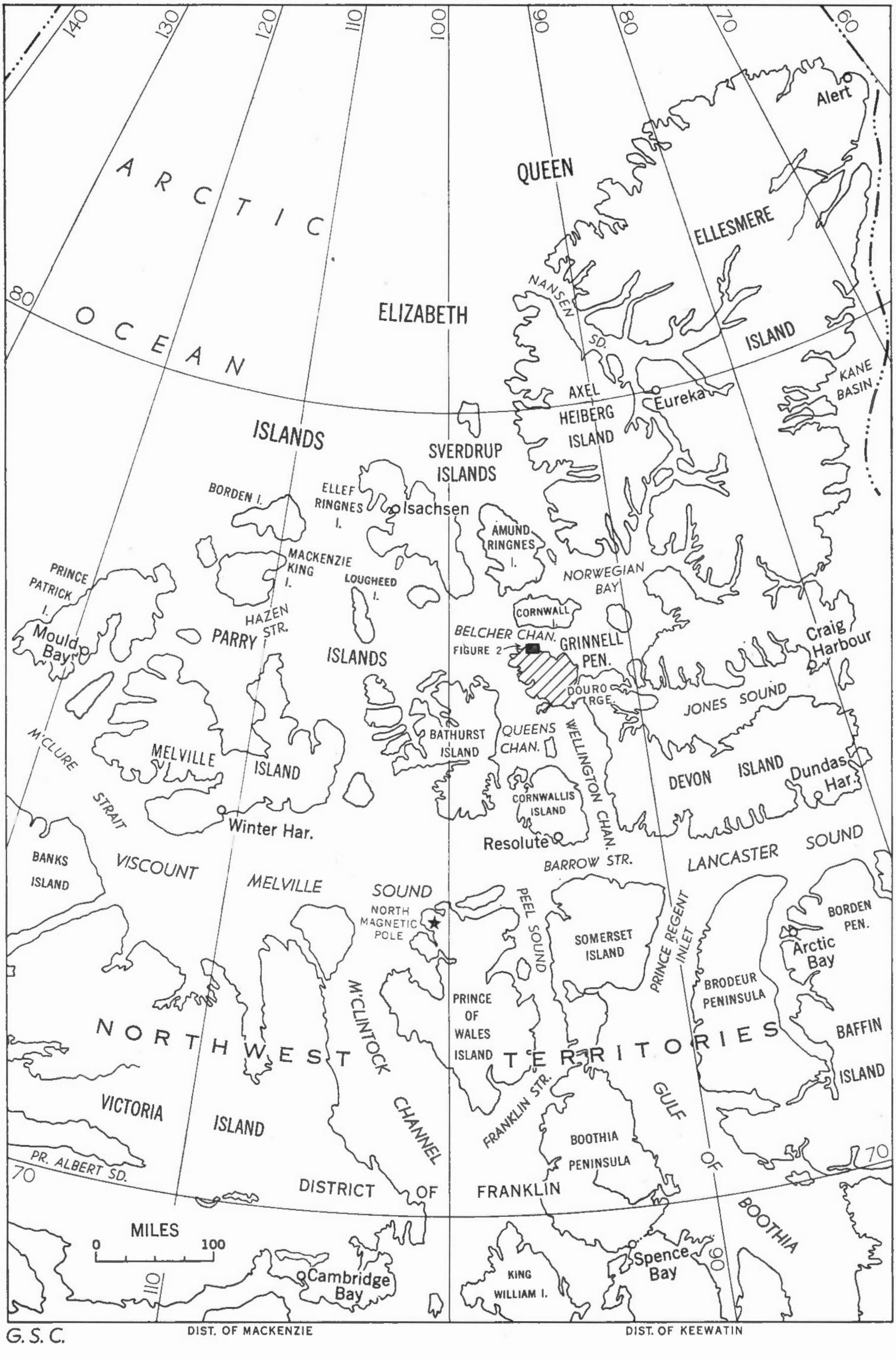

Figure 1. *Index map showing location of Grinnell Peninsula and the geological sketch map of Figure 2.*

Part I

PERMIAN ROCKS AND FAUNAS OF GRINNELL PENINSULA

P. Harker and R. Thorsteinsson

Introduction

Grinnell Peninsula forms the northwestern extremity of Devon Island, one of the larger islands included in the Arctic Archipelago. It has an area of some 2,000 square miles and its approximate centre lies at the intersection of lat. 76°41'N and long. 94°53'W (*see* Figure 1). Large and distinctive in shape, Grinnell Peninsula is connected to Devon Island proper by a narrow isthmus about 4 miles wide. Superficially it appears on maps almost as a separate island in the Canadian Arctic Archipelago.

Marine Permian rocks, rich in well-preserved fossils, outcrop in a narrow belt along the north coast. The stratigraphy and palæontology of these rocks is described in the several parts of this report.

Permian rocks are widely distributed in the Arctic Archipelago and their deposition was an important sequence of events in the geological history of the Arctic regions. The Grinnell section is the first Permian section in the Canadian Arctic to be described in detail and it will form a permanent standard of reference for future stratigraphic correlations both within the Arctic islands and throughout northwestern Canada. Faunal studies show that the Grinnell deposits can be readily correlated with the Permian of Greenland, Spitzbergen, and Novaya Zemlya; with Eurasia and, though perhaps to a lesser extent, with continental North America.

Field Work

This report is based on field work during the period of July 13-18, 1955, by R. Thorsteinsson. Thorsteinsson was at that time a member of "Operation Franklin", a large-scale program of mapping and stratigraphic studies under the direction of Y. O. Fortier. Rotary and fixed-wing aircraft were used on the operation; the camp on Grinnell Peninsula was established by Sikorsky, S.55 helicopter.

History of Exploration

Devon Island may have been visited by members of the lost Icelandic colony that inhabited Greenland between the ninth and thirteenth centuries (*see* Stefansson, 1939, p. 1).[1] There is, however no written record of such a journey. That the Norsemen of Greenland may have explored parts of Devon Island is based solely on the discovery of eider duck shelters found on St. Helena Island in Jones Sound by members of the Second Norwegian Expedition led by Captain Otto Sverdrup (1904, vol. II, p. 311). These shelters were identical with those of the early Norwegians and Icelanders.

The first record of the discovery of Devon Island is that of the British Navigator, William Baffin. In 1616 Baffin sailed his vessel the *Discovery* into the bay that now bears his name and proceeded up the southwest coast of Greenland. After reaching the latitude of Northumberland Island, Baffin crossed the north end of Baffin Bay to the southeast corner of Ellesmere Island where he commenced his homeward journey by way of the east coast of Devon Island and down the northeast coast of Baffin Island. Baffin did not name Devon Island although he did delimit its east coast and named Jones Sound and Lancaster Sound which separate Devon Island from Ellesmere and Baffin Islands respectively.

Two centuries passed before Devon Island was again seen by white men. In 1818 Sir John Ross (1819) in command of the sailing vessels *Isabella* and *Alexander* left England in search of the Northwest Passage. Ross entered Baffin Bay and retraced the route of Baffin. Many geographers had been rather sceptical of Baffin's reports but the voyage of Ross completely vindicated him and in fact added little information to Baffin's remarkable discoveries 200 years previously.

In 1819-20 Lieutenant W. E. Parry (1821) sailed from England in command of an Arctic expedition with the object of searching for a Northwest Passage. This proved to be one of the most successful of all Arctic expeditions. In August of 1819 Parry entered Lancaster Sound and proceeded west as far as Melville Island, discovering and naming most of the important islands and waters along his route. Parry wintered his sailing vessels the *Hecla* and *Griper* in Winter Harbour on the south coast of Melville Island. The following year he returned to England. Parry charted the south coast of Devon Island, bordering on Lancaster Sound, and named the island after the home county of Lieutenant Mathew Liddon, commander of the *Griper* (Parry, 1821, p. 265).

The next British Admiralty expedition to enter the Archipelago in search of a passage from the Atlantic to the Pacific was that of the ill-fated Sir John Franklin, with the vessels *Erebus* and *Terror*. On leaving Baffin Bay they met some whaling vessels but none of the expedition was ever again seen alive. The only first-hand information on Franklin's subsequent exploration is contained in a note that was found in a cairn at the north end of King William Island in 1859 by Lieutenant W. R. Hobson, second-in-command of the *Fox* under the command of Captain F. L.

[1]Names and dates in parentheses are those of references cited in the Bibliography.

M'Clintock (1859, p. 263). This note stated that in 1845 Franklin had ascended Wellington Channel to a latitude of 77 degrees and returned south the same year by sailing through one of the two possible straits between Cornwallis and Bathurst Islands. From there he sailed to Beechey Island at the southwestern extremity of Devon Island where he passed the winter of 1845-46. In 1846 the Franklin expedition sailed down Peel Sound to near the north end of King William Island where they were beset in the ice, from which they were never able to extricate themselves. The note also contained the tragic news that up till April of 1848, nine officers, including Sir John Franklin, and fifteen men had died and that the remaining one hundred and five officers and men were about to commence a journey to the mainland in an attempt to reach civilization.

In circumnavigating Cornwallis Island, Franklin no doubt made many new geographic discoveries and probably charted most of the west coast of Devon Island. But his records perished with the expedition.

In late August of 1850, three British Naval squadrons, setting out to search for Sir John Franklin, entered Barrow Strait. One of these was commanded by Captain Horatio T. Austin (*Parliamentary Papers 1852*) and consisted of the sailing vessels *Assistance* and *Resolute,* together with the steam tenders *Intrepid* and *Pioneer.* Austin's ships wintered about 2 miles off the coast of Griffith Island, between that Island and Cape Martyr on Cornwallis Island. The second squadron, under the command of Captain William Penny (Sutherland, 1852; also *British Parliamentary Papers,* 1852) comprised the *Lady Franklin* and *Sophia.* These squadrons were accompanied by a privately financed expedition led by Sir John Ross in the *Felix.* Penny and Ross wintered in Assistance Bay on the south coast of Cornwallis Island. Many miles of new coast-lines were charted in the spring of 1852 by man-hauled sledging parties of these squadrons as they searched for traces of Franklin's parties. At the same time officers and men from Penny's command mapped the west coast of Devon Island as far north as the south coast of Grinnell Peninsula. Penny himself with the aid of a whale boat explored parts of Queens Channel, as well as charting a part of the south coast of Grinnell Peninsula to which he gave the name of Prince Albert Land. Austin, Penny and Ross returned to England in 1852.

An American squadron consisting of the *Advance* and *Rescue* and under the command of Lieutenant Edwin J. De Haven (Kane, 1854) accompanied the British ships as far west as Griffith Island. In the autumn of 1850 De Haven's ships became beset by ice in Wellington Channel and drifted northward to pass part of the following winter locked in the ice. On September 22 the *Advance* and *Rescue* appeared to have attained their maximum northing. At that time they lay a few miles off the east coast of Cornwallis Island, at a latitude of 75°24′21″ (Kane, 1854, p. 200). It was from this position that De Haven and Kane (who was surgeon on De Haven's expedition) claim to have seen and named Grinnell Land. Kane described the sighting of land, which was probably at a distance of 40 to 50 miles, as follows: "I now saw land to the north and west; its horizon that of rolling ground, without bluffs, and terminating abruptly at its northern end.

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Still further on to the north came a strip without visible land, and then land again, with mountain tops distant and rising above the clouds. This last was the land which received from Captain De Haven the name of Mt. Grinnell."

The discoveries of De Haven were unknown to Captain Penny when he explored these regions of Devon Island the following spring. A somewhat bitter controversy then followed between British and American interests on priority of name Albert Land versus Grinnell Land (*see* Kane, 1854, pp. 206-209). Eventually Grinnell became the accepted name. It now seems probable that the mountainous land to which De Haven and Kane gave the name of Grinnell was in fact the Douro Range of Devon Island proper.

In 1852 another Franklin search expedition sailed from England commanded by Captain Sir Edward Belcher (1855). Belcher had five ships, the *Assistance, Resolute, Pioneer, Intrepid,* and *North Star.* He reached Beechey Island in August of 1852 where he divided his squadron. The *Resolute* and *Intrepid,* under command of Captain Henry Kellett, proceeded to Melville Island. The *North Star* remained at Beechey Island as a depot and retreat vessel in case of disaster to the advancing vessel. Belcher himself, with the *Assistance* and *Pioneer,* proceeded via Wellington Channel to the western extremity of Grinnell Peninsula where he passed the first winter.

In late August, shortly after the ships had been frozen in on the north side of Northumberland Sound, Belcher led a party with three man-hauled sledges on a journey to the north. Two light boats were taken along in case of open water. Accompanying Belcher in this exploration and search party were his senior officers, Commander G. H. Richards and Lieutenant Sherard Osborn. By alternate hauling over sea ice and rowing their boats across leads and open water, Belcher and his party reached the north coast of Grinnell Peninsula and went on to discover and to explore Ekin, Exmouth, Table, and Cornwall Islands. The party returned to the ships in early September. Shortly afterwards they made another search and exploration journey, this time along the southwest shore of Grinnell Peninsula.

In the spring of 1853 the main body of officers and men of the *Assistance* and *Pioneer* explored the north coast of Bathurst Island and travelled as far west as Melville Island where they established contact with the *Resolute* and *Intrepid.* At the same time Belcher personally conducted a survey of the north coast of Grinnell Peninsula and Devon Island. On this survey Belcher followed the shore as far east as the Cardigan Straits. From there he retraced his steps to Arthur Fiord which he explored to its head. Belcher is thus almost solely responsible for delimiting Grinnell Peninsula, although he incorrectly interpreted Arthur Fiord as a strait and regarded Grinnell Peninsula as a separate island—an error that persisted for half a century. After retracing his route to the mouth of Arthur Fiord, Belcher crossed the channel that bears his name to explore Buckingham Island before returning to his ships.

Attempts by the advanced vessels to return home in the summer of 1853 failed. Kellett's ships passed the winter of 1853-54 frozen in the ice off Cape Cockburn, 28 miles off the southwestern tip of Bathurst Island. That winter

Assistance and *Intrepid* were also beset in the ice off Cape Osborn, Devon Island in Wellington Channel. Fearful of another winter in the Arctic, Belcher ordered abandonment of the four advanced ships. In the summer of 1854 the crews from these ships walked over the ice to Beechey Island where they assembled on board the *North Star* and two relief ships, the *Phoenix* and *Talbot,* that had just arrived from England. From Beechey Island the three ships returned to England.

It remained for the second Norwegian expedition in the *Fram* under Captain Otto Sverdrup (1898-1902) to demonstrate that "Arthur Strait" of Belcher was a fiord and that Grinnell Peninsula was in fact joined to Devon Island by an isthmus. Moreover, members of the *Fram* expedition completed the mapping of Devon Island by charting the north coast that faces Jones Sound.

The early expeditions that resulted in the discovery and charting of Grinnell Peninsula were essentially naval operations and no serious geological studies were attempted. However, Penny, Austin, M'Clintock, and Belcher made fossil collections which were studied by various palæontologists when the ships returned home.

Belcher was a keen and discerning observer and his reports contain many comments on geological features observed during his travels. His party collected fossils on the north coast of Grinnell Peninsula and from the adjacent islands. J. W. Salter, who described them in an appendix to the second volume of Belcher's report (Belcher, 1855, p. 377) stated that they were of Carboniferous age (op. cit., p. 379). Some of these fossils were re-examined during the present study. In a note written by Belcher and published in an appendix on some Saurian remains by Professor Owen (op. cit., p. 391), Belcher described and illustrated his "fossiliferous oval". He stated that no fossils were found outside the area bounded by "the assumed oval curve which would be formed by the dotted line connecting Exmouth, Table, and Princess Royal Islands, continued by the mainland up to Cape Briggs". Some Mesozoic strata is included within this oval area on the islands off the mainland but it does show the approximate area of outcrop of Permian deposits in the region. In a historical sense it could be almost regarded as a geological map.

Geology

Introduction and Physical Features

The area covered by this report lies within the drainage basin of Lyall River which flows northwards and enters Belcher Channel between Cape Ogle and Depot Point, near the northern extremity of Grinnell Peninsula. Figure 2 is a geological sketch map of the area.

Most of Grinnell Peninsula consists of a youthfully dissected plateau rising gradually from the coast to the interior where a maximum relief of about 1,500 feet is attained. In the region studied the maximum relief is 600 feet and the land slopes gradually down to Belcher Channel. Away from the sea the terrain is moderately dissected and is cut by numerous tributaries of Lyall River. Resistant units within the Belcher Channel formation, which dips gently northwards, form

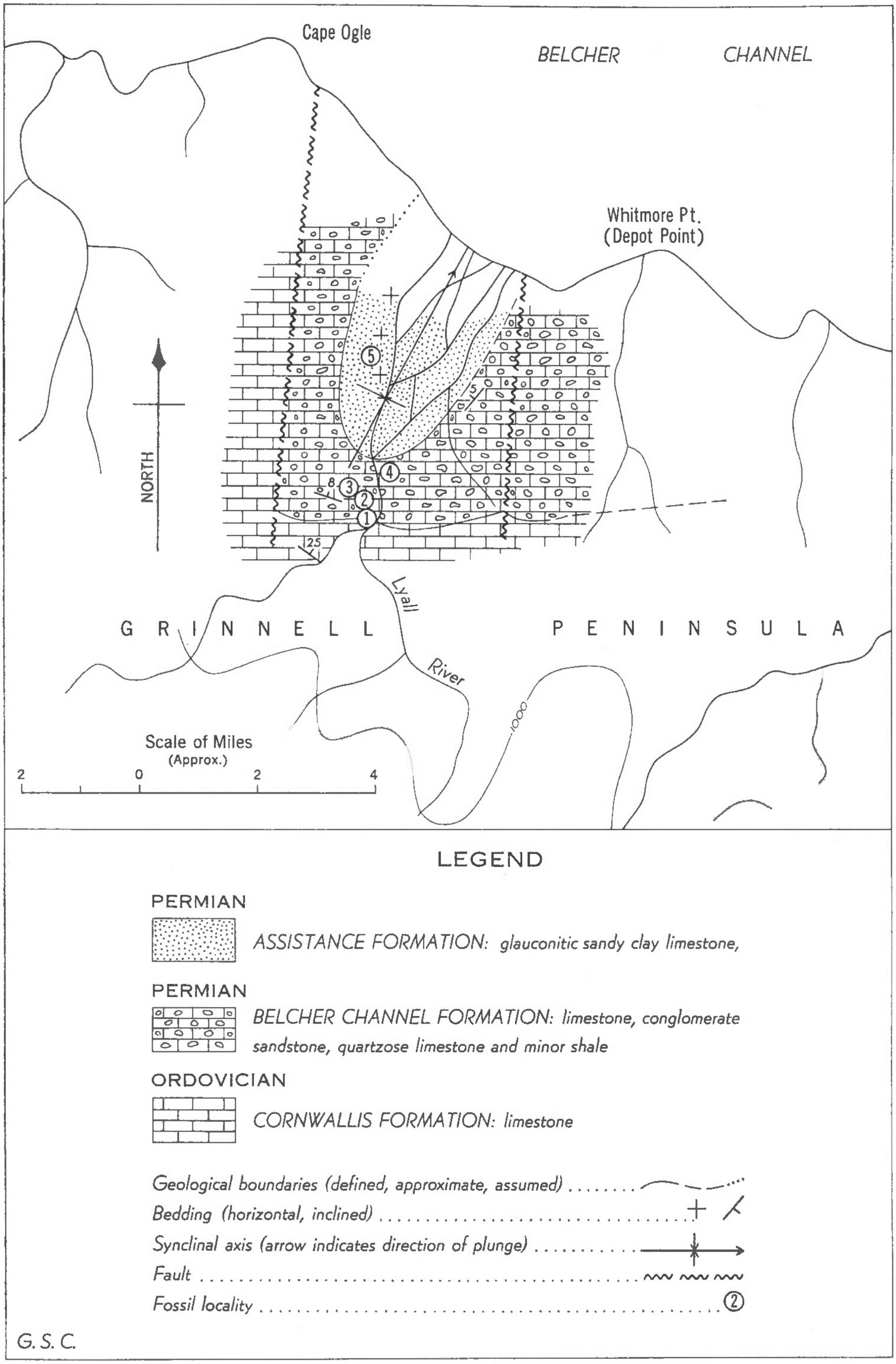

Figure 2. **Geological sketch map of part of Grinnell Peninsula.**

a series of low and somewhat ill-defined south-facing escarpments. Raised strand lines are well developed in the immediate vicinity of the coast and can be clearly seen from the air. The occurrence of marine shells at several localities, ranging up to 225 feet above sea-level, affords further evidence of fairly recent marine emergence.

Structure

The oldest rocks in the area are limestones of Ordovician age, tentatively assigned to the Cornwallis formation (Thorsteinsson, 1959, p. 33). The Belcher Channel formation and overlying Assistance formation, of Permian age, form a conformable sequence that rests with structural unconformity on the Cornwallis formation and dips homoclinally northwards.

Ground observations in conjunction with a detailed study of air photographs have demonstrated the presence of several roughly north-striking faults in this region of Grinnell Peninsula. To the west of Lyall River a topographic depression followed by several minor streams marks the location of a fault that has displaced beds of the Belcher Channel formation against the Ordovician Cornwallis formation. The remarkable linearity of this topographic depression and the structural relationship of the formations involved suggest a steeply dipping normal fault with considerable displacement. Moreover, it is possible that this fault is responsible for the development of the shallow syncline in which the Assistance formation is presently preserved. Examination of air photographs indicates that Permian rocks of Grinnell Peninsula are confined to a narrow strip of terrain that extends from the prominent fault described above for about 70 miles along the coast of Belcher Channel.

Although little is known about the major structural features involving the Cornwallis formation on the north coast of Grinnell Peninsula, this formation appears to have been folded prior to deposition of Permian sediments. Moreover, the proximity of this area to structures of the Central Ellesmere Fold Belt that have been shown by McLaren (MS. rept.) to extend into northeastern Grinnell Peninsula, suggests that the deformation of the Cornwallis formation may be related to the Variscan orogeny that also produced the Central Ellesmere structures. The region of Permian outcrops on Grinnell Peninsula clearly belongs to the late Palæozoic to early Tertiary Sverdrup Basin.

Belcher Channel Formation

The Belcher Channel formation of Permian age varies in thickness from 650 to 820 feet and comprises a varied assemblage of carbonate and clastic sediments that rest unconformably on the Cornwallis formation. Typical rocks of the Belcher Channel formation outcrop along the banks of Lyall River some 4 miles upstream from the coast. The uppermost 65 feet or so of the formation at its type locality is shown on Plate I B.

The Belcher Channel formation may be conveniently divided into three fairly distinctive lithological units. These are described briefly in ascending order as follows:

Unit 1. The basal beds form a uniform succession of conglomeratic beds consisting mainly of subangular to rounded, aphanitic to fine-grained limestone pebbles embedded in fine-grained, dense calcareous and hematitic cement. The fragments vary from less than a quarter inch to about an inch in diameter. The colour of the limestone fragments varies, but shades of grey and red predominate. Angular pebbles of grey chert form a minor constituent. Crossbedding is common in some of the finer beds. The basal conglomerate varies in thickness from 20 to 200 feet. No fossils were found in this unit.

Unit 2. This unit consists of very pale green, pale green, and moderate red, fine- to generally medium-grained, thin-bedded, quartzose sandstone. These rocks are, in part, crossbedded and alternate with minor thin beds of greenish grey limestone, shale, and chert conglomerate. Only the upper 60 feet or so was seen completely exposed. Frost-riven debris and sporadic outcrops at lower levels in this unit, however, suggest that the above rock types persist throughout. The contact with the overlying limestone beds of unit 3 is sharp, yet conformable; the lower contact with the basal conglomeratic beds (unit 1) was not observed. No fossils were seen in this unit which is about 140 feet thick.

Unit 3. The uppermost unit of the Belcher Channel formation is limestone, which is mainly light grey, fine to coarse grained and thin to medium bedded. The total thickness of this unit as measured at the type section is 490 feet. The upper 330 feet is a highly fossiliferous, coarse-grained, bioclastic limestone which is variably quartzose with greyish green and dusky red shale occurring as bedding plane partings. Many of the upper beds are veritable biostromes of colonial corals situated in the position of growth. Specks of limonite are common in beds throughout the entire unit and are especially characteristic of the bioclastic beds. These specks occur as pore fillings and as an intimate part of the matrix. The lower 160 feet of the unit consists of yellowish grey to light grey, fine-grained limestone and quartzose limestone, with minor beds of light grey, fine-grained, quartzose sandstone. Bioclastic limestone is a minor constituent of these lower beds.

The limonite is responsible for the dusky red weathering colours of the Belcher Channel formation. It gives a similar colour to the overmantel of frost-shattered debris derived from and resting on this formation. As a consequence the Belcher Channel formation stands out in marked contrast to the adjacent Ordovician limestone terrain, which is characterized by drab greyish yellow and yellowish grey.

The inclusion of all three units of the Belcher Channel in a single formation is open to question. The lower two units are known to be separated from the third unit by a marked change in lithology and a sharp contact that could conceivably represent a disconformity. Moreover there is a remarkable lithological similarity between the lower two units of the Belcher Channel formation and the basal conglomerate and immediately overlying beds of the typical rocks of the Canyon Fiord formation, of Pennsylvanian age, on Ellesmere Island.

Three faunules were collected from unit 3. These are shown in their relative stratigraphic position on the accompanying stratigraphic column (*see* Figure 3).

Assistance Formation

The Assistance formation comprises approximately 200 feet of mainly unconsolidated clastic sediments. It is the youngest formation exposed in this area and its upper limit forms the present-day erosion surface. The contact of Assistance beds with the underlying Belcher Channel formation has not been observed but exposures within a few feet of the junction indicate that the contact is one of structural conformity, which is probably sharp. The transgressive character of the Assistance formation in other parts of the Arctic islands suggests that a disconformity separates Assistance and Belcher Channel beds on Grinnell Peninsula. At Trold Fiord on Ellesmere Island, Tozer (MS. rept.) reports that the Assistance formation rests on Lower Palæozoic strata, whereas on Cameron Island in the Bathurst Island group, Assistance beds rest on rocks of Upper Devonian age (Greiner, MS. rept.).

The type section of the Assistance formation on the west bank of Lyall River and near its junction with the sea is illustrated in Plate I A.

The Assistance formation is composed principally of alternating 1- to 2-foot beds of dusky yellowish orange and medium greyish green, glauconitic, sandy clay and argillaceous sand. Dusky red ironstone and sandstone concretions, commonly bearing fossils, occur abundantly in the fossiliferous beds of the upper part of the formation. The uppermost 12 feet of beds comprise alternating very dusky red, loosely consolidated sandstone and dark yellowish green and dusky grey clay.

A rich and well-preserved fauna is concentrated between 148 and 188 feet stratigraphically above the base of the formation and its stratigraphic position is indicated on Figure 3.

Discussion of Faunas

The fossils of the Belcher Channel formation are restricted to the uppermost of the three units that make up the formation. The fauna consists of seven species of fusulinids, of which four are new; nine species of corals including one new species; and three species of brachiopods. These species are distributed over three faunules which are listed in ascending stratigraphic order as follows:

Faunule 1 GSC locality 26418, from the basal 8 feet of unit 3.

Schubertella kingi Dunbar and Skinner
Pseudofusulinella utahensis Thompson and Bissel
Pseudoschwagerina grinnelli Thorsteinsson
Caninia belcheri Harker
Clisiophyllum ? *tumulus* Salter

Faunule 2 GSC locality 26421, 194 feet from base of unit 3.

Schwagerina paralinearis Thorsteinsson

Faunule 3 GSC localities 26407 and 26420, from the top 65 feet of the unit.

Schwagerina jenkinsi Thorsteinsson
Schwagerina hyperborea (Salter)
Parafusulina belcheri Thorsteinsson
Caninia ovibos (Salter)
Lithostrotion grandis (Heritsch)
Lithostrotion kunthi (Stuckenberg)
Lithostrotion cf. *L. portlocki* M.-E. and H.
Lithostrotion ? sp.
Stylastraea cf. *S. toulai* (Stuckenberg)
Roemeripora wimani Heritsch
Derbyia sp.
Chonetina cf. *C. timanicus* (Tschernyschew)
Spiriferella saranae (de Verneuil)

The actual position of these localities is shown on the accompanying geological map (*see* Figure 2), and their relative stratigraphic position is indicated on Figure 3. The fossils are described in Parts II and III of this report.

The fauna of the Assistance formation was collected from about the uppermost 60 feet of the formation. Most of the fossils were found as free specimens or in soft nodules in the unconsolidated matrix. The preservation is good although many specimens have lost some of their finer sculpture due to abrasion by the rather coarse sandy material in which they were buried. The total fauna identified from the formation comprises twenty-four species of brachiopods, three molluscs, including two ammonites, and two species of conularids. A rather surprising feature of the fauna is the complete lack of corals. This is in striking contrast with the Belcher Channel formation in which corals, especially colonial corals, are locally very abundant. This absence of corals is probably mainly ecological and may serve to emphasize the pronounced lithological difference between the two formations.

The fauna is listed below; most of the fossils were collected from a single locality (GSC locality 26406) which is shown on the map as fossil locality 5. The stratigraphic position is shown on Figure 3.

Lingula cf. *L. arctica* Miloradovich
Orbiculoidea sp.
Streptorhynchus kempei Andersson
Streptorhynchus triangularis Wiman
Derbyia cf. *D. grandis* Waagen
Chonetes (*Paeckelmannia* ?) *capitolinus* Toula
Dictyoclostus cf. *D. neoinflatus* Licharew

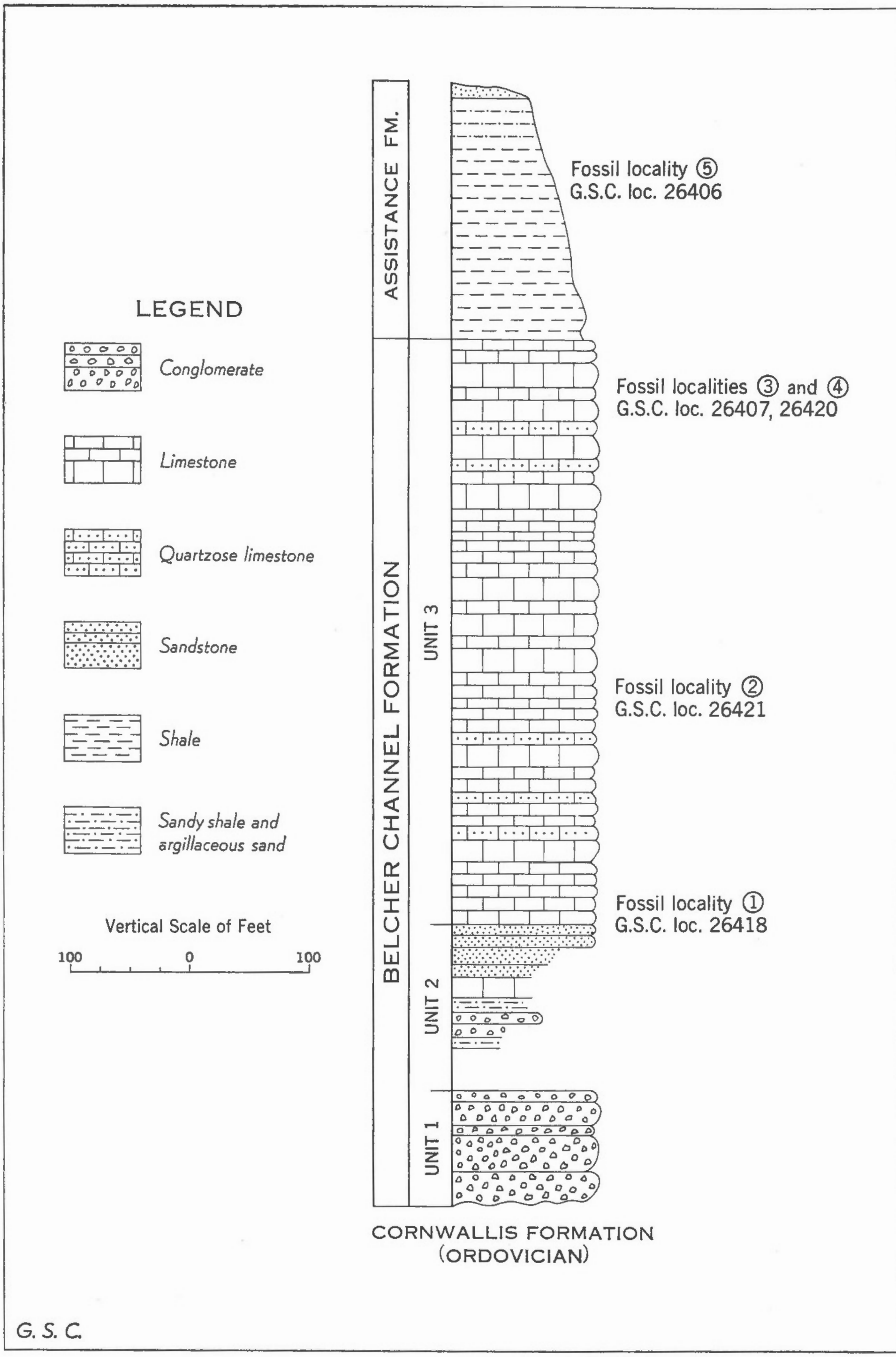

Figure 3. *Diagrammatic and composite columnar section of Belcher Channel and Assistance formations showing the stratigraphic position of fossil localities shown on geological sketch map, see Figure 2.*

Cancrinella cf. *C. germanicus* (Frebold)
Muirwoodia mammatus (Keyserling)
Kochiproductus freboldi (Stepanow)
Waagenoconcha payeri ? (Toula)
Waagenoconcha cf. *W. irginaeformis* Stepanow
Stenoscisma cf. *S. kochi* (Dunbar)
Stenoscisma plicatum (Kutorga)
Rhynchopora cf. *R. nikitini* Tschernyschew
Squamularia asiatica Chao
Spirifer osborni Harker
Spirifer striato-paradoxus Toula
Pterospirifer cf. *P. alatus* (Schlotheim)
Pterospirifer ? sp. A
Spiriferella saranae (de Verneuil)
Spiriferella keilhavii (von Buch)
Cleiothyridina cf. *C. subexpansa* (Waagen)
Dielasma cf. *D. plica* Kutorga
Pseudogastrioceras fortieri Harker
Metalegoceras sp.
Plagioglypta sp.

Age Relationships of the Permian Formations of Grinnell Peninsula

Each of the three faunules listed from the uppermost unit of the Belcher Channel formation has its own distinctive fusulinid assemblage. No single species occurs in more than one faunule.

Of the species found in the oldest faunule, *Schubertella kingi* Dunbar and Skinner has been described by Thompson (1954, p. 33) as "among the most widely distributed, both stratigraphically and geographically, of American Wolf-campian fusulinids, having been recognized from rocks of this age in California, New Mexico, Kansas, Nebraska, and in north-central Texas from lowermost to uppermost fusulinid bearing Wolfcampian rocks". *Schubertella kingi* has also been reported from rocks of Wolfcampian (early Permian) age in Japan by Kobayashi (1957, p. 267). *Pseudofusulinella utahensis* Thompson and Bissel has been described from Utah and Idaho (Thompson, Dodge and Youngquist, 1958, p. 118) in strata of Wolfcampian age. The other fusulinid species from this faunule, *Pseudoschwagerina grinnelli* is new. However, its developmental stage, whether it is considered to belong to *Pseudoschwagerina* or *Schwagerina,* is most consistent with a Wolfcampian age.

The sole fusulinid species from the middle faunule, *Schwagerina paralinearis* is new. On the basis of its seemingly close relationship with *Schwagerina linearis* Dunbar and Skinner and also with *Schwagerina prolongada* (Berry) a Wolfcampian age is suggested.

The dating of the youngest faunule, which is especially characterized by *Schwagerina hyperborea* (Salter), is difficult as none of the species is known to occur outside the Canadian Arctic. Nevertheless the stage of biological development exhibited by the new species *Schwagerina jenkinsi* and particularly by *Schwagerina hyperborea* is distinctly more advanced than that of the Wolfcampian forms and is more comparable with the Leonardian *Schwagerina* species. Moreover, a Leonard dating may be considered most consistent with *Parafusulina belcheri.* This new species, though found only in talus, is believed to occur in the topmost beds of the Belcher Channel formation. Primitive forms of *Parafusulina* are known from the Wolfcamp, but they are rare and the genus is regarded as the index fossil of the Leonard and the Lower Guadalupe of the Western United States (Thompson, 1948, p. 24). *Parafusulina belcheri* is a primitive representative of this genus.

The fusulinids provide a reasonably satisfactory means of relating the Belcher Channel faunas with the North American Permian sequence. The youngest beds present are high Wolfcamp or low in the Leonard (*see* Figure 4). An approximate correlation based on fusulinids can be made with the Cyathophyllumkalk of Spitzbergen and possibly also with the *Schwagerina*-bearing beds of the Russian sequence. Such a correlation with Spitzbergen is supported by the presence in the fauna of the Belcher Channel formation of *Caninia ovibos* (Salter), which is synonymous with *Caninia calophylloides* Holtedahl. Correlation of the Spitzbergen section with Novaya Zemlya and some of the Russian sections is well summarized in tabular form in Frebold (1951, p. 65). Staff and Wedekind (1910, p. 115) reported fusulinids from the Cyathophyllumkalk of Spitzbergen and Bear Island. These fusulinids are Permian by North American standards (Thompson, 1937, p. 123) and they are comparable in age with those from the Belcher Channel formation described in this report. The base of the Permian must therefore be placed lower than as shown by Frebold (op. cit., p. 65), and would now be placed below the beds indicated on his chart as Fusulinenkalk (*see* Figure 4). All the Belcher Channel faunas would lie within the Artinskian of the Russian sequence; whether or not the oldest subdivision of the Artinskian, the so called Sakmarian stage, is represented on Grinnell Peninsula cannot be demonstrated as there remains some uncertainty of the precise relationship of the Sakmarian to the Wolfcampian of North America.

In the Grinnell section there is some evidence of disconformity at the top of the Belcher Channel formation and it is interesting to note that a disconformity also occurs in Spitzbergen at the top of the Cyathophyllumkalk (Nathorst, 1910, p. 284). Whatever the magnitude of this disconformity, the base of the overlying Assistance formation cannot be older than late Wolfcampian or early Leonardian and is probably still within the Artinskian.

Having set this approximate lower limit, we can consider the age of the fauna of the Assistance formation. The difficulties are considerable. There are no fusulinids and the faunal content, with few exceptions, has little in common

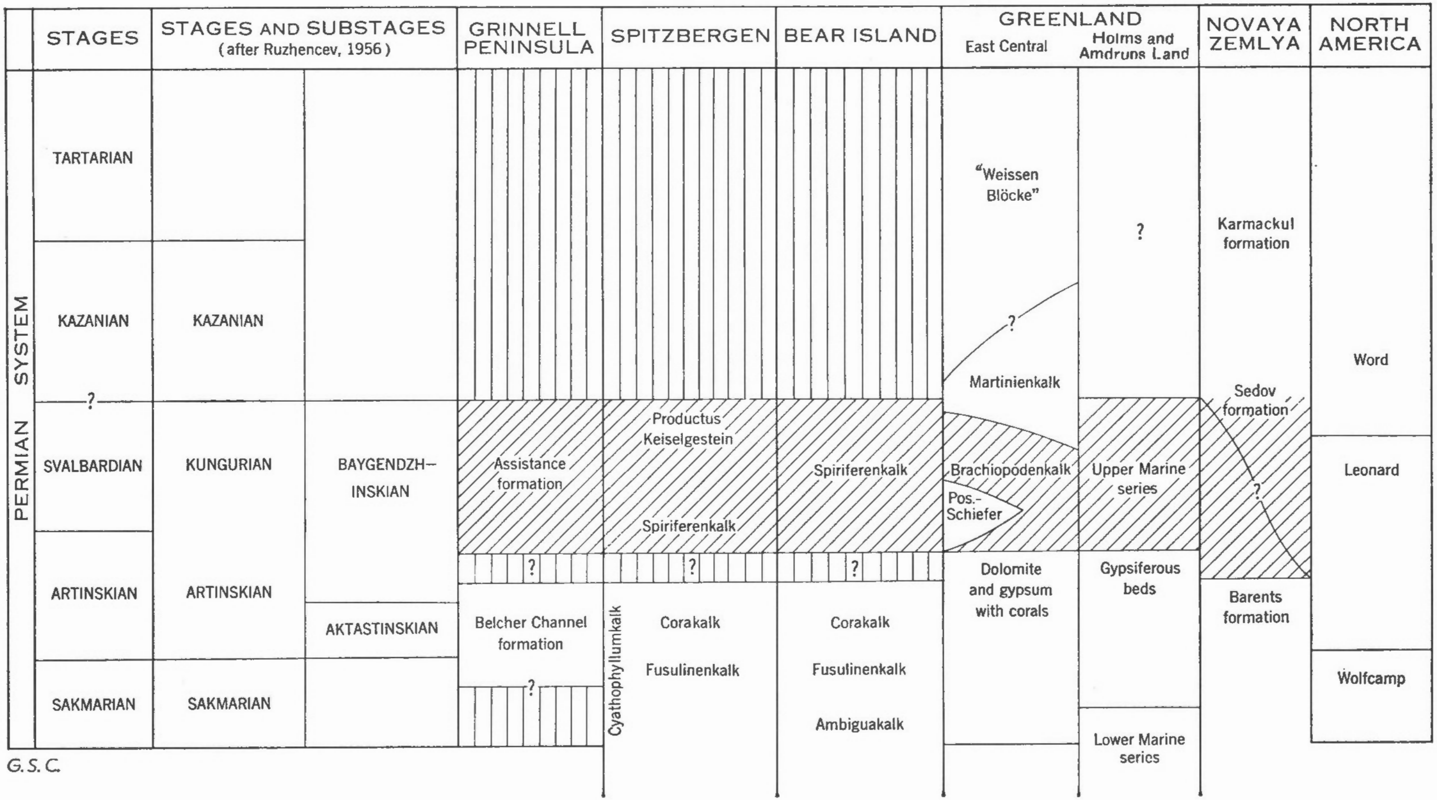

Figure 4. *Permian correlation table; some occurrences of the Arctic Permian fauna are shown by oblique shading.*

with other Permian faunas of North America. Turning to the European sections, much of the post-Artinskian Permian is represented by non-marine beds or by rather specialized faunal environments such as the Kazanian, the Zechstein, and the British Magnesian limestone formations. It becomes apparent, therefore, that a suitable scale of Permian chronology based on marine faunas is not readily available for comparison.

A fauna having many similarities with that of the Assistance formation is widespread in the boreal regions. It is especially characterized by species of the following genera: *Streptorhynchus, Derbyia, Dictyoclostus, Muirwoodia, Kochiproductus, Waagenoconcha, Stenoscisma, Rhynchopora, Pterospirifer* and *Spiriferella.* For convenience, this fauna has been referred to as the Arctic Permian fauna (Harker and Thorsteinsson, 1958, p. 1577). It occurs in the Canadian Arctic, Greenland, Bear Island, Spitzbergen, and Novaya Zemlya. Main occurrences of the Arctic Permian fauna are shown on Figure 4. Similar faunas occur in Russia and there are easily discernible similarities in the faunas of the Salt Range of Pakistan and in some of the Permian faunas of the Orient. In many of these regions there is a general overall similarity of sequence with *Parafusulina*-bearing beds beneath the rocks containing the Arctic Permian fauna.

After these preliminary generalizations it becomes necessary to determine to what extent the various occurrences of the Arctic Permian fauna are synchronous and to see whether any of them can offer evidence for dating the fauna as a whole.

Fossiliferous Permian deposits have been studied at a number of localities on the east coast of Greenland, from Scoresby Sound to Holms and Amdrups Land in the northeast corner. The faunas and the facies relationships have been discussed by Frebold in a series of papers dating from 1931 to 1951. More recently Dunbar (1955) described the Permian fauna from central East Greenland, based on collections made by various Danish field parties.

Frebold (1950, p. 73) pointed out that there were some distinct faunal differences between the faunal content of his Upper Marine series at Holms and Amdrups Land and those of central East Greenland. He mentioned particularly the rarity of *Productus timanicus* Stuckenberg in the north, the absence of *Productus weyprechti* Toula, *Productus freboldi* Stepanow and *Marginifera,* all of which are well represented in central East Greenland. Conversely, productids of the neo-inflatus group and also *Productus cancriniformis* were not then known from central East Greenland. The fauna described by Dunbar, however, includes two species of *Cancrinella,* but it also includes other forms not reported by Frebold from the north, notably perhaps species of *Liosotella.* Faunal differences do exist, but they are perhaps less important than the similarities. Frebold (op. cit., p. 74) considered that these differences could be readily rationalized as local variation in faunal content and possibly also as facies differences. He had no doubt that the fauna of his Upper Marine series was equivalent in age to the fauna of central East Greenland.

The fauna of the Assistance formation has fifteen species which are identical with or similar to those described by Dunbar from central East Greenland. They are as follows:

Derbyia sp.
Streptorhynchus kempei
Chonetina timanicus cf. *C. noe-nygaardi*
Chonetes capitolinus cf. *C. toulai*
Cancrinella germanicus
Muirwoodia sp.
Kochiproductus freboldi—K. plexicostatus
Waagenoconcha payeri
Stenoscisma kochi
Rhynchopora sp.
Spirifer striato-paradoxus
Pterospirifer alatus
Spirifer keilhavii
Cleiothyridina sp.
Dielasma sp.

Notable absentees from the Assistance fauna are species of *Marginifera, Liosotella* and the large productids of the *timanicus* group. In this respect it follows the Holms-Amdrups Land pattern but the close faunal relationships of all three regions is clearly apparent.

The fauna of the *Spirifer* limestone of Spitzbergen has been studied by Toula, Wiman, Frebold, Stepanow and others. Of the thirty-one species described and figured by Wiman (1914), eleven occur in the Assistance fauna. This number is increased to fifteen when Frebold's lists (Frebold, 1937, p. 60) are taken into account. Dunbar (1955, p. 57) showed that many of these species, and also some of those described by Wiman (1914) from Bear Island, were well represented in his faunas from central East Greenland.

The Permian fauna of Novaya Zemlya has been described by Licharew and Einor (1939). The fauna has the following forms that have identical or similar representatives in the Assistance formation:

Derbyia sp.
Chonetes capitolinus
Waagenoconcha irginaeformis
Productus cancriniformis
Camarophoria=Stenoscisma sp.
Rhynchopora nikitini var.
Neophricodothyris asiatica=Squamularia asiatica
Spirifer alatus=Pterospirifer alatus
Spirifer sp. cf. *S. osborni*

Spirifer ravana=Spirifer striato-paradoxus
Spiriferella keilhavii
Spiriferella saranae
Dielasma sp.

The close faunal similarity between the Permian of Spitzbergen, Bear Island, and Novaya Zemlya is shown in tabular form by Licharew and Einor (1939, p. 189).

There are undoubted faunal differences between the regions considered, and the age range of some of the species may be considerable. The similarities are, however, very strong and there are good reasons for supposing that the Arctic Permian fauna wherever it occurs is approximately contemporaneous. Having reached this conclusion, we can consider the various opinions as to its age in relation to the age of the fauna of the Assistance formation.

Dunbar (1955, p. 48) considered his Greenland fauna to be of Upper Permian, Zechstein age, and regarded the Zechstein fauna described by Frebold (1933) from the "White blocks" in the Triassic conglomerate at Kap Stosch as belonging to the same faunal complex. Internal evidence of Zechstein age for the brachiopod fauna is not strong, as few if any of the brachiopods are typically Zechstein. The main argument for an Upper Permian age rests on the occurrence of cyclolobid ammonites. These were first found by Frebold (1932) and later by Maync and others from the upper beds of the Martinienkalk. The stratigraphic and facies relationships of these beds were discussed by Frebold (1950, p. 73). They contain no diagnostic fossils, except for the ammonites in the uppermost beds. Dunbar (op. cit., p. 43) regarded them as facies equivalents of the main brachiopod-bearing beds; their age, however, remains undemonstrated. The late Permian age of the Greenland ammonites was suggested by Miller and Furnish (1940, p. 6). This opinion was based on their general similarity with species from the Salt Range and elsewhere that have been regarded as Upper Permian. Cyclolobids range through the Middle and Upper Permian, Miller and Furnish (op. cit., p. 6) stated: "The sutures (of the Greenland forms) are somewhat more primitive than those of typical representatives of *Cyclolobus*". It would seem, therefore, that a late Permian age is not proved beyond doubt and whatever conclusions of age can be drawn from the ammonites, the dating would only refer to the upper beds of the Martinienkalk and would not necessarily be applicable to the Arctic Permian fauna as a whole.

Frebold (1950, p. 58, etc.), and Licharew and Einor (1939, p. 224) considered the Arctic Permian fauna to be Lower Permian. As already shown in this report the fauna of the Belcher Channel formation includes beds of fairly late Artinskian age. If we are to set aside the Zechstein age for the Arctic Permian fauna as being unproven, its possible age range is considerably reduced and the stratigraphic position of the Assistance formation becomes clearer.

In a correlation chart of the Permian, based on ammonoid occurrences, Ruzhencev (1956, p. 34) shows the Artinskian together with the non-marine Kungurian as equivalent to two substages based on ammonite faunas, a younger

Baygendzhinskian and an older Aktastinskian. He considers the North American affinities of the Baygendzhinskian to be with the Leonard. The two ammonites from the Assistance formation are similar to two forms that occur in the younger of these two substages, namely *Uraloceras suessi* (Karpinsky) and *Metalegoceras sogurense razumowskajae* (Voinova). Both forms have distinct Lower Permian affinities. We are faced then with the dilemma of having to include a major and widespread Permian fauna within the Lower Permian having already disposed of much of the Lower Permian to the Belcher Channel formation and to the disconformity that separates it from the overlying Assistance formation with its Arctic Permian fauna.

In a recent paper, D. L. Stepanow (1957, p. 20) resolved some of these difficulties. He proposed a new Permian stage, the Svalbardian, typified by the Spiriferenkalk of Spitzbergen. This new stage is the marine equivalent of the Kungurian and is defined as lying between the marine Artinskian and the marine, Upper Permian Kazanian. Further studies may show its relationships with the Baygendzhinskian of Ruzhencev. By referring the Arctic Permian fauna to the Svalbardian the fauna takes its rightful place as an important stage of Permian chronology and it is no longer necessary to make forced correlations with either the older Artinskian or the younger Zechstein or Kazanian faunas.

Correlation with Western Canada and Alaska

Permian fossils have been found in many parts of British Columbia and also in the Yukon. In British Columbia the Permian deposits have been generally assigned to the Cache Creek group, a name first introduced by Selwyn in 1872. The Cache Creek faunas are scanty and poorly preserved but they include species of *Spiriferella, Stenoscisma,* and productids. Crockford and Warren (1935, p. 160) showed that the relationship of the Cache Creek fauna is with Russia and China rather than with the Texas Permian faunas. Species of *Schubertella, Schwagerina, Pseudoschwagerina,* and *Parafusulina* have been reported from British Columbia (Thompson, Wheeler and Danner, 1950, p. 47). A part of the British Columbia Permian succession must therefore have been deposited at the same time as the Belcher Channel formation.

Farther north, the faunal relationships with the Arctic Permian fauna are more definite. Several collections have been made by J. E. Muller of the Geological Survey of Canada in the northeastern front ranges of the St. Elias mountains, Yukon. The collections include: *Caninia* aff. *C. ovibos* (Salter), *Derbyia* sp., *Dictyoclostus* sp., *Kochiproductus* cf. *K. freboldi* (Stepanow), *Waagenoconcha* sp., *Muirwoodia* ?, *Stenoscisma* sp., *Rhynchopora* sp., *Squamularia* sp., *Spiriferella* cf. *S. keilhavii* (von Buch). With the exception of *Caninia ovibos,* which occurs in the Belcher Channel formation, this fauna can be readily identified with the fossils of the Assistance formation.

The Permian rocks of the Yukon extend into Alaska and, although there has been no recent work on the Permian fossils of Alaska, there are published faunal lists that can be interpreted in terms of the faunal content of the Belcher Channel and Assistance formations.

Moffit (1954, pp. 116-117) lists an extensive fauna from the Alaska Range which was studied by Schuchert and later revised by Girty. Girty (*in* Moffit, 1954) concluded that the fauna is closely related to the Permian of Russia. The list contains many names that suggest a close similarity with the Arctic Permian fauna. Collections from the Chitna Valley made over a period of 30 years by Moffit and others, are listed in an earlier report by Moffit (1938, p. 36). These faunas were examined by Girty who dated them as Permian. Again the similarities with the Assistance formation are very pronounced. It is interesting to see that *Zaphrentis* cf. *Z. ovibos* together with several species of *Clisiophyllum* and two species of *Lithostrotion,* including *L. portlocki,* is listed. The occurrence of these corals, in addition to elements of the Arctic Permian fauna of the Assistance formation, suggests that strata equivalent to the Belcher Channel are represented.

The palæogeographic relationships of the Permian seas of the Arctic with those of the Western Cordillera cannot yet be clearly defined. However, the occurrence of common faunal elements suggests a fairly free marine connection. The well-preserved, and relatively easily datable, Permian faunas of the Arctic islands may well provide some basis of Permian geochronology, applicable to the Permian deposits of the western mainland.

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Part II

PERMIAN FUSULINIDS OF GRINNELL PENINSULA

R. Thorsteinsson

Introduction

This account describes the Permian fusulinids from the Belcher Channel formation collected by the writer in 1955. The redescription of *Schwagerina hyperborea* (Salter) is partly based on paratype material studied by Salter from the Belcher collection in the British Museum (Natural History) London. Grateful acknowledgment is made to Dr. R. H. Hedley of the British Museum (Natural History) who arranged for the loan of these specimens and for permission for them to be sectioned in Ottawa. Thanks are also due to Dr. M. L. Thompson of the Illinois State Geological Survey for helpful suggestions during the preparation of this report.

Lists of Species

Genus *Schubertella* Staff and Wedekind

Schubertella kingi Dunbar and Skinner

Genus *Pseudofusulinella* Thompson

Pseudofusulinella utahensis Thompson and Bissel

Genus *Schwagerina* Möller

Schwagerina paralinearis n. sp.

Schwagerina jenkinsi n. sp.

Schwagerina hyperborea (Salter)

Genus *Pseudoschwagerina* Dunbar and Skinner

Pseudoschwagerina grinnelli n. sp.

Genus *Parafusulina* Dunbar and Skinner

Parafusulina belcheri n. sp.

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Systematic Descriptions

Family FUSULINIDAE

Subfamily SCHUBERTELLINAE Skinner 1931

Genus *Schubertella* Staff and Wedekind 1910

Schubertella kingi Dunbar and Skinner

Plate II, figures 1-8

1937 *Schubertella kingi* DUNBAR and SKINNER, p. 610, pl. 45, figs. 10-15.
1946 *Schubertella kingi* Dunbar and Skinner. THOMPSON and WHEELER, p. 24, pl. 8, figs. 6-10.
1946 *Schubertella kingi* Dunbar and Skinner. THOMPSON and HAZZARD, p. 40, pl. 10, figs. 1-9.
1954 *Schubertella kingi* Dunbar and Skinner. THOMPSON, p. 33, pl. 5, figs. 11-42; pl. 7, figs. 11-13.
1957 *Schubertella kingi* Dunbar and Skinner. KOBAYASHI, p. 262, pl. 1, figs. 6-8.

Description. The shell is minute and in shape varies from elongate fusiform with bluntly pointed polar extremities to suboval. The axis of coiling is straight to gently curved. Mature specimens comprise four to five volutions. The first two volutions attain a diameter of about 90 to 120 microns, and are coiled approximately at right angles to the outer volutions. Two mature specimens elongate fusiform in shape, measured 1.12 mm and 1.2 mm in length, and 0.39 mm and 0.54 mm in width, respectively. Their form ratios are 2.8 and 2.3. Average form ratios of the third to the fifth volution in these two specimens are 2.3, 2.6, and 3.2.

The proloculus is minute; outside diameter measurement in three specimens, 33, 33, and 49 microns. The heights of the first four volutions in one specimen are 16, 24, 41, and 58 microns. Average heights of the third to the fifth volution in four specimens are 34, 54, and 72 microns.

The septa are unfluted throughout and vary in number from about seven in the first volution to about twenty in the fifth.

The spirotheca of the volutions outside of the juvenarium consists of two layers, an upper tectum and lower diaphanotheca. The average thicknesses of the spirotheca in the third and fourth volutions of four specimens are 7.5 and 9 microns. The spirotheca of the juvenile part of the shell is too thin for study or accurate measurements.

The tunnel is clearly visible in the later volutions where it is about one half as high as the chambers. The average tunnel angles in the third to the fifth volution in three specimens are 21, 30, and 42 degrees. The chomata are highly asymmetrical with steep to overhanging tunnel sides and sloping poleward extensions.

Measurements of *Schubertella kingi* from the Belcher Channel formation are shown in Table I, page 31.

Discussion. The specimens of *Schubertella kingi* from the Belcher Channel formation are similar to those described from widely separated localities in the United States, as well as from Japan. The apparently larger dimensions of some of the Arctic forms may be a direct result of their occurrence in hard, coarsely crystalline limestone. From this matrix specimens could not be freed and well-oriented sections were difficult to obtain. This necessitated the detection of specimens in thin sawed slices, and only the larger specimens were readily observed.

Occurrence. *Schubertella kingi* (GSC locality 26418) occurs sparingly with *Pseudofusulinella utahensis* Thompson and Bissel and *Pseudoschwagerina grinnelli* n. sp. These three fusulinids occur in the basal 8 feet of unit 3 in the Belcher Channel formation.

Subfamily FUSULININAE Möller 1878

Genus ***Pseudofusulinella*** Thompson 1951

Pseudofusulinella utahensis Thompson and Bissel 1954

Plate II, figures 9, 10; Plate III, figures 1-6

1954 *Pseudofusulinella utahensis* THOMPSON and BISSEL, p. 34, pl. 7, figs. 1-10.
1958 *Pseudofusulinella utahensis* Thompson and Bissel. THOMPSON, DODGE and YOUNGQUIST, p. 118, pl. 18, figs. 1-8.

Description. The shell is small, inflated fusiform with extended and narrowly rounded polar extremities, and concave lateral slopes. The axis of coiling is almost straight to slightly irregular. Mature shells of five and a half to six and a half volutions are 4.5 to 7.5 mm long and 1.5 to 2.4 mm wide, giving form ratios of 2.6 to 3. The inner three volutions have short axes of coiling and are subspherical in shape. In succeeding volutions the polar extremities are progressively extended with distinct concavities developed along the lateral slopes. The average form ratios of the first to the sixth volution in six specimens are 1.9, 1.9, 1.9, 2.1, 2.4, and 2.8.

The proloculus is small and generally spherical, but in a few specimens it is somewhat oval in shape. The outside diameters of the proloculus in ten specimens measure 74 to 190 microns and average 120 microns. The chambers are lowest above the tunnel and increase in height towards the poles. Average chamber heights from the first to the sixth volution in ten specimens are 51, 90, 112, 151, 237, and 243 microns.

The spirotheca consists of a thin tectum and lower clear layer in which pores are not evident. Average thicknesses of the spirotheca in the first to the sixth volution in six specimens are 10, 11, 25, 25, 26, and 31 microns.

The septa are fluted in the polar regions of the shell but plane across the central region. Average septal counts of the first to the sixth volution in three specimens are 9, 12, 15, 18, 21, and 23.

The tunnel is narrow in the inner volutions and widens in the outer volutions. The tunnel angles in the first to the sixth volution in six specimens average 11, 12, 12, 15, 22, and 25 degrees. The tunnel has a straight to slightly irregular path. The chomata are massive with steep overhanging tunnel margins and moderately steep polar sides. The chomata extend to one half or two thirds of the height of the chambers except along the septa where they may reach the tops of the chambers.

Measurements of *Pseudofusulinella utahensis* from the Belcher Channel formation are shown in Table II, page 32.

Discussion. Specimens of *Pseudofusulinella utahensis* from Grinnell Peninsula are similar to some of those described from the western United States. There are, however, some slight morphological differences. The Grinnell Peninsula specimens apparently never attain more than six and a half volutions whereas specimens with up to nine volutions have been described from Idaho (Thompson, *et al.,* 1958, p. 118). Moreover, certain of the Grinnell Peninsula forms are characterized by more inflated inner volutions and some specimens have larger proloculi than those from the western United States. Nevertheless, the measurable characters of most Arctic and United States forms of this species are almost identical.

Occurrence. Pseudofusulinella utahensis (GSC locality 26418) is associated sparingly with *Pseudoschwagerina grinnelli* n. sp. and *Schubertella kingi* in basal beds of unit 3 of the Belcher Channel formation.

Subfamily SCHWAGERININAE Dunbar and Henbest 1930

Genus *Schwagerina* Möller 1877

Schwagerina paralinearis n. sp.

Plate IV, figures 1-8

Description. The shell of *Schwagerina paralinearis* is highly elongate subcylindrical with straight to gently convex lateral slopes and rounded polar extremities. The axis of coiling is straight to generally irregular. Mature specimens of five to six and a half volutions are 8 to 11.5 mm in length and 1.5 to 2 mm in width, giving form ratios of 4.4 to 6. The inner volutions are elongate fusiform and it is only with the development of the fifth or sixth volution that the elongate subcylindrical shape is obtained. Average form ratios from the first to the sixth volution in five specimens are 2.6, 3.2, 4.0, 4.7, 5.0, and 5.0.

The proloculus is of moderate size; the outside diameter varies from about 130 to 230 microns. The average size of the proloculus in eight specimens is 180 microns. The proloculus is commonly irregular in shape and its wall is about 12 microns thick. Average heights of the chambers above the tunnel from the first to the sixth volution in seven specimens are 54, 86, 111, 161, 206, and 251 microns.

The spirotheca increases gradually in thickness; average thicknesses of the first to the sixth volution in seven specimens are 17, 23, 34, 49, 56, and 73 microns. The spirotheca consists of a distinct tectum and alveolar keriotheca.

In the polar extremities the septa are narrowly and irregularly fluted to their upper borders but across the central regions fluting is low and regular. Average septal counts of the first to the sixth volution in two specimens are 9, 14, 15, 16, 16, and 20.

The tunnel is generally high, especially in the outer three or four volutions where it appears to be about one half to two thirds of the height of the chambers. Averages of tunnel angles in the first to the fifth volution in five specimens are 21, 29, 48, 61, and 63 degrees. Chomata occur throughout the shell but are low and discontinuous in the outer volutions. Light axial fillings occur but are inconstant and irregular.

Measurements of this species are shown in Table III, page 33.

Discussion. *Schwagerina paralinearis* bears a close resemblance to *Schwagerina linearis* described by Dunbar and Skinner (1937, p. 637) from the Wolfcamp and Hueco formations of the southwestern United States. *S. paralinearis* may be distinguished from *S. linearis* by its lighter and more variable axial fillings, the presence of chomata and by its generally smaller size. *S. paralinearis* appears to be also very close to *S. prolongada* (Berry) from strata of Wolfcampian age in South America and which Dunbar and Newell (1946, p. 458) suggested may be only a varietal form of *S. linearis.*

Occurrence. This species is very abundant in a zone about 170 feet above the base of unit 3 of the Belcher Channel formation. (GSC locality 26421.)

Schwagerina jenkinsi n. sp.

Plate IV, figures 9-12; Plate V, figures 1-4

Description. The shell of *Schwagerina jenkinsi* is large. The axial profile varies from highly elongate fusiform to subcylindrical with bluntly rounded poles. The axis of coiling is broadly arched to straight. The holotype (Pl. V, fig. 1) is 13.5 mm long and 3.0 mm wide. Four specimens, including the holotype, of five to six and a half volutions have lengths of 11 to 13.5 mm and widths of 2.2 to 3.0 mm with form ratios varying from 4 to 5. Average form ratios of the first to the sixth volutions in four specimens are 2.7, 3.2, 4.1, 4.4, 4.6, and 4.3.

The proloculus is of moderate size and round to oblong in shape. It has an outside diameter that varies from 168 to 273 microns and averages 220 microns in six specimens. Average heights of chambers over the tunnel in the first to the sixth volutions in six specimens are 92, 132, 189, 266, 353, and 365 microns. The chambers are lowest over the tunnel. They increase gradually in height towards the polar extremities and this results in the general subcylindrical shape of the shell.

The spirotheca is moderately thick, rather finely alveolar and of uniform thickness throughout the shell length. Average thicknesses of the spirotheca from the first to the sixth volution in six specimens are 27, 41, 58, 81, 83, and 83 microns.

The septa are narrowly and fairly uniformly fluted throughout the central region of the shell, with the fluting extending nearly to the tops of the chambers to form closed chamberlets. In the polar regions the septa are irregularly and narrowly fluted throughout the length of the chambers. Average septal counts of the first to the sixth volution in two specimens are 11, 18, 22, 26, 27, and 32.

The tunnel is inconspicuous in axial sections because chomata are lacking on all but the inner one or two volutions. Nevertheless where the tunnel can be approximately made out it appears to be almost straight. Average tunnel angles in the first to the fourth volution in four specimens are 22, 28, 33, and 35 degrees. Dense calcite fills the chambers in the axial region of the inner second to fourth volutions.

Measurements of *Schwagerina jenkinsi* are given in Table IV, page 34.

Discussion. Schwagerina jenkinsi is probably related to *S. campensis* Thompson (1954, p. 57), *S. pinosensis* Thompson (op. cit., p. 58), *S. turki* (Skinner) (*see* Thompson, op. cit., p. 57), and *S. longissimoidea* (Beede) (*see* Thompson, op. cit., p. 58), although it seems to be somewhat more biologically advanced. These are all long and slender *Schwagerinas* that appear to form a distinctive species group within the genus *Schwagerina*. *S. jenkinsi* may be readily distinguished from *S. campensis* by its generally larger dimensions and difference in the form ratios of the volutions. In size, proportions, and other characters, *S. jenkinsi* appears to be related to *Parafusulina* (?) *lutungi* Schellwien as described by Gvosdilova (1938, p. 128). The lack of cuniculi in *S. jenkinsi,* however, readily distinguished it from *Parafusulina* (?) *lutungi.*

This species is named for Mr. Jenkins (*see* Belcher, 1855, vol. II, p. 212), who rendered able assistance to Captain Sir Edward Belcher during his exploration of the north coast of Grinnell Peninsula.

Occurrence. Schwagerina jenkinsi (GSC localities 26421 and 26407) occurs some 3 feet stratigraphically higher than *S. hyperborea* in the uppermost beds of the Belcher Channel formation (*see* Pl. I B).

Schwagerina hyperborea (Salter)

Plate VI, figures 1-6; Plate VII, figures 1-3

1855 *Fusulina hyperborea* SALTER, p. 380, pl. 36, figs. 1-3.

Description. Schwagerina hyperborea is a large fusulinid with an elongate fusiform, but more commonly subcylindrical, profile. The polar extremities are bluntly pointed to broadly rounded and the axis of coiling is generally irregular. Mature specimens of six volutions are 12.1 to 15 mm in length and 2.6 to 3.5 mm in width giving form ratios of 3.8 to 5. Average form ratios of the first to the sixth volution in six specimens are 2.4, 2.9, 3.6, 4.6, 4.9, and 4.7.

The proloculus is of average size and commonly subrounded. In six specimens the outside diameter varies from 190 to 273 microns and averages 227 microns. The chambers are lowest over the tunnel. Poleward expansions commonly occur in the outer one to three volutions and produce a constriction over the tunnel that imparts a distinct peanut-shape to many specimens. Average heights of chambers over the tunnel in the first to the sixth volution in eight specimens are 77, 99, 189, 252, 364, and 503 microns.

The alveoli of the spirotheca are of average density. The spirotheca increases considerably in thickness from the first to the last volutions in mature specimens. Average thicknesses from the first to the sixth volution in eight specimens are 23, 32, 52, 65, 99, and 108.

The fluting of the septa is high and narrow throughout the chambers and two distinct sets of salients of the fluting intersect in the outer volutions of some axial sections. Closed chamberlets extend to above the tunnel. Average septal counts of the first to the sixth volution in two specimens are 13, 21, 24, 26, 29, and 32. Of the many tangential sections that were examined cuniculi were observed in only one specimen. These cuniculi are low and narrow and are illustrated as figure 1 of Plate VI. As cuniculi do not appear to be a persistent character, this species is referred to the genus *Schwagerina* rather than *Parafusulina.*

Low and inconspicuous chomata occur on the inner one or two chambers only. Where it can be seen, the tunnel is low, narrow and slightly irregular. Average tunnel angles of the first to the fifth volution in six specimens are 14, 20, 25, 27, and 42 degrees. Secondary calcite fillings are located in the polar axial regions of all but the last one to three volutions.

Measurements of this species are given in Table V, page 35.

Discussion. Schwagerina hyperborea was originally described as *Fusulina hyperborea* by Salter from material collected by Belcher on the north coast of Grinnell Peninsula. Salter's type specimen bears the number P651 in the British Museum (personal communication from Dr. R. H. Hedley) but it has not been seen by the writer. However, some specimens, stated to be paratype material of *'Fusulina' hyperborea* from Belcher's original collection were loaned by the authorities of the British Museum (Natural History) and have been included in the present study. They are illustrated as figures 3 and 4 on Plate VI and figure 2 on Plate VII. Belcher's collection of *Schwagerina hyperborea* was obtained from loose blocks at Depot Point which is some 6 miles from the place where the writer collected *Schwagerina hyperborea.* It is very probable that the specimens of *Schwagerina hyperborea* collected by Belcher and by the writer came from the same stratum of limestone. Not only are the fossils identical but they occur in both instances in a similar and quite distinctive rock matrix.

Dunbar and Skinner (1937, p. 654), in their description of *Schwagerina setum,* discussed the resemblance of that form to *Schwagerina hyperborea.* It is now possible to give a more detailed comparison of these two rather specialized *Schwagerinas.* Although these two forms closely resemble each other in general shell features, including an axial constriction, *Schwagerina hyperborea* may be distinguished by its smaller adult size, smaller number of volutions and wider salients of the fluting.

Occurrence. *Schwagerina hyperborea* (GSC localities 26420 and 26407) occurs in the upper beds of the Belcher Channel formation where it appears to form a separate zone some 3 feet below *S. jenkinsi.*

Genus *Pseudoschwagerina* Dunbar and Skinner 1936

Pseudoschwagerina grinnelli n. sp.

Plate VII, figures 4-8; Plate VIII, figures 1-8

Description. The shell is of medium size. In profile it varies from subglobular, to inflated fusiform with bluntly pointed poles, to subcylindrical with bluntly rounded poles and gently convex lateral slopes. The holotype, illustrated as figure 6 on Plate VII, is 8 mm long and 2.58 mm wide. Eight mature specimens including the holotype vary from 5.3 to 8 mm in length and 1.7 to 2.6 mm in width, giving form ratios of 2.2 to 3.4. The poles of the first one or two volutions are commonly pointed whereas those of succeeding volutions are bluntly rounded. Average form ratios of the first to the fifth volution in eight specimens are 1.8, 1.9, 2.3, 2.8, and 2.9.

The proloculus varies considerably in outside diameter among different specimens, measurements range between 189 to 462 microns and the average for twelve specimens was 285 microns. The proloculus is generally round to subround but in a few specimens it was highly irregular (Pl. VII, fig. 5). Average heights of the chambers in the first to the fifth volution in twelve specimens are 104, 163, 229, 273, and 273 microns. The height of the chambers is generally lowest over the tunnel and expands in the direction of the poles.

The spirotheca is moderately thick with a well-defined tectum and keriotheca that is coarsely alveolar. Average thicknesses of the spirotheca in the first to the fifth volution in ten specimens are 30, 42, 57, 74, and 67 microns.

The septa are narrowly fluted to their tops across the axial region of the shell but appear to be much more intense and irregular in the end thirds of the shell. Cuniculi were observed in only one specimen assigned to this species (Pl. VIII, fig. 8). The septal counts of the first to the fifth volution in four specimens are 12, 22, 23, 25, and 24.

The tunnel is somewhat irregular, especially in the innermost chambers. It is narrow in the inner parts of the shell but widens rapidly in the outer volutions. Chomata with steep to overhanging tunnel slopes and steep poleward slopes are conspicuous in the inner two or three chambers where these deposits extend to about one half the height of the chambers. In the outer volution they are irregular deposits on the septa that extend to the tops of the chambers and laterally along the sides of the septa. Average tunnel angles in the first to the fourth volution of eight specimens are 19, 24, 35, and 50 degrees.

Measurements of this species are given in Table VI, page 36.

Discussion. There is considerable individual variation in specimens assigned to *Pseudoschwagerina grinnelli.* Certain forms possess characters that ally them most closely with *Schwagerina* (e.g. Pl. VIII, fig. 7) whereas others are more typically *Pseudoschwagerina* (e.g. Pl. VIII, fig. 4). However, in the abundant material at hand a complete gradational series of forms can be demonstrated between these two extremes. *P. grinnelli* does not closely resemble typical members of the genus *Pseudoschwagerina.* However, the large proloculus, somewhat tightly coiled inner volutions, and the fact that the height of the outer volution is commonly equal to, if not lower than, the penultimate, seem ample justification for its inclusion in the genus *Pseudoschwagerina.*

The variable characters of *Pseudoschwagerina grinnelli* serve to distinguish it from other species of *Pseudoschwagerina. P. grinnelli* may be readily distinguished from *P. texana* Dunbar and Skinner (1937, p. 662) by its smaller numbers of volutions, greater variations in form and size of the proloculus and generally smaller size at maturity.

Occurrence. Pseudoschwagerina grinnelli (GSC locality 26418) occurs abundantly throughout 8 feet of limestone beds that form the basal beds of unit 3 of the Belcher Channel formation. It is found in association with *Schubertella kingi* Dunbar and Skinner and *Pseudofusulinella utahensis* Thompson and Bissel.

Genus *Parafusulina* Dunbar and Skinner 1931

Parafusulina belcheri n. sp.

Plate IX, figures 1-5; Plate X, figures 1-5

Description. The shell of *Parafusulina belcheri* is large and elongate subcylindrical to highly elongate fusiform with a straight to slightly irregular axis of coiling and rounded to bluntly pointed polar extremities. The holotype (Pl. IX, fig. 5) is 12.1 mm long and 3.2 mm wide; its form ratio is 3.8. Six paratype specimens characterized by six to seven volutions are 9.7 mm to 13.5 mm in length and 3 mm to 3.9 mm in width, giving form ratios of 3 to 3.8. Average form ratios of the first to the seventh volution in six specimens including the holotype are 2, 2.5, 2.8, 3, 3.5, 3.3, and 3.6. These figures show that the form ratio increases almost uniformly for the first three volutions but increases slowly in the outer three.

The proloculus is small and not uncommonly irregular. The outside diameter of ten specimens varies from 147 microns to 273 microns and averages 204 microns. The chambers are lowest above the tunnel and increase in height uniformly towards the polar ends. Average heights of the chambers above the tunnel in the first to the seventh volution in nine specimens are 80, 139, 195, 269, 291, 329, and 340 microns. In some specimens there is a slight constriction of outermost chambers over the tunnel.

The spirotheca is moderately thin with a well-defined tectum and keriotheca. Average thicknesses of the spirotheca in the first to the seventh volution in nine specimens are 20, 37, 46, 68, 79, 91, and 95 microns.

The septa are narrowly fluted throughout the length of the shell in all volutions. The fluting extends to the tops of the chambers. Two sets of salients of the septal folds are commonly developed in the outer five or six chambers. The average septal counts of the first to the seventh volution in three specimens are 12, 15, 18, 21, 24, 28, and 28. Low and narrow cuniculi are developed in, at least, the outer two to three volutions.

The tunnel varies from irregular to almost straight and is commonly difficult to make out in axial sections because chomata are developed on the inner one or two volutions only. Average tunnel angles of the first to the sixth volution in five specimens are 18, 24, 39, 37, 56, and 57 degrees.

Measurements of *Parafusulina belcheri* are given in Table VII, page 37.

Discussion. This species is referred to the genus *Parafusulina* mainly on the presence of cuniculi. The cuniculi are low and narrow and are visible only in certain favourably oriented parallel sections. The general character of the shell including the absence of axial filling and rather small and generally spherical proloculus are characters mostly consistent with the genus *Schwagerina.* This species is presumably a primitive representative of the genus *Parafusulina.*

P. belcheri closely resembles *P. apiculata* Knight (1956, p. 785), but is distinguished from that species by its larger size, generally subcylindrical shell and by the absence of axial fillings.

This species is named in honour of Captain Sir Edward Belcher who in 1853 was the first to collect fusulinids in the Canadian Arctic Archipelago.

Occurrence. This form was collected in talus only (GSC locality 26419) near the locality where *S. hyperborea* and *S. jenkinsi* were collected from bedrock. The rock in which *P. belcheri* occurs is a greenish grey calcareous sandstone which is a common rock in the upper part of the Belcher Channel formation and quite unlike the unconsolidated materials of the overlying Assistance formation.

Table I

Measurements of Schubertella kingi *Dunbar and Skinner*

(in millimetres)

Specimen	L	W	R	Diam. of prol.	Height of volutions					Form ratio of volutions				
					V1	V2	V3	V4	V5	V1	V2	V3	V4	V5
13909	1.12	.39	2.8	.033	.016	.024	.041	.058	—	—	—	2.7	2.8	—
13910	1.2	.54?	2.3	—	—	—	.025	.045	.074	—	—	2	2.5	3.2
13911	—	—	—	.033	—	—	.028	.055	.070	—	—	1.3?	2.6?	2.4?
13912	—	—	—	.049	—	—	—	—	—	—	—	—	—	—
13913	—	3.7	—	—	—	—	.041	.058	—	—	—	—	—	—

Specimen	Thickness of spirotheca					Septal count					Tunnel angle (degrees)				
	V1	V2	V3	V4	V5	V1	V2	V3	V4	V5	V1	V2	V3	V4	V5
13909	—	—	.007	.008	—	7?	11?	—	—	—	—	—	20	35	—
13910	—	—	.007	.008	.009	—	—	—	—	—	—	—	24	22	44?
13911	.009?	.007?	.008	.008	—	8?	—	—	—	—	—	—	20	33	41
13912	—	—	—	—	—	10?	13?	17?	20	—	—	—	—	—	—
13913	—	—	.008	.012	—	—	—	10	19	20	—	—	—	—	—

Table II

Measurements of Pseudofusulinella utahensis *Thompson and Bissel 1954*

(in millimetres)

Specimen	L	W	R	Diam. of prol.	Height of volutions						Form ratio of volutions					
					V1	V2	V3	V4	V5	V6	V1	V2	V3	V4	V5	V6
13917	4.5	1.5	3	.094	.041	.063	.105?	.136	.147	.273	2	2	2	2.4	3	3
13918	4.7	1.9	2.6	.168	.066	.09	.147	.189	.252	—	2	1.9	2	2.1	2.2	—
13919	5	1.6	3	.126	.049?	.083	.126	.168	.210	—	2	2	2.1	2.2	2.3	—
13920	5.4	2.1	2.6	.190	.057?	.091	.116	.147	.200	.190	2	1.8	2	2	2.3	2.5
13921	6	2.1	3	.10?	.066	.107	.141	.182	.210	.250	1.7	2	1.6	2.2	2.3	3
13922	7.5	2.4	3	.150	—	.10	.147	.210	.270	.250	1.6	2	2	2	2.6	2.6
13923	—	.5	—	.084	.049	.066	.083	—	—	—	—	—	—	—	—	—
13924	—	.73	—	.074	—	.049	.083	.10	—	—	—	—	—	—	—	—
13925	—	1.42	—	.094	—	—	.084	.115	.180	—	—	—	—	—	—	—
13926	—	.71	—	.10	.033	.63	.083	.116	—	—	—	—	—	—	—	—

Specimen	Thickness of spirotheca						Septal count						Tunnel angle (degrees)					
	V1	V2	V3	V4	V5	V6	V1	V2	V3	V4	V5	V6	V1	V2	V3	V4	V5	V6
13917	—	—	—	.016?	.020	.033	—	—	—	—	—	—	9	14	14	21	21	—
13918	.008	.012	.016	.024	.041	—	—	—	—	—	—	—	15	11	13	8	25	—
13919	—	.008?	.012?	.016	.024	—	—	—	—	—	—	—	10	12	14	16	25	30
13920	—	.012	.066?	.066	.024	.033	—	—	—	—	—	—	13	10	14	16	18	23
13921	.012?	.016	.016	.016	.024	.024	—	—	—	—	—	—	11	13	17	16	—	23
13922	—	.010?	.016	.020	.024	.033	—	—	—	—	—	—	—	12	13	15	24	31
13923	—	—	—	—	—	—	10	12	18	—	—	—	—	—	—	—	—	—
13924	—	—	—	—	—	—	7?	10	14	17	—	—	—	—	—	—	—	—
13925	—	—	—	—	—	—	11	13	14	20	21	23	—	—	—	—	—	—
13926	—	—	—	—	—	—	9	13	16	18	—	—	—	—	—	—	—	—

Table III

Measurements of Schwagerina paralinearis *n. sp.*

(in millimetres)

Specimen	L	W	R	Diam. of prol.	Height of volutions						Form ratio of volutions					
					V1	V2	V3	V4	V5	V6	V1	V2	V3	V4	V5	V6
13931	11.5	1.9	6	.190?	.042	.94	.100	.147	.22	.23	3.1	3.3	4.4	5.2	5.4	6
13932	8	1.6?	5?	.215	.063	.105	.150	.231	—	—	2.9	3.7	4.4	5	5?	—
13933	8	1.6?	5	.231	.084	.105	.136	.178	.21	—	2.7	3	4.5	5	5?	—
13934	8	1.8	4.4	.149	.049	.083	.105	.175	.21	.273	2.1	3	3.3	4	5	4.4
13935	9.2	2	4.5	.130	.057	.090	.126	.147	.230	.315	2.3	2.9	3.4	4.4	4.8	4.5
13936	—	1.9	—	.170	.040	.063	.080	.126	.21	.25?	—	—	—	—	—	—
13937	—	1.5	—	.168	.042	.063	.084	.126	.157	.190	—	—	—	—	—	—

Specimen	Thickness of spirotheca						Septal count						Tunnel angle (degrees)					
	V1	V2	V3	V4	V5	V6	V1	V2	V3	V4	V5	V6	V1	V2	V3	V4	V5	V6
13931	.024	.033	.033	.058	.066	.066	—	—	—	—	—	—	30	40	70	74	—	—
13932	.025	.033	.041	.058	(?)	—	—	—	—	—	—	—	20	20	40	71	—	—
13933	.016	.033	.041	.058	—	—	—	—	—	—	—	—	16	23	44	50	58	—
13934	.016	.016	.030	.041	.066	.074	—	—	—	—	—	—	17	23	40	51	71	—
13935	.014	.016	.041	.050	.050	.074	—	—	—	—	—	—	25	23	30	58	60	—
13936	.012	.016	.030	.045	.058	.074	10	14	15	17	17	22	—	—	—	—	—	—
13937	.016	.016	.024	.033	.041	.80?	9	14	16	15	16	19	—	—	—	—	—	—

Table IV

Measurements of Schwagerina jenkinsi *n. sp.*

(in millimetres)

Specimen	L	W	R	Diam. of prol.	Height of volutions						Form ratio of volutions					
					V1	V2	V3	V4	V5	V6	V1	V2	V3	V4	V5	V6
13940	13.5	3.0	4.5	.168	.058	.100	.190	.270	.336	.400	2.6	3.4	4.5	4.8	5	4.7
13941	11.8	3	3.9	.190	.105	.147	.190	.280	.357	.380	3	3.4	3.6	4.1	4.3	3.9
13942	12.2	2.8	4.4	.273	.084	.130	.168	.231	.357	.315	2.5	2.3	3	3.5	4	4.4
13943	11.1	2.2	5	.210	.094	.100	.210	.290	.378	—	2.7	3.9	5.3	5.2	5	—
13945	—	2.5	—	.250	.105	.147	.168	.250	.310	—	—	—	—	—	—	—
13946	—	3.2	—	.231	.105	.168	.21	.280	.380	—	—	—	—	—	—	—

Specimen	Thickness of spirotheca						Septal count						Tunnel angle (degrees)					
	V1	V2	V3	V4	V5	V6	V1	V2	V3	V4	V5	V6	V1	V2	V3	V4	V5	V6
13940	.025	.033	.058	—	.083	.091	—	—	—	—	—	—	22	—	—	—	—	—
13941	.025	.050	.058	.066	.083	.100	—	—	—	—	—	—	23	28?	26?	34	—	—
13942	.025	.041	.058	.083	.083	.066	—	—	—	—	—	—	20	17?	31	—	—	—
13943	.033	.041	.066	.091	.083	—	—	—	—	—	—	—	25	40	41	37	—	—
13945	.025	.033	.050	.083	.083	—	12	18	19	25	25	—	—	—	—	—	—	—
13946	.033	.050	.058	.083	.083	.074	10	18	25	28	29	32?	—	—	—	—	—	—

Table V

Measurements of Schwagerina hyperborea *(Salter)*

(in millimetres)

Specimen	L	W	R	Diam. of prol.	Height of volutions							Form ratio of volutions						
					V1	V2	V3	V4	V5	V6	V7	V1	V2	V3	V4	V5	V6	V7
13476	15	3?	5	.273?	.084	.063	.168	.230	.295	.378	—	2.4	2.7	3.2	4.5	5.1	5.2	—
13947	15	3	5	—	.084	.105	.190	.250	.378	.504	—	2.2	2.7	3.7	4.9	5	5	—
13948	12.4	2.9	4.3	.190	.063	.095	.168	.270	.330	.440	—	2.8	3.2	3.7	4	4.6	4.3	—
13949	13	2.7	4.8	.210?	.084	.126	.168	.270	.420	—	—	2.4?	3?	4.3	5.1	5.2	—	—
13476a	14	2.6	5.3	?	.084	.125	.168	.280	.400	?	—	3	3.1	3.4	5.3	5.5	5.3	—
13950	12.1	3.2	3.8	.220	.084	.100	.168	.273	.420	.651	—	2	3	3.3	3.9	4	3.8	—
13476b	—	3.5	—	.273	.063	.094	.147	.210	.250	.420	.480	—	—	—	—	—	—	—
13951	—	3.5	—	.20	.073	.084	.175	.231	.420	.525	—	—	—	—	—	—	—	—

Specimen	Thickness of spirotheca							Septal count							Tunnel angle (degrees)						
	V1	V2	V3	V4	V5	V6	V7	V1	V2	V3	V4	V5	V6	V7	V1	V2	V3	V4	V5	V6	V7
13476	—	.033	.041	.061	.091	.091	—	—	—	—	—	—	—	—	12	20	21	—	—	—	—
13947	.025	.033	.058	.066	.109	.124	—	—	—	—	—	—	—	—	11	22	24?	31?	—	—	—
13948	—	.033	.050	.058	.100	.100	—	—	—	—	—	—	—	—	15	23	—	—	—	—	—
13949	.025	.033	.066	.091	.125	—	—	—	—	—	—	—	—	—	—	18	—	31	35	—	—
13476a	—	.033	.058	.074	.124	—	—	—	—	—	—	—	—	—	—	20	28	48	50	—	—
13950	.025?	.041	.060	.066	.116	.141	—	—	—	—	—	—	—	—	18	21	27	37	41	—	—
13476b	.020	.025	.041	.050	.058	.091	.10	13	21	25	24	29	31	—	—	—	—	—	—	—	—
13951	—	.025	.041	.058	.074	.100	—	12?	21	23	29	29	34	—	—	—	—	—	—	—	—

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Table VI

Measurements of Pseudoschwagerina grinnelli *n. sp.*

(in millimetres)

Specimen	L	W	R	Diam. of prol.	Height of volutions					Form ratio of volutions				
					V1	V2	V3	V4	V5	V1	V2	V3	V4	V5
13954	6	2.1	3	.21	.084	.136	.220	.252	.273	1.7	1.9	2.2	3	3
13955	7	2.1	3.3	.315	.126	.190	.273	.294	—	1.8	2.1	2.6	3.5	—
13956	5.3	2.4	2.2	.315	.042	.168	.252	.336	.294	1.4	1.6	1.7	2.2	2.2
13957	6.9	2.3	3	.189	.084	.147	.210	.290	.330	1.7	2	2.7	3	3
13958	7.1	2.1	3.4	.22	.115	.147	.189	.231	.220	1.7	2.2	3	3	3.4
13959	8	2.58	3	.357	.147	.189	.231	.273	.273	1.3	1.7	2.2	2.7	3
13960	6.5	2.7	2.4	.462	.140	.230	.273	.281	.231	1.6	2	2.1	2.4	2.4
13961	6.0	2.1?	3	.294	.094	.147	.189	.189	—	1.8	2	2.4	3	3
13962	—	2.3	—	.21	.084?	.126	.210	.294	.315	—	—	—	—	—
13963	—	2.4	—	.273?	.120?	.120	.252	.290	.252	—	—	—	—	—
13964	—	1.7	—	.315	.126	.210	.250	—	—	—	—	—	—	—
13965	—	2.1	—	.31?	.084	.150	.210	.270	—	—	—	—	—	—

Specimen	Thickness of spirotheca					Septal count					Tunnel angle (degrees)				
	V1	V2	V3	V4	V5	V1	V2	V3	V4	V5	V1	V2	V3	V4	V5
13954	.024	.041	.058	.083	.083	—	—	—	—	—	19	20	29	51	—
13955	.033	.049	.058	.066	—	—	—	—	—	—	15	31	—	—	—
13956	—	.042?	.042	.063	—	—	—	—	—	—	26	31	—	—	—
13957	.021	.031	.084?	.105?	—	—	—	—	—	—	21	22	36	40	—
13958	.031	.042	.063	.084	.063?	—	—	—	—	—	14	23	47	—	—
13959	.042	.042	.063	.084	.063	—	—	—	—	—	20	17	24	60	—
13960	.042	.057	.063	.063	.042	—	—	—	—	—	16	23	37	51	—
13961	.031	.042	.042	.042	—	—	—	—	—	—	23	27	40	—	—
13962	—	.031	.042	.063	.063	12	17	23	23	24	—	—	—	—	—
13963	—	.031	.063	.084	.042	11	21	22	24	24	—	—	—	—	—
13964	.031	.057	.042	—	—	14	21	26	—	—	—	—	—	—	—
13965	.021	.042	.063	.089	—	10	18	22	29	—	—	—	—	—	—

Table VII
Measurements of **Parafusulina belcheri** ***n. sp.***
(in millimetres)

Specimen	L	W	R	Diam. of prol.	Height of volutions							Form ratio of volutions						
					V1	V2	V3	V4	V5	V6	V7	V1	V2	V3	V4	V5	V6	V7
13971	13.5	3.9	3.5	.256	.084	.147	.210	.290	.250	.310	.350	2	2.5	2.7	3	3.2	3.1	3.4
13972	9.7	3.3	3	.190	.084	.210	.294	.273	.273	.399	—	2	2.2	2.4	2.4	3	3	—
13973	10.8	3	3.6	.190	.063	.105	.168	.189	.252	.252	.357	2	2.8	2.3	3	3.4	3.5	3.6
13974	12.1	3.2	3.8	.147	.054	.084	.147	.252	.231	.252	.294	2	2.1	2.8	2.9	3.5	3.7	3.8
13975	12	3.7	3.2	.190	.105	.136	.210	.315	.357	.378	—	1.8	2.5	3.3	3.4	3.2	3	—
13976	11	3	3.6	.210	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13977	11.8	3.4	3.7	.189	.063	.105	.126	.273	.325	.336	.357	2	2.8	3.2	3.6	3.8	3.6	3.7
13978	—	3.8	—	.273	.115	.189	.220	.325	.325	.420	—	—	—	—	—	—	—	—
13979	—	3.2	—	.190	.073	.126	.189	.231	.252	.315	.315	—	—	—	—	—	—	—
13980	—	3.6	—	.210	.084?	.147	.189	.273	.357	.299	.357	—	—	—	—	—	—	—

Specimen	Thickness of spirotheca							Septal count							Tunnel angle (degrees)						
	V1	V2	V3	V4	V5	V6	V7	V1	V2	V3	V4	V5	V6	V7	V1	V2	V3	V4	V5	V6	V7
13971	.021	.031	.042	.063	.057	.084	.084	—	—	—	—	—	—	—	16	21	46?	—	—	—	—
13972	.024	.057	.063	.063	.063	.105	—	—	—	—	—	—	—	—	22	32	31	25	45	—	—
13973	—	.021	.042	.063	.073	.094	.105	—	—	—	—	—	—	—	20	24	32	44	52	—	—
13974	.021	.021	.031	.073	.084	.084	.084	—	—	—	—	—	—	—	23	23	—	42	58	60	—
13975	.021	.042	.084	.084	.094	.105	—	—	—	—	—	—	—	—	17	—	—	—	68	65	—
13976	—	—	—	—	—	—	—	—	—	—	—	—	—	—	14	20	48	—	60	52	—
13977	.020	.021	.042	.084	.10	.10	.100	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13978	.021	.031	.042	.057	.084	.084	.105	12	17	22	23	27	29	—	—	—	—	—	—	—	—
13979	.012	.027	.037	.063	.063	.084	.094	12	14	16	20	22	24	25	—	—	—	—	—	—	—
13980	.021	.042	.052	.062	.094	.084	.094	11	14	17	21	25	31	32	—	—	—	—	—	—	—

Part III

CORALS, BRACHIOPODS, AND MOLLUSCS OF GRINNELL PENINSULA

P. Harker

Introduction

This account describes the Permian corals, brachiopods and some of the molluscs of the Belcher Channel and Assistance formations of Grinnell Peninsula. Except for some of the corals, all the fossils described were collected by R. Thorsteinsson. The corals are a part of the Belcher collection from the British Museum (Natural History), London, and were collected by Sir Edward Belcher during his voyages in search of Sir John Franklin 1852-54. Grateful acknowledgment is made to Dr. H. Dighton Thomas of the British Museum (Natural History) who arranged for the loan of these corals and supplied the photographs reproduced as Plate XI, figures 1 and 2, and Plate XIII, figures 1 and 2.

The molluscs described here comprise two ammonoid species and a scaphopod. The molluscan fauna also includes fragments of a large nautiloid and several species of gastropods. The gastropods are mainly preserved as internal casts and have not been studied.

The age and correlation of the faunas are given in the first part of this report, which deals with the stratigraphy of the Permian rocks of Grinnell Peninsula.

List of Species

Genus *Caninia* Michelin
- *Caninia ovibos* (Salter)
- *Caninia belcheri* n. sp.

Genus *Clisiophyllum* Dana
- *Clisiophyllum* ? *tumulus* Salter

Genus *Lithostrotion* Fleming
- *Lithostrotion grandis* (Heritsch)
- *Lithostrotion kunthi* (Stuckenberg)
- *Lithostrotion* cf. *L. portlocki* M.-E. & H.
- *Lithostrotion* ? sp.

Genus *Stylastraea* Lonsdale
- *Stylastraea* cf. *S. toulai* (Stuckenberg)

Genus *Roemeripora* Kraicz
- *Roemeripora wimani* Heritsch

Genus *Lingula* Bruguière
- *Lingula* cf. *L. arctica* Miloradovich

Genus *Orbiculoidea* d'Orbigny
- *Orbiculoidea* sp.

Genus *Streptorhynchus* King
- *Streptorhynchus kempei* Andersson
- *Streptorhynchus triangularis* Wiman

Genus *Derbyia* Waagen
- *Derbyia* cf. *D. grandis* Waagen
- *Derbyia* sp.

Genus *Chonetes* Fischer
- *Chonetes (Paeckelmannia ?) capitolinus* Toula

Genus *Chonetina* Krotov
- *Chonetina* cf. *C. timanicus* (Tschernyschew)

Genus *Dictyoclostus* Muir-Wood
- *Dictyoclostus* cf. *D. neoinflatus* Licharew

Genus *Cancrinella* Fredericks
- *Cancrinella* cf. *C. germanicus* (Frebold)

Genus *Muirwoodia* Licharew
- *Muirwoodia mammatus* (Keyserling)

Genus *Kochiproductus* Dunbar
- *Kochiproductus freboldi* (Stepanow)

Genus *Waagenoconcha* Chao
- *Waagenoconcha payeri* ? (Toula)
- *Waagenoconcha* cf. *W. irginaeformis* Stepanow

Genus *Stenoscisma* Conrad
- *Stenoscisma* cf. *S. kochi* (Dunbar)
- *Stenoscisma plicatum* (Kutorga)

Genus *Rhynchopora* King
- *Rhynchopora* cf. *R. nikitini* Tschernyschew

Genus *Squamularia* Gemmellaro
- *Squamularia asiatica* Chao

Genus *Spirifer* Sowerby
Spirifer osborni n. sp.
Spirifer striato-paradoxus Toula
Genus *Pterospirifer* Dunbar
Pterospirifer cf. *P. alatus* (Schlotheim)
Pterospirifer ? sp. A
Genus *Spiriferella* Tschernyschew
Spiriferella saranae (de Verneuil)
Spiriferella keilhavii (von Buch)
Genus *Cleiothyridina* Buckman
Cleiothyridina cf. *C. subexpansa* (Waagen)
Genus *Dielasma* King
Dielasma cf. *D. plica* (Kutorga)
Genus *Pseudogastrioceras* Spath
Pseudogastrioceras fortieri n. sp.
Genus *Metalegoceras* Schindewolf
Metalegoceras sp.
Genus *Plagioglypta* Pilsbry
Plagioglypta sp.

Systematic Descriptions

Phylum COELENTERATA

Class *ANTHOZOA*

Order TETRACORALLA

Family CYATHOPSIDAE Dybowsky 1873

Genus *Caninia* Michelin *in* Gervais 1840

Caninia ovibos (Salter)

Plate XI, figures 1-8

1855 *Zaphrentis ovibos* SALTER, p. 382, pl. 36, fig. 5.
1913 *Zaphrentis calophylloides* HOLTEDAHL, p. 32, pl. 10, figs. 9-12.
1929 *Caninia calophylloides* Holtedahl. HERITSCH, p. 21, pls. 1-7.
1939 *Siphonophyllia calophylloides* Holtedahl. HERITSCH, p. 37, pl. 1, fig. 9; pl. 3, figs. 7-10; pl. 12, figs. 3-5; pl. 13, figs. 4, 6; pl. 16, figs. 1-4; pl. 19, figs. 10, 12, 13.

Description. External characters: Simple corallites, "curved, sometimes strongly, and either gradually tapering or somewhat abruptly conical at the base, and thence cylindrical, and often a little contracted above. The surface is smooth, and regularly marked by ridges of growth,—calyx circular, deep, rather thin edged, with numerous, 36-44, prominent (major) septa extending to within the margin of the smooth central tabula, which is elevated in the middle into a narrow crest continuous with the primacy septum, but not carried into the fossula. The latter is rather large, deep, placed on the (convex) curved side (of the corallite), and not at all invading the central tabula. One, or more frequently two, of the septa are abbreviated by it. The intermediate (minor) septa are extremely small and quite marginal." (from the original description by Salter).

Transverse sections: Thirty-nine to forty-four major septa (lectotype has forty-two at diameter of 41 mm), partly crossing tabularium. Septa in cardinal quadrants dilated except within dissepimentarium; cardinal septum much shorter than the others. Major septa three quarters of the radius of corallite, minor septa one third the length of the majors. Dilated major septa consist of thin median septa proper between layers of lateral schlerenchyme; dilation may affect the rims of the tabulae but does not extend into the dissepimentarium. Dissepimentarium occupies from one third to almost one half of the length of the major septa; about twelve ranges of dissepiments, mainly concentric but with some tendency to herringbone pattern in the outermost ranges, especially in the cardinal quadrants. Tabulae almost flat, several tabulae reflexed sharply into cardinal fossula.

Longitudinal sections: Tabulae flattened, complete and incomplete strongly reflexed into the cardinal fossula where they tend to be dilated, about ten tabulae occupy 10 mm. Dissepiments concentric and steeply inclined.

Material. The specimen figured by Salter was from a collection made by Belcher at "Depot Point Albert Land" during his voyage in search of Sir John Franklin. Some part of this collection was presented to the Geological Survey of Great Britain in 1855. In 1880, this material together with other overseas collections at the Survey were deposited at the British Museum of Natural History. Salter's figured specimen is no longer in existence, it may have been wholly or partly destroyed as he refers to polished sections in his description. A specimen (B.M. R 90151) closely resembling the figure and bearing an original label: "Formn. Carboniferous. Loc. Depot Point (Arctic R.). Sp. *Zaphrentis ovibos* n. sp. Pres. by Sir E. Belcher." was loaned by the British Museum and is stated by Dr. H. Dighton Thomas (personal communication) to be an original specimen and a syntype. This specimen is here designated as lectotype. Albert Land is now known as Devon Island and "Depot Point" is near the northern tip of Grinnell Peninsula. The lectotype probably came from near GSC locality 26418, Belcher Channel formation.

R 90125 Small specimen with thirty-six, very dilated septa. Bears original Survey label and assumed to be from same locality as lectotype.

R 35823 Large specimen. Bears label "*Clisiophyllum tumulus* ? Salter. Carb. Limest. Arctic America". This is not an original label but the specimen came from the collection presented by Belcher to the Geological Survey. Transverse section (*see* Pl. XI, fig. 6) clearly indicates specific identity with *Caninia ovibos*. The specimen bears some resemblance to Salter's figure for

Z. ovibos but it lacks the encrusting organism shown in the figure and cannot be identified as the original. Probably from the same locality as the lectotype.

R 13990, and R 13991 These two specimens were purchased by the British Museum in 1908 from F. H. Butler, a well known dealer. They are both labelled "Paphrentis curbos. Depot Point, Melville Island, Lat 77N. Brought by Lieut. Sherard Osborne. From the collection of Admiral Sir Edward Belcher K.C.B." The name is obviously meant to be *Zaphrentis ovibos;* it is in Butler's handwriting and is a mistranscription. Osborn certainly visited Melville Island but it is not clear whether he was with the party on Grinnell Peninsula. The latitude shown on the label, however, is that of Grinnell Peninsula rather than Melville Island. The locality of these specimens is therefore rather uncertain. R 13990 is probably *C. ovibos,* R 13991 is almost certainly not.

GSC Nos. 13500, 13500a-b, 13501, 13501a-b. Belcher Channel formation, GSC locality 26407.

Discussion. Caniniid corals from the Arctic have been described under various genera, more especially *Caninia, Siphonophyllia* and *Campophyllum.* Huang (1932, p. 34) discussed two groups of *Caninia;* those in which dissepiments are only developed in the later stages, typified by the type species *Caninia cornucopiae* and those in which dissepiments are more fully developed, typified by *Caninia gigantea.* Following Scouler (*in* McCoy, 1844, p. 187) some authors have assigned species of the second group to *Siphonophyllia* Scouler, based on *Siphonophyllia cylindrica* Scouler=*C. gigantea* Michelin. Lang, Smith, and Thomas (1940, p. 120) considered *Siphonophyllia* to be a synonym of *Caninia.* Easton (1944) discussed the relationships of the caniniid corals in some detail and concluded (p. 121) that *Campophyllum* and *Siphonophyllia* are junior subjective synonyms of *Caninia.* This opinion is followed here. In *Caninia ovibos* early growth stages show fewer dissepiments than later stages; septal dilation decreases with growth.

The publication of this little known species of Salter antedates by several decades the descriptions of any other similar or related corals from the Permo-Carboniferous of the boreal regions. *Zaphrentis calophylloides* Holtedahl from the Cyathophyllumkalk of W. Spitzbergen is considered identical. A full account of the specific relationships of this species was given by Heritsch (1929) and need not be repeated here.

Caninia belcheri n. sp.

Plate XII, figures 1-5

Diagnosis. Large curved *Caninia* with deep, open calyx, septa dilated in youth, thin in adult stages.

Description. External features: Simple corallites, curved, trochoid in youth nearly cylindrical in later stages, calyx deep with steep walls and almost flat calicular floor. Prominent cardinal fossula on convex side of corallite. Outer surface with irregular ridges of growth. External surface of epitheca not preserved.

Transverse sections: About fifty-five major septa (holotype has fifty-five at diameter of 40 mm), partly crossing tabularium; cardinal septum about half as long as the others. Major septa about three quarters of the radius of the corallite, minor septa about one quarter the length of the majors. Major septa dilated in early youth, thin in adult stages. Dissepimentarium consisting of fifteen or more ranges occupies about one half of the length of the major septa, forms a distinctly herringbone pattern. Tabulae almost flat, reflected slightly into cardinal fossula.

Longitudinal sections: Tabulae almost flat, complete and incomplete, reflexed proximally; dissepiments concentric and steeply inclined.

Material. Holotype, GSC Nos. 13502, 13502a, b; paratypes, GSC Nos. 13503, 13503a, b.

Discussion. This species is similar to *Caninia ovibos* (Salter) from the same locality and to those forms from elsewhere in the Arctic that have been described as *Caninia calophylloides.* It differs however in having consistently more septa, complete loss of the characteristic septal dilation in adult stages and shorter minor septa.

Locality. Belcher Channel formation, GSC locality 26418.

Family AULOPHYLLIDAE Dybowski 1873

Genus *Clisiophyllum* Dana 1846

Clisiophyllum ? *tumulus* Salter

Plate XIII, figures 1-4

1855 *Clisiophyllum tumulus* SALTER, p. 383, pl. 36, fig. 6.

Description. External characters: Simple corallite, "curved and twisted trumpet-shaped tube four inches long, annulated by rough ridges of growth and marked by faint longitudinal ribs. The oblique cup two inches broad, thick edged and deep, with margin recurved, lined by about ninety close and nearly equal lamellae, the intermediate ones being as strong as the others, descending to the bottom of a deep hollow a line broad, which surrounds the conical boss in the centre. The latter is almost cylindrical, more than half an inch broad and long, and much nearer to the concave than the convex side of the tube (corallite). A few only of the principal ribs rise upon it irregularly, and one of them forms a considerably twisted ridge or crest. The boss is formed of close vesicular tissue, a more open tissue occupying the spaces between the lamellae." (from the original description by Salter).

Transverse sections: Eighty-seven septa at a diameter of 40 mm, including minor septa. Minor and major septa not easily distinguished from each other; some minors as long as majors, others much shorter. Septa extend into tabularium, axial ends of some septa slightly dilated. Dissepimentarium occupies about three quarters of the length of the septa; about twelve ranges of mainly concentric dissepiments. Axial structure of curved septal lamellae and minor tabellae occupies about one quarter of the diameter of the corallite and is separated from the septal region by a zone of steeply inclined tabulae; several tabulae extend into the cardinal fossula.

Longitudinal sections: Tabulae arched, conical, incomplete and steeply inclined, axial tabellae numerous, thin, steeply arched over the axis. Dissepiments concentric and steeply inclined, clearly demarked from tabulae but without any dividing wall.

Material. Holotype, Belcher collection, British Museum R 41545; clearly recognizable from Salter's figure. The holotype probably came from near GSC locality 26418, Belcher Channel formation.

Discussion. The affinities of this species clearly lie with the family *Aulophyllidae* and more particularly with the genus *Clisiophyllum*. It is only tentatively assigned to this genus as it differs from the genolectotype *Clisiophyllum keyserlingi* M'Coy in having poorly differentiated minor and major septa, non-septate tabularium surrounding the axial structure and lack of a median plate. Only a single transverse section, cut just below the calicular floor was available for study; it is not possible, therefore, to state whether these differences persist through all stages of ontogeny. *Auloclisia* Lewis loses the axial plate in later stages but has two orders of well-differentiated septa, the plate is sometimes ill defined in the related genus *Cyathoclisia* Dingwall but the major septa are longer and the fossula is more prominent. *Nagatophyllum* Ozawa has some general similarity but has peripheral naotic septal development.

Species of *Clisiophyllum* are abundant and widespread in the Carboniferous, especially in the Lower Carboniferous. Permian species have been described but many of them can be more appropriately reassigned to other genera.

Clisiophyllum ? *tumulus* Salter is not present in the Geological Survey collection from Grinnell Peninsula.

Family LITHOSTROTIONIDAE d'Orbigny 1851

Genus *Lithostrotion* Fleming 1828

Lithostrotion grandis (Heritsch)

Plate XIV, figures 1-3

1939 *Petalaxis grandis* HERITSCH, p. 27, pl. 2, figs. 4-5; pl. 19, fig. 11.

Description. Cerioid, astreoid; outer walls poorly developed between some corallites. About twenty major septa, slightly thickened at inner ends and not reaching the axis, minor septa about half the length of the majors. Outer dissepiments widely spaced, an inner ring of more closely spaced dissepiments forms a rather ill-defined inner wall with the thickened parts of the septa; this structure is very distinct on the weathered upper surface of the corallum (*see* Pl. XIV, fig. 1). Two incomplete sets of tabellae, a thin, almost flat outer series and an inner series of steeply inclined conical tabulae meeting the thin columella. Columella thin, probably rod-like and more or less continuous, not easily distinguishable in transverse sections. Corallites about 10 mm in diameter.

Discussion. This is the largest of the compound coral species from the Belcher Channel formation of Grinnell Peninsula. It is referred to Heritsch's species from Spitzbergen with reasonable certainty, although unfortunately he did not illustrate a longitudinal section of the holotype. It has many similarities with species of *Orionastraea,* more especially *Orionastraea solida* (Stuckenberg). *Orionastraea solida* has been described from the Lower Permian of the Urals (Soshkina, *et al.,* 1941, p. 155) and Spitzbergen (Heritsch, 1939, p. 14), it lacks a columella and has less well-developed minor septa than *Lithostrotion grandis.*

Locality. Belcher Channel formation, GSC locality 26407.

Lithostrotion kunthi (Stuckenberg)

Plate XIII, figures 5, 6

1888 *Petalaxis kunthi* STUCKENBERG, p. 23; p. 29, text figure on p. 49.
1895 *Petalaxis kunthi* STUCKENBERG, p. 78, pl. 12, fig. 7.
1939 *Petalaxis kunthi* Stuckenberg. HERITSCH, p. 25, pl. 11, fig. 1; pl. 13, figs. 3, 7; pl. 19, fig. 14.

Description. Cerioid, astreoid; about fifteen major septa some longer than others and reaching the axis, minor septa about two thirds the length of the majors. Outer dissepiments widely spaced, slight thickening of inner wall. Conical tabulae, arched and meeting the columella. Columella continuous, thickened in places by coalescence of septal ends; in some corallites the columella appears to be a thickened axial plate formed along the line of the cardinal and counter septa. Corallites about 4 mm in diameter.

Discussion. This species is much smaller than the other compound corals from the Belcher Channel formation. *Petalaxis kunthi* was first described from the "Upper Carboniferous" of Russia, it was reported by Heritsch from the Fusulinenkalk of Spitzbergen. *Petalaxis* Edwards and Haime 1852 is a synonym of *Lithostrotion.*

Locality. Belcher Channel formation, GSC locality 26407.

Lithostrotion cf. *L. portlocki* Milne-Edwards and Haime

Plate XII, figures 6, 7

Description. Cerioid, walls clearly defined; fifteen to nineteen major septa, most of them reaching the axis, minor septa about half the length of the majors. About six ranges of dissepiments. Two series of tabellae, outer series flat, inclined; inner series arched, incomplete and meeting the columella. Columella continuous, styliform. Corallites about 8 mm in diameter.

Discussion. This coral is a typical *Lithostrotion.* It is closely similar to the group of species that includes *L. basaltiforme* of authors, *L. araneum* M'Coy, *L. clavaticum* Thomson and *L. portlocki* Milne-Edwards and Haime. All these forms are found in the Lower Carboniferous of Europe and Asia. There is considerable general similarity between the coral faunas of the boreal Permian and the Lower Carboniferous as already noted by Soshkina (1932, p. 266). There might be some justification for describing the Grinnell form as a new species, however, it is here compared with *L. portlocki* to indicate its morphological relationship with corals of this group. *Petalaxis portlocki* was recorded by Stuckenberg (1895, p. 74) from the Upper Carboniferous of Russia. *Lithostrotion peculiare* described by Yabe and Hayasaka (1915, p. 131) from the Permian of Japan is stated to be similar to the Russian forms and to belong to the group of *L. portlocki.* The form described as *Lithostrotion borealis* Stuckenberg from Axel Heiberg Island by Tschernyschew and Stepanow (1916, p. 10) may be identical with our species.

Locality. Belcher Channel formation, GSC locality 26407.

Lithostrotion ? sp.

Plate XIV, figures 4, 5

This coral combines features of several genera of colonial rugose corals and well illustrates the taxonomic difficulties encountered in this group. It has many of the features of *Stylastraea,* but differs from the Grinnell form assigned to *S. toulai* (Stuckenberg) in having an occasionally well-developed columella and having much less well-defined walls. In these respects it resembles species of *Orionastraea* but the walls have not undergone the extreme astreoid changes usually associated with that genus. In some corallites the septa are withdrawn from the epitheca but not to the extent shown in species of *Lithostrotionella* or *Thysanophyllum.* It has many similarities with *Petalaxis timanicus* Stuckenberg, reported by Heritsch (1939, p. 18) from the Permo-Carboniferous of Spitzbergen and originally described by Stuckenberg (1895, p. 76) from the "Upper Carboniferous" of Russia. The walls are, however, more clearly defined in *'Petalaxis' timanicus.*

Locality. Belcher Channel formation, GSC locality 26407.

Genus ***Stylastraea*** Lonsdale 1845

Stylastraea cf. *S. toulai* (Stuckenberg)

Plate XIII, figures 7, 8

Description. Cerioid, walls clearly defined. About twenty-three major septa which do not reach the centre of the corallite. Minor septa about half the length of the majors, a few of the minors are discontinuous. Two or more ranges of rather irregularly spaced dissepiments, steeply inclined near periphery. Tabulae continuous, flat or slightly arched. Columella absent or rudimentary. Corallites very variable in size, up to 10 mm in diameter.

Material. A single specimen, British Museum, R 35832, from "Depot Point Albert Land" (Belcher collection). Probably from near GSC locality 26407, Belcher Channel formation, Grinnell Peninsula.

Discussion. This coral was described and figured by Salter (1855, p. 381, pl. 36, fig. 4) as *Stylastraea inconferta* Lonsdale. The genus and species were originally proposed by Lonsdale in "The Geology of Russia in Europe and the Ural Mountains" by Murchison and others. Smith and Lang (1930, p. 185) redescribed the holotype and gave adequate figures for *Stylastraea inconfertum-inconferta.* The coral described by Salter differs from *Stylastraea inconfertum* in having more and shorter septa, more complex dissepimentarium (shown in longitudinal section) and apparent absence of columella. It is tentatively referred to *Stylastraea toulai* (Stuckenberg). This species is one of several lithostrotionid species described by Stuckenberg (1895, p. 81) from the "Upper Carboniferous" and referred by him to the genus *Columnaria.* Smith and Lang (1930, p. 179) regarded *Stylastraea* as a diphymorph of *Lithostrotion* and proposed the genomorphic name *Diphystrotion* for these modified forms of cerioid *Lithostrotion.* The nature and direction of such trends affecting *Lithostrotion* has been fully discussed by McLaren and Sutherland (1949, p. 631). *Stylastraea* was emended by Meyer (1914, p. 627); the usage followed here is after Hill (1956, p. F 283).

Stylastraea cf. *S. toulai* (Stuckenberg) is not present in the Geological Survey collection from Grinnell Peninsula.

Order TABULATA

Family AULOPORIDAE Milne-Edwards and Haime 1851

Genus *Roemeripora* Kraicz 1934

Roemeripora wimani Heritsch

Plate XIV, figures 6, 7

1939 *Roemeripora wimani* HERITSCH, p. 109, pl. 8, fig. 4; pl. 17, figs. 4, 5; pl. 20, figs. 23, 24; pl. 21, figs. 1-3.

Description. Cerioid to sub-cerioid, corallum consists of erect corallites, polygonal in outline thickened with schlerenchyme to give a rounded outline to the inside of the corallites. Abundant closely set infundibuliform tabulae, deeply depressed axially, coalescing tube that carries scattered short, septal spines. Adjacent corallites connected by round mural pores or syringoporoid tubules. Corallites about 2 mm in diameter.

Discussion. This species was described by Heritsch from the Permo-Carboniferous of Spitzbergen. The taxonomic position of a number of Silurian and Devonian species that had been described under the genus *Roemeria* Milne-Edwards and Haime was discussed by Kraicz (1934, p. 38). She regarded them as bryozoans and proposed the genus *Roemeripora,* with *Roemeria bohemica* as type species, for those forms which she considered to be closely related to the

Monticuliporidae. Heritsch (1939, pp. 109-116) gave an extended account of the morphology and relationships of his species and was convinced that it properly belonged to the genus *Roemeripora*. Despite his detailed treatment of the Spitzbergen material, Heritsch (ibid., p. 116) regarded the final deposition of *Roemeripora* as between the tabulates and the bryozoans to require further study. The Grinnell material shows well-preserved syringoporoid features and the species is here tentatively included with the tabulate corals.

Locality. Belcher Channel formation, GSC locality 26407.

Phylum BRACHIOPODA

Class *INARTICULATA*

Superfamily OBOLACEA Schuchert 1900

Family OBOLIDAE King 1846

Genus *Lingula* Bruguière 1797

Lingula cf. *L. arctica* Miloradovich

Plate XV, figure 12

A species of *Lingula* is fairly common in the Assistance formation. The specimens show the elongate, quadrate outline and other external characters of *Lingula arctica* Miloradovich described from the Lower Permian of the southern island of Novaya Zemlya (Miloradovich, 1937, p. 37). Internal features not seen.

Dimensions (in mm)

GSC No.	Length	Width	Thickness
13510	22	13.5	6
13511	23	15.5	....
13512	22	13.2	7

Locality. Assistance formation, GSC locality 26406.

Superfamily DISCINACEA Waagen 1885

Family DISCINIDAE Gray 1840

Genus *Orbiculoidea* d'Orbigny 1847

Orbiculoidea sp.

Plate XV, figures 10, 11

Description. Large shells 30 to 32 mm in diameter. Outline almost circular. Dorsal valve obtusely conical, apex slightly off centre towards anterior margin. Anterior gently inflate, posterior slope straight. Ventral valve concave anteriorly, slightly convex posteriorly. Pedicle slit short, about one sixth of the diameter of the shell, deeply indented. Surface of both valves marked by strong concentric lirae separated by broader flattened interspaces. Some irregular radial ornament on dorsal valve, mainly on the posterior slope.

These shells differ from other late Palæozoic species mainly in their large size. They bear a superficial resemblance to *Orbiculoidea capuliformis* (McChesney) but differ in the nature of the convexity and vertical profile of the valves. They are much larger than the forms illustrated by Dunbar (1955, p. 62) as *Orbiculoidea* sp. A from the Permian of central East Greenland.

Dimensions.

GSC No.	Diameter (mm)
13513	32
13514	30
13515	31.5

Locality. Assistance formation, GSC locality 26406.

Class *ARTICULATA*

Superfamily ORTHOTETACEA Williams 1953

Family SCHUCHERTELLIDAE Stehli 1954

Genus *Streptorhynchus* King 1850

A number of species of this orthotetid genus have been described from the Arctic regions. Individuals may be locally very abundant forming a distinct and characteristic element of the Arctic Permian fauna. Individual variation within species is great and there is undoubtedly considerable intraspecific gradation. The large and variable collection from the Assistance formation can be placed into two intergrading groups; one group appears to fall within the range of variation of *Streptorhynchus kempei* Andersson, the other within *Streptorhynchus triangularis* Wiman.

Streptorhynchus kempei Andersson

Plate XV, figures 1-6

1914 *Streptorhynchus kempei* ANDERSSON *in* Wiman, p. 58, pl. 10, figs. 22-27; pl. 11; pl. 12, figs. 1-8; pl. 13, figs. 11-13.
1931 *Streptorhynchus kempei* Andersson. FREBOLD, p. 19, pl. 6, figs. 1-3.
1937a *Streptorhynchus kempei* Andersson. STEPANOW, p. 109, pl. 1, figs. 2, 6.
1955 *Streptorhynchus kempei* Andersson. DUNBAR, p. 63, pl. 1, figs. 1-13; pl. 32, figs. 9, 10.

Description. Large shells, length and width subequal, greatest width near mid-length of shell, hinge line shorter than greatest width. Some shells show a distinct lateral asymmetry.

Ventral valve flattened or gently convex, sloping gently towards cardinal extremities, rounded anteriorly, posterior margin reflects low triangular shape of interarea. Interarea flat, 2.5 to 3 times as wide as high, apsicline. Triangular delthyrium closed by convex pseudodeltidium. Interarea and pseudodeltidium marked with irregularly spaced growth lines parallel with hinge line. Hinge line straight.

Dorsal valve convex, varying from low convex to subglobose, slight irregular median depression developed in some shells, beak small, faintly protuberant beyond hinge line.

Surface of both valves covered by fine rounded costellae increasing in number anteriorly by intercalation. Fifteen to twenty costellae occur in 10 mm. Costellae minutely pseudopunctate. Well-defined, concentric growth varices occur at irregular intervals.

Hinge teeth stout, dental lamellae lacking. Diductor muscle scars large but irregular and lightly impressed, adductor scars scarcely discernible. Cardinal process strong, bilobate, stout supporting buttresses fused to crural bases, long, shallow dental sockets. Dorsal muscle scars large and separated by low median ridge.

Dimensions (in mm).

GSC No.	Length	Width	Length of hinge line	Thickness
13517	50	51	35	25
13516	44	45	30	Crushed
13518	42	45	30	20

Discussion. In so far as it is possible to compare this rather variable species, the Grinnell specimens are in fairly close agreement with the examples described and figured by the authors indicated in the synonymy. The ventral muscle impressions are less defined than those shown in the many specimens figured from the Spiriferenkalk of Spitzbergen and Bear Island. Our shells are thinner and more delicate than some of those discussed by Dunbar from central East Greenland. The Greenland specimens have more costellae per centimetre as also does a typical specimen from Spitzbergen which is to hand from the collections of H. Frebold.

Locality. Assistance formation, GSC locality 26406.

Streptorhynchus triangularis Wiman

Plate XV, figures 7-9

1914 *Streptorhynchus triangularis* WIMAN, p. 55, pl. 10, figs. 1-19, 28, 29.
1937a *Streptorhynchus triangularis* Wiman. STEPANOW, p. 109, pl. 1, fig. 3.

Description. Medium sized shells, longer than wide, greatest width at about the mid-length of the dorsal valve. Hinge line about two thirds greatest width of shell. Some shells show lateral asymmetry.

Ventral valve almost flat over most of its surface, gently curved at the margins and curving inwards towards the cardinal extremities as the length of the hinge line is less than the width of the shell at this point. Outline rounded anteriorly, almost triangular posteriorly. Interarea flat or very slightly concave, high, height about three quarters of width, orthocline. Large triangular delthyrium with flat or slightly arched pseudodeltidium bordered by narrow irregularly defined peri-deltidial areas. Interarea and pseudodeltidium marked by irregularly spaced growth lines parallel with hinge line. Hinge line straight.

Dorsal valve convex, length and width subequal.

Surface of both valves covered by fine rounded costellae, increasing in number anteriorly by intercalation. A single line of pseudopunctae clearly shows on slightly eroded costellae. Twenty-five to thirty costellae occur in 10 mm. Irregularly spaced concentric growth varices increase in number anteriorly.

Hinge teeth stout, dental lamellae lacking. Large, ill-defined, lightly impressed muscle field in ventral valve. Cardinal process strong, bilobate.

Dimensions (in mm).

GSC No.	Length	Width	Length of hinge line	Thickness
13519	33	30	18	19
13520	37	26	19	15

Discussion. The Grinnell specimens are similar in outline and high interarea to some of the more elongate forms figured by Wiman from the Spiriferenkalk. They appear to be similar to the single specimen that Stepanow figured from Novaya Zemlya but the illustration is inadequate for accurate comparison. The ventral muscle field, though perhaps less well defined in our specimens, is of comparable size with those shown on Wiman's illustrations.

Shells of this species are easily distinguished from *Streptorhynchus kempei* by their more elongate ventral valve, higher, orthocline interarea and greater number of costellae. Small specimens are less easily differentiated and there may be some overlap in maturity, however, the two species appear to be distinct. *Streptorhynchus stoschensis* Dunbar and *Streptorhynchus pelargonatus* Schlotheim both lack the high triangular interarea of Wiman's species. Schlotheim's species has a distinct ventral fold and dorsal sinus.

Locality. Assistance formation, GSC locality 26406.

Genus *Derbyia* Waagen 1884

Derbyia cf. *D. grandis* Waagen

Plate XVI, figures 9, 10

This large orthotetid species was first described by Waagen (1884, p. 597) from the Salt Range of Pakistan. Following Tschernyschew's use of the species in his study of the brachiopods of Ural and Timan (1902), it soon became well established in faunal lists from the boreal regions. Some authors have merely compared their arctic forms with the Salt Range species, others, as for example Frebold (1950, p. 41) and Tschernyschew and Stepanow (1916, p. 44) identified Waagen's species without reservation.

A specimen from the Assistance formation shows a striking external resemblance to specimens figured by Waagen. It differs mainly in having an irregularly flattened ventral valve, but the significance of this cannot be assessed as the shell is somewhat distorted. The interior of our specimen is not known but the strong median septum is visible through the partly exfoliated shell.

The Grinnell specimen is comparable in size and ornament with the specimen described by Tschernyschew and Stepanow from the Great Bear Cape Limestone, southern Ellesmere Island. It is similar though larger, than those figured by Frebold (1950, pl. 1, fig. 5a) from Amdrups Land, Northeast Greenland. *Derbyia* sp. A of Dunbar (1955, pl. 2, figs. 16-20) is somewhat smaller but could possibly be conspecific.

In the Salt Range *Derbyia grandis* occurs in the Middle and Upper Productus limestones. Tschernyschew stated that it is restricted to the *Schwagerina* horizon in Ural and Timan. In Spitzbergen it occurs in the Cyathophyllumkalk and Spiriferenkalk. The dimensions of the specimen (GSC No. 13521) are as follows: length 77 mm, width 84 mm, length of hinge line 79 mm, height of interarea 15 mm, thickness 25 mm.

Locality. Assistance formation, GSC locality 26406.

Derbyia sp.

Plate XXIII, figure 8

Shells belonging to this genus occur in the upper beds of the Belcher Channel formation. They are smaller and have a lower interarea than the large species from the overlying Assistance formation. All the specimens are dorsal valves and no attempt has been made to assign them to species. Interior not known, but strong median septum is visible in some exfoliated shells.

Locality. Belcher Channel formation, GSC locality 26407.

Superfamily CHONETACEA Shrock and Twenhofel 1953

Family CHONETIDAE Hall and Clarke 1895

Genus *Chonetes* Fischer 1837

Chonetes (*Paeckelmannia* ?) *capitolinus* Toula

Plate XVI, figures 11, 12

1875a *Chonetes capitolinus* TOULA, p. 250, pl. 8, fig. 9a.
1914 *Chonetes capitolinus* Toula. WIMAN, p. 62.
1937 *Chonetes capitolinus* Toula. FREBOLD, p. 13.
1939 *Chonetes* (*Paeckelmannia*) n. sp. aff. *capitolinus* Toula. LICHAREW, p. 26, pl. 2, figs. 10-13.
1955 *Paeckelmannia toulai* DUNBAR, p. 69, pl. 3, figs. 1-8.

Description. Medium sized chonetid, wider than long, greatest width at about the mid-length of the shell. Hinge line about nine tenths of the greatest width.

Ventral valve, gently and almost uniformly convex, cardinal extremities slightly obtuse. Broad, shallow median sulcus present on some shells, barely perceptible on others as a slight median flattening of the curvature. Interarea low, flat, tapering towards cardinal extremities. Beak small. Broad delthyrium filled by cardinal process of the opposite valve. Convex deltidium preserved only at the apex. Surface has faint, widely spaced, concentric lines of growth. Outer layer of shell has numerous fine, radially directed perforations; these appear to have borne fine radially arranged hair-like spines. True radial lirae are not present. Eight or more outwardly directed spines on each half of anterior margin.

Dorsal valve gently concave, fold low or almost absent. Interarea low, tapering towards the cardinal extremities. Surface has concentric lines of growth. Radially directed perforations present in outer layer as in ventral valve. Distinct pattern of fine radial lirae, especially towards the anterior margin. Cardinal process has a fine median groove on the posterior face separating two diverging, bilobed muscular facets.

Dimensions (in mm).

GSC No.	Length	Width	Length of hinge line	Thickness (convexity)
13522	20	29	26	4
13523	18.5	28	25	5

Discussion. Chonetes capitolinus was described by Toula from material collected by Drasche from the Permian of Spitzbergen. Our specimens are in close agreement in size and form with the description and figures of Toula's species and it is probable that they are conspecific. It would, however, be necessary to compare them with Toula's specimens to establish their identity beyond doubt. In the discussion of his species *Paeckelmannia toulai,* Dunbar (1955, p. 69) stated that it may prove to be the same as *C. capitolinus;* it differs mainly in being much smaller. Size may not be very diagnostic in the chonetids. In common with *Paeckelmannia toulai* our specimens show a remarkable dissimilarity of ornament on the two valves.

The subgenus *Tournquistia* was proposed by Paeckelmann (1930, p. 218) for a group of smooth chonetids. Dunbar and Condra (1932, p. 168) restricted its use to those smooth forms lacking a broad fold and sinus. In its emended form *Tournquistia* was given full generic status by Dunbar and Condra. Licharew (1934, p. 526) showed that *Tournquistia* was preoccupied and proposed the new name *Paeckelmannia* for the emended form of *Tournquistia* but retained the subgeneric status of Paeckelmann's original proposal.

The smooth ventral surface of our specimens would place them in the subgenus *Paeckelmannia;* however, owing to the presence of fine, albeit distinct radial ornament on the dorsal surface this assignment can only be regarded as tentative.

Locality. Assistance formation, GSC locality 26406.

Genus ***Chonetina*** Krotov 1888

Chonetina cf. *C. timanicus* (Tschernyschew)

Plate XVII, figure 7; Plate XXIII, figure 8

Description. Ventral valves of this small chonetid species are common in the upper beds of the Belcher Channel formation. They vary in size from a few millimetres to larger specimens with a width at the hinge line of 16 to 18 mm. Surface ornament consists of fine radial lirae. Slight surface exfoliation on most of the specimens reveals radial rows of elongate pseudopunctae. Lightly impressed concentric growth lines are present on well-preserved specimens. Interior has radial rows of fine papillae. Well-developed, narrow, median sulcus extends from near the hinge line to the anterior margin. Three or more cardinal spines occur on each half of the posterior margin.

Our specimens are tentatively compared with Tschernyschew's species which he described from the *Schwagerina* limestone of Timan (1902, p. 601). Many of our specimens are rather larger than the type specimen of *C. timanicus* but in other respects they are closely similar and the smaller specimens appear to be identical. *C. noe-nygaardi* Dunbar from central East Greenland is again very similar to our smaller specimens though it appears to have slightly more strongly developed radial ornament. *C. noe-nygaardi* and *C. timanicus* may well prove to be the same species.

The narrow sulcus is a very noticeable feature in all the Grinnell specimens and readily distinguishes them from most of the other chonetid species listed from the Arctic regions.

Locality. Belcher Channel formation, GSC locality 26407.

Superfamily PRODUCTACEA Waagen 1883

Family DICTYOCLOSTIDAE Stehli 1954

Genus ***Dictyoclostus*** Muir-Wood 1930

Dictyoclostus cf. *D. neoinflatus* Licharew

Plate XVII, figures 1-4

Semi-reticulate productids have a wide distribution in late Palæozoic sediments. They appear to form a fairly homogeneous morphological group and have been assigned to a number of species including *Productus inflatus* McChesney, *Productus uralicus* Tschernyschew and *Productus bolivensis* d'Orbigny. Licharew could not accept the occurrence of the North American species *Productus inflatus* McChesney in the Arctic and Russian Permo-Carboniferous as identified by Tschernyschew (1902, p. 612). Licharew (1939, p. 90) proposed a new species *Productus neoinflatus* for these forms, stating its range as Middle Carboniferous to Lower Permian. A similar species, *D. orientalis* Fredericks, occurs in the Lower

Permian of Ural, Timan and the Orient. Several specimens from the Grinnell collection fall within this group of species and are compared with *D. neoinflatus* Licharew.

Locality. Assistance formation, GSC locality 26406.

Genus *Cancrinella* Fredericks 1928

Cancrinella cf. *C. germanicus* (Frebold)

Plate XVI, figure 6

Description. Medium sized productid, hinge line less than greatest width. Ventral valve strongly curved. Beak small, sharply pointed, extending slightly beyond hinge line, expanding anteriorly into a strongly convex umbo. Hinge line straight, auricles thin, almost flat, cardinal extremities almost right angle. Coarse, irregular concentric rugae originate on the auricles and extend on to the lateral slopes but do not cross the visceral region. Surface ornament consists of fine radial costellae and numerous spines. Spines are random posteriorly and on the auricles, anteriorly they show some tendency towards concentric arrangement. Each spine rises from the posterior end of an elongate node formed by enlargement and elevation of a costella. Shell thin, anterior probably incomplete. Dorsal valve not known.

The dimensions of the specimen (GSC No. 13529) are as follows: length 19 mm, width 27 mm, length of hinge line 21 mm.

Discussion. The taxonomic history of the striato-spinose productids of the *Productus cancrini* group is long and complex. The earliest description of *P. cancrini* is by de Koninck in 1842. de Koninck (1842, p. 179) described the species from the Calcaire de Vise (Lower Carboniferous) of Belgium but he compared the Belgian specimens with some specimens from the Permian of Russia which he claimed had been named *P. cancrini* by de Verneuil and Keyserling in honour of Count Cancrin, Finance Minister to the Czar. It would seem, therefore, that de Koninck must have been acquainted with the work of Murchison, de Verneuil, and Keyserling prior to its publication in 1845. All subsequent authors appear to have attributed *P. cancrini* to de Verneuil with 1845 as its date of publication. Geinitz (1861, p. 101) applied the name to somewhat similar forms from the Zechstein of Germany. Tschernyschew (1889, p. 283) described a distinct, but morphologically similar Permian species which he called *Productus cancriniformis.* In his large monograph of 1902, Tschernyschew recognized two striato-spinose species, *Productus cancriniformis* and *Productus konincki.* This last-named species was attributed to de Verneuil by Tschernyschew and other authors. It was first mentioned by de Verneuil in 1845 as *Productus koninckianus;* no figure was given and it was discussed in connection with some forms from the Lower Carboniferous of Belgium which de Verneuil regarded as similar to the Russian species. Keyserling (1846) was of the opinion that *P. koninckianus* could be distinguished from *P. cancrini* and his criteria are summarized by Frebold (1932, p. 21). Tschernyschew (1885, p. 102), however, claimed that many of the distinguishing characters noted by Keyserling were common to both species.

This group of productids was recognized from the Arctic islands by de Koninck (1850, p. 632) who indicated the presence of *P. cancrini* in the Upper Palæozoic of Spitzbergen. Toula (1873, p. 282) described *P. koninckianus* from southern Spitzbergen. In later papers (1874 and 1875) he described and figured *P. cancrini* and stated that the forms that he had previously described as *P. koninckianus* were in all probability referable to *P. cancrini*. Wiman described *P. koninckianus* from Spitzbergen and Bear Island (Wiman, 1914, p. 71) and placed Toula's *Productus cancrini* in synonymy. Some of Toula's 1874 specimens have a small interarea and these probably belong to a species of *Strophalosia* or related genus.

Frebold (1933, p. 49) claimed that the forms described by Geinitz from the German Zechstein were distinct from those of the Russian Permian and he separated them under varietal names as *Productus cancrini germanicus* and *Productus cancrini rossicus*. Frebold considered that the common representative of the group in Spitzbergen and Greenland was *P. cancrini germanicus*. He did, however, admit the possibility of *P. koninckianus* in the collections. Malzahn (1937, p. 35) gave a full description of *P. cancrini germanicus* from the German Zechstein and in a lengthy discussion he attempted to justify, seemingly with some success, its usage as distinct from the Russian form. Stepanow (1937a, p. 133) adopted an entirely opposite view; he stressed the extreme variability of the group and accepted *P. cancrini* de Verneuil in a broad sense and placed the two varieties of Frebold in synonymy.

In Russia *P. koninckianus* has been reported from the "Cora Horizon" (Tschernyschew, 1902, p. 291), *P. cancrini* from the much younger beds of Zechstein age (Netschajew, 1911, p. 136). Because of the difficulty in distinguishing these two species, it would not be unreasonable to regard them as a single, long-ranging species. The German forms, however, seem to be distinct and merit a separate species name. Dunbar (1955, p. 72) followed Frebold's usage when he described some specimens from the Permian of central East Greenland as *Cancrinella germanicus* (Frebold). We consider that the typical German forms occur in the Arctic Permian and that they occur in beds considerably older than the German Zechstein, Dunbar (1955) notwithstanding.

The group of *Productus cancrini* is represented in the Grinnell collection by a single specimen which is compared with *Cancrinella germanicus* (Frebold). It differs from those figured by Dunbar (1955, pl. 3) in having rather more numerous spines. It is interesting to note its appearance in the fauna, but its occurrence cannot be regarded as having any great stratigraphic significance.

Locality. Assistance formation, GSC locality 26406.

Genus *Muirwoodia* Licharew 1947

Muirwoodia mammatus (Keyserling)

Plate XVI, figures 1-5

1846 *Productus mammatus* KEYSERLING, p. 206, pl. 4, fig. 5.
1847 *Productus mammatus* Keyserling. de KONINCK, p. 146, pl. 7, figs. 4a-e.
1902 *Productus mammatus* Keyserling. TSCHERNYSCHEW, p. 631, pl. 35, figs. 4-6.
1914 *Productus mammatus* Keyserling. WIMAN, p. 73.
1927 *Productus mammatus* Keyserling. CHAO, p. 146, pl. 15, figs. 10-14.
1931 *Productus* (*Linoproductus*?) *mammatus* Keyserling. CHAO *in* Grabau, p. 288, pl. 29, figs. 10-14.
1937a *Productus* (*Thomasina*) *mammatus* Keyserling. STEPANOW, p. 127, pl. 2, figs. 5-7.

Description. Medium sized productid, wider than long; greatest width at hinge line.

Ventral valve inflated, hinge line straight, cardinal extremities well defined, acute and separated from the rest of the shell by shallow depressions that terminate at the steep lateral slopes. Shell almost flat in visceral region, strongly geniculating at about the mid-length so that the trail is almost at right angles to the visceral region of the shell. Broad, shallow median sulcus commences near the beak, it is barely perceptible in the visceral region but becomes more distinct at about the point of geniculation where it gives a smoothly bilobate appearance to this part of the shell. Beak, small and only very slightly protuberant beyond the hinge line. Surface is covered with low rounded costellae, increasing in number by intercalation, about fourteen costellae occur in 10 mm on the anterior slope. Rugae absent. All of the specimens possess six large spines, one on each auricle and two on each flank, just anterior to the line of geniculation. In addition to these consistently occurring spines there are a few smaller spines on the body of the shell; five or six small spines bases occur along the hinge line on each side of the beak. All of the specimens are wholly or partly exfoliated and show the pseudopunctate structure of the shell. Interior of valve not seen.

Dorsal valve concave, with low, rounded costellae, increasing in number by bifurcation. Cardinal process imperfectly preserved but apparently consisting of paired myophores separated by a median ridge. Interior of valve not seen.

On slightly eroded specimens the posterior margin of both valves is serrated, small projections or ridges on one valve fitting into corresponding grooves on the opposite valve when the valves were closed.

Dimensions (in mm).

GSC No.	Length	Width
13530	18	30.5
13531	17.5	27
13532	16.5	26
13533	(crushed)	29

Discussion. *Productus mammatus* was described by Keyserling in 1846 from specimens collected in Petschora-Land. Stepanow described the species from the Permian of Spitzbergen and stated that the Spitzbergen specimens were identical with Keyserling's species. A remarkably consistent feature of this species is the distribution of spines, one on each auricle and a pair on each side of the sulcus, and small spines along the posterior margin. They are shown on Keyserling's somewhat stylized figures and are fully described by Chao in his description of the species from the Permian of Mongolia and also by Stepanow in his description of the Spitzbergen specimens.

Our specimens agree in outline, convexity and distribution of major spines with the species as interpreted by Chao and Stepanow; Stepanow can be regarded as authoritative in so far as he was able to make direct comparison with topotype material. The serrations at the posterior margin were not described by Stepanow; they are, however, present in a related species from the Permian of East Greenland described by Dunbar (1955, p. 103) under the name *Muirwoodia greenlandica.* Dunbar considered Stepanow's material to be distinct from Keyserling's species and also included *Productus weyprechti* Toula in his synonymy for *Muirwoodia greenlandica. Muirwoodia greenlandica* is larger, more inflated and lacks the consistent spine distribution of our specimens. *Productus mammatiformis* Fredericks is similar but according to Fredericks (1926, p. 87) differs in having coarser ribbing, greater inflation of the beak and being larger. *Muirwoodia transversa* Cooper from the Permian of Oregon (Cooper, 1957, p. 39) is similar, but is more strongly geniculate and lacks the characteristic spine distribution.

Stepanow assigned *Productus mammatus* to *Thomasina* Paeckelmann; more recently Licharew (1947, p. 187) proposed the genus *Muirwoodia* for these forms, citing *Productus mammatus* as the type species.

Locality. Assistance formation, GSC locality 26406.

Family ECHINOCONCHIDAE Stehli 1954

Genus ***Kochiproductus*** Dunbar 1955

Kochiproductus freboldi (Stepanow)

Plate XVII, figures 5, 6

1916? *Productus porrectus* Kutorga. TSCHERNYSCHEW and STEPANOW, p. 41, pl. 5; pl. 8, fig. 5.
1931 *Productus porrectus* Kutorga. FREBOLD, p. 20, pl. 1, figs. 1-3.
1937a *Productus (Buxtonia) freboldi* STEPANOW, p. 122, pl. 2, fig. 4.
1942 *Productus (Buxtonia) freboldi* Stepanow. FREBOLD, p. 28, pl. 3, fig. 3.
1955 *Kochiproductus plexicostatus* DUNBAR, p. 109, pl. 17, figs. 1-6; pl. 18, figs. 1-6.

Description. Large productid, slightly wider than long, greatest width at about the mid-length of the shell. Hinge line about eight tenths of the greatest width.

Ventral valve, gently convex, lateral slopes steep, auricles well defined and flattened. Beak, broad, obese. Surface ornament of coarse radial costae, anastomosing anteriorly. Coarse irregular rugae well developed on auricles and crossing the visceral disc in the umbonal region. Centre part of shell surface exfoliated. Scattered spine bases over most of the shell, especially numerous on the auricles.

Dorsal valve almost flat, with rounded, radial costae, increasing in number anteriorly by intercalation. Irregular concentric ridges across the costae to give a distinct semireticulate appearance.

Dimensions (in mm).

GSC No.	Length	Width	Length of hinge line	Thickness
13534	75	89	69	30

Discussion. The name *Productus porrectus* was given by Kutorga in 1844 to a form common in the Sakmarian limestones of Russia. His description was brief and he only figured a single specimen which was probably incomplete and partly exfoliated. Tschernyschew redescribed the species with good illustrations in 1902. Identical, or related forms were listed or described from the Arctic regions by Wiman (1914, p. 74) as *Productus porrectus,* by Tschernyschew and Stepanow (1916, p. 41) as *Productus porrectus,* by Frebold (1931, p. 20; 1933, p. 13) as *Productus porrectus* and by Fredericks (1934, p. 33) as *Buxtonia victorioensis* King. Stepanow (1937a, p. 122) described a new species, *Productus* (*Buxtonia*) *freboldi* from Spitzbergen. Stepanow stated that the Spitzbergen forms although distinct from the Russian *Productus porrectus* as defined by Kutorga were identical to those described by Frebold from East Greenland as *Productus porrectus.*

Two of the specimens figured in a later paper by Frebold (1942, pl. 3) were available for comparison. Frebold identified one of these as *Productus* (*Buxtonia*) *freboldi* Stepanow, the other as *Productus* (*Buxtonia*) *porrectus* Kutorga (var.?). The two are very similar and differ only in the slightly coarser ornament and slightly more prominent rugae on the form designated as *Productus* (*Buxtonia*) *freboldi.* Frebold discussed these species at some length in the text (ibid, p. 28) and considered the differences to be varietal rather than specific. He concluded that a form similar to *Productus porrectus* Kutorga occurs in the late Palæozoic of the Arctic and provides an important link with the Russian fauna.

Dunbar's species and genus *Kochiproductus plexicostatus* is based on a number of Greenland specimens which are very similar to *Productus freboldi* Stepanow. Dunbar states (ibid., p. 113) "In view of the uncertainty and the wholly inadequate description of Stepanow's species, we are describing the Greenland form as a new species even at the risk of coining a synonym". If we are to accept Stepanow's opinion that his species is distinct from the Russian form described by Kutorga as *Productus porrectus,* but is also identical with the Greenland forms, then *Kochiproductus plexicostatus* must be placed in synonymy.

The Grinnell specimen is larger and rather more transverse than those figured by Frebold; it is slightly less convex than the specimens figured by Dunbar. All these arctic forms, however, are here regarded as conspecific and assigned to *Kochiproductus freboldi* (Stepanow).

Locality. Assistance formation, GSC locality 26406.

Genus *Waagenoconcha* Chao 1927

Waagenoconcha payeri ? (Toula)

Plate XVIII, figures 9-11

Large productids having the general features of Toula's species have been reported in the Permian of the boreal regions from a number of localities. Some authors have referred them to Toula's species, some to *Productus purdoni* Davidson (originally described from the Productus limestones of the Salt Range of Pakistan) and yet others to *Productus wimani* Fredericks.

It is probable that all these occurrences relate to a single species. Unfortunately, the specimens described as *Productus payeri* by Toula from southern Spitzbergen were internal moulds. Frebold (1937, p. 19) described some rather better preserved material from the same and other localities in Spitzbergen. He assigned them to *Productus* (*Waagenoconcha*) *payeri* Toula, but they also show little of the surface ornament. Some large specimens from the Spiriferenkalk of Bear Island were described by Wiman (1914, pl. 15) and identified as *Productus purdoni* Davidson. Chao (1927, p. 90) expressed some doubt as to the correctness of Wiman's identification. Frebold (1931, p. 25) identified a single shell from East Greenland as *Productus purdoni* but in a later paper (1937, p. 21) considered that the East Greenland specimen might be *Productus* (*Waagenoconcha*) *payeri* Toula. Dunbar (1955, p. 85) described *Waagenoconcha payeri* (Toula) from the Permian of East Greenland and stated (ibid., p. 87) "Having studied specimens of *Productus purdoni* from its type region, the Salt Range of India, (now Pakistan) 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*".

Two specimens from our collection are probably referable to Toula's species. They are comparable in size and ornament with Dunbar's figures but are somewhat less elongate than Wiman's specimens from Bear Island. The tangentially directed spinose ornament is clearly shown in Plate XVIII, figures 10, 11. The quincunxial pattern of spine bases described by Waagen (1884, p. 705) and by Chao (1927, p. 89) for *Productus purdoni* is lacking. The Grinnell specimens appear to be identical with *Waagenoconcha payeri* (Toula) as interpreted by Dunbar, but owing to the poor material from which the original description was made there is still some uncertainty of the real specific characters and our material in only tentatively referred to Toula's species.

Locality. Assistance formation, GSC locality 26406.

Waagenoconcha cf. *W. irginaeformis* Stepanow

Plate XVI, figures 7, 8

A single specimen is tentatively referred to *Waagenoconcha irginaeformis* Stepanow. Stuckenberg (1898, p. 220) described two closely related species of productid as *Productus irginae* and *Productus gruenewaldti,* the last named differing mainly in being less convex. Stepanow (1937a, p. 124) showed that the species name *gruenewaldti* was preoccupied by a form described by Krotov 10 years earlier and proposed the new name *irginaeformis.* The difference between the two forms was regarded as varietal by Licharew and Einor (1939, p. 205).

Locality. Assistance formation, GSC locality 26406.

Superfamily STENOSCISMATACEA Schrock and Twenhofel 1953

Family STENOSCISMATIDAE Muir-Wood 1955

Genus *Stenoscisma* Conrad 1839

Stenoscisma cf. *S. kochi* (Dunbar)

Plate XVIII, figures 5-8

Shells tentatively referred to this species are fairly common in the Assistance formation. They are rather variable in size, the figured specimen being one of the larger ones. Most are imperfectly preserved and slight pathological deformities are common. There are four plications in the sulcus and five on the fold. The ventral valve has a spondylium, dorsal valve is septate but details of cruralium are not seen. The species was described by Dunbar (1955, p. 121), under the genus *Camerophoria* King, from the Permian of central East Greenland, where it is stated to be common and widely distributed.

Dimensions (in mm).

GSC No.	Length	Width	Thickness
13735	32	36	16.5
13736	30	30	16

Locality. Assistance formation, GSC locality 26406.

Stenoscisma plicatum (Kutorga)

Plate XVIII, figures 1-4

1844 *Pentamerus plicatus* KUTORGA, p. 89, pl. 9, fig. 3.
1902 *Camarophoria plicata* (Kutorga). TSCHERNYSCHEW, p. 502, pl. 21, figs. 1a-d; pl. 50, figs. 17, 18.
1914 *Camarophoria plicata* (Kutorga). WIMAN, p. 29.
1938 *Camarophoria plicata* (Kutorga). KULIKOV, p. 145, pl. 1, fig. 6.
1957 *Stenoscisma* cf. *S. plicatum* (Kutorga). COOPER, p. 54, pl. 10e, figs. 32-35.

Description. Shell large for the genus, transversely pentagonal, beak obtuse. Surface strongly costate: six costae in sulcus, six or seven on fold, five or six on the flanks.

Ventral valve flattened to moderately convex, sulcus originates near mid-length and occupies about half the width at the front. Tongue moderately long, obtuse; costae in sulcus all of about equal strength. Flanks slope gently down to margins.

Dorsal valve deeper and more convex than ventral valve; details of fold not preserved, lateral slopes of fold steep anteriorly. Flanks of valve slope steeply to the margins.

Spondylium in ventral valve, partly obscured near beak by callosity; traces of cruralium and supporting septum in dorsal valve.

Dimensions (in mm).

GSC No.	Length	Width	Thickness
13737	35	39	30
13738	(incomplete)	39	(incomplete)
13739	35	37	(crushed)

Discussion. This large species is readily distinguished from *S. kochi* (Dunbar) and from other species by its larger size and very distinct plications. The Grinnell specimens are somewhat smaller than Kutorga's original and also than those figured by Tschernyschew from the Schwagerinenkalk of Sterlitamak. The specimen figured by Kulikov from the subsurface of the Ischimbaevo oil field (W. slope of the Middle Urals) is rather smaller. *S. plicatum* has been reported from the Urals, Spitzbergen and Bear Island. Cooper has recently compared a form from the Permian of Central Oregon with this species.

Locality. Assistance formation, GSC locality 26406.

Superfamily RHYNCHOPORACEA Moore 1952

Family Rhynchoporidae Muir-Wood 1955

Genus *Rhynchopora* King 1865

Rhynchopora cf. *R. nikitini* Tschernyschew

The genus *Rhynchopora* is represented by a number of small, mostly fragmentary shells. They are about 9 mm in width, have 7-8 ribs on the flanks and 4-5 in the sinus. Dorsal septum, divergent dental lamellae. Surface punctate. They are tentatively assigned to *Rhynchopora nikitini,* a species listed or described from many Arctic Permian collections, and which has probably been rather broadly interpreted by some authors. The Grinnell specimens differ from *Rhynchopora abnormalis* Dunbar (1955, p. 114) in having consistently more ribs in the sinus.

They are similar to *Rhynchopora kochi* Dunbar (ibid, p. 114) which itself is difficult to distinguish from *Rhynchopora nikitini* var. *arctica* Einor (1939, p. 64).

Dimensions (in mm).

GSC No.	Length	Width	Thickness
13740	8.5	10.0	5.5
13741	7	9	5

Locality. Assistance formation, GSC locality 26406.

Superfamily SPIRIFERACEA Waagen 1883

Family SPIRIFERIDAE King 1846

Genus *Squamularia* Gemmellaro 1899

Squamularia asiatica Chao

Plate XVIII, figures 12-15

1883 *Reticularia lineata* (Martin). WAAGEN, p. 540, pl. 42, figs. 6-8.
1892 *Reticularia lineata* (Martin). SCHELLWIEN, p. 38, pl. 6, figs. 100 and 113.
1902 *Recticularia lineata* (Martin). TSCHERNYSCHEW, p. 574, pl. 20, figs. 9-13.
1913 *Recticularia lineata* (Martin). MANSUY, p. 80, pl. 8, fig. 18.
1916 *Spirifer (Recticularia) lineata* (Martin). BROILI, p. 40, pl. 121, fig. 7; pl. 122, figs. 10-13 and 16.
1929 *Squamularia asiatica* CHAO, p. 91, pl. 11, figs. 12-14.
1931 *Squamularia asiatica* Chao. OZAKI, p. 76, pl. 8, figs. 15-19; pl. 9, figs. 2-4.
1937b *Neophricodothyris asiatica* (Chao). STEPANOW, p. 40, pl. 3, figs. 8-9.
1939 *Neophricodothyris asiatica* (Chao). EINOR, p. 157, pl. 27, figs. 3, 6 and 8.

Description. Shell of medium size, slightly wider than long, subovate in outline. Greatest width slightly posterior to mid-length. Anterior commissive rectimarginate.

Ventral valve convex, greatest convexity near the beak. Beak short, pointed and incurved. Interarea concave, about half the width of the shell and not clearly differentiated from the posterior slopes. Delthyrium has an apical angle of about 60 degrees, no remains of any former deltidial covering preserved. Dorsal valve moderately convex, distinctly flatter than the ventral valve. Beak small, pointed and slightly incurved beyond the hinge line. Surface of both valves marked by concentric crenulated bands; the bands are in the form of low terraces with gentle back slopes and steeper anterior slopes. Spines formerly grew out from the forward slopes; complete spines are not preserved but a few remnants show them to have been double-barrelled. Internally the shells are aseptate and the hinge teeth are unsupported by dental lamellae (*see* Figure 5).

Dimensions (in mm).

GSC No.	Length	Width	Thickness
13743	32.5	38	20
13742	33	38.5	21

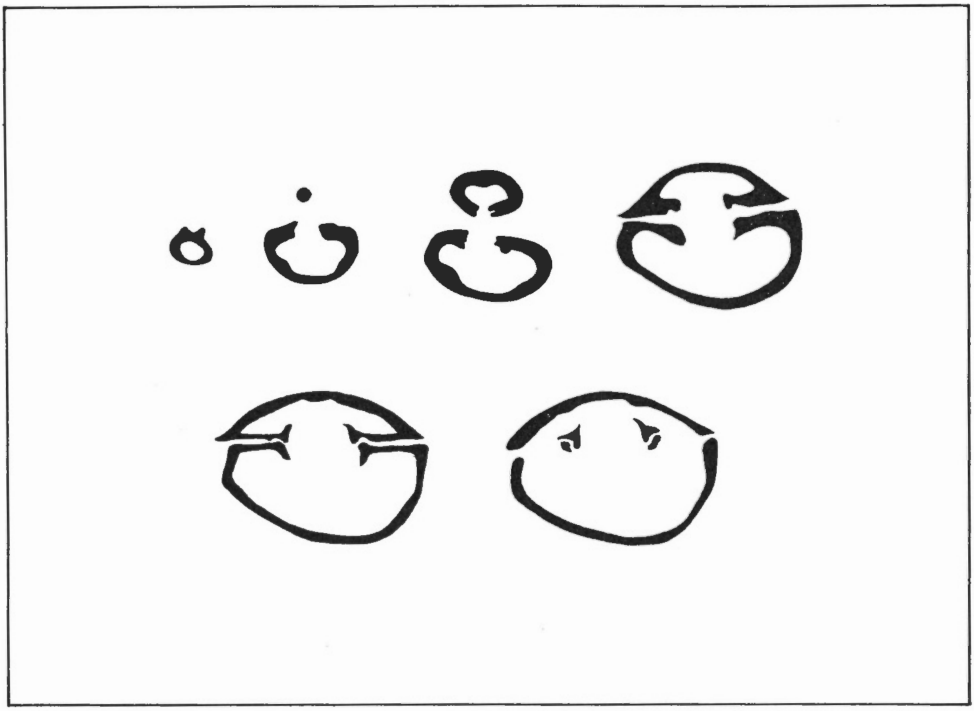


Figure 5. *Squamularia asiatica* Chao
Series of sections of GSC No. 13742. Natural size.

Discussion. Our specimens are rather larger than the type material figured by Chao, but they are similar in form and ornament and there can be little doubt that they properly belong to his species. *S. asiatica* was designated by Licharew (1934, p. 213) as the type species for a new genus *Neophricodothyris*. He claimed that it differed from *Squamularia* in details of sculpture and the direction of the internal spires. These distinctions could not be recognized in our specimens and there is perhaps little justification for the genus *Neophricodothyris*. *Phricodothyris* George and *Torynifer* Hall and Clarke are similar externally but both are triseptate. *Squamularia* is typically Permian, but species do also occur in the Upper Carboniferous.

Locality. Assistance formation, GSC locality 26406.

Genus ***Spirifer*** Sowerby 1818

Spirifer osborni n. sp.

Plate XX, figures 15-17

Description. Shell large, wider than long, transversely oval in outline, greatest width at about the mid-length. Shell substance impunctate.

Ventral valve moderately convex, greatest convexity near the beak, surface sloping steeply down to hinge line, flanks sloping gently to lateral margins. Strongly incurved beak; interarea concave, large triangular delthyrium. Sulcus originates at the beak, opens anteriorly to form a broad shallow depression. Surface covered by coarse, rounded radial costae increasing in number in the umbonal region by bifurcation, regular and consistent in number over most of the valve, about five in 1 cm near the mid-length. About six occur within the sulcus at the anterior margin. Several irregular concentric varices of growth are present.

Dorsal valve moderately convex, maximum convexity slightly posterior to the mid-length. Beak incurved. Gentle fold originates near the beak. Costae similar to those on ventral valve.

Dental lamellae, originating in a thick callosity at the ventral beak, divergent towards the floor of the valve, very slight median ridge on the inside of the ventral valve near the beak (*see* Figure 6).

Named after Lieutenant Sherard Osborn, RN, who accompanied Captain Sir Edward Belcher to Grinnell Peninsula.

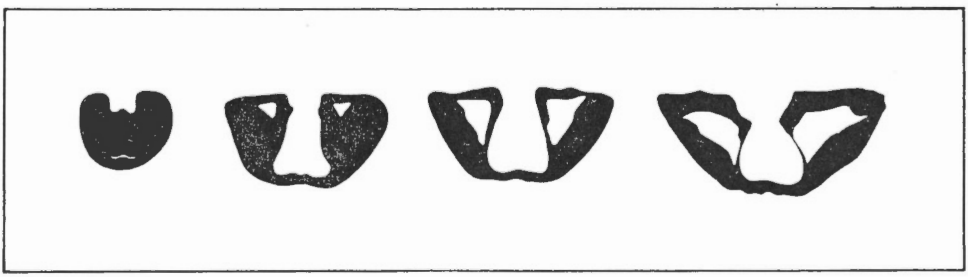


Figure 6. *Spirifer osborni n. sp.*
Series of sections of the ventral valve of paratype, GSC No. 13745. Natural size.

Dimensions (in mm).

GSC No.	Length	Width	Thickness
13744	53	66	28
13745	51	62	25
13746	(distorted)	70	34

Material. Holotype, GSC No. 13744; paratypes, GSC Nos. 13745, 13746.

Discussion. Externally these shells have many of the features of species that have been assigned to the genus *Choristites* Fischer de Waldheim. *Choristites fritschi* Schellwien and related species have been reported by Frebold (1950, p. 63) from the Upper Carboniferous of the Arctic, and as the *'supramosquensis'* group they are well known from the Carboniferous of the U.S.S.R. Similar species have been reported from the Permian of Novaya Zemlya (Einor, 1939, p. 119). Recently

Dunbar (1955, p. 158) described a new species, *Choristites soderberghi,* which he claims "may be the youngest one known". Our *Spirifer osborni* is externally very similar to *Choristites soderberghi.*

Internally *Spirifer osborni* is easily distinguished from *Choristites,* the thin, divergent dental lamellae are quite distinct from the thick, fibrous parallel plates of *Choristites* (*see* Chao, 1929, p. 14, and Rotay, 1951, p. 24). Two Permian species described by Einor (1939, pp. 105-110) from Novaya Zemlya, *Spirifer pseudomosquensis* and *Spirifer pseudoholtedahli,* have the external characters of *Choristites. Spirifer osborni* is rather larger than either of these two species and has coarser costae; however, the figures are inadequate for close comparison.

Locality. Assistance formation, GSC locality 26406.

Spirifer striato-paradoxus Toula

Plate XIX, figures 1-7

1873 *Spirifer striato-paradoxus* TOULA, p. 271, pl. 1, figs. 2a-c.
1875a *Spirifer striato-paradoxus* TOULA, p. 254, pl. 8, fig. 1.
1914 *Spirifer marcoui* Waagen. WIMAN, p. 44, pl. 6, figs. 9-11.
1914 *Spirifer ravana* Diener. WIMAN, p. 43, pl. 5, figs. 17-19; pl. 6, figs. 1, 2.
1916 *Spirifer marcoui* Waagen. TSCHERNYSCHEW and STEPANOW, p. 47, pl. 9, fig. 4.
1931 *Spirifer* cf. *marcoui* Waagen. FREBOLD, p. 16, pl. 4, fig. 2.
1931 *Spirifer ravana* Diener. FREBOLD, p. 39, pl. 4, figs. 1-1b; pl. 5, fig. 1.
1937 *Spirifer cameratus* Morton. FREBOLD, p. 48, pl. 2, fig. 3.
1955 *Spirifer striato-paradoxus* Toula. DUNBAR, p. 131, pl. 23, figs. 1-7; pl. 24, figs. 1-5; pl. 28, figs. 1-6. [Copy of Toula's original illustration is given as pl. 28, fig. 1.]

Description. Shell large, wider than long, hinge line straight. Ratio of length to width very variable, some shells have an extended hinge line with submucronate cardinal extremities, others are much less transverse with obtuse cardinal extremities. Greatest width at or near the hinge line. Shell substance impunctate.

Ventral valve gently convex near the beak, beak incurved. Interarea large, triangular, with vertical and horizontal striations. Delthyrium large, triangular, partly closed by arched deltidium. Large angular sulcus extends from the beak to the anterior margin, tongue prominent and pointed. Entire surface is costate, no differentiation between costae in sulcus and those on flanks. Near the beak the costae are distinctly fasciculate, the bundles generally consisting of three ribs, the median one often the strongest, the fasciculation disappears in later stages. Bifurcation of costae occurs frequently up to about the stage of half growth, in later stages the costae become subequal in size with little further increase in number. Later stages marked by several prominent varices of growth, parallel with the anterior margin.

Dorsal beak short and broad, slightly incurved over the low, triangular interarea. Fold very conspicuous, acute, in some shells it becomes slightly less acute towards the anterior margin. Entire surface covered by costae, similar to those on the ventral valve. Spiralia consist of at least twenty-four volutions.

Dimensions (in mm).

GSC No.	Length	Width	Thickness
13747	43	90	42
13748	47	77	35
13749	39	61	28
13750	41	55	31
13751	38	57	25

Discussion. These large shells form a conspicuous and abundant element in the fauna of the Assistance formation. Similar forms from widely scattered Permian localities have been assigned to the two Himalayan species, *Spirifer ravana* Diener and *Spirifer marcoui* Waagen. In addition it is likely that some of the many reported occurrences of *Neospirifer cameratus* (Morton) refer to *Spirifer striato-paradoxus* Toula.

Toula's species has been little used and it is surprising that Wiman ignored it in favour of the Himalayan names when he monographed the Permian faunas of Spitzbergen, the more especially as some of the collections he studied were from near the sources of Toula's material. Dunbar (1955, pp. 131-136) presented a convincing case for its re-introduction, with a full description and figures based on a large collection of well-preserved specimens from East Greenland. The Grinnell specimens appear to be identical and Dunbar's usage is followed here.

Locality. Assistance formation, GSC locality 26406.

Genus *Pterospirifer* Dunbar 1955

Pterospirifer cf. *P. alatus* (Schlotheim)

Plate XX, figures 1-14

Description. Short spiriferoid with long straight hinge; ratio of length to width variable, some shells are very extended with alate cardinal extremities, others are rather less transverse with more obtuse extremities. Fold and sulcus non-plicate, flanks with about fifteen rounded costae. Surface ornament probably consists of fine concentric lamellae and radial lirae. Impunctate. Ventral interarea almost flat, delthyrium relatively narrow. Delthyrial plate present. Deltidial covering not preserved. Apical region thickened; dental lamellae strong, attached to floor of valve only in early stages, continuing as stout ridges under the edges of the delthyrium and projecting into the visceral cavity. Aseptate (*see* Figure 7).

Discussion. This old species, common in the Zechstein of Europe and the Magnesian limestone of England, has been widely reported from the Permian of Eurasia and the Arctic. The Grinnell specimens lack the faint ridge mentioned by Dunbar as present on his examples from East Greenland and visible on some but not all of the earlier described occurrences. This feature is not considered to be of very high taxonomic significance.

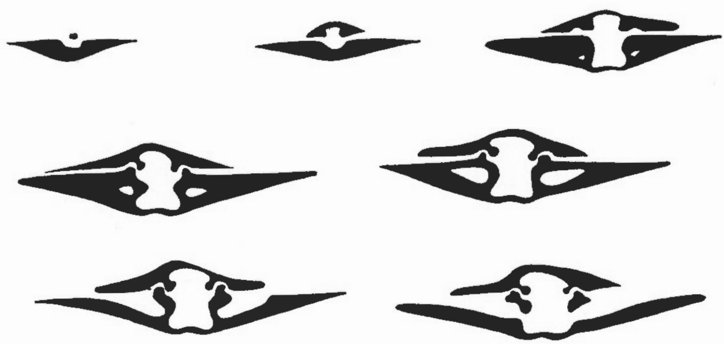


Figure 7. *Pterospirifer cf. P. alatus (Schlotheim)*
Series of sections of a typical specimen from GSC locality 26406. Natural size.

The genus *Pterospirifer* was proposed by Dunbar with *Spirifer alatus* as the generotype, distinguished in part by surface ornament of concentric lamellae and fine radial lirae. Our specimens have suffered considerable surface abrasion and although the concentric lamellae can be clearly seen in the sulcus of one of the specimens there is little or no surface micro-ornament preserved on any of the shells.

Locality. Assistance formation, GSC locality 26406.

Pterospirifer ? sp. A

Plate XXI, figures 1-14

Description. Short spiriferoid with long straight hinge; ratio of length to width variable, some shells are very extended with mucronate cardinal extremities, others are much less transverse. Shallow, non-plicate sulcus originates at the beak, dorsal fold broad, weakly developed and with distinct median furrow. Flanks have eight or more broad, rounded costae feebly dichotomising anteriorly, impunctate. Ventral interarea sub-linear rather than triangular, slightly concave with transverse lines and fine vertical striations. Beak incurved. Moderately broad delthyrium with an apical angle of about 60 degrees, fragments of deltidium preserved on some specimens. Dental lamellae strong and rising out of thick mass of callosity that fills the apical region.

Discussion. This species is very abundant in the collections from the Assistance formation. All the specimens, however, have been badly eroded, the pattern

75803-7—6½

of the costae is consequently obscured and any micro-ornament has been lost. The species is tentatively classified with *Pterospirifer* on the basis of general similarity of form with *P. alatus*. It is readily distinguished from that species by its broader, rounded costae, which are fewer in number, and by the median groove on the dorsal valve.

Locality. Assistance formation, GSC locality 26406.

Genus *Spiriferella* Tschernyschew 1902

Diagnosis. Costate spiriferoids with strongly convex ventral valve, weakly convex dorsal valve. Costae sometimes simple, more commonly dichotomising or fasciculate. Shell substance impunctate. Ventral valve thick shelled, strong dental plates partly immersed in shell substance which fills the apical cavity. Delthyrial plate absent. Prominent heart-shaped muscle platform elevated above the floor of the valve. Dorsal valve thin shelled and rarely preserved.

Discussion. Perhaps the most characteristic feature of the Permian faunas of the Arctic regions is the abundance of spiriferoids of this group. They have been assigned by previous authors to the various rather ill-defined species that comprise the genus. The genus is cosmopolitan and in addition to the boreal regions, representatives have been reported from Australia, the East Indies, India, Pakistan, the U.S.S.R. and the Far East. By contrast the genus is but poorly represented in continental North America, however, species have been reported from the Permian of British Columbia (Crockford and Warren, 1935, p. 157) and more recently from the Permian of Central Oregon (Cooper, 1957, p. 56).

There is great variability of shape and sculpture and the taxonomy has proved to be difficult and complex; it is further complicated by the rather inadequate figures of the original description of the type species, *Spirifer saranae* de Verneuil. A whole series of species and varieties has been proposed, in many instances based on small collections. With larger collections many of the so-called specific distinctions become less apparent and as Einor pointed out (1939, p. 129): "all the features on which the classification of spiriferellas is based are so variable that it is possible to find an uninterrupted series of intermediate specimens between extreme forms with respect to one or other of the features".

In his monograph of the Permian of Mongolia, Grabau recognized many species, varieties, and mutations (Grabau, 1931, pp. 128-168). A more conservative treatment was adopted by Stepanow (1937b, pp. 21-36). He united, under the name *Spiriferella saranae* sensu lato, a series of forms including such apparently well-established species as *Spiriferella salteri* Tschernyschew and *Spiriferella draschei* Toula. Large collections from Novaya Zemlya enabled Einor (1939, pp. 126-154) to attempt a real evaluation of the taxonomic significance of the various features previously used in the classification of the group. Einor's account is probably the most exhaustive yet published and it has the added authority of direct comparison with the original material of *Spiriferella saranae* (de Verneuil). Like

Stepanow, his approach was conservative and he found that most of his material could be put into three species: *S. saranae* sensu lato, *S. rajah* sensu lato, and *S. keilhavii* sensu lato. These broad species were distinguished as follows:

S. saranae, strongly convex, longitudinally extended shells with prominent, narrow-bottomed, angular sulcus. Rib pattern generally simple. Variability within the species includes convexity and height of the area.

S. keilhavii, more transverse shells, moderately convex. Interarea subparallel and of moderate height. Sulcus broad, shallow and often distinctly flat bottomed. Dorsal valve thicker than the other species with feebly elevated fold surmounted by two costae.

S. rajah differs in having bundles of complex dichotomous costae, in other features it resembles *S. saranae.*

Dunbar (1955, p. 142) had difficulty in effecting a natural separation of the spiriferellas of central East Greenland. For purposes of study he distinguished four groups designated by the letters A, B, C, and D. However, he went on to state (ibid, p. 143): "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." Dunbar identified all his specimens as *S. keilhavii* (von Buch) using this species in perhaps an even broader sense than Licharew and Einor.

Spiriferellas occur in both the Belcher Channel and the Assistance formations, but the number of specimens in the Grinnell collections is not large. By selecting the more extreme forms it is fairly easy to separate them into two groups; one group includes the more elongate shells with angular sulcus and fairly simple ribs, the other group comprises the more transverse shells with more complex rib pattern. These two groups correspond respectively with *S. saranae* sensu lato and *S. keilhavii* sensu lato of Einor. There are some intermediate forms and it is probable that there would be a completely intergrading series if more material was available. *S. saranae* occurs in both formations. The forms referred to *S. keilhavii* are only present in the collections from the Assistance formation. No stratigraphic significance is attached to this distribution owing to the relatively small number of specimens available.

Spiriferella saranae (de Verneuil) sensu lato

Plate XXII, figures 1-8; Plate XXIII, figures 3, 4, 8

1845 *Spirifer saranae* de VERNEUIL, p. 169, pl. 6, fig. 15.
1855 *Spirifer keilhavii* von Buch. SALTER, p. 386, pl. 36, fig. 11.
1857 *Spirifer arcticus* HAUGHTON, p. 243, pl. 9, fig. 1.
1902 *Spiriferina* (*Spiriferella*) *saranae* de Verneuil. TSCHERNYSCHEW, p. 121, pl. 12, fig. 4; pl. 40, fig. 7.

1902 *Spiriferina (Spiriferella) salteri* TSCHERNYSCHEW, p. 128, pl. 12, figs. 5, 6.
1916 *Spiriferella parryana* (Toula). TSCHERNYSCHEW and STEPANOW, p. 77, pl. 12, figs. 1-3.
1916 *Spiriferella saranae* (de Verneuil). TSCHERNYSCHEW and STEPANOW, p. 50, pl. 11, fig. 1.
1931 *Spiriferella salteri* Tschernyschew. GRABAU, pp. 131-148, pl. 19, figs. 1-3, 5; pl. 20, figs. 3-6; pl. 23, figs. 1-4.
1937a *Spiriferella polaris* (Wiman). STEPANOW, p. 150, pl. 8, figs. 5-8.
1937 *Spiriferella parryana* (Toula). FREBOLD, p. 45, pl. 11, fig. 6.
1937 *Spiriferella saranae* (de Verneuil). FREBOLD, p. 45, pl. 11, figs. 7, 8.
1939 *Spiriferella saranae* (de Verneuil). EINOR, p. 131, pl. 22, figs. 1-7; pl. 23, figs. 1-5.

Description. Shell medium sized to large, longer than wide, hinge line straight, greatest width near the mid-length.

Ventral valve strongly convex, beak incurved. Interarea high, triangular, concave, with faint transverse striations. Delthyrium large, triangular and partly closed by a prominent arched deltidium. Sulcus commences at the beak and develops anteriorly into a broad angular depression occupying almost half the width of the shell. The costae bounding the sulcus are prominent, a few feeble costae branch off on to the sides of the sulcus near the beak. In young specimens there are two closely spaced thin costae in the bottom of the sulcus. Six or more strong costae on each flank, simple but becoming weakly fascicostellate anteriorly. Dorsal valve thin, with low fold consisting of two small costae, four simple costae on each flank.

Discussion. The broad angular sulcus so well developed on some of the larger specimens from the Belcher Channel formation is perhaps exaggerated by some loss of surface sculpture. The absence in the larger specimens of the two fine ribs at the bottom of the sulcus (*see* Pl. XXII, fig. 5) may also be due to poor preservation. One of the smaller, elongate specimens is similar to *Spiriferella parva* Cooper (1957, p. 57) from the Permian of Central Oregon.

Localities. Belcher Channel formation, GSC locality 26407; Assistance formation, GSC locality 26406.

Spiriferella keilhavii (von Buch) sensu lato

Plate XXII, figures 9-11; Plate XXIII, figures 1, 2

1848 *Spirifer keilhavii* von BUCH, p. 74, fig. 2.
1855 *Spirifer keilhavii* von Buch. SALTER, p. 386, pl. 36, figs. 9, 10.
1875a *Spirifer draschei* TOULA, p. 239, pl. 7, fig. 4.
1875a *Spirifer parryanus* TOULA, p. 256, pl. 7, figs. 7, 8.
1914 *Spiriferina keilhavii* (von Buch). WIMAN, p. 36, pl. 2, figs. 25-30; pl. 3, fig. 1.
1931 *Spiriferella keilhavii* (von Buch). GRABAU, p. 164, pl. 20, fig. 9; pl. 21, figs. 1-5.
1931 *Spiriferella keilhaviiformis* (von Buch). GRABAU, p. 160, pl. 21, figs. 6, 7.
1937 *Spiriferella keilhavii* (von Buch). FREBOLD, p. 40, pl. 11, fig. 9.
1937a *Spiriferella keilhavii* (von Buch) sensu lato. STEPANOW, p. 143, pl. 7, figs. 8-11.
1937a *Spiriferella draschei* (Toula). STEPANOW, p. 149, pl. 8, figs. 9, 10.
1939 *Spiriferella keilhavii* (von Buch) sensu lato. EINOR, p. 139, pl. 23, figs. 6, 7; pl. 24, figs. 1-9.
1955 *Spiriferella keilhavii* (von Buch). DUNBAR, p. 139, pl. 25, figs. 1-9; pl. 26, figs. 1-11; pl. 27, figs. 1-14.

Description. Shell large, wider than long, hinge line straight. Ventral valve convex, beak incurved. Interarea triangular, concave, with faint horizontal striations. Delthyrium large, partly closed by a thick, arched deltidium. Broad shallow sulcus commences at the beak, widening and becoming progressively shallower anteriorly. Sulcus occupied by ten or more costae, most of these originate near the beak, others are added by dichotomy. Seven or more costae occur on the flanks. They are simple near the beak but becomes fascicostellate anteriorly, the original simple costae always remaining prominent. Dental plates strong, slightly oblique and arising from the thick dense mass of shell substance that fills the apical region. Elevated heart-shaped muscle platform with poorly defined median depression and faint irregular flabellate muscle impressions. Dorsal valve not preserved.

Discussion. The large specimen (Pl. XXII, figs. 9-11) is typical of this broadly interpreted species; the complex rib pattern, shallow sulcus and transverse shell contrast with the typical *S. saranae* (Pl. XXII, figs. 1, 2). The smaller specimen (Pl. XXIII, figs. 1, 2) is less typical and though its ribbing, interior and width show that its affinities lie with *S. keilhavii,* the sulcus tends towards the more angular form of *S. saranae.* Conversely the elongate form assigned to *S. saranae* (Pl. XXIII, figs. 3, 4) has a relatively open sulcus. The extreme forms are relatively easy to separate; these comments, however, serve to indicate some of the difficulty in the specific assignment of intermediate forms, a procedure which must, of necessity, remain somewhat arbitrary.

Locality. Assistance formation, GSC locality 26406.

Superfamily ROSTROSPIRACEA Schuchert and Levene 1929

Family ATHYRIDAE Phillips 1841

Genus *Cleiothyridina* Buckman 1906

Cleiothyridina cf. *C. subexpansa* (Waagen)

Plate XXIV, figures 1, 2

Several rather crushed shells are referred to the genus *Cleiothyridina.* They have a well-developed concentric lamellar ornament. The shells are largely exfoliated but the flat spinose fringes on the lamellae, typical of the genus, are preserved in a few places. Some are visible on the figured specimen.

Of the various species of *Cleiothyridina* reported from the Permian of the Arctic, *C. royssii* (of authors) = *Terebratula royssiana* Keyserling and *C. pectinifera* (Sowerby) have been the most often cited. *C. royssii* has been variously interpreted by many authors resulting in an apparent cosmopolitan distribution in Permian deposits. The Grinnell specimens are rather less tranverse than those figured by Netschajew (1911, pl. 12), They also lack any very distinct fold, a feature clearly shown in Wiman's figures (1914, pl. 1). One of the specimens figured by Stepanow (1937a, pl. 9, fig. 10) is similar to ours, but is too inadequately figured for proper comparison. *C. pectinifera* (Sowerby), as interpreted by Dunbar (1955, pl. 22), has a more rounded outline than our specimens. Two Permian species, *C. nielseni* and *C. maynci* described by Dunbar (ibid., pp. 124-125) from central East Greenland are smaller and proportionately less transverse.

The Grinnell specimens appear to be very similar to the Salt Range species, *C. subexpansa* (Waagen), and they are tentatively compared with that species.

Locality. Assistance formation, GSC locality 26406.

Superfamily TEREBRATULACEA Waagen 1883

Family DIELASMATIDAE Schuchert and Levene 1929

Genus ***Dielasma*** King 1850

Dielasma cf. *D. plica* (Kutorga)

Plate XXIII, figures 5-7

Two specimens are compared with this species. They are about the usual size for the genus. Externally they possess a narrow median groove; this reflects an internal median ridge in the ventral valve and extends almost from the beak, opening anteriorly into a broad shallow sulcus. The ventral valve has the divergent dental lamellae typical of the genus. Shell substance minutely punctate.

Dielasma plica has been broadly interpreted by a number of authors and has been reported from Indo-China, India, Russia and from various localities in the Arctic regions. The Grinnell specimens are rather more elongate than Kutorga's original; they are very similar to specimens figured by Wiman (1914, pl. 1, figs. 6-8). *Dielasma moelleri* Tschernyschew has a similar groove but is more transverse than our shells.

Dimensions (in mm).

GSC No.	Length	Width	Thickness
13770	24.5	19	12
13771	22	16	10

Locality. Assistance formation, GSC locality 26406.

Phylum MOLLUSCA

Class *CEPHALOPODA*

Superfamily GONIATITACEA de Haan 1825

Family NEOICOCERATIDAE Hyatt 1900

Genus ***Pseudogastrioceras*** Spath 1930

The genus *Pseudogastrioceras* was established by Spath (1930, p. 8) to include "involute, smooth, subglobose goniatites with *Gastrioceras* suture-line, but rounded umbilical border". He cited *Gastrioceras abichianum* Möller, as figured in Arthaber (1900, pl. 18, figs. 5a-d), as the generotype. In 1934 Spath

(p. 16) referred to the "spiral striation" of *Pseudogastrioceras* from which we can deduce that he had recognized that *Pseudogastrioceras abichianum,* like *Paragastrioceras suessi* and other related forms, was longitudinally lirate.

The group of Permian ammonoids to which *Pseudogastrioceras* belongs presents some taxonomic difficulties and a number of genera have been proposed. They all have a similar simple suture plan and all are lirate. *Pseudogastrioceras* differs from *Paragastrioceras* Tschernow 1907 mainly in being more involute. In 1934, Spath (p. 15) proposed the genus *Strigogoniatites* (with *Glyphioceras angulatum* Haniel as type species) for those forms that show a distinctly angular ventral zone in maturity. In 1936 Ruzhencev (1936b, p. 1087) proposed a new genus *Uraloceras* (with *Paragastrioceras suessi* (Karpinsky) as type species) for gastrioceratids intermediate in conch proportions between *Paragastrioceras* and *Pseudogastrioceras.* He further distinguished *Uraloceras* by its different proportions in the width of the branches of the ventral and first lateral lobes and a tendency towards nodose umbilical zones and whorl constrictions. These last two features are not prominent in *Pseudogastrioceras* though they occur to some extent in the more evolute forms assigned to *Paragastrioceras* and also in the genus *Altudoceras* which was proposed by Ruzhencev (with *Pseudogastrioceras altudense* (Bose) as type species). *Altudoceras* was largely defined on the nature of the constrictions and transverse ornament (Ruzhencev, 1940, p. 288).

Miller and Furnish (1940, p. 89) claimed that there was complete gradation between the type species of *Paragastrioceras, Pseudogastrioceras* and *Strigogoniatites.* Miller and Furnish stated that it would be logical to unite these three genera under a single inclusive genus. Such a course, however, would involve a rather cumbersome terminology of subgenera and they chose to retain the three genera. Their diagnosis of *Pseudogastrioceras* was broad enough to include *Uraloceras. Altudoceras* was placed in synonymy with *Pseudogastrioceras* by Miller, Furnish and Schindewolf (1957, p. L. 63).

Several ammonoid fragments from the Assistance formation are assigned to the genus *Pseudogastrioceras* and are here described as a new species. *Pseudogastrioceras* ranges throughout the Permian.

Pseudogastrioceras fortieri n. sp.

Plate XXIV, figures 3-5; Plate XXV, figures 1-3

Description. Shell moderately involute (subangustumbilicate). Body chamber occupies one complete whorl in the largest specimen. Whorl section fairly high (subplatygyral) and fairly thick (subpachygyral). Venter evenly rounded, flanks slightly convex, umbilical wall steep. Surface ornament consists of longitudinal lirae (about a half mm apart at diameter of 44 mm) crossed slightly obliquely by fine transverse striae (about ten in 1 mm at diameter of 44 mm). No umbilical nodes or transverse constrictions are visible on any of the specimens.

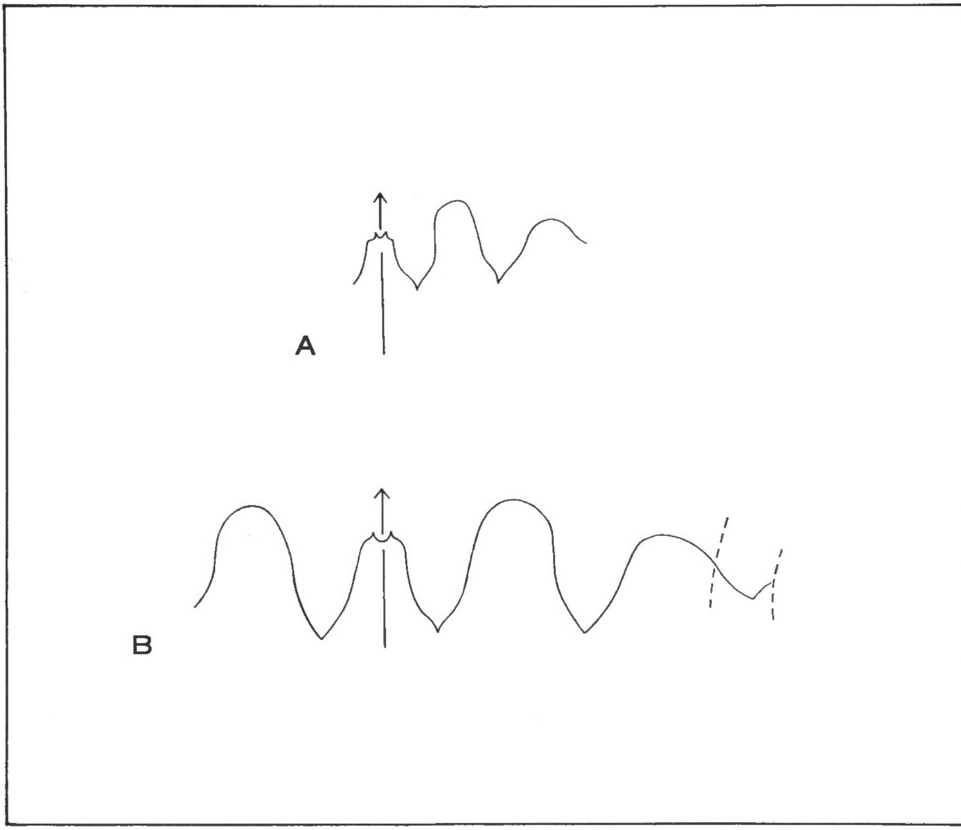


Figure 8. Pseudogastrioceras fortieri n. sp.
A. Diagram of external suture line at a diameter of about 28 mm. Paratype GSC No. 13774, x 2.
B. Diagram of external suture line at a diameter of about 42 mm. Holotype GSC No. 13772, x 2.

Mature suture consists of a broad ventral lobe divided by a ventral saddle, a smaller lateral lobe situated about the middle of the flanks and a much smaller more obtuse umbilical lobe. The lateral saddle is higher than the ventral (*see* Figure 8). Internal suture not seen.

Named after Y. O. Fortier, leader of Operation Franklin, 1955.

Dimensions (in mm).

GSC No.	Diameter (D)	Height of whorl (H)	Thickness (T)	Width of umbilicus (U)	H/D	T/D	U/D
13772	47.3	23	24.5	10	49	52	21
13773	49	24	....	....	48	....	....
13774	166	72	65	38	43	39	23

Material. Holotype, GSC No. 13772; paratypes, GSC Nos. 13773 and 13774.

Discussion. Pseudogastrioceras fortieri is fairly close to the generotype *P. abichianum,* it differs however in having proportionately lower whorl height and a more open umbilicus. If *Uraloceras* is to be regarded as intermediate along the line from *Pseudogastrioceras* to *Paragastrioceras,* then the new species represents a stage fairly close to the *Pseudogastrioceras* end of this morphological series. It is readily distinguished from several new species of *Uraloceras* described by Ruzhencev (1956, pp. 178-192) and also from *U. suessi* (Karpinsky) and *U. federowi* (Karpinsky) as interpreted by him in the same paper. All these forms are much more evolute, have a proportionally lower whorl height and their sutures show a smaller, narrower umbilical lobe. *P. fortieri* is very similar to the antipodal species, *P. pokolbinense* described by Teichert (1954, p. 46) from the Permian of eastern Australia. *P. fortieri* differs in being rather thicker, and has slightly higher whorls without constrictions.

Locality. Assistance formation, GSC locality 26406.

Family METALEGOCERATIDAE Plummer and Scott 1937

Genus *Metalegoceras* Schindewolf 1931

The genus *Metalegoceras* was established by Schindewolf (1931, p. 199) with *Paralegoceras evolutum* Haniel as the type species. It includes thick, globose goniatites with broadly helmet-shaped whorl section, rounded venter, abrupt umbilical shoulder and steep umbilical walls. The suture consists of twelve lobes. In most species, including the generotype the umbilical lobe is well developed. In a few species, as for example *M. somoholense* (Haniel), *M. jacksoni* (Etheridge), *M. colemanense* Plummer and Scott and *M. campbelli* Teichert and Glenister the umbilical lobe is less well developed. This was considered to be a primitive feature by Miller and Furnish (1940, p. 98). All these species are of Lower Permian age. Surface ornament is inconspicuous in many of the species assigned to the genus, however, some species have faint longitudinal lirae, as in *M. schucherti* Miller and Furnish; *M. sogurense razumowskajae* (Voinova) as figured by Ruzhencev (1956, pl. 8) has a distinct reticulate pattern of longitudinal lirae crossed by transverse striae. *Metalegoceras* is Lower and Middle Permian and according to Plummer and Scott (1937, p. 280) was derived from the Upper Pennsylvanian genus *Glaphrites.*

Metalegoceras sp.

Plate XXV, figures 4-6

Description. Shell moderately involute (subangustumbilicate). Whorl section fairly high (subplatygyral) and thick (pachygyral). Venter broadly and evenly rounded, flanks very slightly convex, umbilical shoulder narrowly rounded, umbilical wall steep. Shell wall thick, surface ornament of longitudinal lirae (about 0.5 mm apart at diameter of 35 mm) crossed by faint transverse striae. No umbilical nodes or transverse constrictions are visible.

Complete suture consists of 12 lobes. The broad ventral lobe is divided by ventral saddle. The umbilical lobe is small and obtuse (*see* Figure 9).

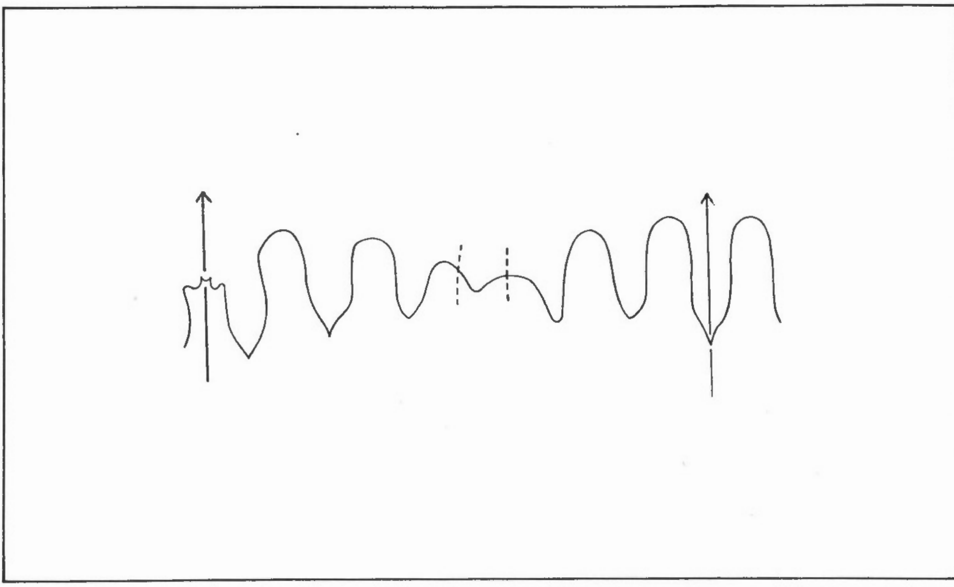


Figure 9. *Metalegoceras sp.*
Diagram of complete suture line at a diameter of about 34 mm. GSC No. 13775, x 2.

Dimensions (in mm).

GSC No.	Diameter	Height of whorl	Thickness	Width of umbilicus	$\frac{H}{D}$	$\frac{T}{D}$	$\frac{U}{D}$
13775	36	15	20	10	41	61	28

Discussion. A single phragmacone from the Assistance formation is referred to the genus *Metalegoceras.* It is similar to *M. tschernyschewi* (Karpinsky) but the suture has a less-developed umbilical lobe. The suture is, however, less primitive than those of the Australian species *M. jacksoni* (Etheridge) and *M. campbelli* Teichert and Glenister. The generotype has thicker whorls and is more evolute than our specimen.

Locality. Assistance formation, GSC locality 26406.

Class SCAPHOPODA

Genus *Plagioglypta* Pilsbry 1898

Plagioglypta sp.

Plate XXV, figures 7, 8

Fragments of scaphopods are common in the Assistance formation. They are circular in cross-section and moderately curved. Three distinct shell layers are preserved. Faint encircling lines, with a spacing of about 1 mm, occur in the outermost layer. There are also sporadic rings of short, feeble, longitudinal wrinkles. No continuous longitudinal ornament is present. The taxonomy of this rather obscure group of organisms has received scanty treatment by systematists and no attempt is made to assign the Grinnell specimens to a species. They are similar to *Plagioglypta herculea* (de Koninck) which occurs in the Permian of the Salt Range, Japan, and the Bokhara region of the U.S.S.R.

Locality. Assistance formation, GSC locality 26406.

BIBLIOGRAPHY

Arthaber, G. von

1900: Das jüngere paläozoicum aus der Araxes-Enge bei Djulfa; *Beitr. Paläont. und Geol. Oesterr.-Ungarns und des Orients,* Vienna, vol. 12, pt. 4, pp. 209-302.

Belcher, E.

1855: The Last of the Arctic Voyages; being a Narrative of the Expedition in HMS *Assistance,* under the Command of Captain Sir Edward Belcher, C.B., in search of Sir John Franklin, during the years 1852-53-54; London, Lovell Reeve.

Broili, F.

1916: Permische Brachiopoden von Timor; *Pal. von Timor,* Lief 7, pt. 12, Stuttgart, pp. 1-104, pls. 1-13.

Bruguière, J. G.

1797: Encyclopedie Méthodique; Tableau Encyclopedique et methodique des trois regnes de la nature; Vers, Coquilles, Mollusques et Polypiers, 2, pls. 96-314.

Buch, L. von

1848: Ueber *Spirifer keilhavii; Abh. der K. Akademie der Wissenschaften zu Berlin (1846),* pp. 65-80, 1 pl.

Buckman, S. S.

1906: Brachiopod Nomenclature; *Ann. Mag. Natural Hist.,* London, ser. 7, vol. 18, No. 107, pp. 321-327.

Chao, Y. T.

1927: Productidae of China, Part 1, Producti; *Palaeont. Sinica,* ser. B, vol. 5, fasc. 2, pp. 1-191, pls. 1-16.

1929: Carboniferous and Permian Spiriferids of China; *Palaeont. Sinica,* ser. B, vol. 2, fasc. 1, pp. 1-133, pls. 1-11.

Conrad, T. A.

1839: Second annual report on the Paleontological Department of the Survey (of New York); *N.Y. Geol. Surv.,* Ann. Rept. 3, pp. 57-66.

Cooper, G. A.

1957: Permian Brachiopods from Central Oregon; *Smiths. Misc. Coll.,* vol. 134, No. 12, pp. 1-79, pls. 1-12.

Crockford, M. B. B., and Warren, P. S.

1935: The Cache Creek Series of British Columbia; *Trans. Roy. Soc. Can.,* ser. 3, vol. 29, pp. 149-161.

Dana, J. D.

1846: Genera of Fossil Corals of the Family Cyathophyllidae; *Am. J. Sci. Arts,* (2), 1, pp. 178-189.

Davidson, T.

1862: On some Carboniferous Brachiopoda collected in India by A. Fleming, M.D., and W. Purdon, Esq., F.G.S.; *Quart. J. Geol. Soc. London,* vol. 18, pp. 25-35, pls. 1-2

1884: A Monograph of the British Fossil Brachiopoda; *Pal. Soc. London,* Mon. 5, pp. 243-476, pls. 18-21.

Dunbar, C. O.

1955: Permian Brachiopod Faunas of Central East Greenland; *Medd. om. Grønland,* bd. 110, No. 3, pp. 1-169, pls. 1-32.

Dunbar, C. O., and Condra, G. E.

1932: Brachiopoda of the Pennsylvanian System in Nebraska; *Nebr. Geol. Surv.,* Bull 5, ser. 2, pp. 1-377, pls. 1-44.

Dunbar, C. O., and Hendest, L. G.
1930: The Fusulinid genera *Fusulina, Fusulinella* and *Wedekinella; Am. J. Sci.,* ser. 5, vol. 20, pp. 357-364.

Dunbar, C. O., and Newell, N. D.
1946: Marine Early Permian of the Central Andes and its Fusuline faunas; *Am. J. Sci.,* ser. 5, vol. 244, pp. 377-402, pp. 457-491, 3 text figs., pls. 1-12.

Dunbar, C. O., and Skinner, J. W.
1931: New Fusulinid genera from the Permian of West Texas; *Am. J. Sci.,* ser. 5, vol. 222, pp. 252-268, pls. 1-3.
1936: *Schwagerina* versus *Pseudoschwagerina* and *Paraschwagerina; J. Paleont.,* vol. 10, pp. 83-91, pls. 10, 11.
1937: The Geology of Texas, Volume III, Part 2. Permian Fusulinidae of Texas; *Texas Univ.,* Bull. 3701, pp. 517-825, pls. 42-81.

Dybowski, W. N.
1873: Monographie der Zoantharia Sclerodermata rugosa aus der Silur-formation Estlands; Nord Livlands und der Insel Gotland; *Arch. Naturk. Liv. Ehst. u. Kurlands.,* ser. 1, bd. 5, pp. 257-532, pls. 1-5.

Easton, W. H.
1944: Revision of *Campophyllum* in North America; *J. Paleont.,* vol. 18, No. 2, pp. 119-132, pl. 22.

Einor, O. L.
1939: *See* Licharew, B., and Einor, O. L.

Fischer von Waldheim, G.
1837: "Oryctographie du gouvernment de Moscou", 2nd ed., pp. 1-202, pls. A-G.

Fleming, J.
1828: "A History of British Animals"; Edinburgh, XXIII, pp. 1-565.

Frebold, H.
1931: Das Marine Oberkarbon Ostgrönlands; *Medd. om Grønland,* bd. 84, No. 2, pp. 1-88, pls. 1-6.
1932: Das Perm von Wollaston Vorland (Nördostliches Ostgrönland); *Medd. om Grønland,* bd. 94, No. 8, pp. 1-76, pls. 1-2.
1933: Die Fauna und Stratigraphische stellung der Oberpalaozoischen Weissen Blöcke (Kap Stosch formation) Ostgrönlands; *Medd. om Grønland,* bd. 84, No. 7, pp. 1-61, pls. 1-6.
1937: Das Festungsprofil auf Spitzbergen, IV; *Skr. om Svalb. og Ishavet,* No. 69, Oslo, pp. 1-94, pls. 1-11.
1942 Uber die Productiden des Brachiopodenkalkes; *Skr. om Svalb. og Ishavet,* No. 84, Oslo, pp. 1-68, pls. 1-3.
1950: Stratigraphie und Brachiopodenfauna des Marinen Jungpalaozoikums von Holms und Amdrups Land (Nordostgrönland); *Medd. om Grønland,* bd. 126, No. 3, pp. 1-97, pls. 1-6.
1951: Geologie des Barentsschelfes; *Abh. Deutschen Akad. der Wiss., Berlin, Kl. Math. und Naturwiss,* Jahrg. 1950, No. 5, pp. 1-150.

Fredericks, G.
1926: Matériaux se rapportant à la faune de l'assise sablo-argileuse de la riv. Kejim-Terovey; *Bull. Com. Geol. Leningrad,* vol. 45, No. 2, pp. 81-91.
1934: Fauna of the Permian Rocks of the Kanin Peninsula; *Trans. Arct. Inst., Leningrad,* vol. 13, pp. 5-42, pls. 1-5.

Geinitz, H. B.
1861: "Dyas, oder die Zechsteinformation und das Rothliegendes"; Heft 1, Leipzig, pp. 1-130, pls. 1-23.

Gemmellaro, G. G.
1899: La Fauna dei Calcari con Fusulina della Valle del Fiume Sosio nella Provincia di Palermo; *Soc. di Sci. Naturali ed Economiche,* Palermo, 22, pp. 95-214.

Gorsky, I. I.
1932: Corals from the Lower Carboniferous deposits of Kirgizian Steppe; *Trans. Cent. Geol. and Prospecting Inst.*, U.S.S.R., Leningrad, No. 1, pp. 1-94, pls. 1-5.

Grabau, A. W.
1931: The Permian of Mongolia; *Am. Mus. Natural Hist.*, Natural Hist. of Central Asia, vol. 4, pp. 1-665, pls. 1-35.

Gray, J. E.
1840: *In* Synopsis of the Contents of the British Museum; 42nd ed., London, pp. 1-370.

Gvosdilova, L. P.
1938: Fusulinids from the oil-bearing Ishimbaevsky Area; *Trudy Neftyanogo Geologo-Rasvedotshnogo Inst.*, ser. A, No. 101, Moscow-Leningrad, pp. 90-141.

Haan, G. de
1825: Monographiae Ammoniteorum et Goniatiteorum Spécimen; 168 pp.

Hall, J., and Clarke, J. M.
1895: Introduction to the Study of Brachiopoda intended as a Handbook for the use of Students, Part 2; Ann. Rept. *N.Y. State Geol.* 13 (1893), pp. 749-1015, pls. 1-54.

Harker, P., and Thorsteinsson, R.
1958: Permian Section on Grinnell Peninsula, Arctic Archipelago, Northwest Territories, Canada; *Bull. Geol. Soc. Amer.*, vol. 69, No. 12, pt. 2, p. 1577 (abstract).

Haughton, S.
1857: *In* M'Clintock, F. L., Arctic Ice Travels in Search of Sir John Franklin; *J. Roy. Dublin Soc.*, vol. 1, pp. 239-250, pls. 5-11.

Heritsch, F.
1929: Eine Caninia aus dem Karbon des de Geer-Berges im Eisfjord-Gebiet auf Spitzbergen; *Skr. om Svalb. og Ishavet,* No. 24, Oslo, pp. 1-21, pls. 1-8.
1939: Die Korallen des Jungpaläozoikums von Spitzbergen; *Arkiv för Zool.*, Stockholm 31A, No. 16, pp. 1-138, pls. 1-21.

Hill, D.
1956: Treatise on Invertebrate Paleontology, Part F, Coelenterata; *Geol. Soc. Amer. and Univ. Kansas Press.*

Holtedahl, O.
1913: Zur kenntnis der Karbonablagerungen des Westlichen Spitzbergens II Allgemeine stratigraphische und tektonische beobachtungen; *Vids. Selss K Skrifter,* I, Mat. Nat. Klasse, Kristiana, No. 23, 1912, pp. 1-91.

Huang, T. K.
1932: Permian corals of Southern China; *Palaeont. Sinica,* ser. B, vol. 8, fasc. 2, pp. 1-163, pls. 1-16.

Hyatt, A.
1900: Cephalopoda, *in* Zittel, K. A. von, edited by Eastman, C. R. *Textbook of Palaeont.,* vol. 1, London, Macmillan, pp. 502-592.

Kane, E. K.
1854: "The U.S. Grinnell Expedition in Search of Sir John Franklin"; New York, Harper.

Keyserling, A.
1846: Wissenschaftliche Beobachtungen auf einer Reise in das Petschora-Land, in Jahre 1843; St. Petersburg, Geognostiche Beobachtungen, pp. 149-406, pls. 1-22.

King, W.
1846: Remarks on Certain Genera Belonging to the Class Palliobranchiata; *Ann. Mag. Natural Hist.*, vol. 18, pp. 26-42, pp. 83-94.
1850: A Monograph of the Permian fossils of England; *Pal. Soc. London,* Mon. 3, XXXVII, pp. 1-258, pls. 1-28.
1865: Remarks on the histology of two specimens of *Rhynchopora geinitziana* de Verneuil, from near the River Oukhla, province of Archangel; *Ann. Mag. Natural Hist., ser.* 3, vol. 16, pp. 124-128.

75803-7—7

Knight, Raymond L.
1956: Permian Fusulinids from Nevada; *J. Paleont.*, vol. 30, pp. 773-792, pls. 83-88, 3 text figs.

Kobayashi, Manabu
1957: Paleontological Study of the Ibu Kiyama limestone, Shiga Prefecture Central Japan; *Sci. Rept., Tokyo Kyoiku Daig.*, sec. c, vol. 5, No. 48, pp. 95-311, pls. 1-10.

Koninck, L. G. de
1842: "Description des Animaux fossiles qui se trouvent dans le terrain Carbonifère de Belgique"; Liège, pp. 1-649, pls. 1-69.
1847: Recherches sur les Animaux fossiles, Première partie. Monographie des genres *Productus et Chonetes*, H. Dessain, Liege, pp. 1-243, pls. 1-20.
1850: Notice sur quelques fossiles du Spitzberg; *Bull. Acad. Sci. Bruxelles*, 16, pp. 632-642.

Kraicz, I.
1934: Die Systematische Stellung von *Roemeria Bohemica* Barrande; *Lotos*, bd. 82, Prague, pp. 38-46, 3 pls.

Krotov, P.
1888: Geologische Forschungen an westlichen Ural-Abhange in den Gebieten von Ischerdyn und Solikamsk; *Mem. Com. Geol.*, St. Petersburg, vol. 6, No. 1, pp. 1-563, 2 pls.

Kulikov, M. V.
1938: Brachiopoda from the Ischimbaevo oil field; *Trudy Neftyanogo Geologo-Rasvedotshnogo Inst.*, ser. A, 115, pp. 145-164.

Kutorga, S.
1844: Zweiter Beitrag zur Paläontologie Russlands; *Abh. Russ. Min. Ges.*, St. Petersburg, pp. 62-104, 10 pls.

Lang, D. L., Smith, S., and Thomas, H. D.
1940: Index of Palaeozoic Coral Genera; *Brit. Museum (Natural Hist.)*, VII, pp. 1-231.

Licharew, B.
1934: On Some New Genera of Upper Palaeozoic Brachiopoda; *Acad. Sci. U.S.S.R. Leningrad Comptes Rendus*, n. ser., vol. 1, No. 4, pp. 210-213.
1939: Atlas of the Leading Forms of the Fossil Faunas of U.S.S.R.; Leningrad, vol. 5, pp. 76-121, pls. 16-29.
1947: *Muirwoodia*, nov. gen.; *Doklady Akad. Nauk U.S.S.R.*, Moscow, n. ser., vol. 57, No. 2, pp. 187-190.

Licharew, B., and Einor, O. L.
1939: Contributions to the Knowledge of the Upper Palaeozoic Fauna of Novaya Zemlya. Brachiopoda; *Trans. Arct. Inst.*, Leningrad, vol. 127, pp. 1-245, pls. 1-38.

Lonsdale, W.
1845: Description of some Palaeozoic corals of Russia, *in* Murchison, de Verneuil and Keyserling, "The Geology of Russia in Europe and the Ural Mountains", vol. 1, appendix A; John Murray, London, and Bertrand, Paris, pp. 591-634.

M'Clintock, F. L.
1859: The Voyage of the *Fox* in the Arctic Seas; A Narrative of the Discovery of the Fate of Sir John Franklin and His Companions; London, Murray.

M'Coy, F.
1844: A Synopsis of the Characters of the Carboniferous Limestone Fossils of Ireland; Dublin, vi, pp. 1-207, pls. 1-29.

McLaren, D. J., and Sutherland, P. K.
1949: *Lithostrotion* from Northeast British Columbia and its Bearing on the Genomorph Concept; *J. Paleont.*, vol. 23, No. 6, pp. 625-634, pl. 103.

Malzahn, E.
1937: Die deutschen Zechsteinbrachiopoden; *Abh. Preuss. Geol. Landesanst.*, Berlin, n. ser., vol. 185, pp. 4-77, pls. 1-4.

Mansuy, H.
1913: Faunes des calcaires à Productus de l'Indochine, Indochina; *Service Geol. Hanoi-Haiphong,* Mem. 2, fasc. 4, pp. 1-133, pls. 1-13.

Meyer, H. L. F.
1914: Carbonfaunen aus Bolivia und Peru; *Neues Jahrb. Min. Geol. Paläont.*, Beilage, 37, Stuttgart, pp. 590-652, pls. 13-14.

Michelin, J. L. A.
1840: *In* Gervais, Astrée, Astraea, Dict. Sci. Nat. Paris, suppl. 1, pp. 481-487.

Miller, A. K., and Furnish, W. M.
1940: Permian Ammonoids of the Guadaloupe Mountain Region and Adjacent Areas; *Geol. Soc. Amer.*, Spec. Paper No. 26, pp. 1-242, pls. 1-44.

Miller, A. K., Furnish, W. M., and Schindewolf, O. H.
1957: Paleozoic Ammonoidea, Treatise on Invertebrate Paleontology, Part L, Mollusca; *Geol. Soc. Amer. and Univ. Kansas Press.*

Milne-Edwards, H. M., and Haime, J.
1851: Monographie des Polypiers fossiles des Terrains Palaeozoiques; *Arch. Mus. Hist. Nat.*, Paris, 5, pp. 1-502, pls. 1-20.

Miloradovich, B. V.
1936: Lower Permian Fauna from the Island Mejdusharsky (Southern Island of Novaya Zemlya); *Trans. Arct. Inst.*, Leningrad, vol. 37, pp. 37-82, pls. 1-4.

Moffit, F. H.
1938: Geology of the Chitna Valley and Adajacent Area, Alaska; *U.S. Geol. Surv.*, Bull. 894, pp. 1-137.
1954: Geology of the Eastern Part of the Alaska Range and Adjacent Area, *U.S. Geol. Surv.*, Bull. 989-D, pp. 1-218.

Möller, V. von
1877: Ueber Fusulinen und ahnliche Foraminiferenformen des russischen Kohlenkalks; *Neues Jahrb. Min. Geol. u. Paläeont.*, Jahrg. 1877, Stuttgart, pp. 139-146, 1 text fig.
1878: Die spiral-gewundenen Foraminiferen des russischein Kohenkalks; *Acad. Imp. Sci.*, St. Petersbourg, Mem., VIIE ser., tome 25, No. 9, pp. 1-147, pls. 1-5.

Moore, R. C.
1952: Brachiopoda, *in* Moore, R. C., Lalicker, C. G., and Fischer, A. G., Invertebrate Fossils; 1st ed. New York, McGraw-Hill, pp. 197-267.

Muir-Wood, H. M.
1930: The Classification of the British Carboniferous Brachiopod Subfamily Productinae; *Ann. Mag. Natural Hist.*, ser. 10, vol. 5, pp. 100-108.
1955: A History of the Classification of the Phylum Brachiopoda; *Brit. Museum* (*Natural Hist.*), London, pp. 1-124.

Nathorst, A. G.
1910: Beitrage zur Geologie der Baren-Insel, Spitzbergens und des Konig-Karl-Landes; *Bull. Geol. Inst. Univ. Upsala,* vol. 10, No. 6, pp. 261-415.

Netschajew, A. W.
1911: Die Fauna der Perm-ablagerungen vom Osten und vom Aeussersten Norden des europaeischen Russlands: Brachiopoda; *Mem. Com. Geol.,* St. Petersburg, n. ser., vol. 61, pp. 1-164, pls. 1-15.

Orbigny, A. d'
1847: Considerations zoologiques et geologiques sur les Brachiopodes ou Palliobranches; *Comptes Rendus,* Paris, vol. 25, pp. 193-195, 266-269.

Ozaki, K.
1931: Upper Carboniferous Brachiopods of North China; *Shanghai Sci. Inst.;* Bull. 1, No. 6, pp. 1-205, pls. 1-15.

Paeckelmann, W.
1930: Die Brachiopoden des deutschen Unterkarbons; *Abh. Preuss. Geol. Landesanst.*, Berlin, n. ser., vol. 122, pp. 143-345, pls. 9-24.

Parliamentary Papers, Arctic Expeditions
1852: Additional Papers to the Arctic Expedition under the orders of Captain Austin and Mr. William Penny. Presented to both Houses of Parliament by Command of Her Majesty; London, H. M. Stationary Office.

Parry, W. E.
1821: Journal of a Voyage for the Discovery of a Northwest Passage from the Atlantic to the Pacific; performed in the years 1819-20, in H. M. ships *Hecla* and *Griper*, under the orders of William Edward Parry; London, John Murray.

Pilsbry, H. A.
1898: *In* Tryon and Pilsbry; *Man. Conchology*, vol. 17, xxxii + pp. 1-348.

Plummer, F. B., and Scott, G.
1937: Upper Paleozoic Ammonites in Texas; *Univ. Texas*, Bull. 3701, pp. 1-516, pls. 1-41.

Rhumbler, L.
1895: Entwurf eines natürlichen Systems der Thalamorphoren; *Nachr. Konigl. Ges. Wiss. Göttingen, Math.-phys.* Kl., Jahrg. 1895, pp. 51-98.

Ross, J.
1819: A Voyage of Discovery, made under the orders of the Admiralty in H. M. ships *Isabella* and *Alexander* for the purpose of exploring Baffins' Bay, and Inquiring into the Probability of a Northwest Passage; London, John Murray.

Rotay, A.
1951: Brachiopods of the Middle Carboniferous of the Donetz basin, Volume 1, Spiriferidae; *State Press Geol. Lit.*, Moscow, pp. 1-127, pls. 1-25.

Ruzhencev, V. E.
1936a: New data on the Stratigraphy of the Carboniferous and Lower Permian of the Orenburg and Aktiubinsk Districts; *Problems of Palaeont.*, Moscow, No. 6, pp. 470-506.
1936b: Palaeontological Notes on the Carboniferous and Permian Ammonoids; *Sovet. Geol.*, 6, pp. 1072-1088.
1940: On the Taxonomic Position of some Upper Palaeozoic Ammonites; *Doklady Akad. Nauk U.S.S.R.*, Moscow, vol. 28, pp. 285-288.
1956: Lower Permian Ammonites of the Southern Urals. 2, Ammonites of the Artinskian Stage; *Trans. Pal. Inst.*, Moscow, tome 60, pp. 1-271, pls. 1-39.

Salter, J. W.
1855: Account of the Arctic Carboniferous fossils; *In* E. Belcher, The Last of the Arctic Voyages, vol. 2, pp. 377-389, pl. 36.

Schellwien, E.
1892: Die Fauna der Karnischen Fusulinenkalks; *Palæontographica*, 39, pp. 91-136, pls. 1-8.

Schindewolf, O.
1931: Uber den Ammoniten-Sipho; *Sitzungsberichte der Preuss. Geol Landesanst*, Berlin, heft 6, No. 24, pp. 197-209, pl. 5.

Schrock, R. R., and Twenhofel, W. H.
1953: Principles of Invertebrate Paleontology; New York, McGraw-Hill, pp. 1-816.

Schuchert, C.
1900: Brachiopoda; *in* Zittel, K. A. von, edited by Eastman, C. R., *Textbook of Paleont.* vol. 1, London, Macmillan, pp. 291-343.

Schuchert, C., and LeVene, C.
1929: Brachiopoda; Fossilium Catalogus 1: *Animalia*, pars 42, Berlin, pp. 1-140.

Skinner, J. W.
1931 Primitive Fusulinids of the Mid-Continent region; *J. Paleont.*, vol. 5, pp. 253-259, pl. 30, 1 text fig.

Smith, S., and Lang, W. D.

1930: Descriptions of the Type-specimens of some Carboniferous Corals of the Genera *'Diphyphyllum'*, *'Stylastraea'*, *Aulophyllum* and *Chaetetes; Ann. Mag. Nat. Hist.*, ser. 10, pp. 177-194, pls. 7-8.

Soshkina, E.

1932: The Lower Permian Corals of the Oufimskoe Plateau; *Bull. Soc. Nat. Moscow*, 10, (2), pp. 251-267.

Soshkina, E., Dobrolyubora, T., and Porfiriev, G.

1941: The Permian Rugose Corals of the European Part of the U.S.S.R.; *Paleont. of U.S.S.R.*, Moscow; vol. 5, pt. 3, fasc. 1, pp. 1-304.

Spath, L. F.

1930: The Eotriassic Invertebrate Fauna of East Greenland; *Medd. om. Grønland*, bd. 83, No. 1, pp. 1-90, pls. 1-12.

1934: Catalogue of the Fossil Cephalopoda in the British Museum (Natural Hist.) Part IV. The Ammonoidea of the Trias, xvi, pp. 1-521.

Staff, H. von, and Wedekind, R.

1910: Der Obercarbone Foraminiferen Sapropelit Spitzbergens; *Bull. Geol. Inst. Univ. Upsala*, vol. 10, pp. 81-123, pls. 2-4.

Stefansson, V.

1939: Unsolved Mysteries of the Arctic; London, Harrap.

Stehli, F. G.

1954: Lower Leonardian Brachiopoda of the Sierra Diablo; *Bull. Amer. Mus. Natural Hist.*, vol. 105, art. 3, pp. 261-358, pls. 1-27.

Stepanow, D. L.

1937a: Permian Brachiopoda of Spitzbergen; *Trans. Arct. Inst.*, Leningrad, vol. 76, pp. 105-185, pls. 1-9.

1937b: Brachiopods of the Bryozoan Limestone of the Kolva area (Northern Urals), Part 2; *Publ. Leningrad State Univ.*, Leningrad, pp. 1-101.

1957: On the New Stage of the Arctic Permian; *Vestnik Univ. Leningrad*, Ser. Geol. and Geog., No. 4, pp. 20-24.

Stuckenberg, A.

1888: Die Anthozoan und Bryozoen des Oberen Mittelrussichen Kohlenkalkes; *Mem. Com. Geol.*, St. Petersburg, vol. 5, No. 4, pp. 1-54, pls. 1-4.

1895: Korallen und Bryozoan der Steinkohlenablager-ungen des Ural und des Timain; *Mem. Com. Geol.*, St. Petersburg, vol. 10, No. 3, pp. 1-244, pls. 1-24.

1898: Allgemeine geologische Kart von Russland, Blatt 127; *Mem. Com. Geol.*, St. Petersburg, vol. 16, No. 1, pp. 1-362.

Sutherland, P. C.

1852: Journal of a Voyage in Baffins' Bay and Barrow Straits, in the years 1850-51, performed by H. M. ships *Lady Franklin* and *Sophia* under the command of Mr. William Penny, in search of the Missing Crews of H. M. ships *Erebus* and *Terror;* London, Longmans.

Sverdrup, O.

1904: "New Land, Four Years in the Arctic Regions"; Longmans, Green, London, New York.

Teichert, C.

1954: A New Ammonoid from the Eastern Australian Permian Province; *J. Proc. Roy Soc. N. S. Wales*, vol. 87, pp. 46-50.

Thompson, M. L.

1937: Fusulinids of the Subfamily Schubertellinae; *J. Paleont.*, vol. 11, No. 2, pp. 118-125.

1948: Studies of American Fusulinids; *Contr. Univ. Kansas. Paleont.*, Protozoa, Art. 1, pp. 1-184, pls. 1-38.

1951: New Genera of Fusulinid Foraminifera; Cushman Lab. Foram. Research Contr., vol. 2, pp. 115-119, pls. 9, 10, 1 text fig.

1954: American Wolfcampian Fusulinids; *Contr. Univ. Kansas Paleont.*, Protozoa, Art. 5, pp. 1-225, pls. 1-52, text figs. 1-14.

Thompson, M. L., and Bissel, H. J.

1954: *In* Thompson, M. L., 1954, pp. 34-35, pl. 7.

Thompson, M. L., Dodge, H. W., and Youngquist, Walter

1958: Fusulinids from the Sublett Range, Idaho; *J. Paleont.*, vol. 32, pp. 113-125, pls. 17-20.

Thompson, M. L., and Wheeler, H. E.

1946: Permian Fusulinids of Northern California (*in* Thompson *et al.* (1946); Permian Fusulinids of California); *Geol. Soc. Amer.*, Mem. 17, pp. 21-35, pls. 1-8.

Thompson, M. L., Wheeler, H. E., and Danner, W. R.

1950: Middle and Upper Permian Fusulinids of Washington and British Columbia; Contr. from the Cushman Foundation for Foraminiferal Research, vol. 1, pts. 3-4, pp. 46-63.

Thompson, M. L., Wheeler, H. E., and Hazzard, J. C.

1946: Permian Fusulinids of California; *Geol. Soc. Amer.*, Mem. 17, pp. 1-77, pls. 1-18.

Thorsteinsson, R.

1959: Cornwallis and Little Cornwallis Islands, District of Franklin, Northwest Territories; *Geol. Surv., Canada,* Mem. 294, pp. 1-133.

Toula, F.

1873: Kohlenkalk-Fossilien von der Sudspitze von Spitzbergen; *Akad. Wiss. Wien,* Sitzungsberichte, vol. 68, pp. 267-291, pls. 1-5.

1874: Kohlenkalk und Zechstein-Fossilien aus dem Hornsund an der Sud-Westkuste von Spitzbergen; *Akad. Wiss. Wien,* Sitzungsberichte, vol. 70, pp. 133-156, 1 pl.

1875a: Permo-Carbon-Fossilien von der Westkuste von Spitzbergen; *Neues Jahrb. Min. Geol. Paläont,* Stuttgart, pp. 225-264, pls. 5-10.

1875b: Eine Kohlenkalk Fauna von den Barents Inseln; *Akad. Wiss. Wien,* Sitzungsberichte, vol. 71, pp. 527-608, 6 pls.

Tschernyschew, T.

1885: Der Permische Kalkstein im Gouvernement Kostroma; *Verh. Russ. Kais. Mineral. Ges.*, St. Petersburg, ser. 2, bd. 20, pp. 265-317.

1889: Allgemeine Geologische Kart von Russland, Blatt 139, Beschreibung des Central Urals und des Westabhanges; *Mem. Com. Geol.*, St. Petersburg, vol. 3, No. 4, pp. 1-393.

1902: Die Obercarbonischen Brachiopoden des Ural und des Timan; *Mem. Com. Geol.*, St. Petersburg, vol. 16, No. 2, pp. 1-749, pls. 1-63.

Tschernyschew, T., and Stepanow, P.

1916: Obercarbonfauna von König Oscars und Heibergs Land, Report of the Second Norwegian Arctic Expedition in the "Fram" 1898-1902; Oslo, No. 34, pp. 1-67; pls. 1-12.

Verneuil, E. de

1845: Paléontologie; Murchison, de Verneuil and Keyserling; "Géologie de la Russie d'Europe et des Montagnes de l'Oural", vol. 2, John Murray, London, and Bertrand, Paris, pp. 1-512.

Waagen, W.
1883: Salt Range Fossils, Part 4, Brachiopods; *Palaeont. Indica,* ser. 13, vol. 1, fasc. 2, pp. 391-546.
1884: Salt Range Fossils, Part 4, Brachiopods; *Palaeont. Indica,* ser. 13, vol. 1, fasc. 3-4, pp. 547-728.
1885: Salt Range Fossils, Part 4, Brachiopods; *Palaeont. Indica,* ser. 13, vol. 1, fasc. 5, pp. 729-770.

Williams, A.
1953: The classification of the Strophomenid Brachiopods; *J. Wash. Acad. Sci.*, vol. 43, No. 1, pp. 1-13.

Wiman, C.
1914: Uber die Karbonbrachiopoden Spitzbergens und Beeren Islands; *Nova Acta Regiae Soc. Sci. Upsaliensis,* ser. 4, vol. 3, No. 8, pp. 1-91.

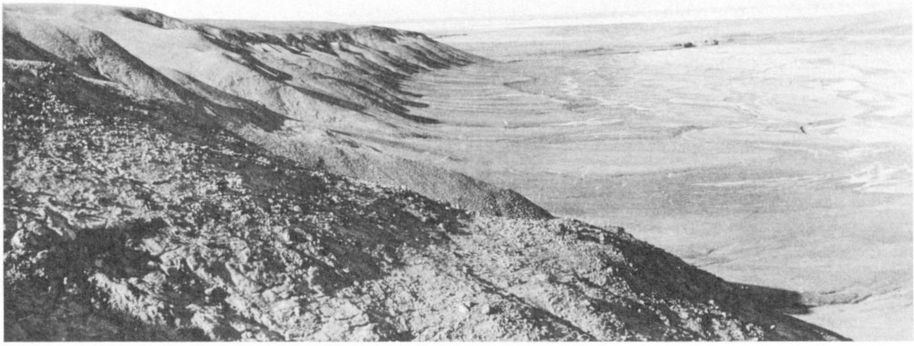
Yabe, H., and Hayasaka, I.
1915: Palaeozoic Corals from Japan, Korea, and China; *J. Geol. Soc. Japan,* 22, pp. 55-70, 79-92, 93-109, 127-146.

PLATES I TO XXV

Plate I

A. West bank of Lyall River looking downstream, showing flat-lying beds of the type section of the Assistance formation. Glauconitic sandy clay and argillaceous sand strewn with concretionary masses of sandstone typical of the formation are shown in the foreground. Outcrops of the upper part of the underlying Belcher Channel formation are visible as low cliffs in the centre background. Note scalloped edge of low cliffs on the Assistance formation formed by nivation processes. Aprons of solifluction masses developed from the nivation hollows and coalesced in the valley floor are now being actively eroded in the braided stream.

B. Uppermost beds of Belcher Channel formation on east side of Lyall River, consisting of about 65 feet of irregularly bedded bioclastic limestone.



A

B

PLATE II

Figures 1-8. *Schubertella kingi* Dunbar and Skinner. 1-3, axial sections, GSC Nos. 13910, 13909 and 13911, respectively; 4-6, tangential sections, GSC Nos. 13916, 13915 and 13914, respectively; 7, 8, sagittal sections, GSC Nos. 13913 and 13912, respectively. All figures about X50. (Page 22.)

Figures 9, 10. *Pseudofusulinella utahensis* Thompson and Bissel. 9, 10, axial sections, GSC Nos. 13928 and 13921, respectively. Both figures about X30. (Page 23.)

PLATE II

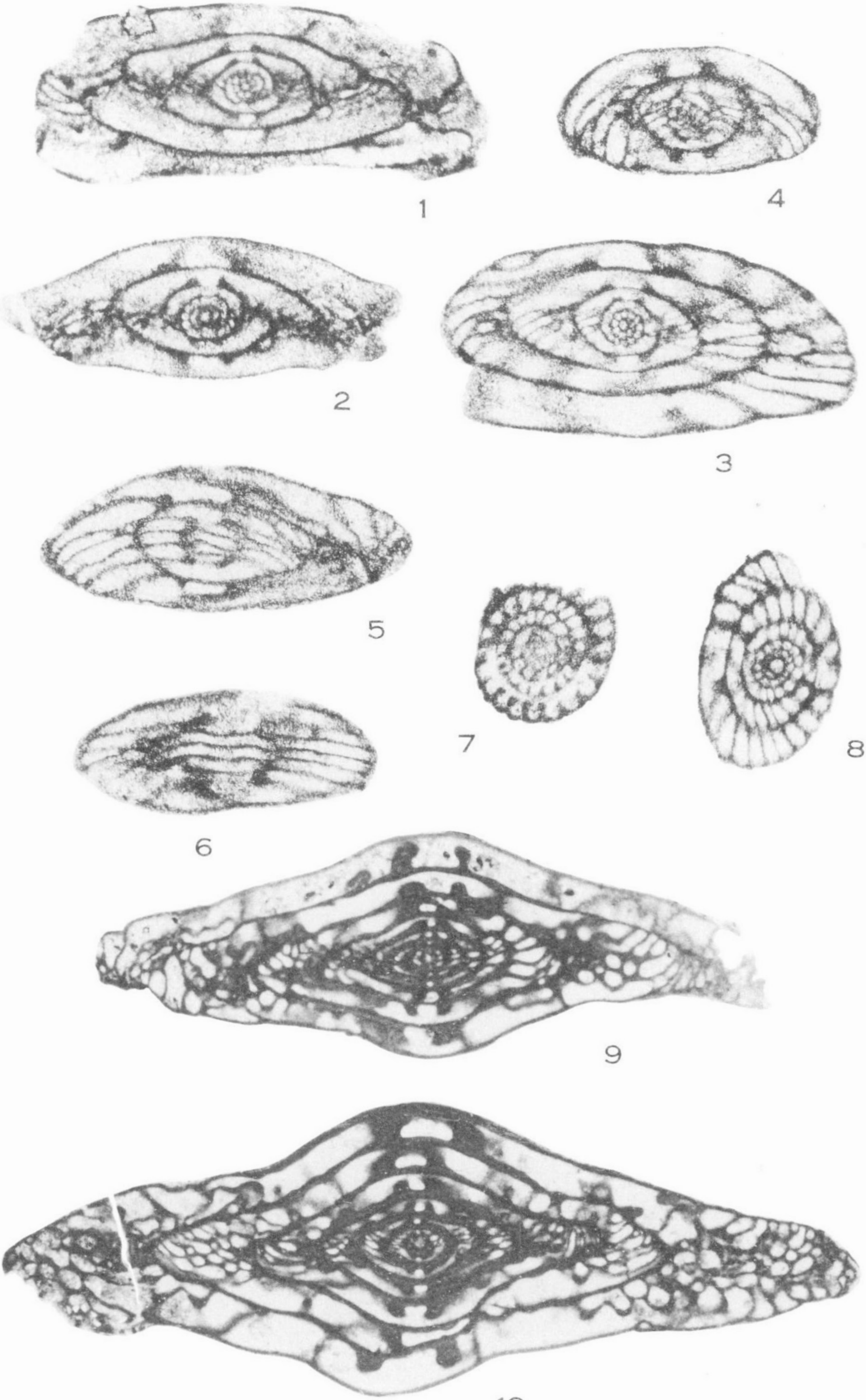
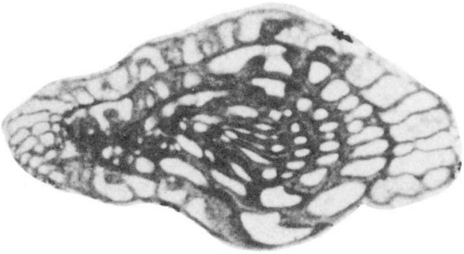


PLATE III

Figures 1-6. *Pseudofusulinella utahensis* Thompson and Bissel. 1, oblique section, GSC No. 13927; 2, 3, sagittal sections, GSC Nos. 13926 and 13923, respectively; 4-6, axial sections, GSC Nos. 13918, 13929 and 13917, respectively. All figures about X30. (Page 23.)



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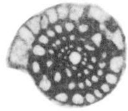

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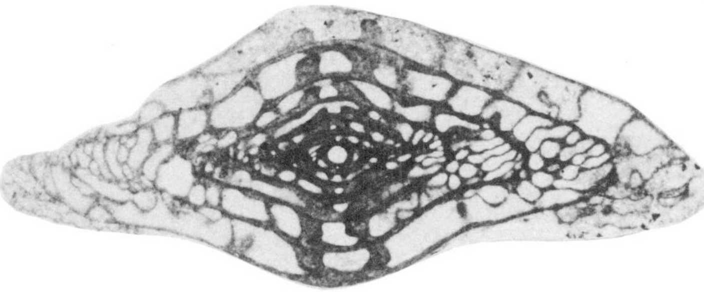

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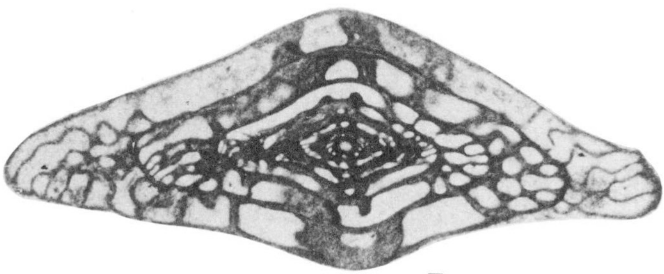

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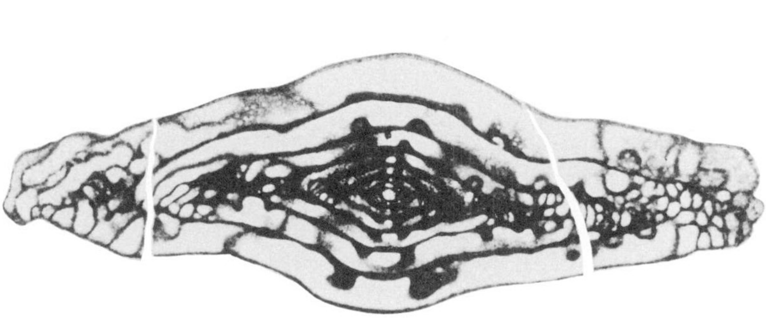

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PLATE IV

Figures 1-8. *Schwagerina paralinearis* n. sp. 1-3, axial sections of paratypes, GSC Nos. 13932, 13933 and 13934, respectively; 4, 5, sagittal sections of paratypes, GSC Nos. 13936 and 13937, respectively; 6, immature specimen, paratype, GSC No. 13930; 7, tangential section, paratype, GSC No. 13938; 8, axial section of holotype, GSC No. 13931. Figure 6, X5; all others about X10. (Page 24.)

Figures 9-12. *Schwagerina jenkinsi* n. sp. 9, mature specimen, paratype, GSC No. 13939; 10, 11, sagittal sections of paratypes, GSC Nos. 13946 and 13945, respectively; 12, tangential section, paratype, GSC No. 13944. Figure 9, X5; all others about X10. (Page 25.)

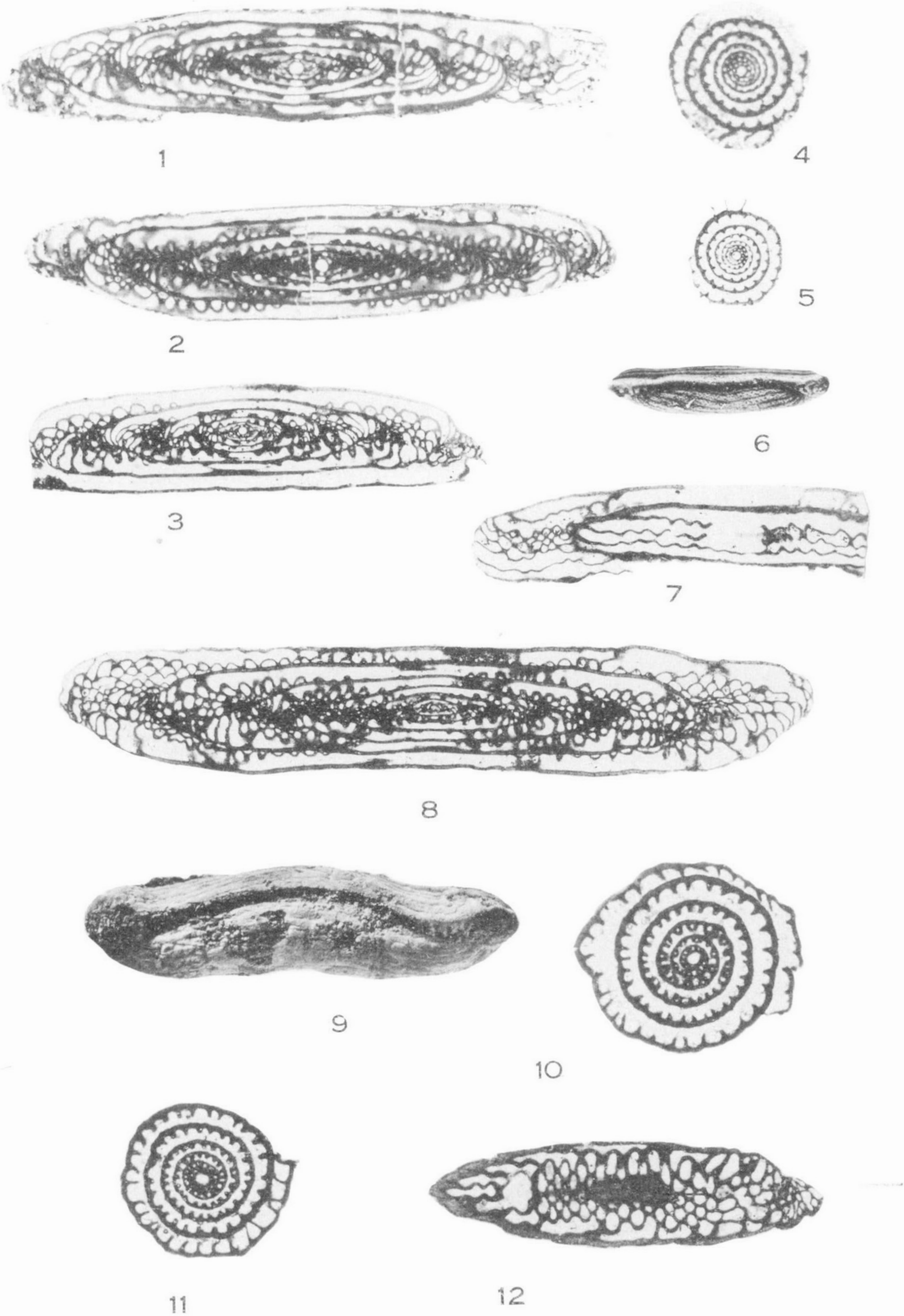
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PLATE V

Figures 1-4. *Schwagerina jenkinsi* n. sp. 1, axial section of holotype, GSC No. 13940; 2-4, axial sections of paratypes, GSC Nos. 13943, 13942 and 13941, respectively. All figures about X10. (Page 25.)

PLATE V

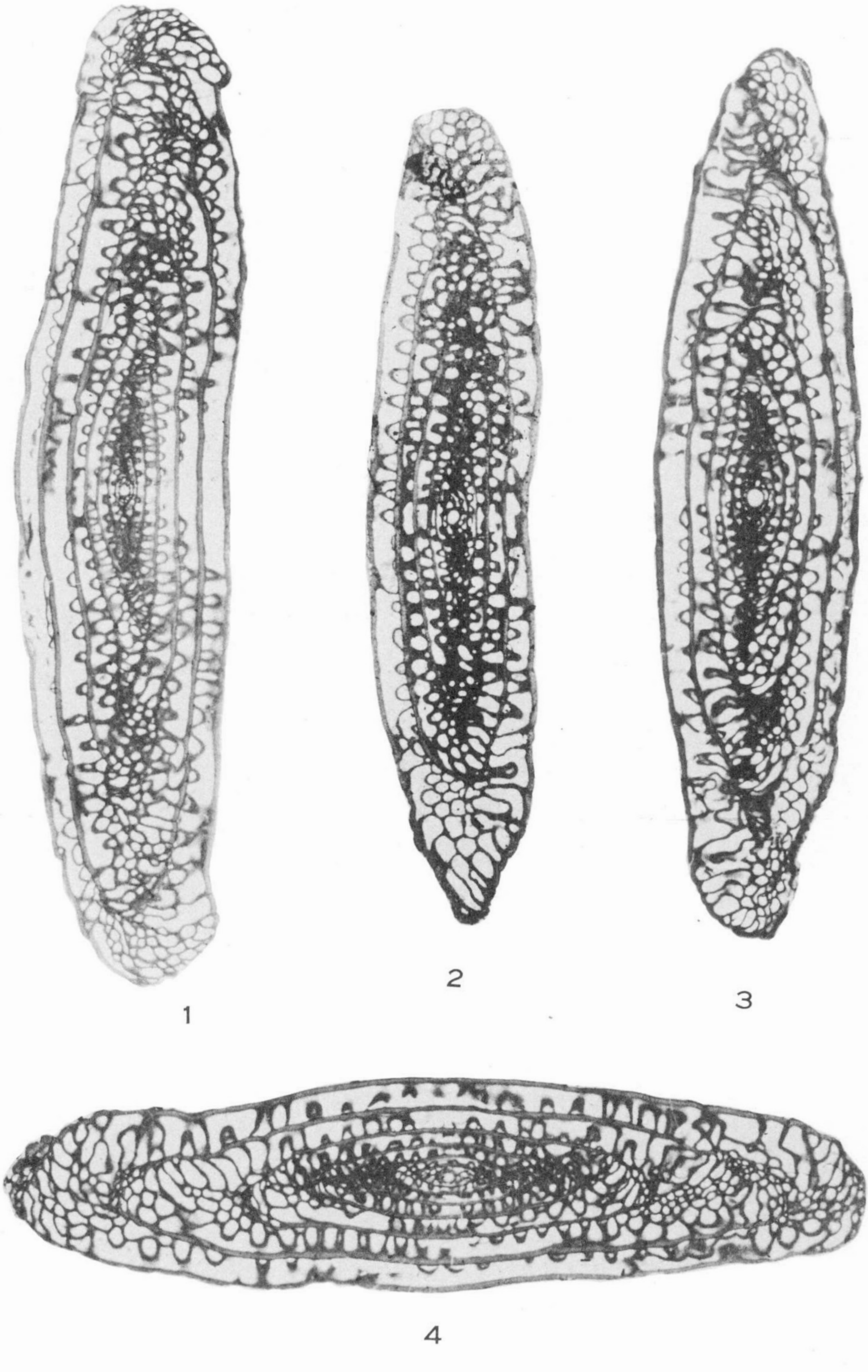

PLATE VI

Figures 1-6. *Schwagerina hyperborea* (Salter). 1, tangential section showing development of low and narrow cuniculi, GSC No. 13953; 2, 3, sagittal sections, GSC Nos. 13476b and 13951, respectively; 4-6, axial sections, GSC Nos. 13476, 13949 and 13947, respectively. All figures about X10. (Page 26.)

PLATE VI

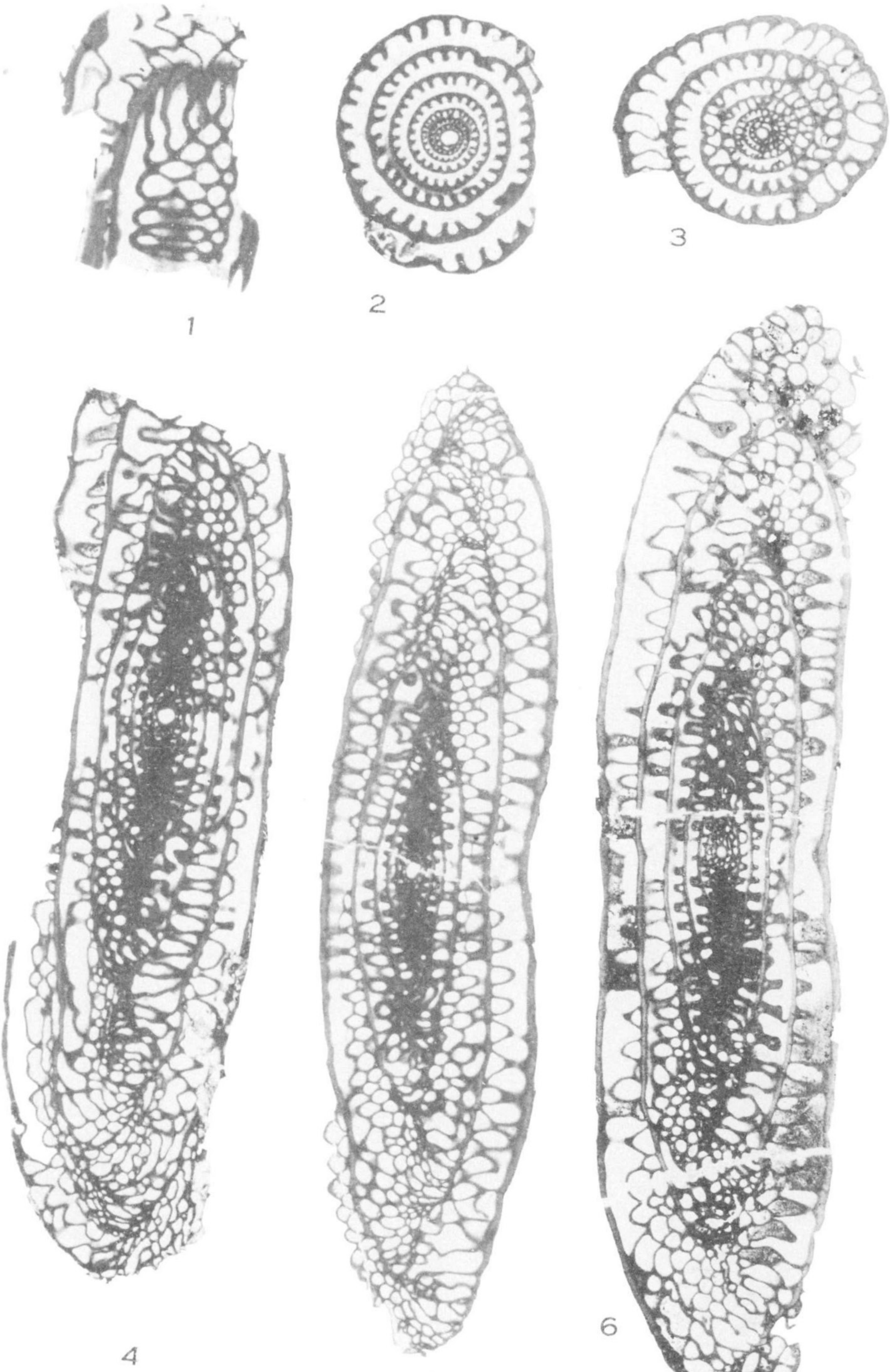

Plate VII

Figures 1-3. *Schwagerina hyperborea* (Salter). 1, 2, axial sections, GSC Nos. 13950 and 13476a, respectively; 3, tangential section, GSC No. 13952. All figures about X10. (Page 26.)

Figures 4-8. *Pseudoschwagerina grinnelli* n. sp. 4, 5, sagittal sections of paratypes, GSC Nos. 13963 and 13965, respectively; 6, axial section of holotype, GSC No. 13959; 7, tangential section of paratype, GSC No. 13966; 8, axial section of paratype, GSC No. 13956. All figures about X10. (Page 28.)

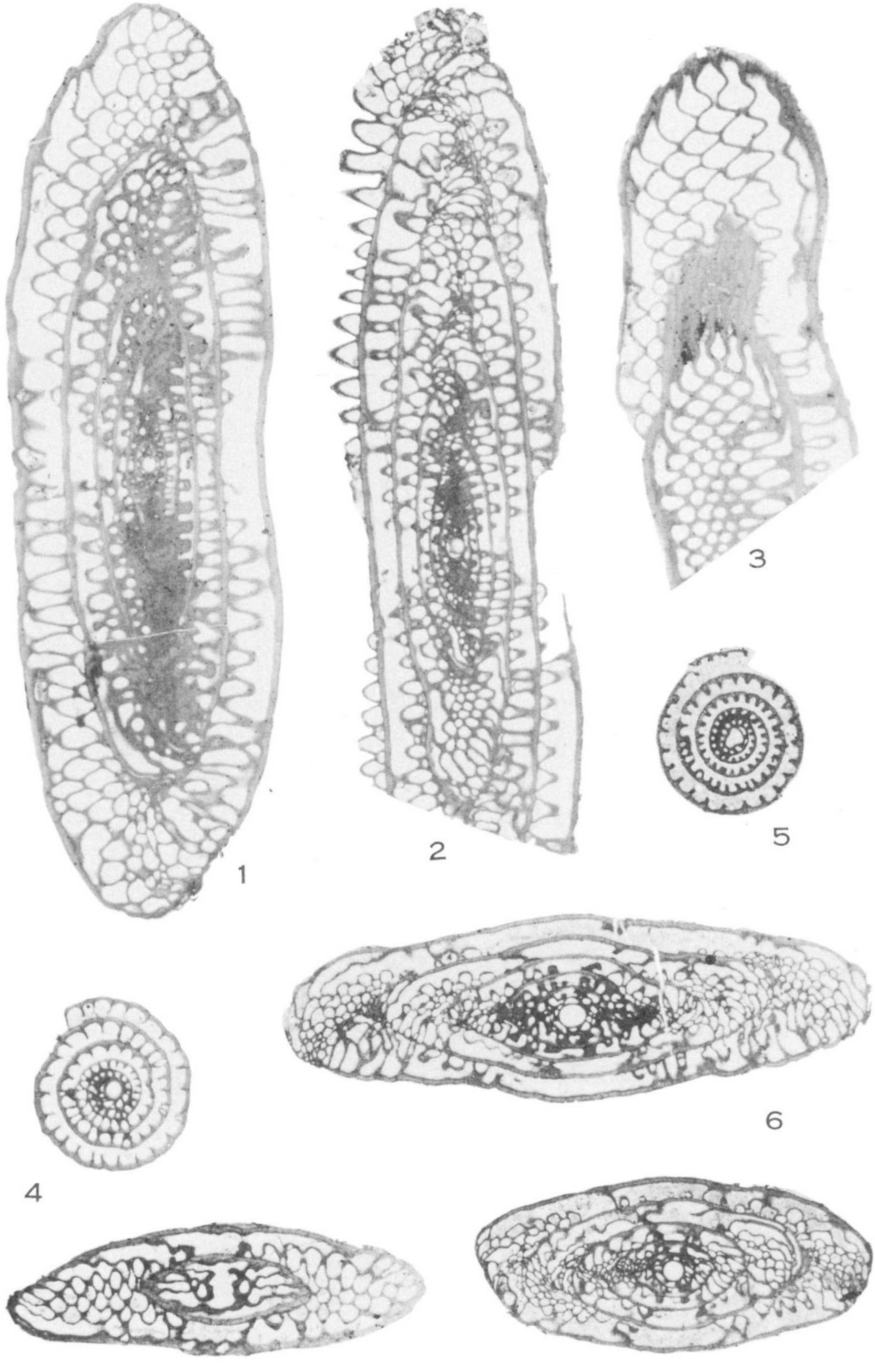
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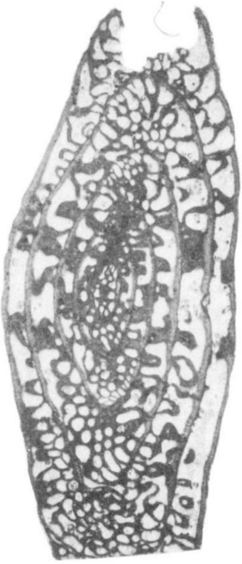
Plate VIII

Figures 1-8. *Pseudoschwagerina grinnelli* n. sp. 1, tangential section of paratype, GSC No. 13969; 2-4, 6, 7, axial sections of paratypes, GSC Nos. 13968, 13958, 13960, 13961 and 13954, respectively; 5, sagittal section, paratype, GSC No. 13962; 8, tangential section showing cuniculi-like structures, paratype, GSC No. 13967. All figures about X10. (Page 28.)



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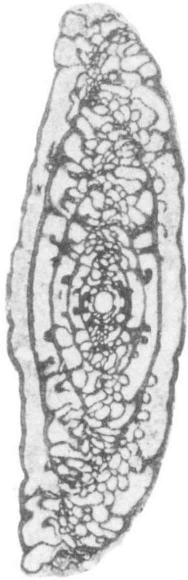

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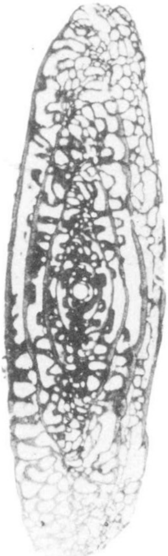

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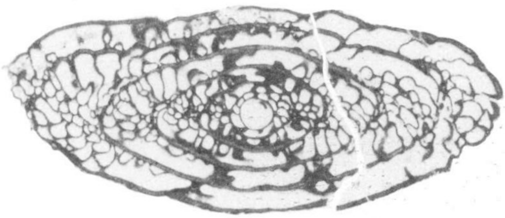

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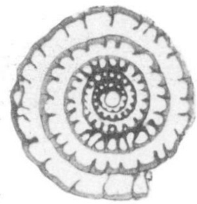

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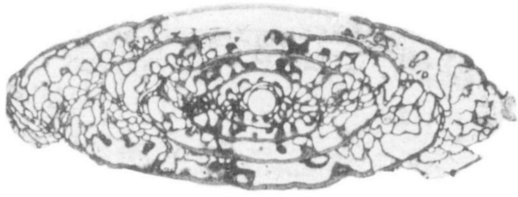

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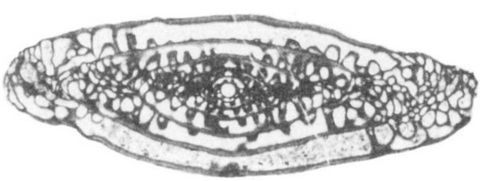

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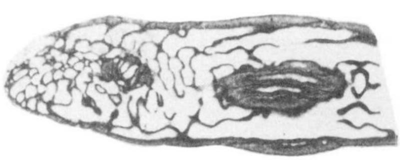

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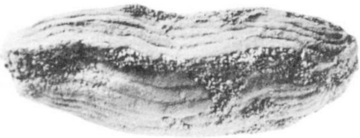
Plate IX

Figures 1-5. *Parafusulina belcheri* n. sp. 1, mature specimen, paratype, GSC No. 13970; 2, 3, sagittal sections, paratypes, GSC Nos. 13979 and 13980; 4, axial section, paratype, GSC No. 13971; 5, axial section, holotype, GSC No. 13974. All figures about X10. (Page 29.)



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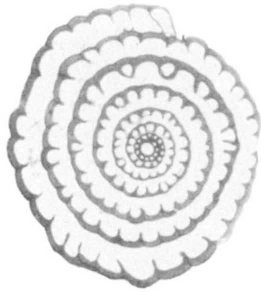

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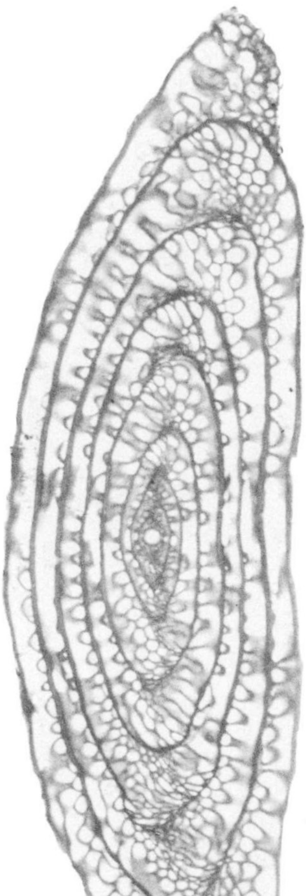

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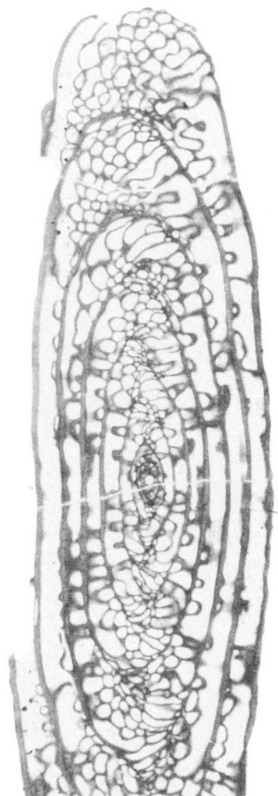

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PLATE X

Figures 1-5. *Parafusulina belcheri* n. sp. 1-4, axial sections, paratypes, GSC Nos. 13975, 13977, 13982 and 13973, respectively; 5, tangential section showing low and narrow cuniculi, paratype, GSC No. 13981. All figures about X10. (Page 29.)

PLATE X

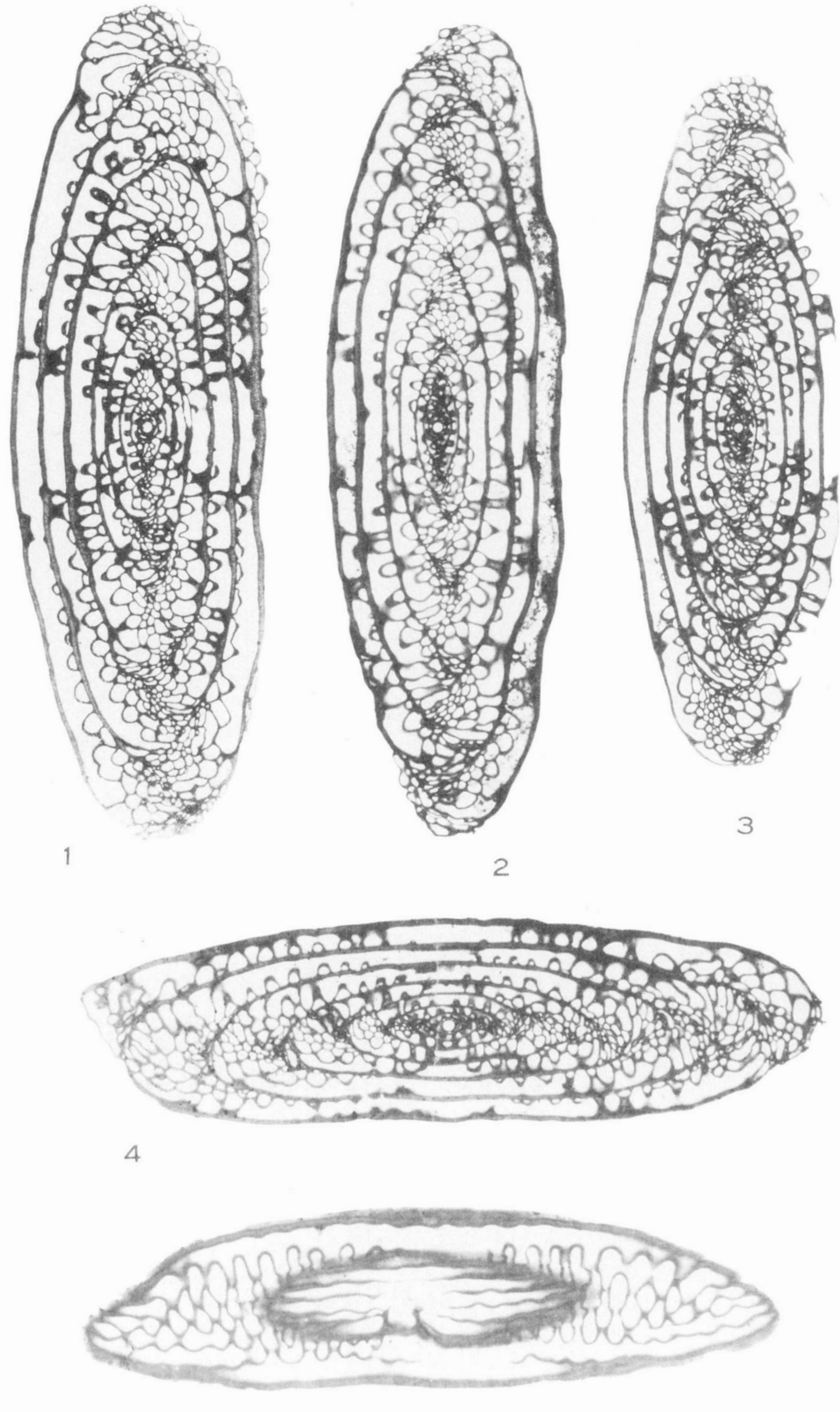

Plate XI

(All figures are natural size)

Figures 1-8. *Caninia ovibos* (Salter). 1, 2, exterior views of lectotype, Belcher collection, British Museum R 90151; 3, transverse section of lectotype R 90151a; 4, 5, longitudinal sections of lectotype R 90151b and R 90151c; 6, transverse section of large specimen from the same collection, R 35823a; 7, 8, transverse sections of two small specimens, GSC Nos. 13500a and 13501a from Belcher Channel formation, Grinnell Peninsula, GSC locality 26407. (Page 41.)

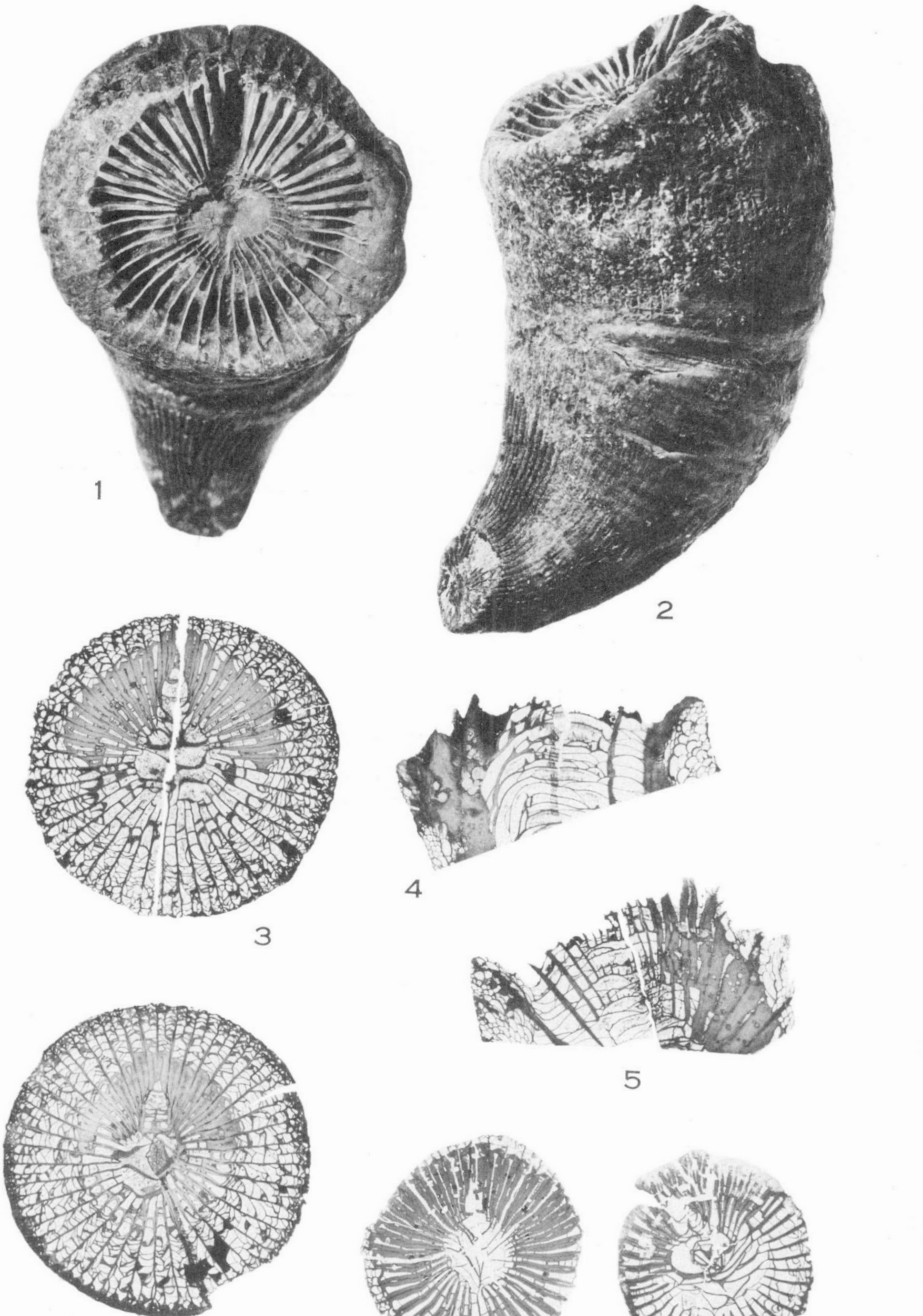
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Plate XII

(All figures are natural size)

Figures 1-5. *Caninia belcheri* n. sp. 1, exterior view of holotype, GSC No. 13502; 2, longitudinal section of holotype, GSC No. 13502a; 3, transverse section of holotype, GSC No. 13502b; 4, transverse section of paratype, GSC No. 13503a; 5, view of polished surface of longitudinal cut through paratype showing calyx, GSC No. 13503. Belcher Channel formation, GSC locality 26418. (Page 43.)

Figures 6, 7. *Lithostrotion* cf. *L. portlocki* Milne-Edwards and Haime. 6, longitudinal section, GSC No. 13507a; 7, transverse section, GSC No. 13507b. Belcher Channel formation, GSC locality 26407. (Page 46.)

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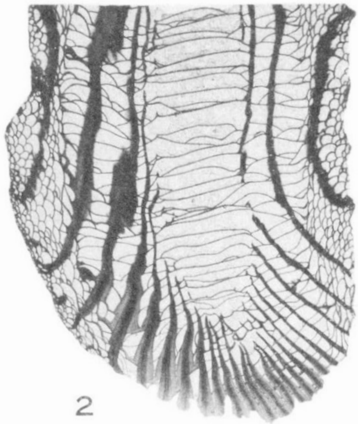

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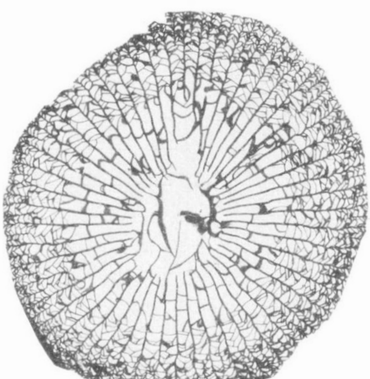

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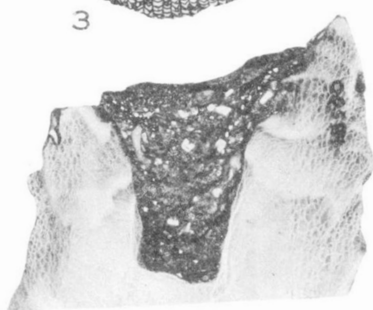

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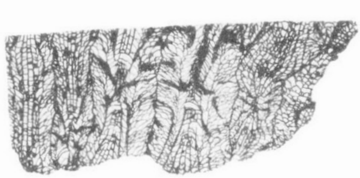

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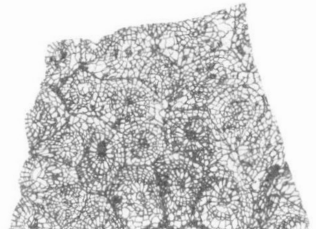

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Plate XIII

(All figures are natural size except where otherwise stated)

Figures 1-4. *Clisiophyllum ? tumulus* Salter. 1, 2, exterior views of holotype, Belcher collection, British Museum R 41545; 3, longitudinal section of holotype R 41545a; 4, transverse section of holotype R 41545b. (Page 44.)

Figures 5, 6. *Lithostrotion kunthi* (Stuckenberg). 5, transverse section, GSC No. 13506a, X2; 6, longitudinal section, GSC No. 13506b, X2. Belcher Channel formation, GSC locality 26407. (Page 46.)

Figures 7, 8. *Stylastraea* cf. *S. toulai* (Stuckenberg). 7, longitudinal section, Belcher collection, British Museum R 35832; 8, transverse section R 35832a. (Page 47.)

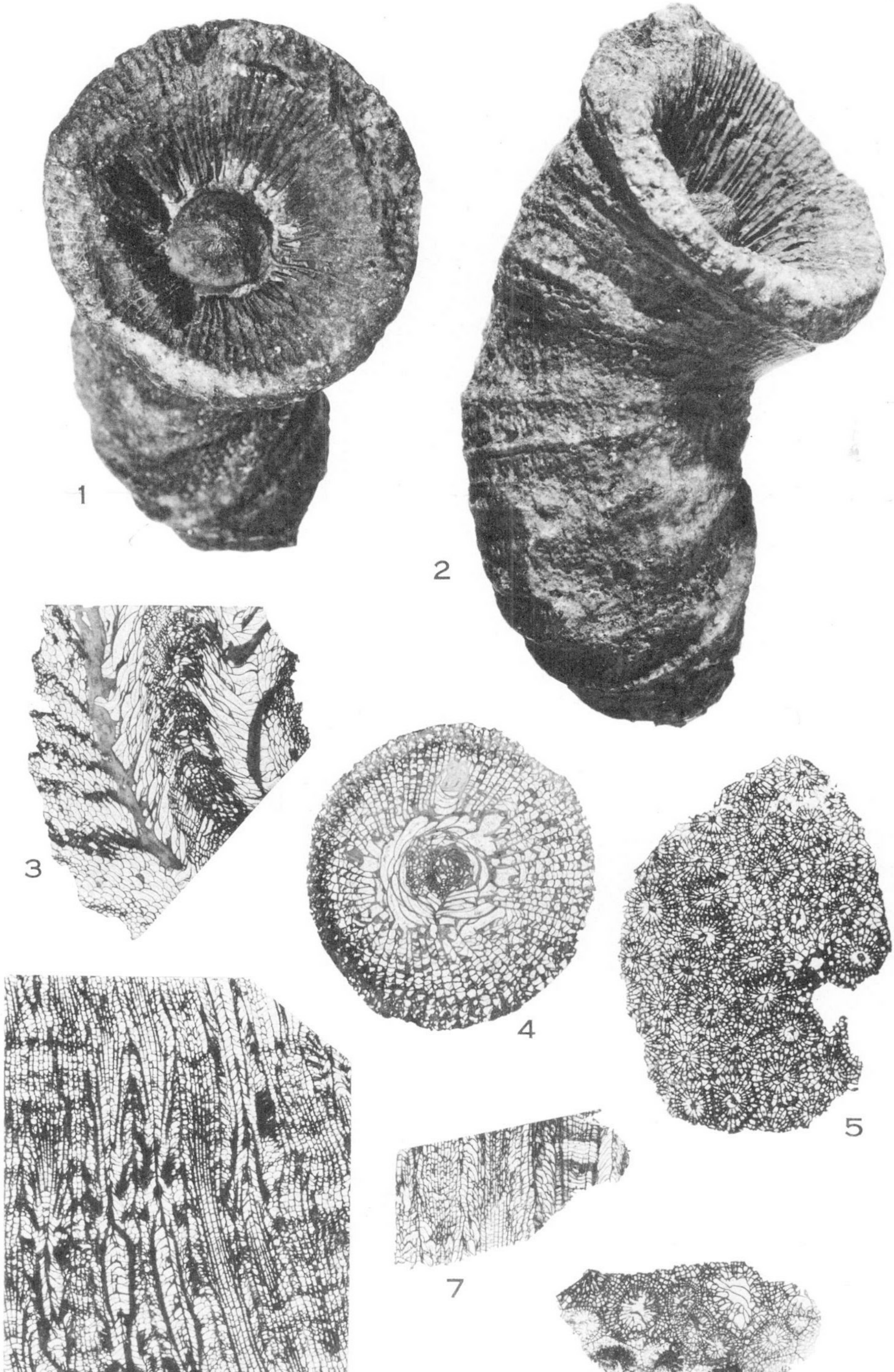
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Plate XIV

(All figures are natural size except where otherwise stated)

Figures 1-3. *Lithostrotion grandis* (Heritsch). 1, external view of upper surface of corallum, GSC No. 13505; 2, transverse section, GSC No. 13505a; 3, longitudinal section, GSC No. 13505b. Belcher Channel formation, GSC locality 26407. (Page 45.)

Figures 4, 5. *Lithostrotion* ? sp. 4, longitudinal section, GSC No. 13508a; 5, transverse section, GSC No. 13508b. Belcher Channel formation, GSC locality 26407. (Page 47).

Figures 6, 7. *Roemeripora wimani* Heritsch. 6, transverse section, GSC No. 13509a, X2; 7, longitudinal section, GSC No. 13509b, X2. Belcher Channel formation, GSC locality 26407. (Page 48.)

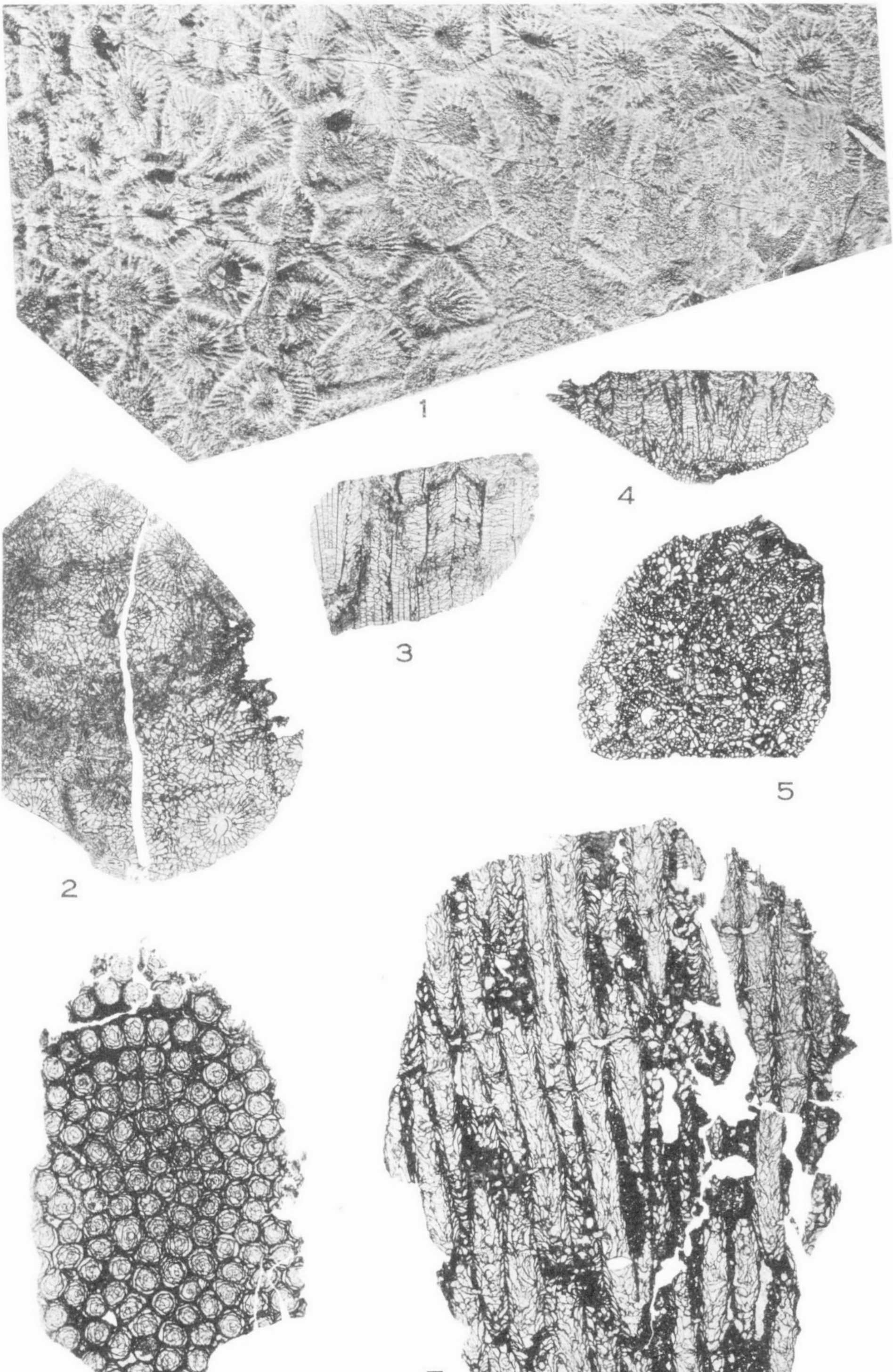
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Plate XV

(All figures are natural size)

Figures 1-6. *Streptorhynchus kempei* Andersson. 1, dorsal view of specimen GSC No. 13516 showing dorsal valve in place; 2, interior view of the dorsal valve of the same specimen showing the cardinal process; 3-5, side, ventral and dorsal views of GSC No. 13517; 6, dorsal view of GSC No. 13518. Assistance formation, GSC locality 26406. (Page 50.)

Figures 7-9. *Streptorhynchus triangularis* Wiman. 7-9, ventral, dorsal and side views of GSC No. 13519. Assistance formation, GSC locality 26406. (Page 51.)

Figures 10, 11. *Orbiculoidea* sp. 10, dorsal view of GSC No. 13513; 11, ventral view of the same specimen showing the pedicle slit. Assistance formation, GSC locality 26406. (Page 49.)

Figure 12. *Lingula* cf. *L. arctica* Miloradovich. Ventral view of GSC No. 13510. Assistance formation, GSC locality 26406. (Page 49.)

PLATE XV

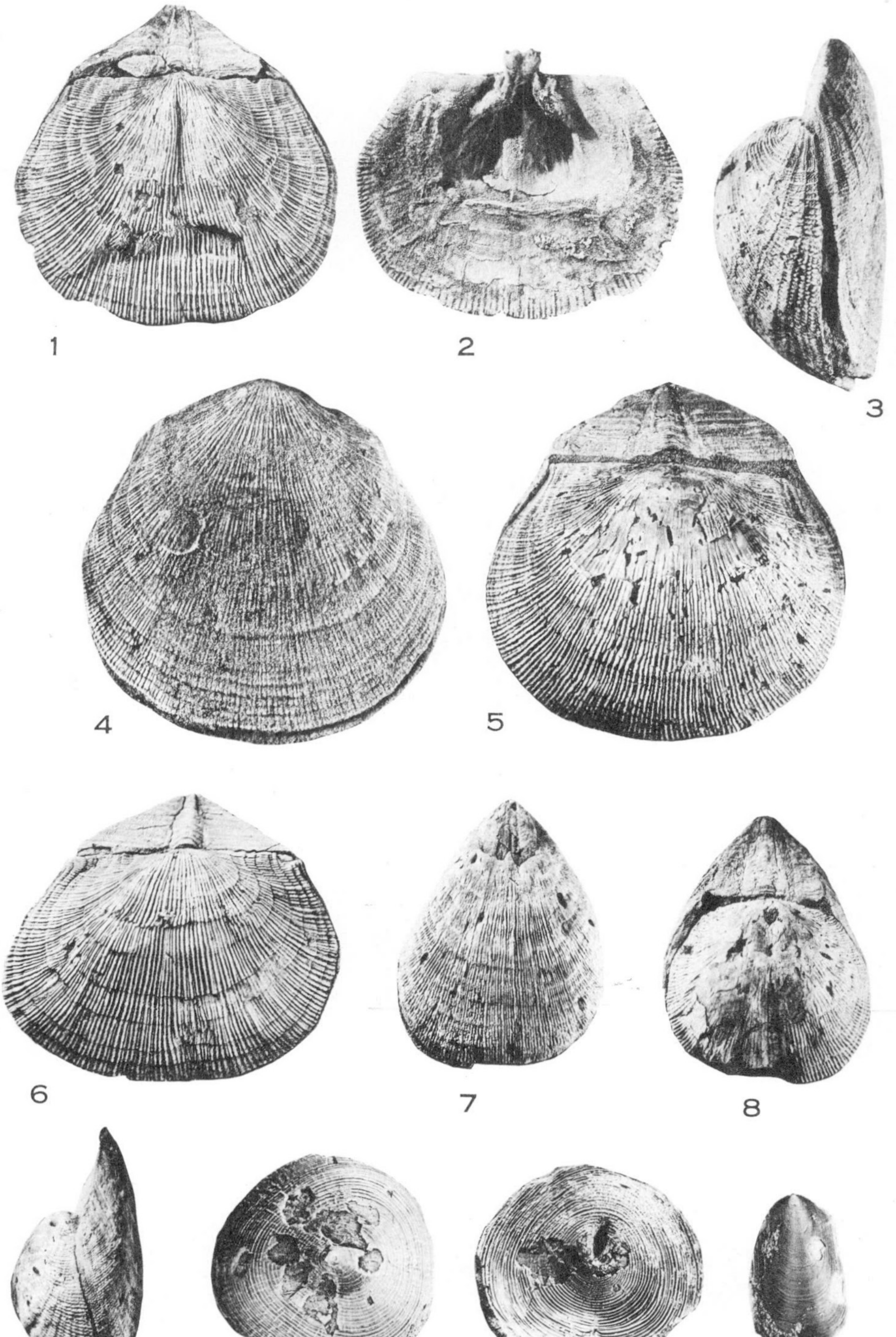

Plate XVI

(All figures are natural size)

Figures 1-5. *Muirwoodia mammatus* (Keyserling). 1-3, ventral, dorsal and side views of GSC No. 13531; 4, 5, ventral and dorsal views of GSC No. 13530. Assistance formation, GSC locality 26406. (Page 58.)

Figure 6. *Cancrinella* cf. *C. germanicus* (Frebold). Ventral view of slightly crushed specimen, GSC No. 13529. Assistance formation, GSC locality 26406. (Page 56.)

Figures 7, 8. *Waagenoconcha* cf. *W. irginaeformis* Stepanow. Ventral and dorsal views of GSC No. 13734. Assistance formation, GSC locality 26406. (Page 62.)

Figures 9, 10. *Derbyia* cf. *D. grandis* Waagen. Dorsal and ventral views of GSC No. 13521. Assistance formation, GSC locality 26406. (Page 52.)

Figures 11, 12. *Chonetes* (*Paeckelmannia* ?) *capitolinus* Toula. Ventral and dorsal views of GSC No. 13522. Assistance formation, GSC locality 26406. (Page 53.)

PLATE XVI

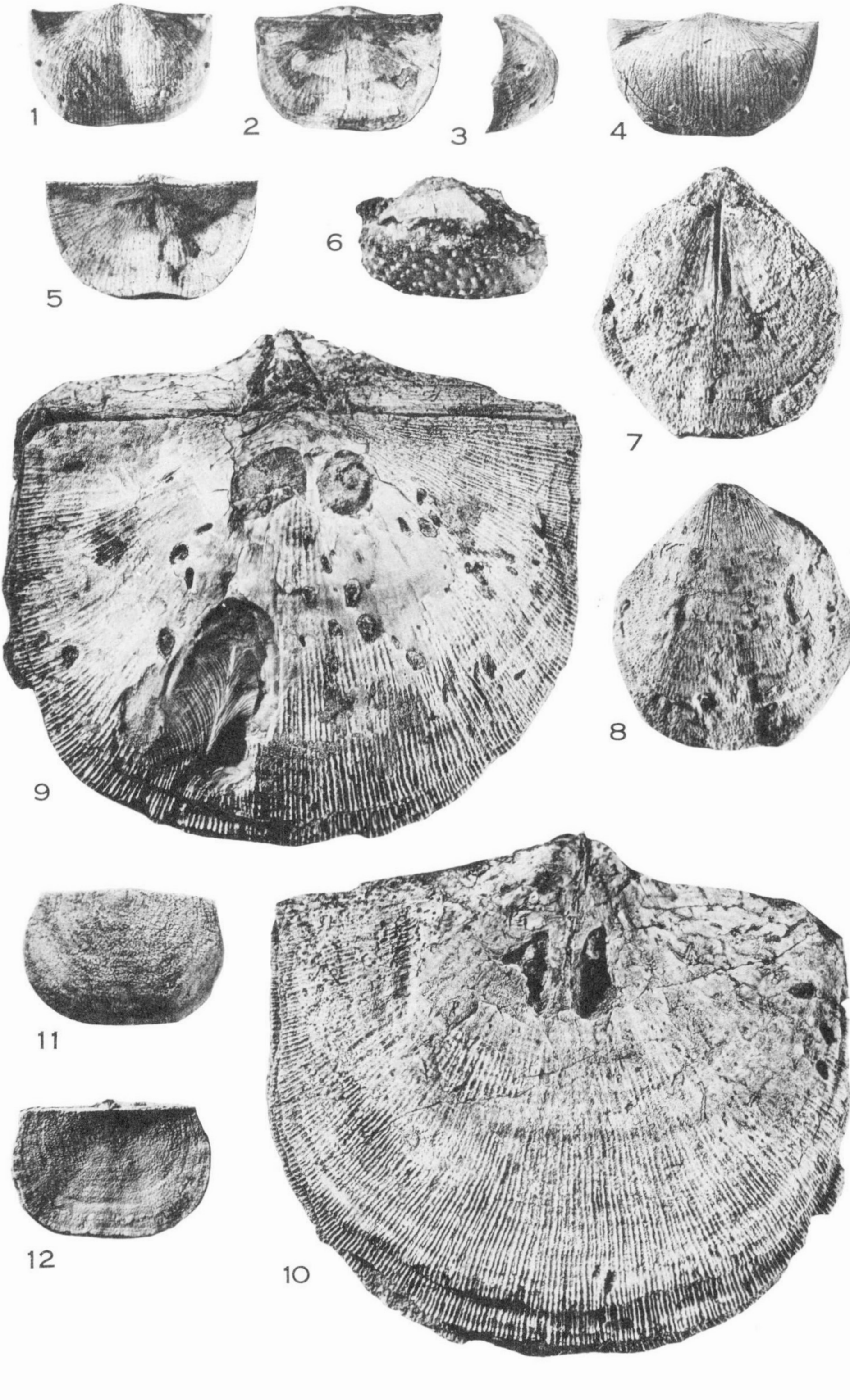

Plate XVII

(All figures are natural size)

Figures 1-4. *Dictyoclostus* cf. *D. neoinflatus* Licharew. 1, 2, side and ventral views of GSC No. 13526; 3, ventral view of GSC No. 13527; 4, interior view of ventral valve showing muscle impressions, GSC No. 13528. Assistance formation, GSC locality 26406. (Page 55.)

Figures 5, 6. *Kochiproductus freboldi* (Stepanow). Ventral and dorsal views of partly exfoliated specimen, GSC No. 13534. Assistance formation, GSC locality 26406. (Page 59.)

Figure 7. *Chonetina* cf. *C. timanicus* (Tschernyschew). Fragment of rock from the Belcher Channel formation showing several specimens in various stages of growth. GSC locality 26407. (Page 55.)

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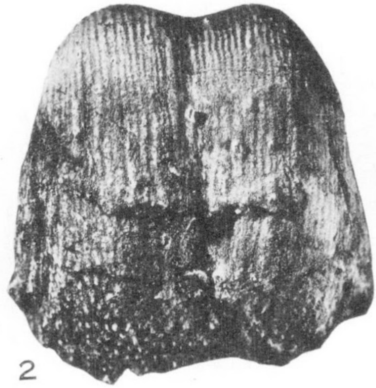

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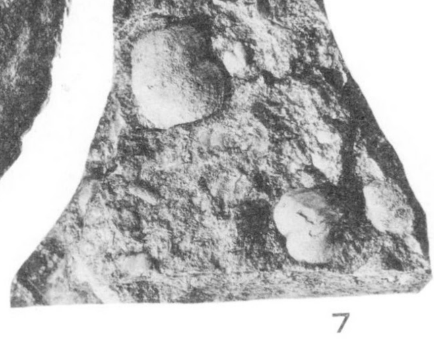

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Plate XVIII

(All figures are natural size)

Figures 1-4. *Stenoscisma plicatum* (Kutorga). 1, anterior view of an incomplete specimen, GSC No. 13738; 2-4, ventral, dorsal and side views of GSC No. 13737. Assistance formation, GSC locality 26406. (Page 62.)

Figures 5-8. *Stenoscisma* cf. *S. kochi* (Dunbar). Ventral, dorsal, side and interior views of GSC No. 13735. Assistance formation, GSC locality 26406. (Page 62.)

Figures 9-11. *Waagenoconcha payeri* ? (Toula). 9, dorsal view of GSC No. 13535; 10, 11, side and ventral views of GSC No. 13783. Assistance formation, GSC locality 26406. (Page 61.)

Figures 12-15. *Squamularia asiatica* Chao. 12, ventral view of GSC No. 13742; 13-15, ventral, side and dorsal views of GSC No. 13743. Assistance formation, GSC locality 26406. (Page 64.)

Plate XVIII

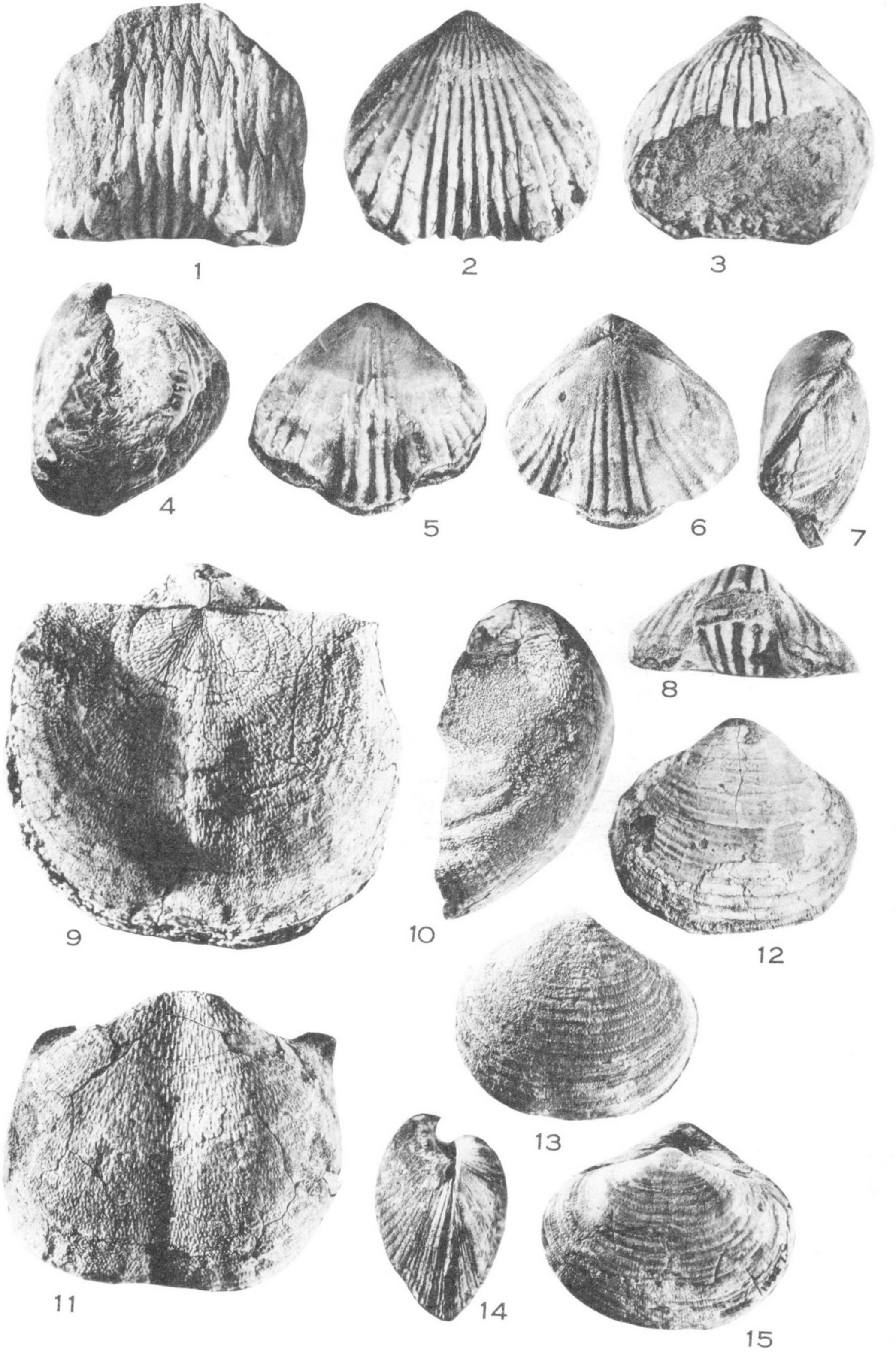

PLATE XIX

(All figures are natural size)

Figures 1-7. *Spirifer striato-paradoxus* Toula. 1-3, ventral, dorsal and anterior views of GSC No. 13748; 4, 5, side and dorsal views of GSC No. 13750; 6, ventral view of GSC No. 13747; 7, ventral view of GSC No. 13750. Assistance formation, GSC locality 26406. (Page 67.)

Plate XIX

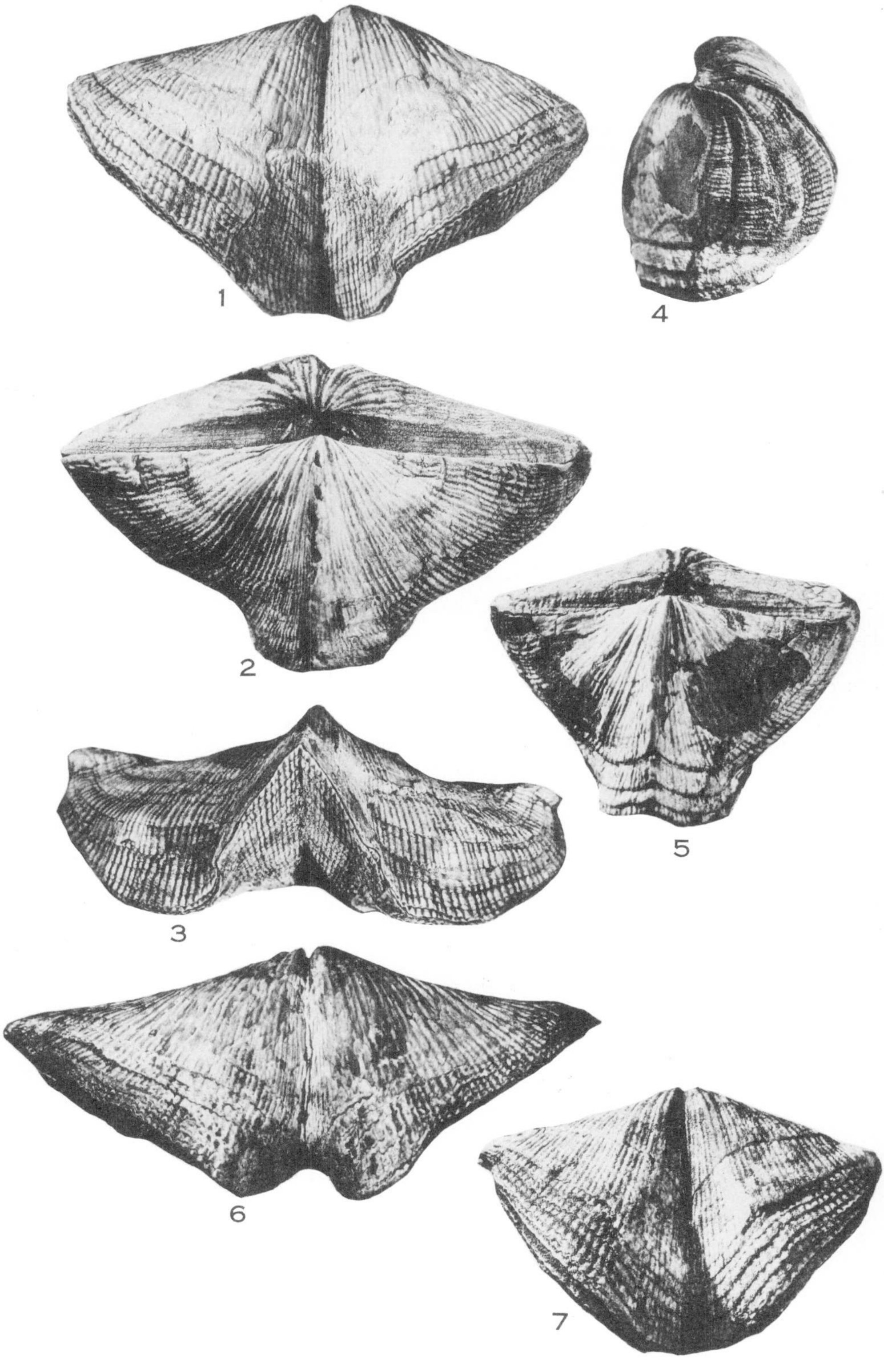

Plate XX

(All figures are natural size)

Figures 1-14. *Pterospirifer* cf. *P. alatus* (Schlotheim). 1-4, ventral, dorsal, side and anterior views of GSC No. 13752; 5-7, ventral, dorsal and side views of GSC No. 13753; 8-10, ventral, anterior and dorsal views of GSC No. 13754; 11, 12, ventral and dorsal views of GSC No. 13755; 13, 14, ventral and dorsal views of a small, slightly crushed specimen, GSC No. 13756. Assistance formation, GSC locality 26406. (Page 68.)

Figures 15-17. *Spirifer osborni* n. sp. 15-17, ventral, side and dorsal views of holotype, GSC No. 13744. Assistance formation, GSC locality 26406. (Page 65.)

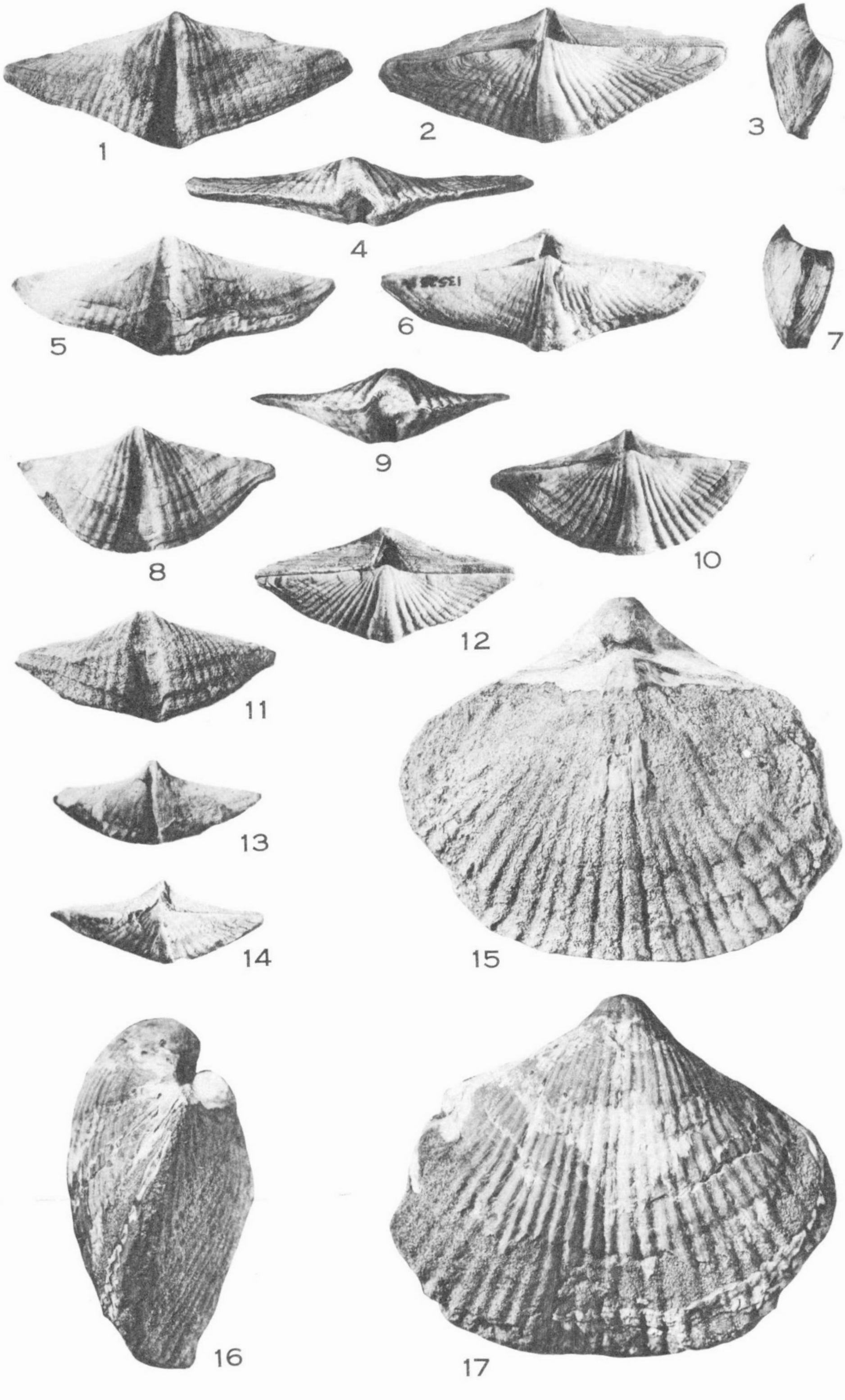
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Plate XXI

(All figures are natural size)

Figures 1-14. *Pterospirifer* ? sp. A. 1, ventral view of GSC No. 13757; 2, interior view of the same specimen showing the vertically striated interarea, apical callosity and strong dental lamellae; 3, 4, ventral and dorsal views of GSC No. 13758; 5-7 and 9, ventral, dorsal, side and anterior views of very mucronate specimen, GSC No. 13759; 8, 11 and 13, side, ventral and dorsal views of GSC No. 13760; 10, 12 and 14, dorsal, ventral and anterior views of GSC No. 13761. Assistance formation, GSC locality 26406. (Page 69.)

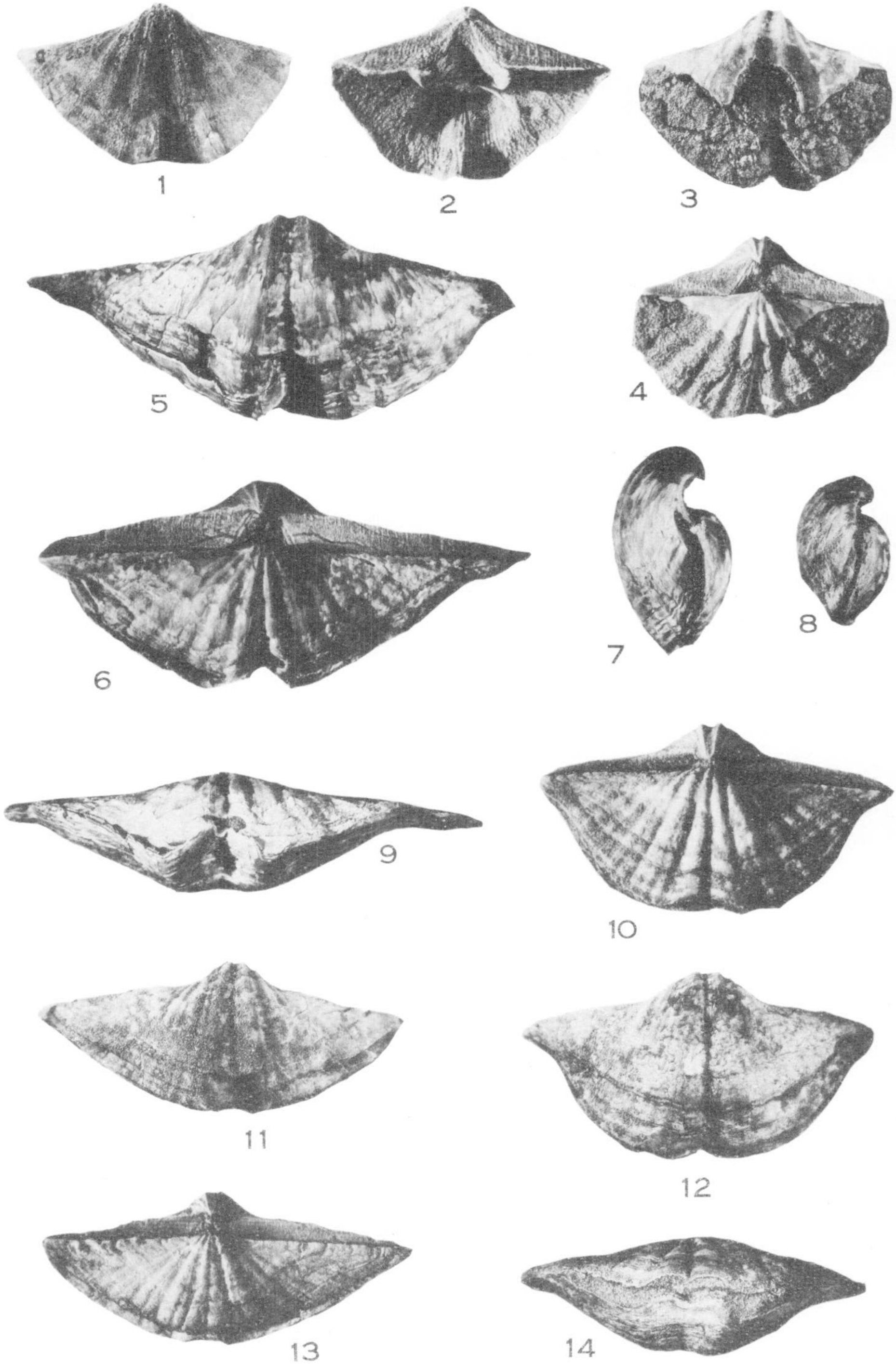
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PLATE XXII

(All figures are natural size)

Figures 1-8. *Spiriferella saranae* (de Verneuil). 1, 2, ventral and side views of a dorsal valve, GSC No. 13762; 3, ventral view of an immature ventral valve, GSC No. 13763. Belcher Channel formation, GSC locality 26407. 4-6, dorsal, ventral and anterior views of a complete immature specimen, GSC No. 13764, two fine ribs at the bottom of the sulcus can be clearly seen; 7, 8, dorsal and ventral views of an immature specimen, GSC No. 13765. Assistance formation, GSC locality 26406. (Page 71.)

Figures 9-11. *Spiriferella keilhavii* (von Buch). Side, ventral and interior views of a large ventral valve, GSC No. 13767. Assistance formation, GSC locality 26406. (Page 72.)

PLATE XXII

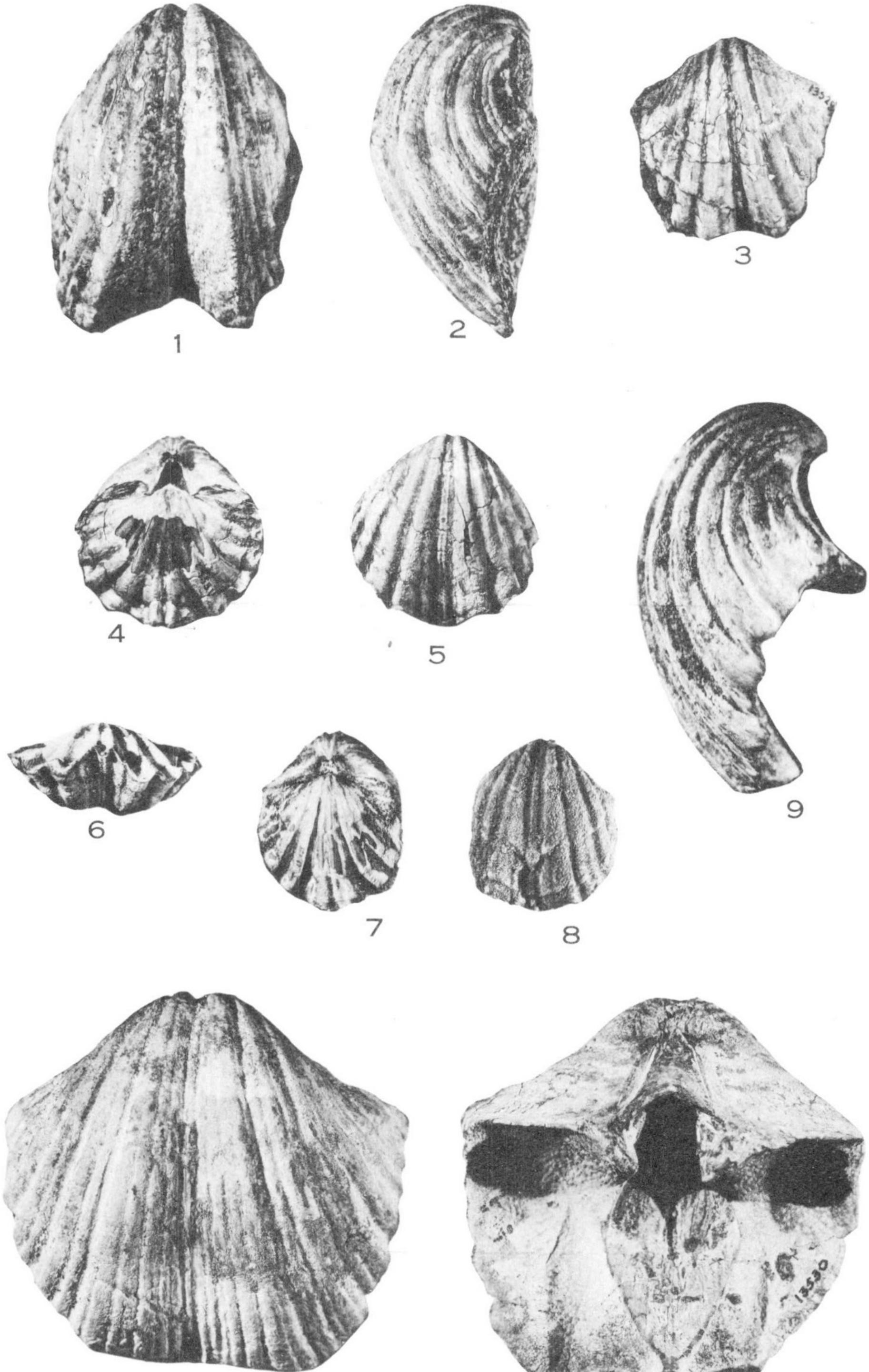

Plate XXIII

(All figures are natural size)

Figures 1, 2. *Spiriferella keilhavii* (von Buch). Ventral and interior views of a ventral valve, GSC No. 13768. Assistance formation, GSC locality 26406. (Page 72.)

Figures 3, 4. *Spiriferella saranae* (de Verneuil). Ventral and side views of an almost complete specimen, GSC No. 13766. Assistance formation, GSC locality 26406. (Page 71.)

Figures 5-7. *Dielasma* cf. *D. plica* (Kutorga). Ventral, side and anterior views of GSC No. 13770. Assistance formation, GSC locality 26406. (Page 74.)

Figure 8. Part of a slab of limestone from the Belcher Channel formation showing *Spiriferella saranae* (de Verneuil), *Parafusulina* sp., *Chonetina* cf. *C. timanicus* Tschern. and *Derbyia* sp.

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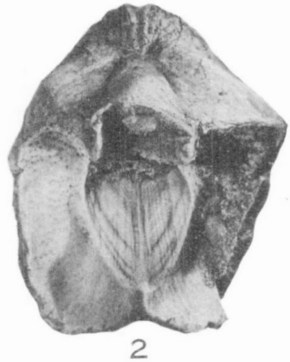

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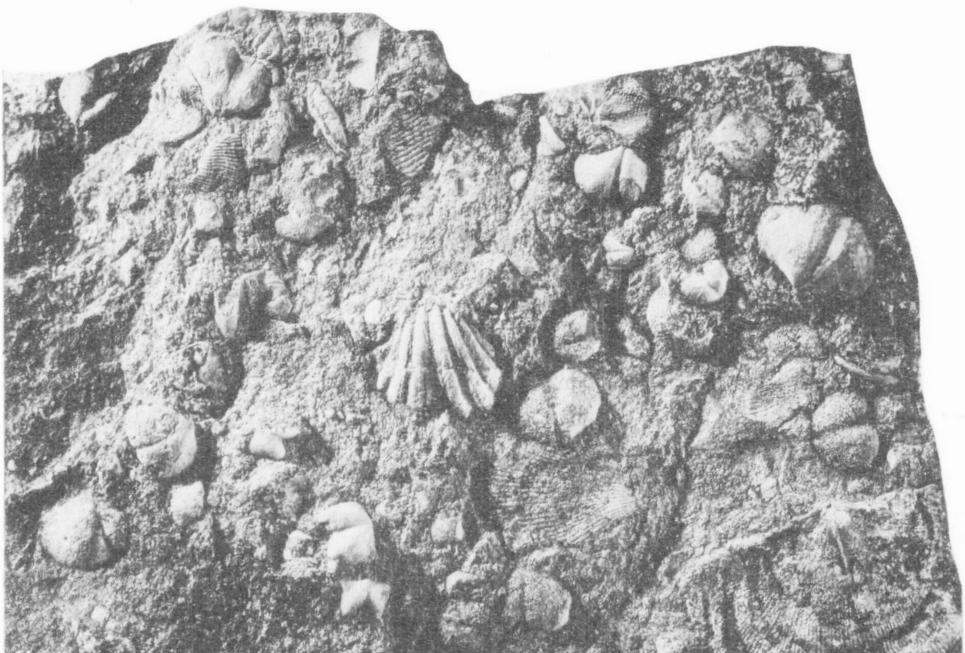

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PLATE XXIV

(All figures are natural size except where otherwise stated)

Figures 1, 2. *Cleiothyridina* cf. *C. subexpansa* (Waagen). Ventral and dorsal views of GSC No. 13769, showing spinose fringes. Assistance formation, GSC locality 26406. (Page 73.)

Figures 3-5. *Pseudogastrioceras fortieri* n. sp. 3, side view of paratype, GSC No. 13773; 4, side view of paratype, GSC No. 13774, the visible part is all living chamber, X½; 5, ventral view of the same specimen showing traces of longitudinal ornament, X½. Assistance formation, GSC locality 26406. (Page 75.)

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PLATE XXV

(All figures are natural size)

Figures 1-3. *Pseudogastrioceras fortieri* n. sp. Holotype, GSC No. 13772. Assistance formation, GSC locality 26406. (Page 75.)

Figures 4-6. *Metalegoceras* sp. GSC No. 13775. Assistance formation, GSC locality 26406. (Page 77.)

Figures 7, 8. *Plagioglypta* sp. GSC Nos. 13776 and 13777. Assistance formation, GSC locality 26406. (Page 79.)

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