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CARBONATE FACIES AND THE LITHOSTROTIONID CORALS OF THE MISSISSIPPIAN KOGRUK FORMATION, DELONG MOUNTAINS, NORTHWESTERN ALASKA

Carbonate Facies and the Lithostrotionid Corals of the Mississippian Kogruk Formation, DeLong Mountains, Northwestern Alaska

By AUGUSTUS K. ARMSTRONG

GEOLOGICAL SURVEY PROFESSIONAL PAPER 664

Systematic paleontologic studies of the lithostrotionid corals from four sections of carbonate rocks in the Mississippian Kogruk Formation, DeLong Mountains, Brooks Range, northwestern Alaska

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CARBONATE FACIES AND THE LITHOSTROTIONID CORALS OF THE MISSISSIPPIAN KOGRUK FORMATION, DELONG MOUNTAINS, NORTHWESTERN ALASKA

By Augustus K. Armstrong

ABSTRACT

The Kogruk Formation of the Lisburne Group is 1,500–2,000 feet thick and is composed of marine carbonate rocks deposited in normal-marine to shoaling-water environments. Carbonate rock types are typically bryozoan-echinoderm packstones and wackestone and lesser amounts of lime mudstones and ooid grainstones and packstones. Extensive dolomitization, dolomites, and carbonate sedimentary features characteristic of intertidal and supratidal environments are absent in the sections studied. The Kogruk Formation was deposited in an open marine environment on a subsiding shelf on which carbonate deposition and subsidence were near equilibrium. Only minor oscillations in environments of deposition are seen in a typical section. Lithostrotionid coral faunas are best developed adjacent to the shoaling-water facies.

Two major coral faunas are recognized and described. The older, 200–600 feet above the base of the Kogruk Formation, consists of *Lithostrotion* (*Siphonodendron*) *sinuosum* (Kelly), *L.* (*S.*) *warreni* Nelson, *Lithostrotionella mclareni* (Sutherland), *Lithostrotionella* aff. L. *banffensis* (Warren), *Thysanophyllum astraeiforme* (Warren), *Thysanophyllum orientale* Thomson, and *Sciophyllum lambarti* Harker and McLaren. This fauna is of middle Meramec age. The younger coral fauna is found in the highest 600–800 feet of the Kogruk Formation and contains many of the species of lithostrotionids from lower beds, plus *Lithostrotionella* sp. A, *L.* sp. B, L. *banffensis* (Warren), *Lithostrotionella birdi* Armstrong, *Thysanophyllum* sp. A, *Sciophyllum alaskaensis* Armstrong, and *Faberophyllum* spp. This fauna is of late Meramec age. The youngest coral fauna in the Kogruk Formation contains *Thysanophyllum orientale* Thomson and *Lithostrotionella birdi* Armstrong and is of very late Meramec age.

Lithostrotionid corals, collected from the Nasorak Formation near Cape Thompson, described and compared to the Kogruk Formation coral fauna, are *Lithostrotion* (*Siphonodendron*) *sinuosum* (Kelly), *L.* (*S.*) *warreni* Nelson, *Lithostrotion* (*Siphonodendron*) sp. A, *Lithostrotionella banffensis* (Warren), *Thysanophyllum astraeiforme* (Warren), *Sciophyllum lambarti* Harker and McLaren, and *Sciophyllum* sp. A.

INTRODUCTION

The material for this study was collected in northwestern Alaska by Shell Oil Co. personnel during two field seasons (fig. 1). In 1960 Dr. Sigmund Snelson measured and collected from the thick section of the Kogruk Formation at Trail Creek (60A–400–403) and from the section near Cape Thompson. In a field party led by Dr. Snelson in 1962, the writer and Dr. Kenneth Bird collected from two sections of the Kogruk Formation (62C–15 and 62C–31) in the DeLong Mountains and from one section (62C–34) in the Lisburne Hills by the Kukpuk River.

The stratigraphic sections described in this report were measured with Jacob's staff and tape. Rock and Foraminifera samples were collected every 5–10 feet. Brachiopod and coral collections were made throughout the sections. Petrographic thin sections were made for carbonate microfacies and microfauna (Foraminifera) studies. The corals collected were studied by means of 2-inch by 3-inch oriented thin sections.

Dunham's (1962) classification of carbonate rocks is used in this report. This system of describing carbonate rocks is based on a terminology that indicates particle type and texture. Table 1 is Dunham's classification. The lithologic and paleontologic symbols used in the present report are shown in figure 2.

ACKNOWLEDGMENTS

The excellent stratigraphic collection which forms the basis for this study is from the Shell Oil Co. collections. The material was made available to the U.S. Geological Survey for study by R. E. McAdams and G. E. Burton, vice presidents, J. C. Threet, exploration manager, Pacific Coast Area, and Quey C. Hebrew, Northwest Division manager, Shell Oil Co.

Dr. Bernard L. Mamet, University of Montreal, studied the Foraminifera in petrographic thin sections made from stratigraphic collection samples.

Duplicate sets of thin sections were cut from the coral samples by Robert Shely, and the photographs were made by Kenji Sakamoto, both of the U.S. Geological Survey.

TABLE 1.—*Classification of carbonate rocks according to depositional texture (Dunham, 1962, p. 117)*

Depositional texture recognizable					Depositional texture not recognizable
Original components not bound together during deposition				Original components were bound together during deposition * * * as shown by intergrown skeletal matter, lamination contrary to gravity, or sediment-floored cavities that are roofed over by organic or questionably organic matter and are too large to be interstices	Crystalline carbonate.
Contains mud (particles of clay and fine silt size)			Lacks mud and is grain-supported		
Mud-supported		Grain-supported			
Less than 10 percent grains	More than 10 percent grains				(Subdivide according to classifications designed to bear on physical texture or diagenesis.)
Mudstone	Wackestone	Packstone	Grainstone	Boundstone	

Special thanks are due J. T. Dutro, Jr., W. A. Oliver, Jr., W. J. Sando, and E. W. Bamber for their help during preparation of the manuscript and for their critical review of the manuscript.

The author is grateful to E. W. Bamber and T. E. Bolton of the Geological Survey of Canada for the loan of a type specimen.

REGIONAL SETTING AND PREVIOUS WORK

The rock sequences which form the DeLong Mountains, northwest Brooks Range, are tentatively grouped by Snelson and Tailleur (1968, p. 567) into five tectonic units, each of which is characterized by northward thrusting of a distinctive rock unit. The light-gray shallow-marine carbonate rocks that contain the lithostrotionid corals discussed in this report belong to the middle tectonic unit (Sequence III, Kelly subunit B). All the stratigraphic sections described in this report are in imbricated, rootless thrust sheets which are many tens of miles north of the original sites of deposition.

The Kogruk Formation, together with the other Mississippian formations of the DeLong Mountains, was named by Sable and Dutro (1961, p. 592) for outcrops on Tupik Mountain. The Kogruk Formation is 520–1,500 feet thick and is composed of cliff-forming light-gray- to bluish-gray-weathering limestone (Sable and Dutro, 1961, p. 590). It is underlain by the Utukok Formation of Early Mississippian age; the Utukok is some 2,500 feet thick at the type locality and consists of ferruginous sandy limestone, calcareous and quartzitic

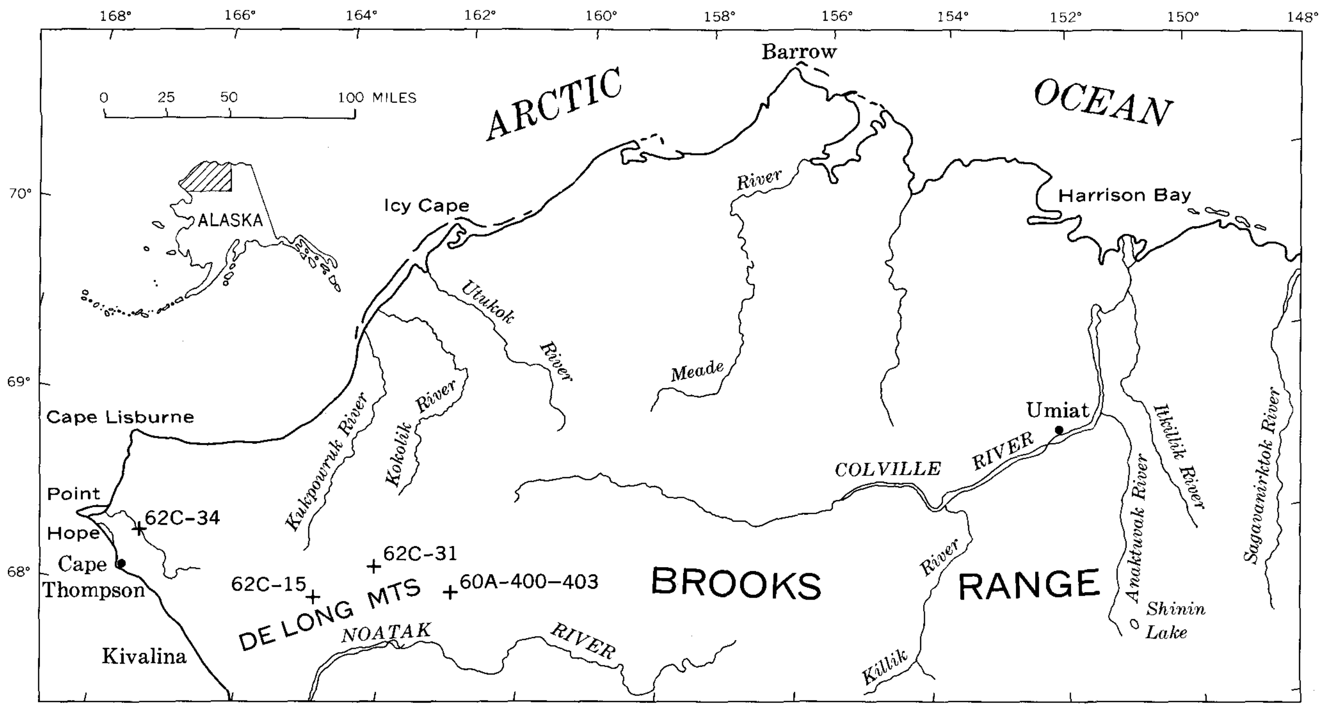


FIGURE 1.—General location of measured sections described in this report.

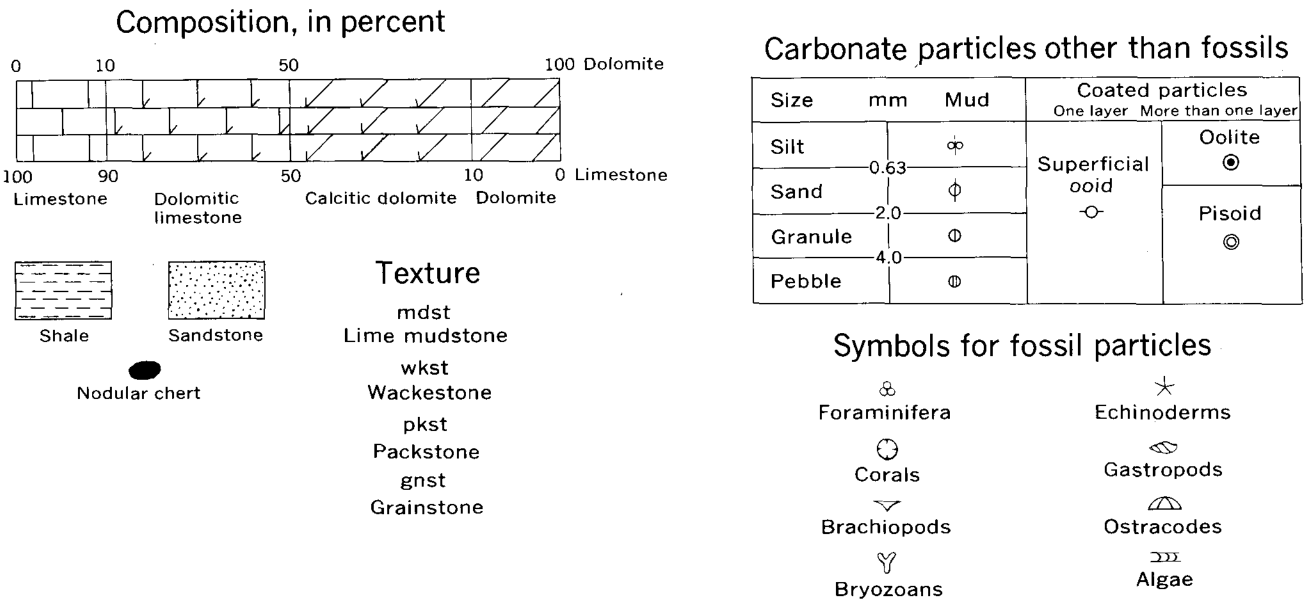


FIGURE 2.—Lithologic and paleontologic symbols used in this report.

sandstone, and calcareous shale. The contact between the Utukok and Kogruk Formations is conformable and gradational. The Tupik Formation, 135–700 feet thick, of Late Mississippian age overlies the Kogruk Formation with apparent conformity, but the lithologic change at the contact is abrupt. The Tupik Formation in outcrop is thin bedded, contains abundant bedded chert, and weathers to a dark gray.

The sections studied in this report do not include the type section of the Kogruk Formation. The locations of the sections are shown in figure 1.

ENVIRONMENTS OF DEPOSITION AND CARBONATE FACIES

The four sections of the Kogruk Formation described in this report are as much as 1,920 feet thick and are composed of carbonate rock deposited in normal-marine to shoaling-water environments; the location of each section is shown in figures 4, 6, 8, and 10. In outcrop the Kogruk Formation is medium- to massive-bedded light-olive-gray to medium-gray limestone and in places is cliff forming. It contains nodular to lenticular light-gray to dark-gray chert. The amount of chert varies markedly at different horizons (figs. 3, 5, 7, 9).

The contact between the Utukok Formation and Kogruk Formation is gradational (Sable and Dutro, 1961). The contact is generally obscured by talus and rubble but was well exposed in section 62C–15 (fig. 3). The silty fine-grained sandstones, shales, and arenaceous limestones of the Utukok Formation grade into the Kogruk Formation carbonates within a stratigraphic distance of 100 feet. In section 62C–15 (fig. 3) the basal 360 feet of carbonates in the Kogruk Formation contain relatively high-energy current-deposited grainstones and packstones. These are ooid-to-oolitic echinoderm grainstones and packstones, carbonate rock types that indicate deposition in shoaling-water and tidal-channel environments.

The most common rock types within the Kogruk Formation are bryozoan-echinoderm wackestones and packstones. These carbonate rock types are similar lithologically and petrographically to the nondolomitized wackestones and packstones from the lower member of the Mississippian Turner Valley Formation of Alberta, Canada, described by Murray and Lucia (1967). Murray and Lucia believe these carbonate rock types are noncurrent deposits because of the presence of lime mud, numerous large bryozoan fronds, and articulated crinoid stems.

Ooid grainstones are present at various levels some 250–400 feet below the top of section 62C–31 (fig. 5). The coating on these particles is not well developed, and the ooids tend to be less than 500 microns in diameter. The carbonate rocks of these four sections are in general only slightly dolomitized: the bryozoan-echinoderm wackestone-packstone facies commonly has lime mud containing small amounts (1–15 percent) of floating dolomite rhombs which range in size from 40–150 microns, but the only beds of dolomite known are in the upper 350 feet of section 62C–31 (fig. 5).

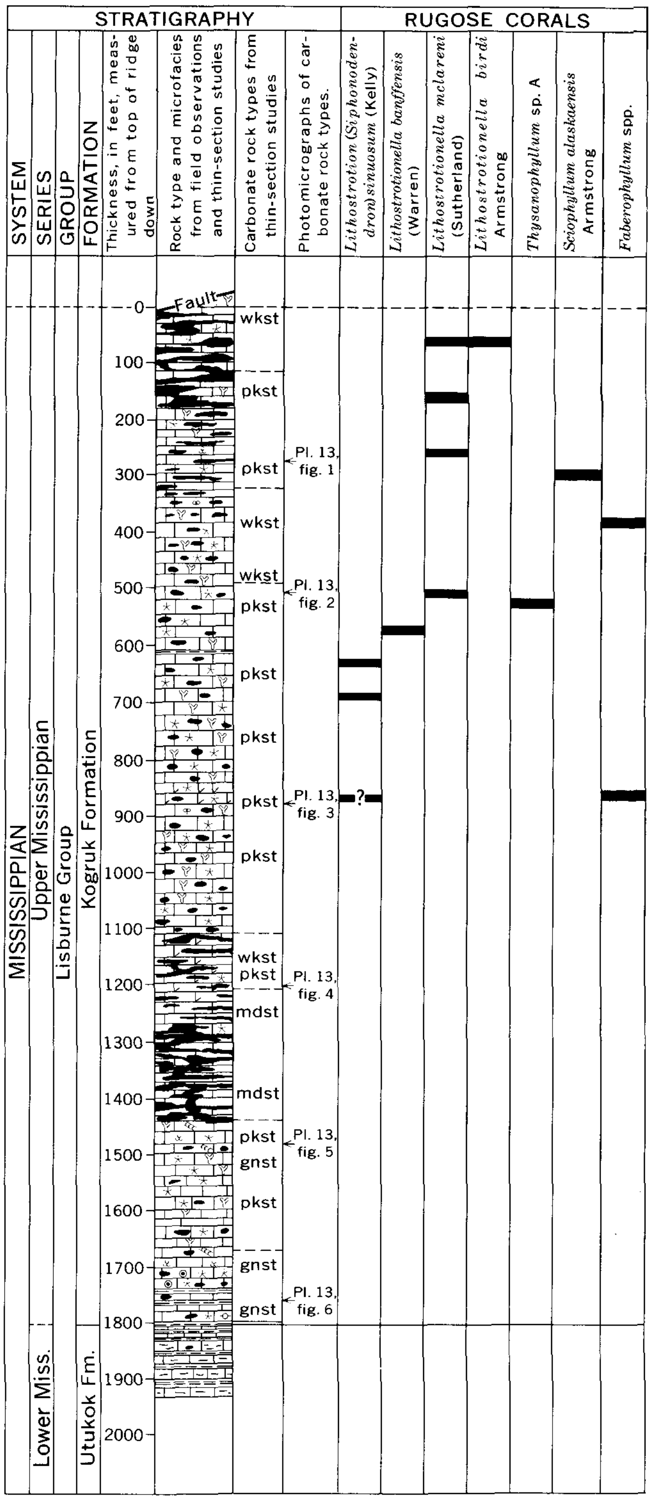


FIGURE 3.—Carbonate stratigraphy and coral distribution, section 62C–15, USGS loc. M1019. Samples from this section have prefix 62C–15.

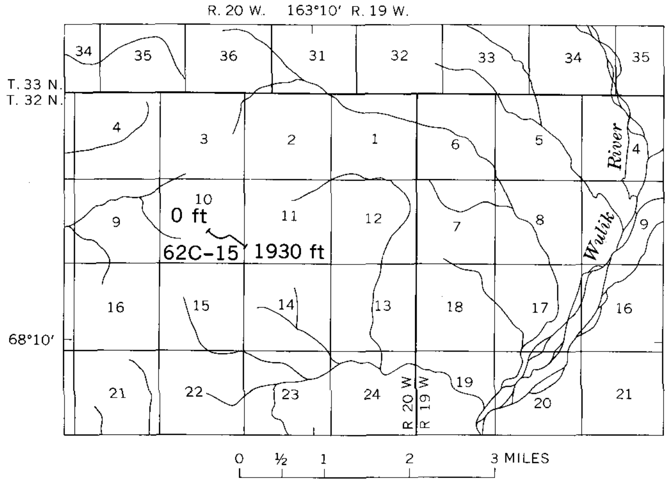


FIGURE 4.—Location of section 62C–15. Map base from U.S. Geological Survey, 1 : 63,360, DeLong Mountains, A–2, A–3, 1955.

Sedimentary structures which would indicate intertidal and supratidal sedimentary facies, such as birdseye structures, stromatolites, chips, and mud cracks, were not found in any of the measured sections of the Kogruk Formation.

Within the four sections measured, no sedimentary features or microfacies indicative of carbonate deposition on bank slope to basinal environments, such as those defined by McDaniel and Pray (1967, p. 474) and Wilson (1967a, p. 485, 486; 1969), were observed in the field or during petrographic studies of the Kokruk Formation.

Carbonate depositional cycles such as were described by Armstrong (1967) from the Mississippian of northern New Mexico or by Wilson (1967b) from the upper Pennsylvanian Virgil Series of southern New Mexico or by Wilson (1967c) from the Upper Devonian Duperow Formation of western Canada appear to be absent within the Kogruk Formation.

Field and laboratory studies of carbonate microfacies strongly suggest the Kogruk Formation was deposited in an open marine environment on a subsiding shelf on which carbonate deposition and subsidence were in near equilibrium. During deposition of the Kogruk Formation, only minor oscillations in environments of deposition are recorded in the sections studied.

Field studies and the petrographic examination of the suites of stratigraphic lithologic samples from each measured Kogruk Formation section clearly show the corals are most abundant in certain carbonate rock

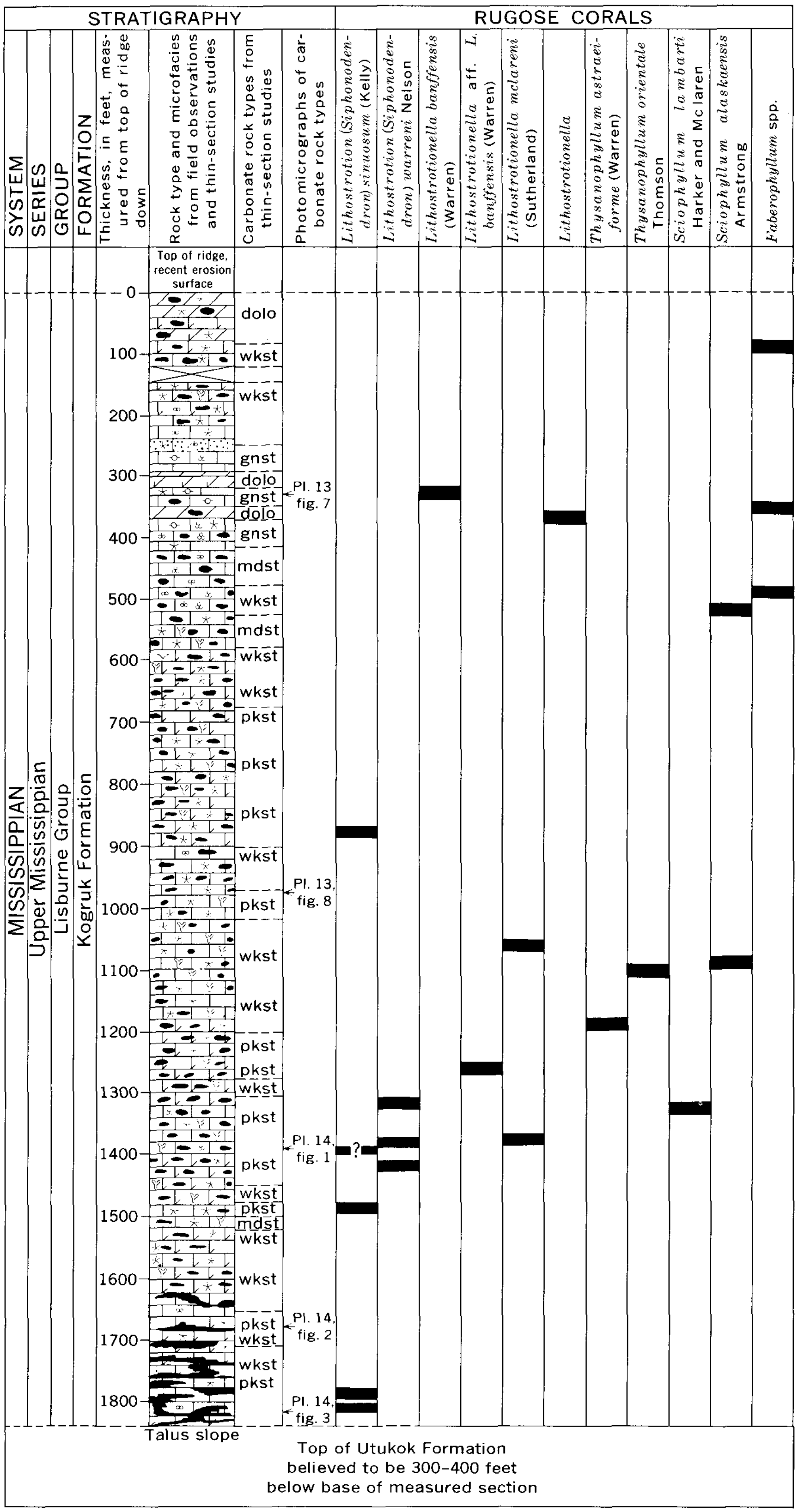


FIGURE 5.—Carbonate stratigraphy and coral distribution, section 62C–31, USGS loc. M1020. Samples from this section have prefix 62C–31.

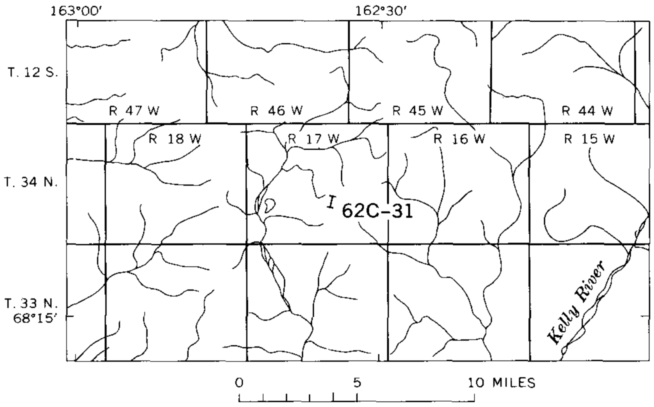


Figure 6.—Location of section 62C–31. Map base from U.S. Geological Survey 1 : 250,000 DeLong Mountains, 1955.

types. The lithostrotionid corals are common in bryozoan-echinoderm packstones and ooid packstones adjacent to oolitic grainstone and well-sorted crinoid grainstone facies. These grainstones are interpreted to represent shoaling-water environments. A similar relationship was observed by Armstrong (1970) in the Mississippian Peratrovich Formation, Prince of Wales, Island, southeastern Alaska.

CHARACTERISTIC CARBONATE ROCK TYPES

MARINE LIME MUDSTONES TO ECHINODERM-BRYOZOAN WACKESTONES

The lime mudstones (pl. 14, fig. 2) are typically composed of clotted pellets, which range in size from 50 to 200 microns, and some pellets are more distinct and darker in color than others. Commonly present are larger size pellets or mud clasts which are generally ellipsoidal and which may contain fossil fragments. These larger pellets are interpreted as aggregates of muddy lime sediments whose exact mode of origin is uncertain. Wilson (1967c, p. 238) believes that small lithoclasts of this type in Devonian carbonates are derived from pieces of "previously deposited lime mud, partially lithified which were torn up and re-incorporated in the bottom sediments." Within the lime mudstones and wackestones, the dominant fossil fragments are echinoderm and bryozoan debris. Commonly present are fragments of Foraminifera, Ostracoda, and unidentified remains of sticklike or spicular organic fragments. Generally all fossil fragments are less than 1 mm in size. The fossil particles and pellets have undergone intense mixing and comminution, which probably indicates extensive burrowing of organisms into the sediments. The fauna of these rocks is considered representative of a marine environment of normal salinity.

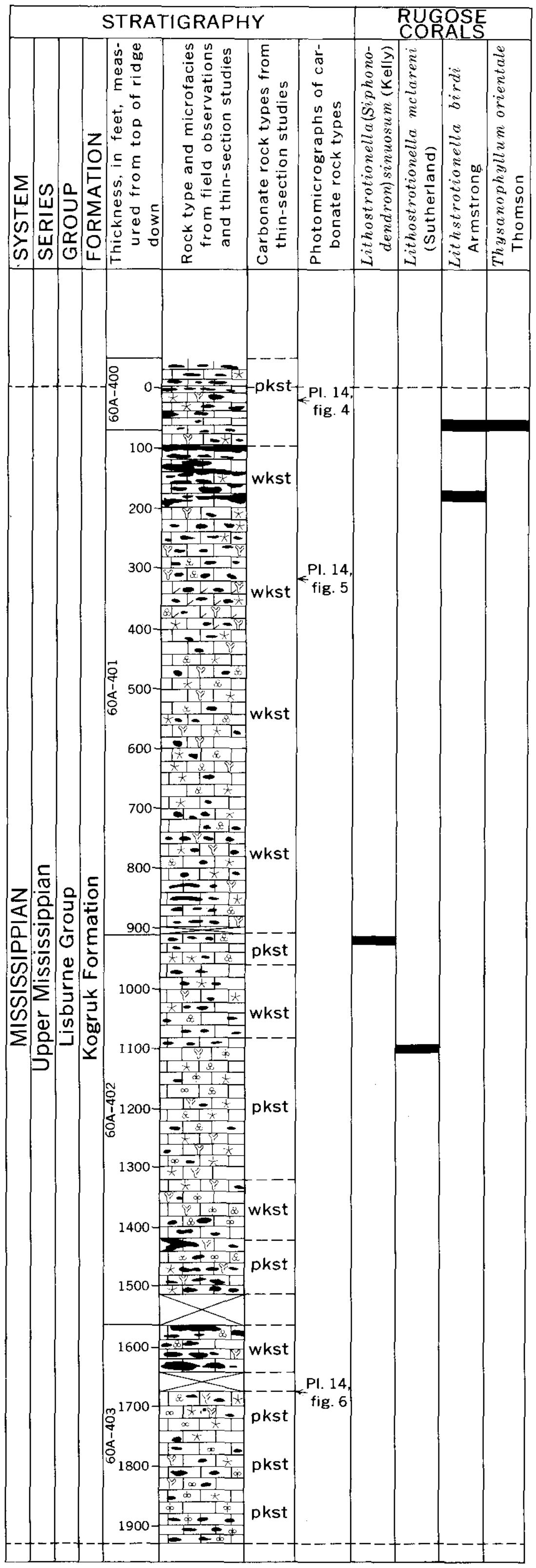


Figure 7.—Carbonate stratigraphy and coral distribution, section 60A–400–403, USGS loc. M1021. Samples from this section have prefix 60A–400 to 60A–403.

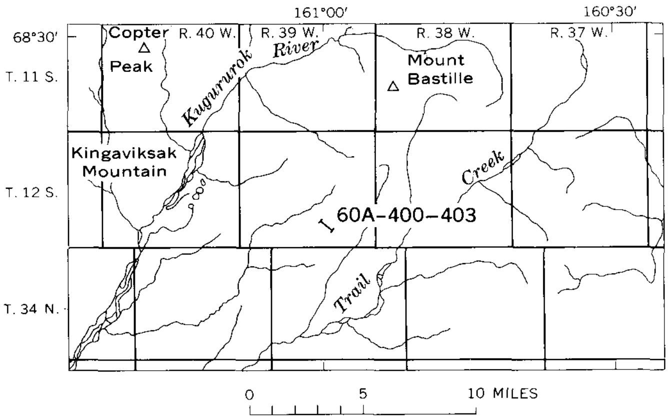


Figure 8.—Location of section 60A-400—403. Map base from U.S. Geological Survey 1 : 250,000, Misheguk Mountain, 1956.

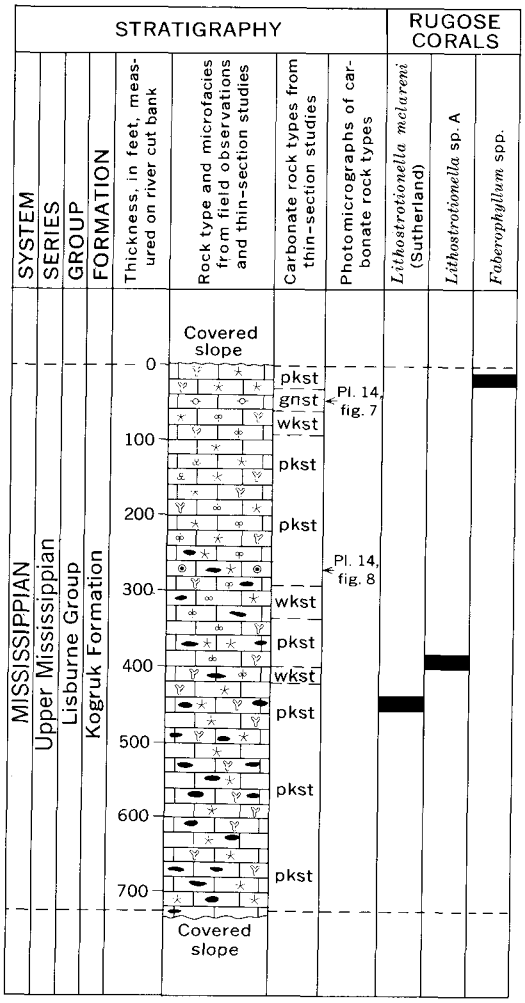


Figure 9.—Carbonate stratigraphy and coral distribution, section 62C-34, USGS loc. M1022. Samples from this section have prefix 62C-34.

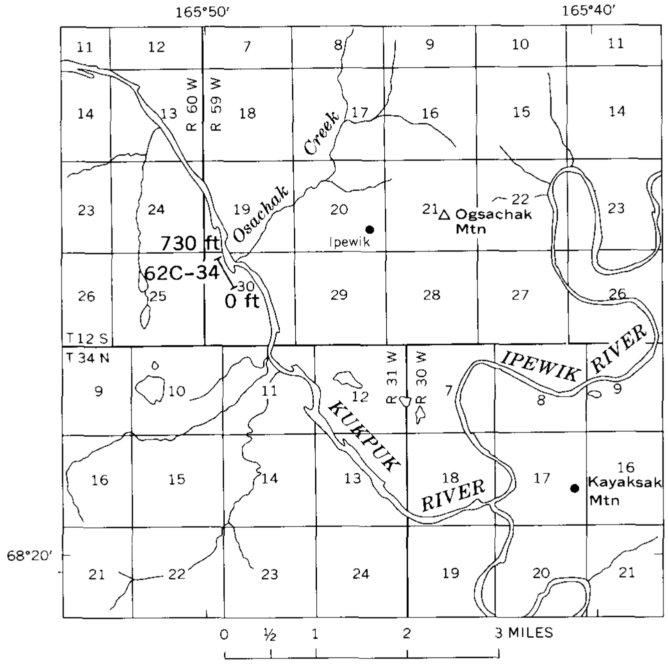


Figure 10.—Location of section 62C-34. Map base from U.S. Geological Survey 1 : 63,360, Point Hope B-2, 1955.

ECHINODERM-BRYOZOAN WACKESTONES TO PACKSTONES

Echinoderm-bryozoan wackestones to packstones are the most abundant rock types within the measured sections of the Kogruk Formation (pl. 13, figs. 1–4, 8; pl. 14, figs. 1, 3–5). The majority of the fossils are broken and abraded fragments of crinoids and bryozoans, but there are lesser amounts of brachiopods, foraminifers, ostracodes, and calcareous algae. Dolomite makes up typically 1–15 percent of the rock. It occurs as scattered rhombs, ranging in size from 40 to 150 microns, within the lime mud or as rhombs impinging on larger crinoid fragments. These rocks are believed to be low-energy, possibly non-current-deposited, open marine sediments.

OOID TO OOLITIC GRAINSTONES

The ooid grainstones (pl. 13, figs. 6, 7) are composed of rounded fossil fragments, which are generally less than 500 microns in size, and these fragments typically have one layer of oolitic coating. The fragments are broken skeletal remains of bryozoans, echinoderms, ostracodes, foraminifers, and calcispheres. Pellets of lime mudstone with oolitic coating are common. This carbonate rock type is only a small percentage of a Kogruk Formation section. These rocks are interpreted as shoaling-water sediments.

ECHINODERM-BRYOZOAN GRAINSTONES

The echinoderm-bryozoan grainstones form a relatively small percentage of the carbonates in the Kogruk Formation (pl. 13, fig. 5; pl. 14, fig. 7). The grainstones are composed of rather large, relatively poorly sorted angular fragments of crinoids, varying amounts of bryozoan fragments, and lesser amounts of calcareous algae and brachiopods. These grainstones are believed to be current-deposited sediments of shoaling-water or tidal-channel environments.

CALCITIC DOLOMITES AND DOLOMITES

Dolomites are relatively rare within the four measured sections of the Kogruk Formation. The only thick unit of dolomite found was the highest 100 feet of section 62C–31 (fig. 5). Here the dolomite is typically composed of 60–100 percent dolomite rhombs 150–200 microns in size, less than 5 percent silt-size rounded quartz grains, and 0–40 percent residual unaltered lime mud and crinoid fragments. The dolomites were originally lime mudstones and crinoid wackestones. In all samples studied, the crinoid fragments are still calcite, but dolomite crystals impinge on the outside of the crinoid fragments.

AGE AND CORRELATION OF THE LITHOSTROTIONID CORAL FAUNAS

Coral zonation of thick Mississippian carbonate sections has been used in the northern Cordilleran region of the United States by Parks (1951), Sando and Dutro (1960), Dutro and Sando (1963a, b), Sando (1967a, b), and Sando, Mamet and Dutro (1969). In the Cordilleran region of western Canada, Sutherland (1958), Nelson (1960, 1961), and Macqueen and Bamber (1967, 1968) have utilized rugose corals for zonation and correlation of thick Mississippian carbonate sequences.

Detailed collecting from the three thicker sections of the Kogruk Formation in the DeLong Mountains indicates that fasciculate lithostrotionids are apparently absent in the lower 200–600 feet of the Kogruk Formation and that cerioid lithostrotionids are absent from the lower 400–800 feet of these sections (figs. 3, 5, 7). Dutro (in Sable and Dutro, 1961, p. 592) states that fossil brachiopods in the lower part of the Kogruk Formation indicate an Early Mississippian (probable Osage) age in some places.

At a stratigraphic level about 1,800 feet below the top of section 62C–31 (fig. 5) and 900 feet below the top section 62C–15 (fig. 3), the first lithostrotionid corals were found. The fauna consists of *Lithostrotion* (*Siphonodendron*) *sinuosum* (Kelly), *L.* (*S.*) *warreni* Nelson, *Lithostrotionella mclareni* (Sutherland), *Lithostrotionella* aff. *L. banffensis* (Warren), *Thysanophyllum astraeiforme* (Warren), *Thysanophyllum orientale* Thomson, and *Sciophyllum lambarti* Harker and McLaren.

The writer has collected from Bowsher and Dutro's (1957) type section of the Alapah Limestone (shaly limestone and dark limestone member) at Shainin Lake the following species: *Lithostrotion* (*Siphonodendron*) *sinuosum* (Kelly), *L.* (*S.*) *warreni* Nelson, *Lithostrotionella mclareni* (Sutherland), and *Thysanophyllum astraeiforme* (Warren).

The lower lithostrotionid coral fauna of the Kogruk Formation appears to be Meramec in age in the measured sections of this report and is possibly equivalent to the lower part of the Alapah Limestone, Lisburne Group, at Shainin Lake, Endicott Mountains, central Brooks Range.

This fauna may be in part equivalent to assemblage 2 of Macqueen and Bamber's (1968, p. 261–264, figs. 7, 8) from the Mount Head Formation of southwestern Alberta.

The youngest lithostrotionid coral fauna, found in the higher 600–800 feet of the Kogruk Formation, also contains elements of the lower fauna, *Lithostrotionella mclareni* (Sutherland) and *Thysanophyllum orientale* Thomson, but is characterized by the species *Lithostrotionella birdi* Armstrong, *L. banffensis* (*Warren*), *L.* sp. A, *L.* sp. B, and *Sciophyllum alaskaensis* Armstrong. This fauna is found in association with the solitary coral *Faberophyllum* spp. Above the *Faberophyllum* spp. are found *Thysanophyllum orientale* Thomson and *Lithostrotionella birdi* Armstrong in association with latest Meramec age Foraminifera (B. L. Mamet, oral commun., December 1969).

Armstrong (1970) reports *Lithostrotionella birdi* Armstrong, *L.* aff. *L. mclareni* (Sutherland), *L. banffensis* (Warren). *Sciophyllum alaskaensis* Armstrong, and *Faberophyllum girtyi* Armstrong, and a large fauna of microfossils of late Meramec age from the upper beds of the limestone and chert member, Peratrovich Formation, northwest coast of Prince of Wales Island, southeastern Alaska.

Nelson (1960, 1961) reports *Thysanophyllum astraeiforme* (Warren), *Lithostrotionella banffensis* (Warren), *Lithostrotion* (*Siphonodendron*) *warreni* Nelson, *L.* (*S.*) *sinuosum* (Kelly), and *Faberophyllum leathemanense* Parks from the Mount Head Formation of British Columbia.

The younger Kogruk Formation coral fauna is probably equivalent to assemblage 3 of Macqueen and Bamber's (1968, p. 259–266, figs. 7, 8) from the Mount Head Formation of southwestern Alberta. The common species there are *Thysanophyllum astraeiforme* (Warren), possibly *Lithostrotionella mclareni* (Sutherland), and *Faberophyllum* spp.

In southeastern Idaho, Dutro and Sando (1963a, p. B94, fig. 23.2; 1963b, p. 1974) found *Faberophyllum* in the Chesterfield Range Group in their faunal zone F. They stated that "*Faberophyllum*-rich strata are common throughout the Great Basin region in the Great Blue Limestone and correlative stratigraphic units. They are present also in the upper Mount Head Formation of western Canada. Zone F is certainly of Meramec age, in part, but may include correlatives of the lower Chester as well."

The youngest lithostrotionid coral fauna of the Kogruk Formation is believed to be late Meramec in age.

More recent work by Sando, Mamet, and Dutro (1969) indicates that the top of the *Faberophyllum* zone coincides with the top of the Meramec Series (W. J. Sando, written commun., 1969) and that the zone is exclusively late Meramec.

The Kogruk lithostrotionid coral fauna has many species which occur in the coral fauna from the upper part of the limestone and chert member of the Peratrovich Formation, on Prince of Wales Island, southeastern Alaska, and from the Mount Head Formation of British Columbia and Alberta, Canada. Significant aspects of these two boreal faunas are apparently absent from the arctic Kogruk faunas. *Lithostrotionella pennsylvanica* (Shimer), a common element to these boreal faunas, has not been found in the Kogruk Formation. Furthermore, fasciculate acolumellate corals have not been found as yet by the writer in the Kogruk Formation of the DeLong Mountains. *Diphyphyllum* aff. *D. klawockensis* Armstrong is abundant in latest Meramec and earliest Chester carbonates of the Lisburne Group in the Cape Lewis, Niak Creek sections, northwestern Alaska. It is also found in the Lisburne Group outcrops near the headwaters of the Hulahula River. Romanzof Mountains, northeastern Alaska. The Peratrovich Formation has two species of *Diphyphyllum*, *D. klawockensis* Armstrong and *Diphyphyllum venosum* Armstrong. E. W. Bamber (oral commun., 1967) has found corals which possibly belong to the genus *Diphyphyllum* to be rather common in the Mount Head Formation.

SYSTEMATIC PALEONTOLOGY

In the systematic study of this coral fauna, no new species are described. Most species in this collection are represented by only a few specimens from a given horizon in any one section. Oliver (1968, p. 27) considers that for Paleozoic corals, samples of 20 corallites adequately characterize a corallum and that a sample of 20 coralla may be a representative sample of a local population from one environment over a limited area. Collections of this nature were not available from the Kogruk Formation.

Morphological terminology follows that of Hill (1956, p. 34–251).

Conventional treatment has been followed in the taxonomic hierarchy above of the species level. The classification is generally that of Hill (1956), but there are some minor changes. The terminology of the microstructure is that of Kato (1963).

Phylum COELENTERATA
Class ANTHOZOA
Order RUGOSA Milne-Edwards and Haime, 1850
Family LITHOSTROTIONIDAE d'Orbigny, 1851
Genus LITHOSTROTION Fleming, 1828

Lithostrotion Fleming, 1828, A history of British Animals, Edinburgh, p. 508.

Lithostrotion Fleming. Hill, 1956, *in* Moore, R. C., ed., *Treatise* on invertebrate paleontology, Part F, Geol. Soc. America, p. F282.

Type species.—(Opinion 117, International Commission of Zoological Nomenclature) *Lithostrotion striatum* Fleming. Lower Carboniferous, British Isles.

For detailed synonymy of the genus see Hill (1940, p. 165–166; 1956, p. F282).

Diagnosis.—Phaceloid or cerioid; typically with columella, long major septa, and large conical tabulae, generally supplemented by outer, smaller, nearly horizontal tabulae; dissepiments absent in very small forms, normal and well developed in large forms; increase nonparricidal; diphymorphs common (Hill, 1956, p. F282).

Subgenus SIPHONODENDRON McCoy, 1849

Siphonodendron McCoy, 1849, Annals and Mag. Nat. History, p. 127.

Siphonodendron McCoy. Sando, 1963, Jour. Paleontology, v. 37, no. 5, p. 1075.

Type species.—*Lithostrotion pauciradialis* (McCoy), Carboniferous, Ireland.

Diagnosis.—Same internal features as *Lithostrotion* except the growth form of the corallum is fasciculate.

Lithostrotion (Siphonodendron) sinuosum (Kelly)

Plate 1, figures 1–7; plate 3, figures 3, 4

Lithostrotion flexuosum Warren, 1927, Canada Geol. Survey Bull. 42, p. 47–48, pl. 3, fig. 7, pl. 4, fig. 2. [Not, *Lithostrotion flexuosum* Trautschold, 1879, p. 37, pl. 5, figs. 7a–b.]

Diphyphyllum sinuosum Kelly, 1942, Jour. Paleontology, v. 16, p. 358.

Lithostrotion cf. *pauciradiale* (McCoy). Sutherland, 1958, Canada Geol. Survey Mem. 295, p. 92–93, pl. 32, figs. 1, 2, 3a, c.

Lithostrotion sinuosum (Kelly). Nelson, 1960, Jour. Paleontology, v. 34, p. 121, pl. 24, figs. 4–10.

Lithostrotion sinuosum (Kelly). Nelson, 1961, Geol. Assoc. Canada Spec. Paper 2, pl. 11, figs. 1–7.

Lithostrotion (*Siphonodendron*) *sinuosum* (Kelly), Bamber, 1966, Canada Geol. Survey Bull. 135, p. 7, 8, pl. 1, figs. 3, 4a–i.

Lithostrotion (Siphonodendron) sinuosum (Kelly). Bamber, 1967, Canada Geol. Survey Paper 67-47, pl. 1, figs. 11a-c, 12a, b.

Material.—Fragments of nine colonies, each fragment of which was about 8 by 8 by 10 cm, were available for study. Specimen USNM 160988 was studied in five transverse and three longitudinal thin sections. Typically five transverse and three longitudinal thin sections were made from each corallum.

Description.—The specimen USNM 160989 (pl. 1, figs. 1, 2) from the measured section 62C-15, DeLong Mountains, has a dendroid fasciculate corallum and offsets that arise by lateral increase. In transverse thin section the corallites are 0.5-4 mm apart, and they are 2.7-3.7 mm in diameter and have 16-18 major septa (figs. 11, 12). The major septa are 0.7-1.2 mm long and in some corallites reach the columella. This latter condition is noted in random thin sections which transact some corallites at a level at which the major septa reach the columella on the surface of tabulae. The minor septa are always present and are short, 0.3-0.5 mm long. The epitheca is 80-100 microns thick. The major septa at their bases are 150-180 microns thick and taper to their distal ends. The original microstructure of the corallum has been extensively affected by calcite neomorphism (Folk 1965) (pl. 3, figs. 3, 4). The epitheca appears to have been composed of calcite crystals that have their long axes perpendicular to the exterior. The septa are composed of 8-15-micron calcite crystals. The columella is lens shaped, 0.35-0.5 mm wide and 0.5-0.8 mm long, and has short projections which are ridges made by the axial edges of septa on the surface of the upsloping tabulae. The columella has a median plate about 50 microns thick which is in the plane of the cardinal-counter septa. The composition of the columella is interlocking crystals of calcite, ranging from 8-15 microns in size, and the columella appears to have the same microstructure as the septa.

In longitudinal section, the tabulae are generally complete and slope away from the columella for a distance of approximately 1 mm at angle of 20°-25° before bending downward to angles of 45°-60° near the dissepimentarium. Some 9-12 tabulae occur in a distance of 5 mm. The dissepimentarium is composed of a single row of globose dissepiments of which 12-16 occur in 5 mm. The walls of the tabulae and dissepiments are 20-30 microns thick and are formed by crystals of calcite which range in size from 8 to 15 microns. Microscopic examination of the junction of tabulae to the columella clearly indicates the tabulae do not contribute to the structure of the columella.

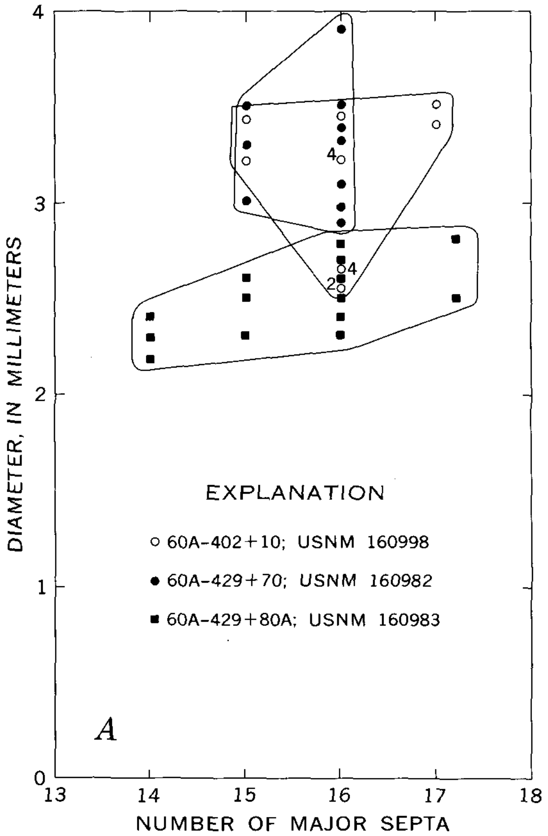
Occurrence.—Specimen USNM 160989, described in detail above, and specimen USNM 160988 (pl. 1, figs. 3-5) were collected at 690 and 620 feet respectively below the top of measured section 62C-15, Kogruk Formation, DeLong Mountains. They were found in association with *Lithostrotionella banffensis* (Warren), *L. mclareni* (Sutherland), and *Faberophyllum* spp. (fig. 3). Specimens USNM 160982 and 160983 were collected by the writer in 1962 from the lower half of Campbell's (1967, p. 49) Cape Thompson Member of the Nasorak Formation, south of Nasorak Creek, near Cape Thompson. Other corals from the same bed are *Lithostrotion (Siphonodendron) warreni* Nelson, *Thysanophyllum astraeiforme* (Warren), and *Sciophyllum* sp. A. *Lithostrotion (S.) sinuosum* (Kelly), USNM 161032, was collected from 30 feet above the base of the Cape Thompson Member of the Nasorak Formation, at Cape Thompson (Campbell, 1967, pl. 2A). From measured section 62C-31 (fig. 5), Kogruk Formation, DeLong Mountains, the following specimens of *L. (S.) sinuosum* (Kelly) were collected at the indicated level below the top of the section: USNM 160987 at 870 feet (pl. 1, figs. 6, 7), USNM 160985 at 1,490 feet, USNM 161014 at 1,790 feet, and USNM 160986 at 1,810 feet. The specimens occur with *Lithostrotion (Siphonodendron) warreni* Nelson, *Sciophyllum lambarti* Harker and McLaren, and *Lithostrotionella* aff. *L. banffensis* (Warren).

L. (S.) sinuosum (Kelly), USNM 160998, was found in association with *Lithostrotionella mclareni* (Sutherland) in section 60A-400—403, Kogruk Formation in the DeLong Mountains (fig. 7).

Bamber (1966, p. 7) states that *Lithostrotion (Siphonodendron) sinuosum* (Kelly) is found in the Prophet Formation north of the Peace River in British Columbia and in the upper 400 feet of the Livingstone Formation and the basal Mount Head Formation, Rocky Mountains of southern British Columbia and Alberta.

Macqueen and Bamber (1967, p. 12, figs. 7, 8) found that *L. (S.) sinuosum* in the Mississippian rocks of southwestern Alberta ranges from Osage into Meramec age rocks, through most of the Livingstone Formation and into the overlying Mount Head Formation. In Alberta it normally occurs below the lithostrotionid species it is found associated with in the Kogruk Formation of Alaska.

Remarks.—The coralla, assigned to the species *Lithostrotion (Siphonodendron) sinuosum* (Kelly) from the Lisburne Group of northwestern Alaska, agree in corallite diameter, number, and development of septa, tabulae, dissepiments, and columella with Nelson's (1960, pl. 24, figs. 4-10) illustration of the holotype from the basal Mount Head Formation and with Bamber's (1966, pl. 1, figs. 3, 4a-i) illustrations of a syntype and a hypotype. Specimen USNM 160986 was col-



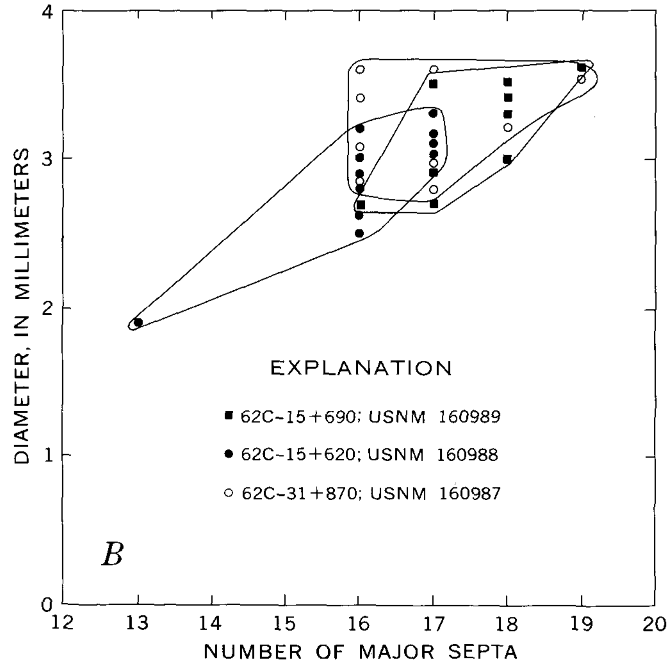
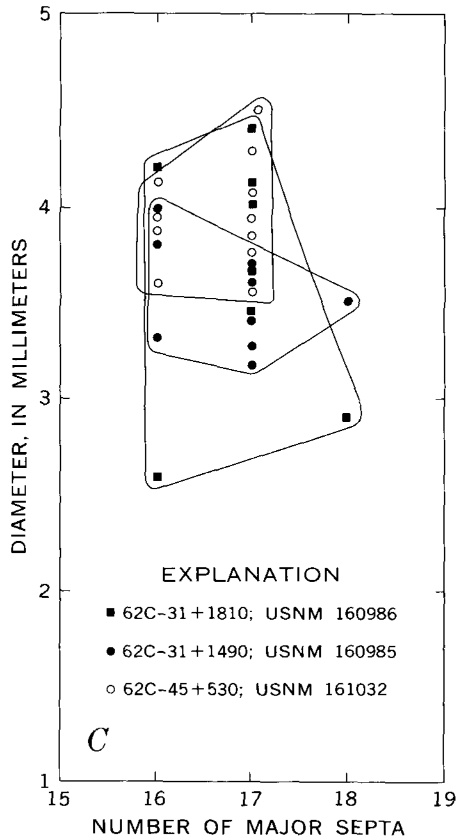


FIGURE 11.—Corallite diameter and number of major septa in *Lithostrotion* (*Siphonodendron*) *sinuosum* (Kelly). Each unnumbered symbol represents a single corallite. If more than one corallite shows the same diameter and number of septa, the number of similar corallites is shown.



lected from a bed at a level approximately 300–500 feet above the base of the Kogruk Formation in the DeLong Mountains in section 62C–31 (fig. 5). This specimen differs from the stratigraphically higher Kogruk examples of the species because its corallites have major septa which are 0.2–0.3 mm shorter and because they have thin columellae. These differences are not considered to be of specific or subspecific significance. *L.* (*S.*) *sinuosum* (Kelly), specimen USNM 160987, collected 870 feet below the top of section 62C–31, at about the middle of the Kogruk Formation, is characterized by longer major septa which generally join the columella intransverse section. Other specimens, which have long major septa, were collected in stratigraphically younger beds of the Kogruk Formation at section 62C–15 and section 62C–31.

The Kogruk Formation specimens of *L.* (*S.*) *sinuosum* (Kelly) suggest a trend in this species towards septal elongation and thicker columellae in stratigraphically younger coralla.

Specimen USNM 160997, *Lithostrotion* (*Siphonodendron*) aff. *L.* (*S.*) *sinuosum* (Kelly) (pl. 1, fig. 8; pl. 3, figs. 1, 2), is the stratigraphically lowest specimen of the subgenus in this collection from the Lisburne Group, DeLong Mountains. It was collected by Dr. Sigmund Snelson 540 feet below the top of the Utukok Formation. It differs from typical examples of *L.* (*S.*) *sinuosum* by

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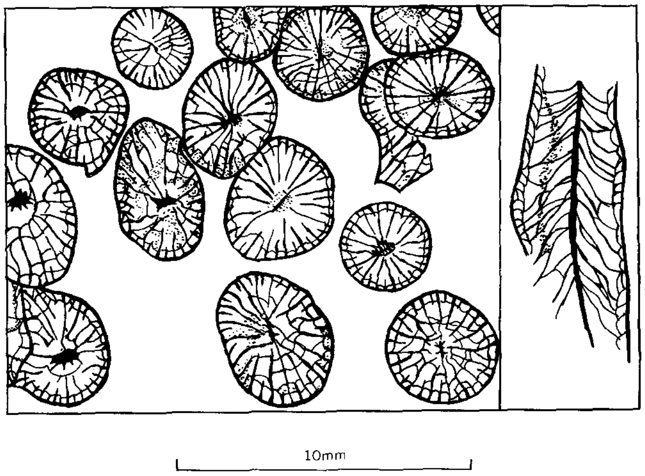

FIGURE 12.—Sections of *Lithostrotion* (*Siphonodendron*) *sinuosum* (Kelly), USNM 160989.

having corallites in which the minor septa are usually absent and in which the major septa are short and are withdrawn from the axial region.

Lithostrotion (*Siphonodendron*) *oculinum* Sando (1963) is readily distinguished from *L.* (*S.*) *sinuosum* (Kelly) by its larger corallites; they range in diameter from 4 to 6 mm and have 20 to 25 major septa. Another distinguishing feature is its tabulae, which near the periphery of the tabularium are reflexed downward about 50°–70° and then are reflexed to nearly horizontal just before they contact the dissepimentarium.

Morphologically similar in some respects to *L.* (*S.*) *sinuosum* (Kelly) from the Lisburne Group is Dobroljubova's (1958, p. 153–155, pl. 22, figs. 1a, b, 2a, b) *Lithostrotion volkovae* Dobroljubova from the lower Carboniferous of the Russian Platform. Its corallites have a diameter of 4–5 mm; they have 17–18 long major septa and well-developed columelae. The minor septa are about one-third the length of the major septa. It differs from *L.* (*S.*) *sinuosum* (Kelly) by having tabulae which tend to be incomplete and a well-developed double to triple row of dissepiments.

The lectotype of *Lithostrotion pauciradiale* (McCoy), chosen by Hill (1940, p. 169, pl. 9, figs. 1, 2) specimens at the National Museum of Ireland, has 18–22 major septa per corallite and a corallite diameter of 4–5.5 mm. The species has a slightly larger corallite diameter, a higher number of septa, and a more pronounced tendency towards incomplete tabulae than does *L.* (*S.*) *sinuosum* (Kelly).

Yü's (1933, pl. 19, figs. 4, 4a–d; pl. 20, figs. 1, 1a–c) illustration of *Lithostrotion* (*Siphonodendron*) *irregulare* (Phillips) var. *asiatica* Yabe and Hayasaka from China shows specimens which closely resemble some specimens of *L.* (*S.*) *sinuosum* (Kelly) from the Kogruk Formation, in particular USNM 160987, from the middle of the formation, section 62C–31.

Lithostrotion (Siphonodendron) aff. L. (S.) sinuosum (Kelly)

Plate 1, figure 8; plate 3, figures 1, 2

Material.—A fragment approximately 8 by 10 by 15 cm of a corallum was collected. The corallum is preserved as calcite in a partially dolomitized arenaceous crinoidal wackestone. Two transverse and three longitudinal thin sections were available for study. Transverse sections of 65 corallites were studied.

Description.—The specimen, USNM 160997, has a fasciculate corallum and offsets that arise by lateral increase. In transverse thin section, corallites are 0.5–7 mm apart, are 3–4.5 mm in diameter, and have 15–18 major septa (figs. 13, 14). The major septa are 0.7–1.3 mm long and in the thin section studied do not reach the columella (pl. 1, fig. 8; pl. 3, fig. 2). In most of the corallites, minor septa are absent, but where present they are less than 0.1 mm long. The calcite of the internal structures has been recrystallized, and most of the original microstructure has been destroyed. The interiors of the corallites are filled with sparry calcite, and the columella has been extensively recrystallized (pl. 3, figs. 1, 2). The epitheca is 90–100 microns thick, and the major septa at their bases are 70–100 microns thick. The columella is lens shaped, 0.5–0.7 mm long and 0.1–0.2 mm wide.

In this section all longitudinal sections of corallites are crushed and distorted (pl. 4, fig. 2). Reconstruction of individual corallites suggests they had complete

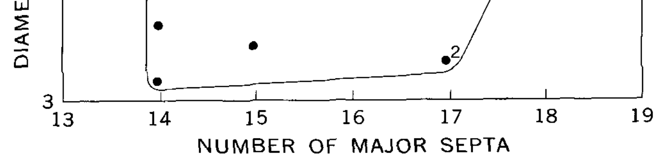

FIGURE 13.—Corallite diameter and number of major septa in *Lithostrotion* (*Siphonodendron*) aff. *L.* (*S.*) *sinuosum* (Kelly). Each unnumbered symbol represents a single corallite. If more than one corallite shows the same diameter and number of septa, the number of similar corallites is shown. Specimens from section 60A–303+410; USNM 160997.

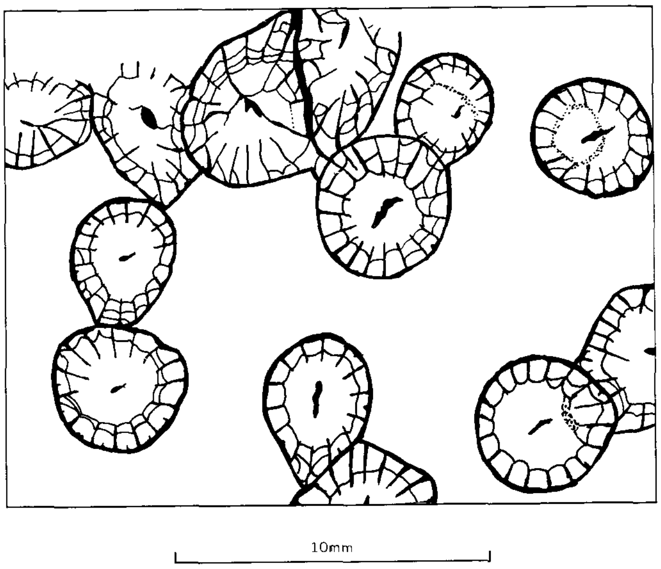

FIGURE 14.—Section of *Lithostrotion* (*Siphonodendron*) aff. *L.* (*S.*) *sinuosum* (Kelly), USNM 160997.

tabulae which sloped 15°–25° away from the columella for a distance of approximately 1 mm before bending downward to angles of 40°–50° near the dissepimentarium. In a distance of 5 mm, there are 5–8 tabulae. The globose dissepiments are not persistent and occur as a discontinuous single row in which 8–10 dissepiments are present in 5 mm.

Occurrence.—Specimen USNM 160997 was collected by Dr. Sigmund Snelson about 540 feet below the top of the Utukok Formation at the headwaters of Nunaviksok Creek, sec. 36, T. 10 S., R. 41 W. This specimen is the stratigraphically lowest example of the subgenus *Siphonodendron* collected by Shell Oil Co. geologists from the Lisburne Group, DeLong Mountains.

Remarks.—*L.* (*S.*) aff. *L.* (*S.*) *sinuosum* (Kelly) differs from *L.* (*S.*) *sinuosum* (Kelly) by having corallites in which the minor septa may be absent or only weakly developed, the major septa are withdrawn from the axial region, and the dissepiments are not continuous in the corallites. (See remarks under *L.* (*S.*) *sinuosum.*) Kelly (1942, p. 358) describes the holotype of the Lower Mississippian species of *Lithostrotion* (*Siphonodendron*) *mutabile* (Kelly) as having corallites with a diameter of 4.0–6.5 mm and 24 major septa and long minor septa. In transverse section this species differs from *L.* (*S.*) aff. *L.* (*S.*) *sinuosum* (Kelly) by having larger corallites and more numerous and much longer minor septa.

Lithostrotion (Siphonodendron) warreni Nelson

Plate 1, figures 9, 10; Plate 2, figures 1–4

Lithostrotion (*Diphyphyllum*) sp. A. Sutherland, 1958, Canada Geol. Survey Mem. 295, p. 98, pl. 32, figs. 4a–d.

Lithostrotion warreni Nelson, 1960, Jour. Paleontology, v. 34, p. 121, 122, pl. 24, figs. 11–14.

Lithostrotion warreni Nelson, Nelson, 1961, Geol. Assoc. Canada Spec. Paper 2, pl. 13, figs. 4–8.

Lithostrotion (*Siphonodendron*) *warreni* Nelson, Bamber, 1966, Canada Geol. Survey Bull. 135, pl. 1, fig. 2.

Lithostrotion (*Siphonodendron*) *warreni* Nelson, Armstrong, 1970, U.S. Geol. Survey Prof. Paper 534, p. 18–20, pl. 4, figs. 1–6.

Material.—Fragments of four colonies were collected from measured stratigraphic sections. The specimens are typically 8 by 8 by 10 cm and are preserved as calcite in a matrix of limestone or dolomitic limestone. Four transverse and two longitudinal thin sections were made of each colony.

Description.—Specimen USNM 160990 (pl. 2, figs. 1, 2), from measured section 62C–31 in the DeLong Mountains, has a dendroid corallum and offsets that arise by lateral increase. In transverse thin section, corallites are 0.5–5 mm apart and are 4.0–5.5 mm in diameter; they have 21–23 major septa (figs. 15, 16). The major

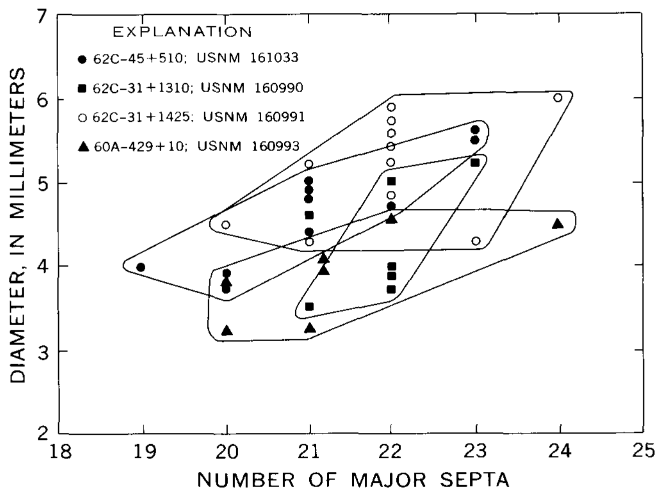

FIGURE 15.—Corallite diameter and number of major septa in *Lithostrotion* (*Siphonodendron*) *warreni* Nelson.

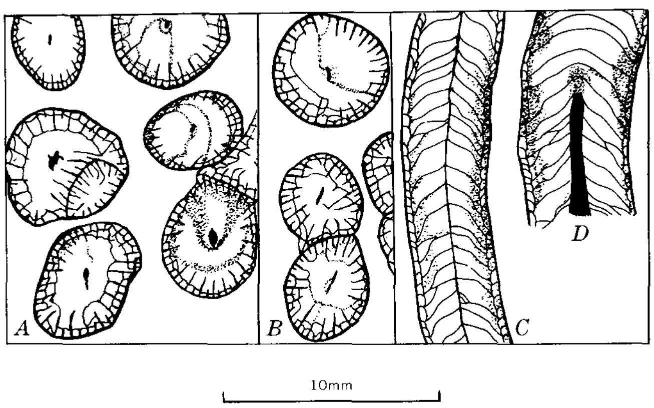

FIGURE 16.—Sections of *Lithostrotion* (*Siphonodendron*) *warreni* Nelson; *A*, USNM 160993; *B*, *C*, *D*, USNM 160990.

septa are 0.8–1.3 mm long; the minor septa are 0.3–0.4 mm long. The major septa at their bases are 70–100 microns thick, and the epitheca appears to be in excess of 100 microns thick. The epitheca and septa, along with all internal structures, have undergone calcite neomorphism and are composed of interlocking calcite crystals ranging in size from 20 to 80 microns (pl. 1, fig. 10). The columella is elongated in the plane of the cardinal-counter septa. The septa, in the thin section studied, generally do not reach the columella. The columellae range in size from 0.5 to 1 mm long and 0.1 to 0.2 mm wide and generally have short radiating projections formed by the septa which are low ridges on the surface of the upsloping tabulae.

A median plate, 20–40 microns thick, is present in the columella and is preserved as a dark-colored band (pl. 1, fig. 10).

In longitudinal section (pl. 1, fig. 9; pl. 2, fig. 2) the tabulae are complete and slope peripherally from the columella at angles of 25°–35° in the axial region, then are deflected downward 50°–65° near the periphery of the tabularium. A few tabulae near the periphery of the tabularium are reflexed to a near-horizontal plane, but the vast majority of tabulae join the dissepimentarium at angles of 50°–65°. The tabulae are 50–70 microns thick. In a distance of 5 mm there are 5–7 tabulae. The columella (pl. 1, fig. 9) is a continuous, straight axial plate to which the tabulae are fused, but the tabulae do not contribute to its structure.

In all corallites studies the dissepimentarium is present and is a single row of regular dissepiments of relatively uniform globose shape; the dissepiments are typically 0.5 mm long and 0.2–0.3 mm wide and have a wall that is 20–30 microns thick.

Occurrence.—Specimens USNM 160990 and 160991 were collected in the Kogruk Formation at 1,310 and 1,425 feet below the top of measured section 62C–31, DeLong Mountains, in association with a coral fauna of *Lithostrotion* (*Siphonodendron*) *sinuosum* (Kelly), *Thysanophyllum astraeiforme* (Warren), *T. orientale* Thomson, *Sciophyllum lambarti* Harker and McLaren, *S. alaskaensis* Armstrong, *Lithostrotionella* aff. *L. banffensis* (Warren), and *L. mclareni* (Sutherland) (fig. 5).

Specimen USNM 160993 (pl. 2, figs. 3, 4) was collected in association with *Thysanophyllum astraeiforme* (Warren) and *Sciophyllum* sp. A. in the lower half of the Cape Thompson Member (Campbell, 1967, p. 49, pl. 2B) of the Nasorak Formation south of Nasorak Creek, near Cape Thompson.

L. (*S.*) *warreni* Nelson USNM 161033, was collected 10 feet above the base of the Cape Thompson Member of the Nasorak Formation at Cape Thompson.

L. (*S.*) *warreni* Nelson has been found in the lower 20 feet of Bowsher and Dutro's (1957) dark limestone member of the Alapah Formation, Lisburne Group, at Shainin Lake. It occurs here with a large fauna of Meramec lithostrotionid corals and Foraminifera.

Armstrong (1970, p. 19) reports *L.* (*S.*) *warreni* Nelson with *Lithostrotionella birdi* Armstrong, *L. pennsylvanica* (Shimer), and a Foraminifera microfauna of Meramec age from the limestone and chert member of the Peratrovich Formation, northwest coast, Prince of Wales Island, Alaska.

Nelson (1960, p. 121) reports *L.* (*S.*) *warreni* Nelson in Alberta from the "Lower Mount Head Formation, ranging from the lower to upper *Lithostrotionella* beds."

Macqueen and Bamber (1968, p. 261–262) found *L.* (*S.*) *warreni* Nelson in their Meramec age faunal assemblages 1 and 2 from the Mount Head Formation of southwestern Alberta.

Remarks.—*Lithostrotion* (*Siphonodendron*) *warreni* Nelson (1960, p. 121–122, pl. 24, figs. 11–14) from the lower Mount Head Formation, Alberta, and *Lithostrotion* (*Siphonodendron*) *oculinum* Sando (1963, p. 1075–1076, pl. 145, figs. 1–5) from the Redwall Limestone, Arizona, are similar in diameter of the corallites, the number of major septa, and development of the columellae. They differ, however, in that *L.* (*S.*) *oculinum* Sando has slightly longer minor septa and in particular has, in longitudinal section, tabulae that are sharply deflected downward near the periphery of the tabularium but that are bent to nearly a horizontal plane adjacent to the dissepimentarium. Furthermore, in *L.* (*S.*) *oculinum* Sando (p. 1075) rare tabulae are so sharply deflected at the tabular shoulder that they rest upon the underlying tabulae. In contrast, the tabularium of *L.* (*S.*) *warreni* Nelson has tabulae which are generally flatter and lack well-defined shoulders.

In the transverse sections the specimens of *L.* (*S.*) *warreni* Nelson from the Kogruk Formation compare closely with Bamber's (1966, pl. 1, fig. 2) illustration of a transverse section of the holotype. Some parts of an individual corallite within one colony may show a few tabulae whose configuration is suggestive of some of the characteristics of *L.* (*S.*) *oculinum* Sando. But among all the Kogruk Formation specimens, not one corallite or any one colony has well-developed or consistent characteristics typical of *L.* (*S.*) *oculinum* Sando.

Lithostrotion (*Siphonodendron*) sp. A, which occurs in the Lisburne Group in the same beds as *L.* (*S.*) *warreni*, can be distinguished from the latter by its tabulae which slope peripherally from the columella to the dissepimentarium at angle 50°–65°.

Lithostrotion (*Siphonodendron*) *sinuosum* (Kelly), which also occurs in the Lisburne Group with *L.* (*S.*) *warreni*, differs from the latter by having corallites with a diameter of only 3–4.5 mm and longer major septa that may extend across the tabularium and join with the columella.

Lithostrotion (*Siphonodendron*) *oregonensis* Merriam (1942, p. 379, pl. 57, figs. 1–8), from the Mississippian Coffee Creek Formation of Oregon, is closely related to and has a corallite diameter similar to *L.* (*S.*) *warreni*. *L.* (*S.*) *oregonensis* differs by having 17–20 major septa which are always thickened in the dissepimentarium and tabulae that are commonly discontinuous.

Lithostrotion (Siphonodendron) sp. A

Plate 2, figures 5–9

Material.—Specimen USNM 160992 was collected from a measured section of the Nasorak Formation at Cape Thompson. Specimen USNM 160996 was collected from the dark limestone member of the Alapah Limestone at Shainin Lake, central Brooks Range. Both specimens are fragments about 6 cm square and contain coralla which are preserved as calcite in a limestone matrix. Two transverse and three longitudinal thin sections have been made from specimen USNM 160992. Approximately 62 corallites were studied in transverse section, and 25 in longitudinal section. The specimen from the Shainin Lake section, USNM 160996, was studied in one longitudinal and three transverse thin sections; 72 corallites in the transverse sections, and 10 in the longitudinal section.

Description.—Specimen USNM 160992 (pl. 2, figs. 5–9) from the type locality of the Cape Thompson Member of the Nasorak Formation has a dendroid corallum and offsets that arise by lateral increase. In transverse thin section, corallites are 0.5–6 mm apart and have a diameter of 3–4.5 mm; they have 20–26 major septa, which are 0.7–1.0 mm long and which are 100 microns thick at their bases (figs. 17, 18). Minor septa are always present and are 0.3–0.4 mm long. The epitheca is 50–70 microns thick. The columellae are lens shaped, 0.7–1.2 mm long, 0.3–0.5 mm wide, and in some corallites are attached to the counter septum. The major septa extend to the columella as low ridges on the surfaces of the tabulae. A few corallites were cut on the plane at which the tabulae joined the columella.

In longitudinal section, the tabularium is well defined and regular. The tabulae (pl. 2, figs. 5–8) slope downward from the columella at angles of 50°–65° across the tabularium to join the dissepimentarium. Some tabulae are reflexed to slopes of 20°–30° before reaching the dissepimentarium. There are 5–6 tabulae in 5 mm. In all corallites studied, the dissepimentarium is present and is a single row of uniform globose-shaped dissepiments, 0.4–0.6 mm long, 0.2–0.3 mm wide. The walls of both dissepiments and tabulae are 50–70 microns thick.

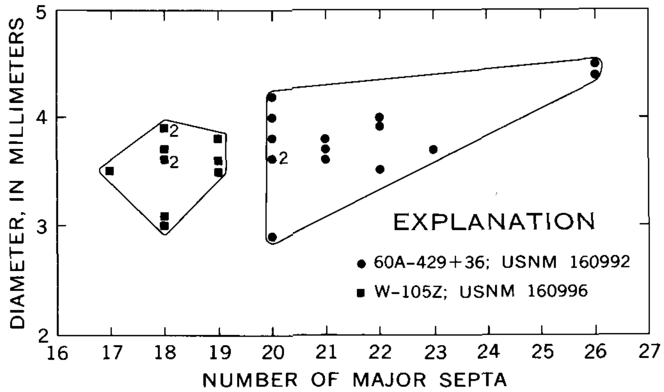

FIGURE 17.—Corallite diameter and number of major septa in *Lithostrotion* (*Siphonodendron*) sp. A. Each unnumbered symbol represents a single corallite. If more than one corallite shows the same diameter and number of septa, the number of similar corallites is shown.

Specimen USNM 160996 collected from the dark limestone member of the Alapah Limestone of the Lisburne Group, near Shainin Lake, central Brooks Range, is similar to specimen 160992 in its development of the tabulae, dissepiments, columellae, and septa, but does differ by having corallites of a slightly smaller diameter and with fewer major septa. In specimen USNM 160996, the corallites are typically 3.5–4.0 mm in diameter and have 18–19 major septa.

Occurrence.—Specimen USNM 160922 was collected from the Cape Thompson Member of the Nasorak Formation, south of Nasorak Creek, near Cape Thompson, Alaska (Campbell, 1967, pl. 2B). It occurs with a Meramec coral fauna of *Lithostrotion* (*Siphonodendron*) *warreni* Nelson, *Thysanophyllum astraeiforme* (Warren), and *Sciophyllum* sp. A. Specimen USNM 160996 was collected in the lower 20 feet of Bowsher

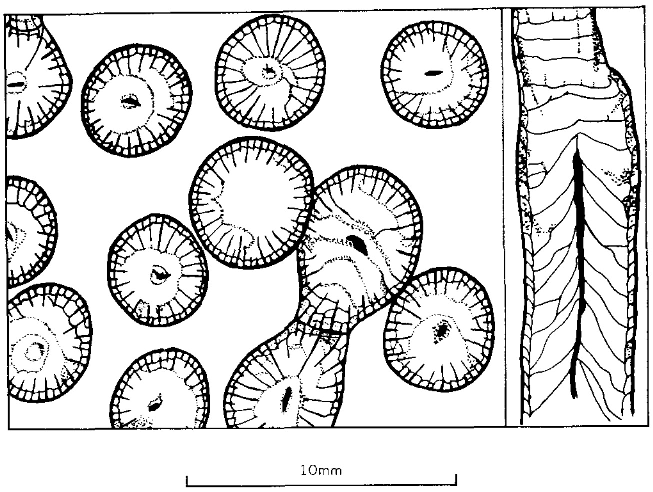

FIGURE 18.—Sections of *Lithostrotion* (*Siphonodendron*) sp. A, USNM 160992.

and Dutro's (1957) dark limestone member of their type section of the Alapah Limestone, Shainin Lake, Alaska. It occurs with a large fauna of Meramec Foraminifera and cerioid *Lithostrotionella* corals.

Remarks.—The most distinctive feature of *Lithostrotion* (*Siphonodendron*) sp. A is the tabulae which slope peripherally from the columella to the dissepimentarium at angle's of 50°–65°. This is in marked contrast to *Lithostrotion* (*Siphonodendron*) *warreni* Nelson (in which tabulae slope away from the columella at angles of 25°–35° and then are reflexed downward at an angle of 50°–65°. In *Lithostrotion* (*Siphonodendron*) *oculinum* Sando the tabulae are reflexed even more sharply; furthermore, they are frequently reflexed to a nearly horizontal plane just before joining the dissepimentarium.

In size of the corallite diameter, number of major septa, development of the dissepimentarium, and type of columella, *L.* (*S.*) sp. A, *L.* (*S.*) *warreni* Nelson, and *L.* (*S.*) *oculinum* Sando are very similar.

Family LONSDALEIIDAE Chapman, 1893

Genus LITHOSTROTIONELLA Yabe and Hayasaka, 1915

Lithostrotionella Yabe and Hayasaka, 1915, Geol. Soc. Tokyo Jour., v. 22, p. 94.

Lithostrotionella Yabe and Hayasaka. Hayasaka, 1936, Taihoku Imp. Univ., Formosa, v. 13, no. 5, p. 47–58.

Lithostrotionella Yabe and Hayasaka. Hill, 1956, *in* Moore, R. C., ed., Treatise on invertebrate paleontology, Part F, Geol. Soc. America, p. F306–307.

Type species.—*Lithostrotionella unicum* Yabe and Hayasaka, 1915, Permian, Chihsia Limestone, Yun-nan, South China.

Diagnosis.—Cerioid corallum, primatic corallites, columella a persistent vertical lath frequently continuous with counter and cardinal septa. Lonsdaleoid dissepiments. All major septa intermittently reach the wall along the tops of the dissepiments. Minor septa short. Tabulae frequently complete, conical. (Summarized from Yabe and Hayasaka, 1915, p. 94.)

Lithostrotionella banffensis (Warren)

Plate 3, figures 5–8; plate 4, figures 1–4; plate 10, figure 1

Lithostrotion banffense Warren, 1927, Canada Geol. Survey Bull. 42, p. 46–47, pl. 3, figs. 5, 6, pl. 5.

Lithostrotionella floriformis Hayasaka, 1936, Taihoku Imperial University Memoirs Faculty of Science and Agriculture, v. 13, no. 5, p. 64–65, pl. 17, figs. 1a, b.

Lithostrotionella vesicularis Hayasaka, 1936, Taihoku Imperial University, Memoirs Faculty of Science and Agriculture, v. 13, no. 5, p. 68–69, pl. 14, figs. 3a, b.

Lithostrotionella banffensis (Warren). Kelly, 1942, Jour. Paleontology, v. 16, p. 354–356.

Lithostrotionella banffense (Warren). Nelson, 1960, Jour. Paleontology, v. 34, p. 119, pl. 23, figs. 4, 5.

Lithostrotionella banffense (Warren). Nelson, 1961, Geol. Assoc. Canada Spec. Paper 2, pl. 17, figs. 1, 2.

Lithostrotionella banffensis (Warren). Bamber, 1966, Canada Geol. Survey Bull. 135, p. 17–19, pl. 3, fig. 5.

Lithostrotionella banffensis (Warren). Armstrong, 1970, U.S. Geol. Survey Prof. Paper 534, p. 29–31, pl. 10, figs. 1–8, pl. 13, figs. 1–7.

Material.—Fragments of three coralla, USNM 161011, 161012, and 161013, each about 5 by 10 by 10 cm, were collected from the Lisburne Group in 1962. The specimens are from measured stratigraphic sections. Internal features were studied by eight transverse and 12 longitudinal thin sections. The coralla are preserved as calcite with some minor silicification. The preservation of the microstructure in the specimens is generally poor, owing to calcite neomorphism.

Description.—Specimen USNM 161011 is cerioid. In transverse section (pl. 3, figs. 5, 8) the corallites are 8–10.5 mm in diameter and have 21–25 major septa (fig. 19). The major and minor septa are discontinuous and poorly developed in the dissepimentarium and are short ridges less than 0.5 mm long on the corallite wall. The major septa are well developed in the tabularium and extend to the columella as ridges on the surfaces of the tabulae. In the dissepimentarium, the major septa are short and discontinuous. The minor septa reappear near the tabularium wall and penetrate it; they are short, generally less than 1 mm in length. The dissepiments are lonsdaleoid and show considerable variation in size in a given corallite and between corallites. The columella is generally continuous with the counter septum; it is typically 1–1.5 mm long and 0.25 mm wide.

In longitudinal section (pl. 3, figs. 6, 7) the dissepimentarium consists of 3–6 rows of dissepiments which are inclined upward at angles of 25°–35°. In a corallite 10 mm wide, the tabularium is approximately 5 mm wide. The tabulae are normally incomplete and slope away from the columella at angles of 30°–40°. The interior of the corallum is filled with sparry calcite. These calcite crystals are in the 0.5–2 mm size range and have by grain growth engulfed, penetrated, or in some cases destroyed the smaller (5–30 microns in size) calcite crystals which form the internal structures of the corallum.

The corallite walls are 100–125 microns thick and have a central dark band of calcite 10–20 microns thick. The major septa in the tabularium are 150 microns thick and also have a central dark band on which fibrous calcite is deposited. The tabulae and dissepiments have walls that are 20–40 microns thick and that are composed of interlocking crystals of calcite which range in size from 4 to 10 microns (pl. 3, fig. 7).

Specimen USNM 161012 is cerioid (pl. 4, figs, 1, 2). In transverse section the corallites are 5.6–7.0 mm in

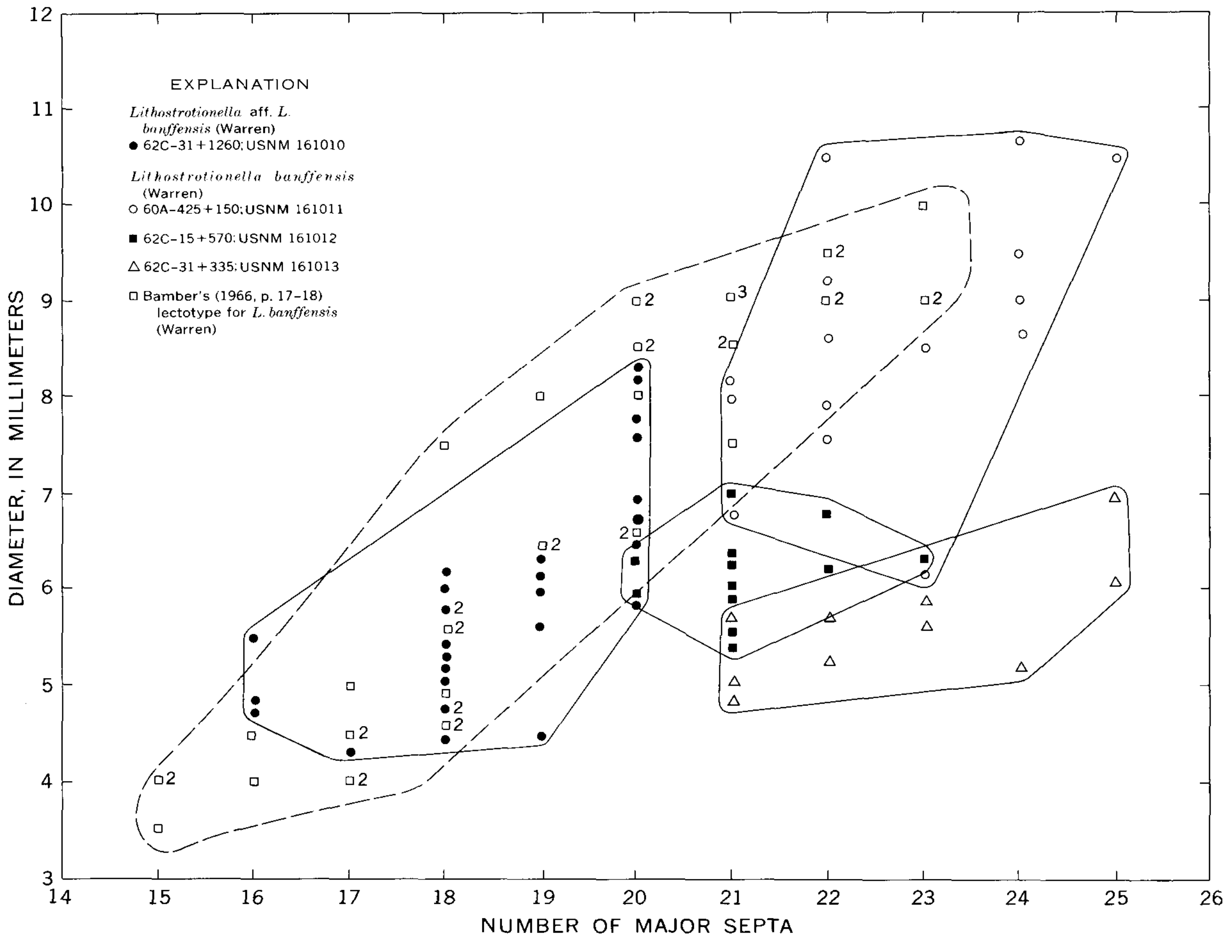

FIGURE 19.—Corallite diameter and number of major septa in Bamber's (1966, p. 17–18) lectotype of *Lithostrotionella banffensis* (Warren); three specimens of *Lithostrotionella banffensis* (Warren) and *Lithostrotionella* aff. *L. banffensis* (Warren) from the Lisburne Group. Each unnumbered symbol represents a single corallite; if more than one corallite shows the same diameter and number of septa, the number of similar corallites is shown.

diameter and have 18–21 major septa (figs. 19, 20). The dissepiments are lonsdaleoid. The major and minor septa occur in the dissepimentarium as short ridges on the epitheca and as projections on the outer wall of the tabularium. Minor septa are present in the tabularium and may project into the dissepimentarium. The tabularium is from 3.5–4.5 mm wide. Major septa extend one-half to two-thirds the distance from the tabularium wall to the center of the corallite. Major septa are commonly curved or sinuous, are thickened in the peripheral part of the tabularium, and are thinner toward the axis and in to the dissepimentarium. The septa are radially arranged. The columellae are typically 1–1.5 mm long and 0.2–0.3 mm wide, lens shaped, and frequently attached to the cardinal-counter septa. The edges of the columella have small projections which are formed by the major septa on the surfaces of the tabulae.

A longitudinal section (pl. 4, fig. 2) of a 4-mm wide

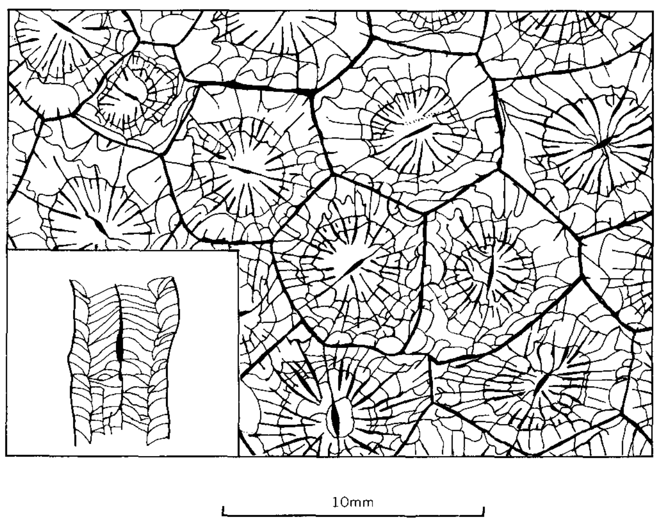

FIGURE 20.—Sections of *Lithostrotionella banffensis* (Warren), USNM 161012.

corallite shows the dissepimentarium to be composed of 1–2 rows of swollen, globose dissepiments. Dissepiments have considerable size variation. Tabulae are generally incomplete. Tabulae slope away from the columella at angles of 15°–40° and, within 0.7–0.4 mm of the dissepiments, are reflexed to 15°–25°.

The columella is clearly formed by the axial ends of the cardinal and counter septa plus the axial edges of other septa which reach the columella as ridges on the surface of the tabulae.

The preservation of the corallum is poor (pl. 10, fig. 1). The calcite crystals ranging in size from 40 to 150 microns, which fill the interior of the corallites have, by grain growth, penetrated and replaced much of the calcite which forms the internal structures of the corallites.

The corallite walls are typically 150–200 microns thick (pl. 10, fig. 1). A central dark band 20–30 microns thick is present in the corallite walls. The walls are composed of long fibrous calcite which was deposited normal to the dark bands. The discontinuous major septa which project from the wall into the dissepimentarium appear to have a composition similar to the epitheca. Near the tabularium wall, the major septa are formed by interlocking crystals of calcite which range in size from 20 to 40 microns. The septal microstructure suggests that septa were made of divergent fibers of calcite with a central trabeculae band.

Specimen USNM 161013 (pl. 4, figs. 3, 4) is cerioid, and in transverse section the corallites are 4.9–7 mm in diameter and have 18–21 major septa (fig. 19). The dissepiments are lonsdaleoid. Minor septa are present and are one-half to two-thirds the length of the major septa. Major septa reach the columella as low ridges on the upper surfaces of tabulae. Major and minor septa are slightly sinuous, are thickened in the peripheral part of the tabularium, and become thinner towards the axis and into the dissepimentarium. The septa are radially arranged. Many columellae are continuous with cardinal and counter septa are typically lens shaped, 1.0–1.5 mm long, and have a maximum thickness of 0.2–0.3 mm. The major septa are generally discontinuous in the dissepimentarium. In all specimens they are present on the epitheca wall as ridges which project from 0.3 to 1 mm into the dissepimentarium. The discontinuous major septa are 60–80 microns thick at the tabularium wall and 150 microns thick near the epitheca.

In longitudinal section, the dissepimentarium is composed of 3–5 rows of swollen dissepiments. The typical dissepiment is 1–1.5 mm long and 1–2 mm wide. The tabulae tend to be complete and slope away from the columella at angles of 30°–50°. Six to eight tabulae occur in 5 mm.

The microstructure of the corallum is affected by calcite neomorphism, which obscures many of the finer details. The wall is 150–200 microns thick, has a clearly defined central band of gray calcite 20–25 microns thick. The epitheca is composed of fibrous calcite deposited normal to the central gray band. The septa have an irregular central band of trabeculae from which divergent fibrous calcite radiates.

Occurrence.—Near Cape Thompson south of Nasorak Creek, the writer in 1962 collected *L. banffensis* (Warren) from Campbell's (1967, p. 44–45, pl. 2B) measured section of the upper member of the Nasorak Formation at his stratigraphic level of 950 feet, specimen USNM 161011 (pl. 3, figs. 5–8), and at 690 feet, specimen USNM 161009. Associated with *L. banffensis* are *Lithostrotionella mclareni* (Sutherland) and *Lithostrotion* (*Siphonodendron*) *warreni* Nelson.

In the measured sections of the Kogruk Formation in the western DeLong Mountains, *L. banffensis* (USNM 161012) was found in section 62C–15 at 570 feet below the top of the section with *Lithostrotionella mclareni* (Sutherland), *Lithostrotion* (*Siphonodendron*) *sinuosum* (Kelly), *Thysanophyllum* sp. A, and *Faberophyllum* spp. (fig. 3).

At section 62C–31, *L. banffensis* (USNM 161013) was collected 335 feet below the top of the section with *Lithostrotionella* sp. B and *Faberophyllum* sp. (fig. 5).

From the limestone and chert member of the Peratrovich Formation, Prince of Wales Island, southeastern Alaska, Armstrong (1970, p. 29) reports *L. banffensis* occurring with late Meramec Foraminifera microfauna and a rugose coral fauna of *Faberophyllum girtyi* Armstrong, *F. williamsi* Armstrong, *Lithostrotionella pennsylvanica* (Shimer), *Thysanophyllum astraeiforme* (Warren), *Sciophyllum alaskaensis* Armstrong, *S. lambarti* Harker and McLaren, *Diphyphyllum venosum* Armstrong, and *D. klawockensis* Armstrong.

The type material for *L. banffensis*, according to Warren (1927, p. 47), came from Alberta, Canada, "near the top of the Rundle Limestone on Stoney Mountain." Nelson (1960, p. 119) is of the opinion that "the holotype was derived from the upper *Lithostrotionella* beds (lower Mount Head Formation)."

Remarks.—Bamber's (1966, p. 17–18) description of the lectotype of *L. banffensis* (Warren) indicates that the corallites are 7–10 mm in diameter and have 18–23 major septa. Minor septa are very short, but present. The dissepiments are lonsdaleoid. As Bamber (p. 23) redescribed *L. pennsylvanica* (Shimer) it differs from *L. banffensis* (Warren) by having flat-lying tabulae which are sharply reflexed upwards near the columella and which are better developed than those of *L. banffen-*

sis and by having larger lonsdaleoid dissepiments and larger corallites (average diameter 10–14 mm).

The writer's concept of *Lithostrotionella banffensis* (Warren) is rather wide and embraces forms which show some variation from the holotype in corallite diameter and development of the dissepimentarium.

The holotypes of *Lithostrotionella vesicularis* Hayasaka (1936) and *Lithostrotionella floriformis* Hayasaka (1936) from the Mississippian Peratrovich Formation, Prince of Wales Island, southeastern Alaska are considered by Armstrong (1970) to be junior synonyms of *L. banffensis* (Warren).

The diameter of the corallites and number of major septa in the coralla assigned to this species are graphically compared to Bamber's (1966) lectotype of the species in figure 19.

Specimen USNM 161013, as figure 19, shows has corallites which are more uniform in size and typically 1–2 mm smaller than Bamber's (1966) lectotype of the species. Specimen USNM 161013 also has smaller dissepiments, in which the lonsdaleoid trait is not as well developed as in the lectotype.

Specimen USNM 161012, from 570 feet below the top of section 62C–15, also has corallites with diameters 1–2 mm less than those in Bamber's lectotype of *L. banffensis* (fig. 19). The major and minor septa are more strongly developed and more persistent in the dissepimentarium, but the lonsdaleoid dissepiments are similar to those of the lectotype.

Some of the corallites in specimen USNM 161011 have a slightly larger diameter, 1–2 more major septa, and larger lonsdaleoid dissepiments than Bamber's lectotype of *L. banffensis*. Specimen USNM 161011 from the Lisburne Group compares closely with examples of *L. banffensis* collected by the writer (1970) from carbonate rocks of Meramec age collected on the northwest side of Prince of Wales Island, southeastern Alaska.

Lithostrotionella aff. L. banffensis (Warren)

Plate 4, figures 5, 6

Material.—Specimen USNM 161010 is a 6 by 8 by 11 cm fragment of a corallum collected from measured section 62C–31. Two longitudinal and three transverse thin sections were made. Thirty corallites were studied in transverse, and 11 in longitudinal thin section. The specimen is preserved as calcite in which much of the original microstructure is preserved.

Description.—The corallum is cerioid. The corallites (pl. 4, fig. 5) are from 4.5 to 8.5 mm in diameter and have 16–20 major septa (fig. 19). In mature corallites, the major septa are discontinuous in the dissepimentarium, and the dissepiments are lonsdaleoid. Minor septa alternate with major septa, but in some corallites minor septa may be absent between a few pair of the major septa. Major septa are generally withdrawn from the columella. Minor septa are one-thrid to one-half the length of major septa. Major septa are 75–150 microns thick near the tabularium wall. Septa of both classes taper from the tabularium wall towards the axis and into the dissepimentarium (fig. 21).

The columella, simple is present in all corallites, and is lens shaped. It is typically 0.6–0.8 mm long and 0.2–0.3 mm wide. The columella commonly shows projections which are the ridges formed by the major septa on the surface of the tabulae. The columella appears to be the result of axial thickening of the counter septum.

In transverse section (pl. 4, fig. 6) the dissepimentarium consists of 1–3 rows of dissepiments which are inflated and strongly arched upward. There are 7–9 dissepiments in 5 mm. In mature corallites the dissepimentarium occupies about half the diameter. The tabulae are generally complete and slope upward from the dissepimentarium at 20°–35° before meeting the slightly sinuous columella. There are 8–11 tabulae in 10 mm.

The corallite walls are 250–300 microns thick and contain a well-developed central band of dark-gray calcite 20–25 microns thick. The corallite walls are composed of fibrous calcite crystals with their long axes normal to the central band. The major and minor septa are composed of fibrous calcite crystals similar to those in the corallite walls. The septa have a central band of trabeculae. The microstructure of the tabulae and dissepiments is now composed of interlocking calcite crystals which range in size from 10 to 20 microns.

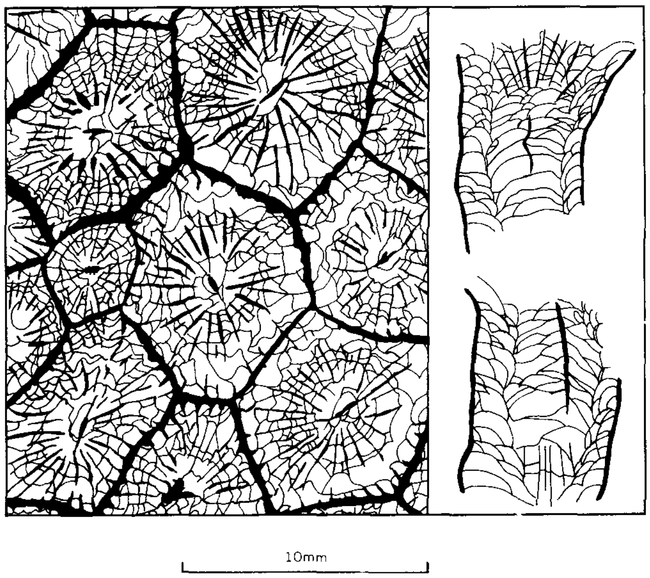

FIGURE 21.—Sections of *Lithostrotionella* aff. *L. banffensis* (Warren); USNM 161010.

Occurrence.—The single sample of *Lithostrotionella* aff. *L. banffensis* was collected 1,260 feet below the top of measured section 62C–31 in the Kogruk Formation, western DeLong Mountains. It occurs with *Lithostrotion* (*Siphonodendron*) *warreni* Nelson, *Lithostrotion* (*Siphonodendron*) *sinuosum* (Kelly), and *Lithostrotionella mclareni* (*Sutherland*) (fig. 5).

Remarks.—*Lithostrotionella* aff. *L. banffensis*, USNM 161010, has close affinities to *L. banffensis* Warren. It differs from Bamber's (1966) lectotype (fig. 19) in that its corallites are generally 2 mm smaller in diameter but they typically have 18–20 major septa. It also differs by having longer and consistently better developed minor septa. The major and minor septa are also more persistent and better developed in the dissepimentarium.

Specimen USNM 161012 was collected 570 feet below the top of measured section 62C–15 and is placed with *L. banffensis*. (See remarks under that species.) In diameter of the corallites, it resembles *Lithostrotionella* aff. *L. banffensis* but differs by having larger, better developed lonsdaleoid dissepiments and 1–8 additional major septa per corallite.

Lithostrotionella birdi Armstrong

Plate 4, figure 7; plate 5, figures 1–3, 5, 6

Lithostrotionella birdi Armstrong, 1970, U.S. Geol. Survey Prof. Paper 534, p. 32–35, pl. 7, fig. 1–4, pl. 8, figs. 1–7.

Material.—Specimen USNM 161024 is an 8 by 8 by 10 cm fragment, of a corallum, and specimen USNM 161031 is a 5 by 6 by 8 cm fragment of a corallum. These were collected from measured section 60A—400–403 by Dr. Sigmund Snelson in 1960. Sample USNM 161024 was studied in six transverse thin sections and three longitudinal thin sections, and USNM 161031 in one transverse thin section and two longitudinal thin sections. Specimen USNM 161023 is a 10 by 10 by 12 cm fragment of a corallum collected from measured section 62C–15. This sample was studied by four transverse and four longitudinal thin sections.

Description.—The corallum is cerioid. Specimen USNM 161024 in transverse thin section (pl. 4, fig. 7) has mature corallites which are 3.5–6.5 mm in diameter and which have 15–19 slightly sinuous major septa (figs. 22, 23). The major septa may be weakly dilated in the tabularium, and they extend two-thirds or more the distance to the axis. Major septa are generally discontinuous in the dissepimentarium. Minor septa are inconsistently developed. In some corallites minor septa are short ridges on the epitheca or are absent. In some corallites most of the major and minor septa are continuous through the dissepimentarium. The dissepiments may be arranged in a herringbone pattern in many specimens but generally are lonsdaleoid, and interrupt from 2 to 8 major septa. Columellae are present in the majority of corallites and vary in their development. Most are lens shaped, and many are connected to the counter septa (pl. 5, fig. 6). A typical columella is 1 mm long and 0.2 mm wide. Many columellae have short projections which are formed by axial ends of the major septa as ridges on the upper surfaces of the tabulae.

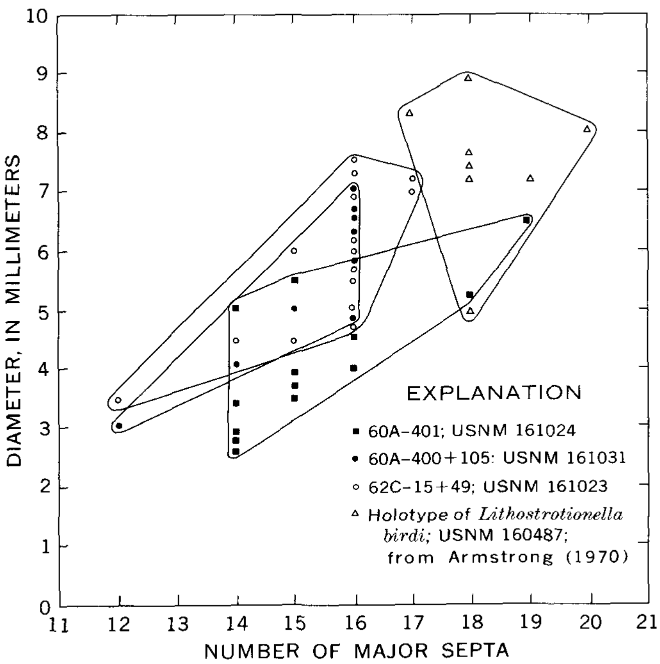

FIGURE 22.—Corallite diameter and number of major septa in *Lithostrotionella birdi* Armstrong. Each symbol represents a single corallite.

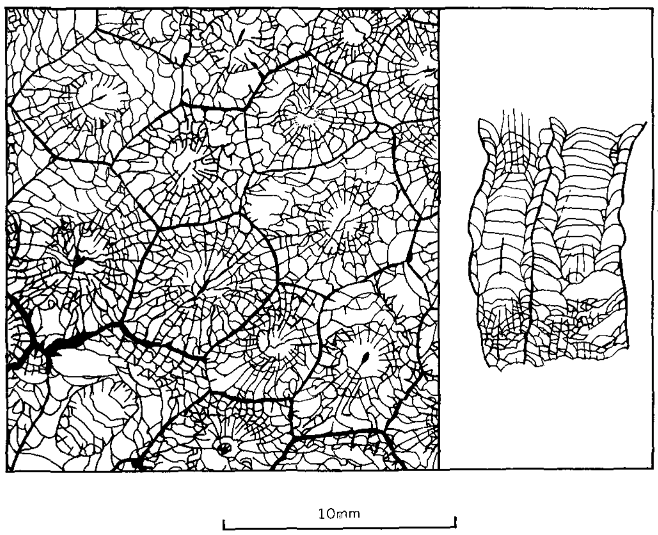

FIGURE 23.—Sections of *Lithostrotionella birdi* Armstrong, USNM 161024.

In longitudinal section (pl. 5, figs. 3, 5), the dissepimentarium is 1–2 and in a few examples 3 rows of inflated and inclined dissepiments. There are 7–10 dissepiments in 5 mm. The majority of tabulae are complete and convex, sloping upwards at angles of 35°–45° from their junction with the dissepiment to their apex at the columella. The columella is thin, nonpersistent, and sinuous.

The internal structures of the corallites are preserved by neomorphic calcite ranging in size from 50 to 150 microns and much of the original microstructure has been destroyed. The internal voids of the collallum are filled with chalcedony (pl. 5, fig. 5).

Specimen USNM 161031 (not illustrated) does not differ in any significant way from the above specimen.

Specimen USNM 161023 (pl. 5, figs. 1, 2) is similar to the above specimens but has corallites that are typically 4.5–7.5 mm in diameter and that have 15–17 major septa. Within the corallum, the typical corallite tends to have larger, well developed lonsdaleoid dissepiments, and the septa are amplexoid. In general the typical corallites show a stronger trend toward the characteristics of the genus *Thysanophyllum.* The internal preservation of this specimen is similar to that described for specimen USNM 161024 above.

Occurrence.—*L. birdi* specimens, USNM 161031 and 161024, were collected 105 and 180 feet respectively below the top of measured section 60A–400—403 (fig. 7), near Trail Creek, DeLong Mountains. They were found with a Foraminifera fauna of earliest Chester age, equivalent to Mamet's (1968) and Mamet and Mason's 1968) microfaunal assemblage zone 16i (B. L. Mamet, oral commun., March 1969). *L. birdi*, USNM 161023, was also collected in the Kogruk Formation at 49 feet from the top of stratigraphic section 62C–15, USGS loc. M1019 in the DeLong Mountains (fig. 3). This specimen was found in association with *Faberophyllum* spp. and *Lithostrotionella mclareni* (Sutherland).

The holotype and paratypes of *L. birdi* are reported by Armstrong (1970) from the chert and limestone member of the Peratrovich Formation, Prince of Wales Island, southeastern Alaska. Here *L. birdi* occurs with a late Meramec fauna of Foraminifera and a coral fauna characterized by *Faberophyllum girtyi* Armstrong, *F. williamsi* Armstrong, *Lithostrotionella banffensis* (Warren), *L. pennsylvanica* (Shimer), *Thysanophyllum astraeiforme* (Warren), and *Sciophyllum alaskaensis* Armstrong.

Remarks.—*L. birdi* as defined by Armstrong (1970) has a consistent ratio of the diameter of mature corallite to the number of major septa. Serial transverse sections of corallites reveal that a given corallite may show considerable variation in the organization of its internal structures. Variation in its vertical length is particularly pronounced in the dissepimentarium, where the dissepiments and septa may show a wide range of forms and shapes. At the levels at which a corallite has herringbone dissepiments it will also have persistent major septa in the dissepimentarium. At another level the corallites may have discontinuous septa in the dissepimentarium and large lonsdaleoid dissepiments. An individual corallite and the majority of corallites within a corallum may have the characteristics of the genus *Lithostrotionella*, but also can be acolumellate and have the traits of the genus *Thysanophyllum.* A few corallites may display a columella and persistent continuous major septa that join the wall and have the traits of the genus *Lithostrotion.* The same type of corallite variation or plasticity exists in the closely related species of *Lithostrotionella mclareni* (Sutherland). (See Sutherland, 1958, and McLaren and Sutherland, 1949.)

Lithostrotionella birdi Armstrong is distinguished from *L. mclareni* (Sutherland) by *L. mclareni's* smaller corallites, which have a diameter of 3–4 mm and which have only 12–14 major septa and, typically, by *L. mclareni's* dissepimentarium, in which lonsdaleoid dissepiments are not as well developed.

On any given transverse thin section, 80 percent of the corallites of specimen USNM 161024 have internal structures characteristic of the genus *Lithostrotionella.* Some corallites have persistent septa in the dissepimentarium and are suggestive of cerioid *Lithostrotion.* Only 20 percent of the corallites have the traits of the genus *Thysanophyllum*, and none were found that have the traits of *Sciophyllum.*

Specimen USNM 161023 (pl. 5, figs. 1, 2) from section 62C–15 has slightly more than half of its corallites with the characteristics of *Lithostrotionella.* Corallites characteristic of *Sciophyllum* make up about 20 percent of the corallites. (See remarks under *Sciophyllum alaskaensis* Armstrong.)

Lithostrotionella mclareni (Sutherland)

Plate 5, figures 4, 7, 8–10; plate 6, figures 1, 2, 7–9

Lithostrotion sp. McLaren and Sutherland, 1949, Jour. Paleontology, v. 23, p. 631, pl. 103, figs. 1–9, text figs. 2–4.

Lithostrotion [*Lithostrotionella*] [*Thysanophyllum*] *mclareni* Sutherland, 1958, Canada Geol. Survey Mem. 295, p. 95, 96, pl. 33, fig. 1a–g.

Material.—Fragments of eight coralla were collected from three measured sections of the Kogruk Formation in the DeLong Mountains.

The internal features of the specimens from the DeLong Mountains are preserved as crystals of neomorphic calcite, which range in size from 10 to 20 microns, embedded in chalcedony which fills the internal voids within the corals. The majority of specimens available for study had some of the voids within the corallites filled with sparry calcite. In these corallites, vestiges of the original microstructure are preserved.

The specimens were studied as shown in the tabulation below:

USNM No.	*Number of transverse thin sections*	*Number of corallites*	*Number of longitudinal thin sections*	*Number of corallites*
160999	3	95	1	7
161000	3	185	2	27
161001	3	225	4	30
161002	2	90	2	18
161003	2	160	2	20
161004	2	100	3	38
161016	1	32	3	26
161030	3	190	5	50

Description.—Specimen USNM 160999 is a cerioid corallum and in transverse section (pl. 5, fig. 10) has mature corallites which are 3.5–4.4 mm in diameter and have 13–15 slightly sinuous major septa (fig. 24). Corallites have common walls which average about 150–200 microns thick and which are now composed of crystals of calcite ranging in size from 10 to 20 microns. The centers of the walls have a dark-gray calcite band 12–15 microns thick. Near the epitheca the major septa are 40–50 microns thick. In the tabularium the major septa are dilated and are 60–70 microns thick and taper to their distal ends. They do not reach the columella, and many are discontinuous in the dissepimentarium. The minor septa are inconsistently developed, are generally short spikes on the epitheca wall, and only a few appear on the inside of the tabularium wall. Most of the corallites have lonsdaleoid dissepiments, and some corallites have herringbone dissepiments. Many columellae are swollen extensions of the counter septum and are typically 0.5–1.0 mm long and 0.1–0.2 mm wide. The columella is thin, persistent, and slightly sinuous.

In longitudinal section (pl. 5, figs. 4, 9) the dissepimentarium is a single to double row of inflated and inclined dissepiments. There are 10–13 dissepiments in 5 mm. Many tabulae are incomplete. They are convex upward, sloping away from the columella at angles of 10°–30° to their junction with the dissepimentarium.

Occurrence.—*Lithostrotionella mclareni* (Sutherland) is common in the Kogruk Formation of the DeLong Mountains. In section 62C–15, it is found below the top of the measured section at 49 feet, USNM 161000; 150 feet, USNM 161001; 250 feet, USNM 161002; 510 feet, USNM 161003 (pl. 6, figs. 1, 2) and 161004. In this section the species occurs with *Faberophyllum* spp., *Lithostrotionella banffensis* (Warren), *Thysanophyllum* sp. A, and *Sciophyllum alaskaensis* Armstrong. *L. mclareni* (USNM 160999) was found at 1,065 feet, and (USNM 161016) at 1,390 feet, below the top of section 62C–31 (fig. 5). Here it also occurs in association with a large fauna of lithostrotionid corals (fig. 3).

L. mclareni, USNM 161030 (pl. 6, figs. 8, 9), was collected 1,100 feet from the top of section 60A–400–403 in the Kogruk Formation by Dr. Sigmund Snelson in 1960. It occurs with a foraminiferal fauna of Meramec age (fig. 7).

In the Kogruk Formation *L. mclareni* occurs with a coral fauna of Meramec age. The holotype of the species, according to McLaren and Sutherland (1949, p. 633; Sutherland, 1958, p. 96), was found 4 feet from the top of the Prophet Formation, in beds of Middle Mississippian age, near the headwaters of Bull Creek, British Columbia.

Macqueen and Bamber (1968, p. 261, fig. 7) found a few specimens of *L. mclareni* (Sutherland) in their faunal assemblage 2, Meramec Mount Head Formation, southwestern Alberta. Bamber, Taylor, and Proctor (1968, p. 8) report the holotype was collected from member C of the Prophet Formation and the associated coral fauna is middle to late Meramec in age.

Remarks.—The holotype of *Lithostrotionella mclareni* (Sutherland), as described by McLaren and Sutherland (1949) and Sutherland (1958), has corallites with the internal structures which are typically developed in genera of *Lithostrotion*, *Lithostrotionella*, and *Thysanophyllum*.

The specimens assigned to *L. mclareni* from the Kogruk Formation display, within a single colony, corallites which have the generic characteristics of three different genera (fig. 25). Thin section studies of the coralla indicate corallites characteristic of a particular generic type tend to group together within one part of a corallum with transitional types occurring between two distinct generic types. Within the coralla, the *Lithostrotionella* type of corallite is the most common and the rarest configuration is the *Lithostrotion* type of corallite.

Specimen USNM 161003, which is assigned to this species, has the greatest deviation from the holotype. It occurs 520 feet below the top of section 62C–15 and was collected from the same bed and a few feet from typical specimens of *L. mclareni* (Sutherland). Any one of the serial thin sections shows a predominance of corallites of the *Thysanophyllum* and *Sciophyllum* type, but also contains many corallites with well-developed columellae typical of *Lithostrotionella* and in particular of *L. mclareni*. Within the corallum of specimen USNM 161003, the cluster of corallites which have the structure of *Sciophyllum* are morphologically identical to the corallites of *Sciophyllum lambarti* Harker and McLaren. This latter species also has the same general stratigraphic range in the Kogruk Formation as *L. mclareni*. Specimen USNM 161003 strongly suggests *S. lambarti* was derived from *L. mclareni* through the degeneration and amplification of structure towards large lonsdaleoid dissepiments, peripheral

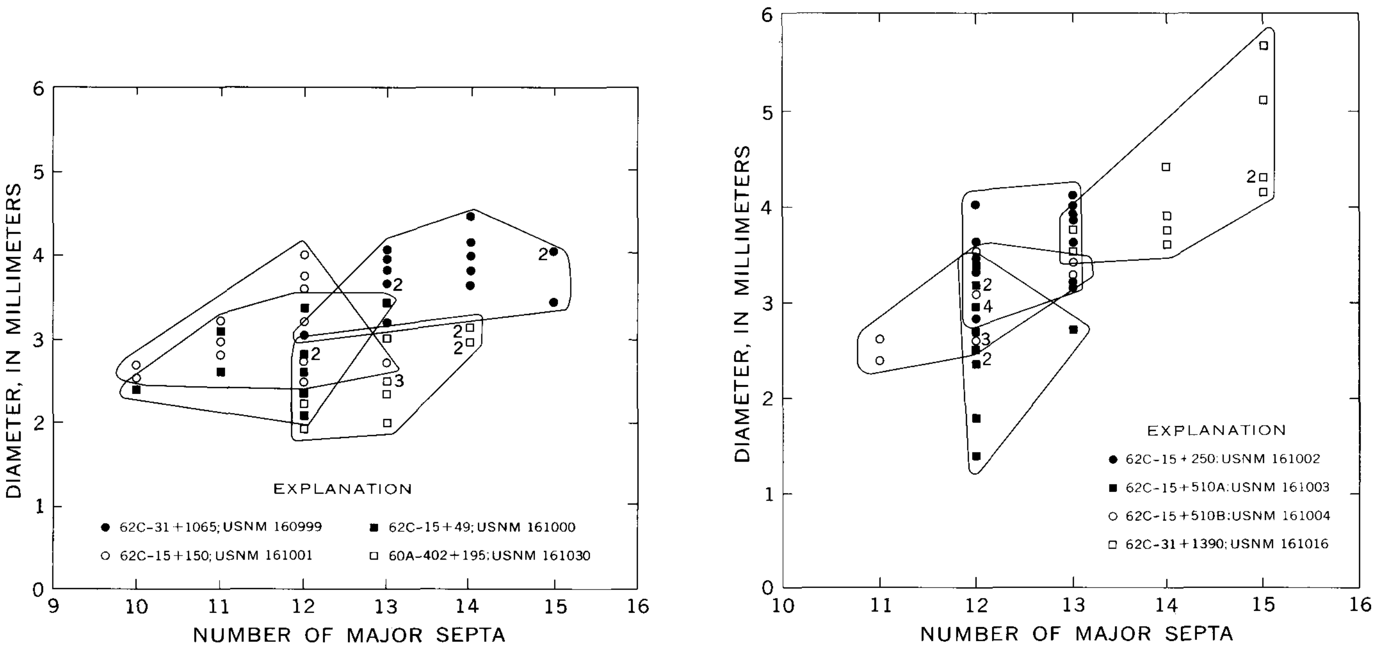

FIGURE 24.—Corallite diameter and number of major septa in *Lithostrotionella mclareni* (Sutherland). Each unnumbered symbol represents a single corallite; if more than one corrallite shows the same diameter and number of septa, the number of similar corallites is shown.

withdrawal of the septa, and elimination of the columella.

Lithostrotionella mclareni (Sutherland) is closely related to *Lithostrotionella birdi* Armstrong, both of which are characterized by coralla with individual corallites that have structural arrangements of the genera *Lithostrotionella*, *Lithostrotion*, and *Sciophyllum*. *L. birdi* consistently has larger corallites, which are 4.5–6.5 mm in diameter and which have 17–20 slightly sinuous major septa, and the corallites typically have well-developed lonsdaleoid dissepiments.

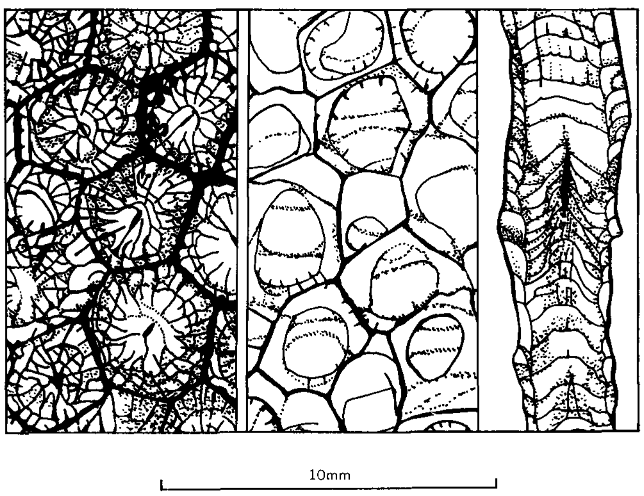

FIGURE 25.—Sections of *Lithostrotionella mclareni* (Sutherland), USNM 161003.

Lithostrotionella macouni (Lambe)

Plate 12, figures 1–6

Lithostrotion macouni Lambe, 1899, Ottawa Naturalist, v. 12, p. 220.

Lithostrotion macouni Lambe. Lambe, 1901, Canada Geol. Survey, Contr. Canadian Paleontology, v. 4, pt. 2, p. 176, 177, pl. 14, figs. 11, 11a, 11b.

Lithostrotion? macouni Lambe. Nelson, 1960, Jour. Paleontology, v. 34, p. 122, 123, pl. 23, figs. 1, 2.

Description of syntype.—Geological Survey of Canada No. 4327. The material available for study consists of one transverse and one longitudinal thin section each on a 27 mm by 48 mm slide. The transverse thin section (pl. 12, fig. 4) had about 30 complete corallite sections available for study. In longitudinal thin section, sections of five corallites are present (pl. 2, fig. 3). The corallum is preserved as calcite, and the voids within the corallites have been filled by sparry calcite. The two thin sections are the same material on which Nelson (1960, p. 122–123) based, in part, his redescription of Lambe's 1899 species.

Description.—In transverse section the corallites are 1.9–2.8 mm in diameter and have 9–11 major septa which generally extend to the axial region and fuse with the columella (figs. 26, 27). In about half of the corallites studied, one or more major septa are discontinuous within the dissepimentarium (pl. 12, fig. 1). The major septa are 60–80 microns thick at their junction with the corallite wall and progressively taper towards the columellae. In the tabularium they are typically only 20–40

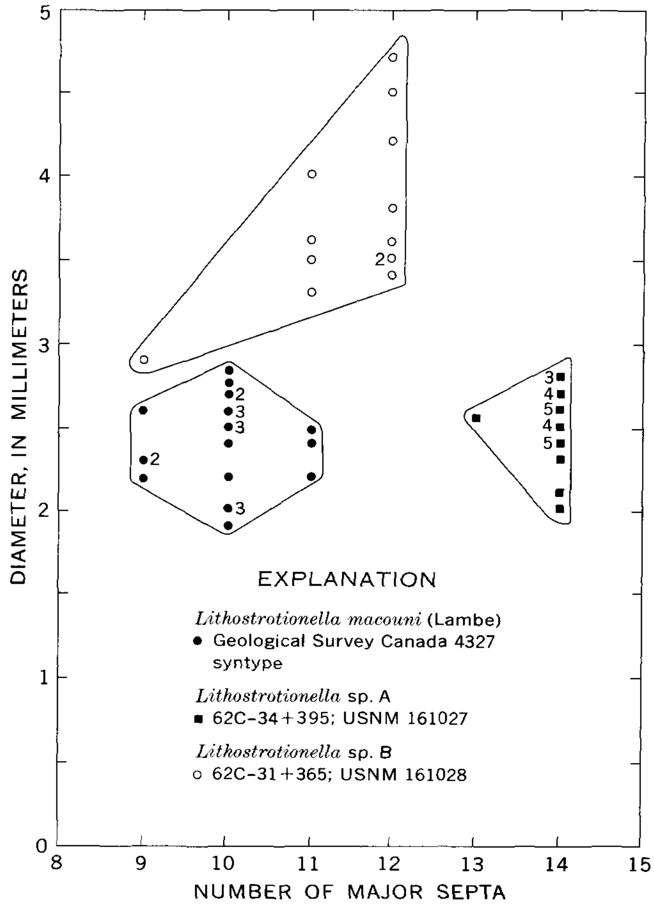

FIGURE 26.—Corallite diameter and number of major septa in *Lithostrotionella macouni* (Lambe), syntype; *Lithostrotionella* sp. A and *Lithostrotionella* sp. B. Each unnumbered symbol represents a single corallite; if more than one corallite shows the same diameter and number of septa, the number of similar corallites is shown.

microns thick. Minor septa are inconsistently developed; they are generally only 0.2–0.5 mm long and in many corallites are absent between the major septa. The corallite walls are 100–150 microns thick and have a central dark band of calcite 20–30 microns thick. The walls are composed of fibrous calcite crystals deposited normal to the dark band (pl. 12, fig. 2). The columella is an extension of the counter septum to which the cardinal septum is generally fused. One or all of the other major septa may reach the columella. The majority of the dissepiments are regular but almost half the corallites have lonsdaleoid dissepiments.

In longitudinal thin section the tabulae are generally complete and about 30–40 microns thick. As was pointed out by Nelson (1960, p. 122), this longitudinal section is apparently off center, and the exact relationship of the tabulae to the columella is not clear. About 12–15 tabulae occur in 5 mm. One section of a corallite suggests the presence of a columella. The tabulae are bent

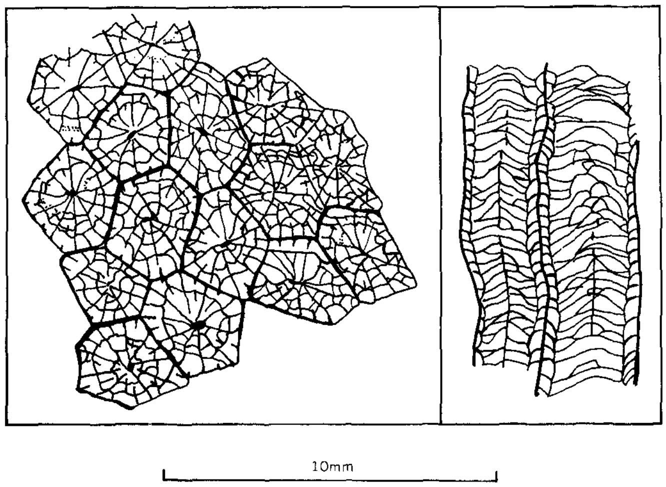

FIGURE 27.—Sections of *Lithostrotionella macouni* (Lambe), syntype GSC No. 4327.

upwards 20°–25°. The dissepimentarium consists of a single row of globose dissepiments, 9–12 occurring in 5 mm.

Occurrence.—According to Lambe (1901, p. 177) the specimen, GSC No. 4327, was collected at "Fossil Point, Peace River, British Columbia" by J. Macoun in 1875. Dr. E. W. Bamber of the Geological Survey of Canada reports (written commun., May 1968) "as far as I know *L. macouni* is late Meramecian in age and I have found it only in the lower range of *Faberophyllum*, and slightly below; never in the upper part of the *Faberophyllum* zone, or in the overlying Chesterian beds."

Remarks.—*Lithostrotionella macouni* is distinguishable from the late Kinderhook and early Osage corals *Lithostrotionella micra* Kelly (1942, p. 357, pl. 50, fig. 7) and *Lithostrotionella lochmanae* Armstrong (1962, p. 38–39, pl. 4, figs. 6–8, which have similar corallite diameters, by its smaller lonsdaleoid dissepiments. It is separated from *Lithostrotionella mclareni* (Sutherland) by its better developed major septa and well-developed columella.

Within the Kogruk Formation, two forms of *Lithostrotionella* were collected which appear to be morphologically similar and possibly even conspecific with the syntype of *L. macouni*. Because each form is represented by only a few specimens, their taxonomic relationship to *L. macouni* is somewhat uncertain. Accordingly they have been designated *Lithostrotionella* sp. A and *Lithostrotionella* sp. B. The morphological relationships of these two forms with each other and with *L. macouni* are discussed in this study within the "Remarks" of *L.* sp. A and *L.* sp. B.

Groot (1963, p. 49–52, pl. 6, figs. 1, 2) describes a cerioid, trimorphic coral, *Lithostrotion trimorphum* Groot from the Numurian age, Perapertu Formation of

Spain, which has corallites 4–5 mm in diameter that have 13–14 major septa, poorly developed minor septa, and a single row of steeply inclined dissepiments. *L. trimorphum* (Groot, pl. 6, fig. 1a) shows strong similarity to the syntype of *L. macouni* (Lambe) and to *Lithostrotionella* sp. A and *L.* sp. B.

A species from eastern Asia which morphologically shows some relationship to the above species was described by Yü (1933, p. 91, pl. 18, figs. 2, 3; 1937, p. 42–43, pl. 11, figs. 1, 3) from the Viséan of China. *Lithostrotion mccoyanum* Edwards and Haime var. *mutungense* Yü has corallites that are 4–5 mm in diameter and that have 12–13 major septa. It differs from *L. macouni*, *L.* sp. A, and *L.* sp. B by having long minor septa and 2–3 rows of dissepiments.

Lithostrotionella sp. A

Plate 7, figures 1–6

Material.—Specimen USNM 161027 was collected from stratigraphic section 62C–34, 395 feet below the top, and is a fragment of a corallum 8 by 8 by 10 cm. It was studied in five transverse and five longitudinal thin sections. The specimen is preserved as calcite in a calcite matrix. The microstructure of the corallum is well preserved.

Description.—Specimen USNM 161027 (pl. 7, figs. 1, 2) is cerioid in transverse section and has uniform prismatic corallites which are typically 2.0–2.8 mm in diameter; the corallites have 13–14 major septa. The major septa are 0.4–0.7 mm long, and the minor septa are 0.15–0.3 mm long (figs. 26, 28). The major septa, with rare exceptions, are continuous through the dissepimentarium. The dissepiments are regular, and only in the larger diameter corallites have weakly developed lonsdaleoid dissepiments which may intercept 1–2 major septa. A columella is present in the majority of the corallites; it is lath to lens shaped and is apparently not connected to any septa. Serial sections show some corallites at various levels are acolumellate. Serial transverse thin sections reveal that the major septa extend one-fourth to three-fourths the distance to the axial region as short ridges on the upper surfaces of the tabulae. The cardinal-counter septa extend farther on the tabulae than the other septa. The adjacent lateral septa are weakly incurved to form poorly defined open fossulae.

In longitudinal section (pl. 7, figs. 3, 5, 6) the dissepimentarium is present generally throughout the length of mature corallites and consists of a single row of swollen, uparched dissepiments. The typical dissepimentarium is 0.5 mm wide and has 13–17 dissepiments in 5 mm. The tabulae are complete and dome shaped. They slope downward from the columella at angles of 15°–30°. The tabulae within 0.5 mm of the dissepimentarium are reflexed downward about 40°–50°, and adjacent to the dissepimentarium they are reflexed upward before joining to the dissepiments (pl. 7, figs. 5, 6). The columella is a rodlike vertical structure composed of calcite crystals arranged similarly if not identically to the septa. The tabulae abut against the columella (pl. 7, fig. 3) but do not contribute to the structure of the columella.

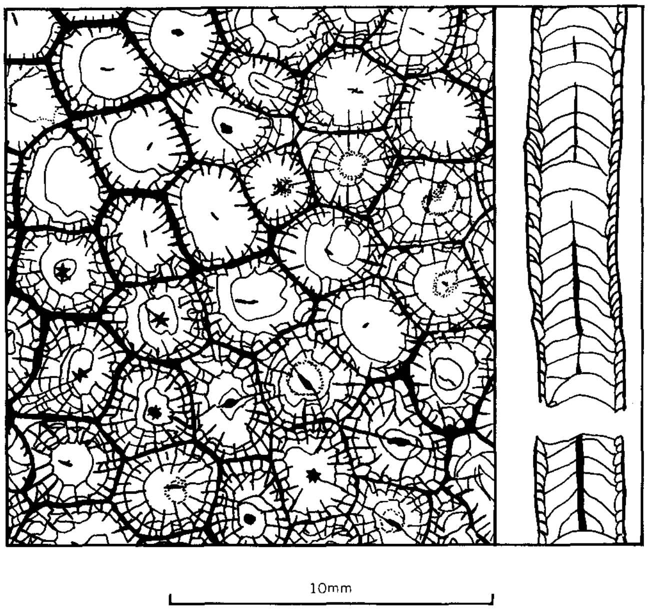

FIGURE 28.—Sections of *Lithostrotionella* sp. A, USNM 161027.

The corallite walls are typically 150 microns thick and contain at their center a band of dark-gray calcite 20 microns thick (pl. 7, figs. 3, 4). The corallite walls are formed by fibers of calcite that have the long axis normal to the gray central band. The microstructure of the septa appears to be similar to the epitheca. The septa lack a central dark-gray band and are composed of fibrous calcite deposited parallel to the calcite of the epitheca (that is, in optical continuity). In transverse section the microstructure of the columellae appears to be similar to that of the septa.

Occurrence.—Specimen USNM 161027 was collected 395 feet below the top of section 62C–34, on a river cut bank exposure, west side of the Kukpuk River, in the Lisburne Hills (fig. 9). The specimen is preserved in echinoderm-foraminiferal wackestone. The specimen was found in association with *Faberophyllum* sp.; (the genus indicates a late Meramec age.

Remarks.—*Lithostrotionella* sp. A shows close affinities to *Lithostrotionella macouni* (Lambe). *Lithostrotionella* sp. A differs from *L. macouni* in a number of significant details, in possessing few lonsdaleoid dissepiments, better developed minor septa, major septa which are withdrawn from the axial region, and a thicker, better developed columella. *Lithostrotionella* sp. A differs from *Lithostrotionella* sp. B, in that the latter has major septa which extend to the columella, much longer minor septa, corallites which have a diameter 1–2 mm larger, which have 1–2 less major septa, and which are more irregularly shaped.

Lithostrotionella sp. B

Plate 7, figures 7–9

Material.—Specimen USNM 161028 is a fragment, 6 by 6 by 8 cm, of a corallum collected 365 feet below the top of stratigraphic section 62C–31. The specimen was studied in two transverse and one longitudinal thin sections. The corallum retains much of the original microstructure and is preserved as calcite in a limestone matrix.

Description.—Specimen USNM 161028 is cerioid. In transverse section it has somewhat uniform prismatic corallites that are 2.9–4.7 mm in diameter and that have 9–12 major septa (figs. 26, 29). The major septa are typically 1.0–1.2 mm long, and many reach the columella. In all specimens minor septa are present between major septa and are 0.5–0.7 mm long. Dissepiments are regular to herringbone type with major and minor septa continuous from axial region to epitheca. Within some corallites a few lonsdaleoid dissepiments may be present at corners of the prismatic corallites. Lonsdaleoid dissepiments intercept 1–3 major septa. The columella is lens shaped, 1 mm long to 0.3 mm wide, and generally continuous with cardinal and counter septa. A few corallites are acolumellate with amplexoid septa. The septa are typically dilated in the tabularium.

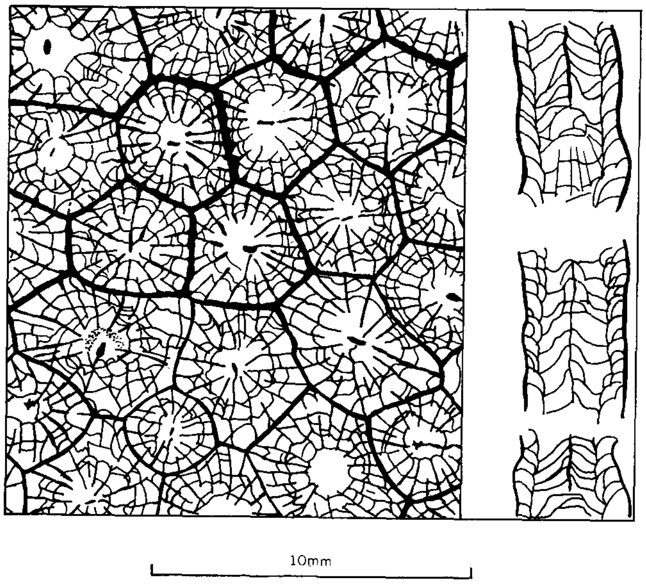

FIGURE 29.—Sections of *Lithostrotionella* sp. B, USNM 161028.

In longitudinal section the dissepimentarium is about half the radius of the corallite and consists of 1, or rarely 2, rows of swollen and inflated dissepiments of which 9–13 occur in 5 mm. The tabulae are complete, dome shaped, and slope away from the columella at angles of 20°–40°. The tabulae near the dissepimentarium may be reflexed to nearly horizontal before joining the dissepiments.

The microstructure of the corallum is similar to that of specimen USNM 161027.

Occurrence.—Specimen USNM 161028 was collected 365 feet below the top of measured section 62C–31 from the Kogruk Formation in the DeLong Mountains. *Lithostrotionella* sp. B is found in association with *Faberophyllum* spp., *Lithostrotionella banffensis* (Warren), and *Sciophyllum alaskaensis* Armstrong (fig. 5). This association is late Meramec in age.

Coralla conspecific with *Lithostrotionella* sp. B have been collected, some 250 stratigraphic feet below the contact of the Lisburne Group with the Permian Siksikpuk Formation in a measured section at Skimo Creek in the Endicott Mountains. At the Skimo Creek locality, *Lithostrotionella* sp. B is found in association with Chester age Foraminifera (B. L. Mamet oral commun., March 1969).

Remarks.—*Lithostrotionella* sp. B is very similar to *Lithostrotionella macouni* (Lambe). *L.* sp. B in comparison with the syntype of *L. macouni* (Lambe) has longer minor septa, septa that are more persistent in the dissepimentarium, major septa that are dilated in the tabularium, and a dissepimentarium which is commonly formed by a double row of dissepiments.

Lithostrotion mccoyanum Edwards and Haime var. *mutungense* Yü from the Viséan of China Yü (1933, p. 91, pl. 18, figs. 3a–b) is similar to *Lithostrotionella* sp. B except for the presence of 2–3 rows of dissepiments in the dissepimentarium.

For a comparison of *Lithostrotionella* sp. B with *Lithostrotionella* sp. A, see discussion under the latter species.

Genus THYSANOPHYLLUM Nicholson and Thomson, 1876

Thysanophyllum Nicholson and Thomson, 1876, Royal Soc. Edinburgh Proc., v. 9, no. 95, p. 150.

Thysanophyllum Nicholson and Thomson. Thomson, 1880, Royal Philos. Soc. Glasgow Proc., v. 12, p. 255.

Thysanophyllum Nicholson and Thomson. Thomson, 1883, Royal Philos. Soc. Glasgow Proc., v. 14, p. 387.

Thysanophyllum Nicholson and Thomson. Thomson, 1926, Annals and Mag. Nat. History, v. 18, p. 148.

Lithostrotion Fleming, genomorph [*Diphystrotion* Smith and Lang], 1930, Annals and Mag. Nat. History, v. 5, p. 184.

Thysanophyllum Nicholson and Thomson. Hill, 1940, Palaeontographical Soc., p. 160–162.

Thysanophyllum Nicholson and Thomson. Hill, 1940, *in* Moore, R. C., ed., Treatise on invertebrate paleontology, Part F, Geol. Soc. America, p. 306.

Type species.—Thysanophyllum orientale Thomson, 1876, lower Carboniferous, Viséan; Scotland.

Diagnosis.—Compound rugose corals with a lonsdaleoid dissepimentarium; the septa are withdrawn from the axis except for the counter septum which may be very long, particularly in young stages; the tabulae are complete; typically they consist of flat-topped domes, but sometimes may be slightly sagging (Hill, 1940, p. 161).

Thysanophyllum orientale Thomson

Plate 8, figures 1–5

Thysanophyllum orientale Thomson, 1880, Royal Philos. Soc. Glasgow Proc., p. 257, text fig. 4, pl. 3, figs. 11, 11a, 14, 14a.
Thysanophyllum orientale Thomson. Hill, 1940, Paleontographical Soc. Mon., p. 162, 163, pl. 8, figs. 26–32.
Thysanophyllum orientale Thomson. Jull, 1967, Paleontological Assoc., v. 10, pt. 4, text fig. 5, pl. 102, figs. 5a–b.

Material.—Specimen USNM 161018 is a 7 by 8 by 12 cm fragment of a corallum collected by the writer within measured section 62C–31. Three transverse and four longitudinal thin sections were made. Specimen USNM 161019 was collected by Dr. Sigmund Snelson near Trail Creek, DeLong Mountains, from stratigraphic section 60A–400–403. This specimen is a 6 by 6 by 10 cm fragment of a corallum. It has been cut into one transverse and one longitudinal thin section. Both specimens are preserved as calcite which has retained some of the original microstructure.

Description.—Specimen USNM 161018 is a fragment of a cerioid corallum. In transverse thin section (pl. 8, fig. 2) the corallites are 9–19 mm in diameter and have 23–28 major septa (fig. 30). Within the dissepimentarium the major septa are short, extending 1 mm or less from the epitheca. Minor septa are very short, poorly developed, and found between the major septa in only a few corallites. The major septa reappear near the tabularium wall, are 1.4–1.7 mm long, 200–300 microns thick near the wall, and taper both toward the axis and into the dissepimentarium. Minor septa are absent in the tabularium. Major septa are withdrawn from the axis. Dissepiments are lonsdaleoid and vary in size; the dissepiments typically intercept 2–4 septa. Columellae are rare and occur as small, 0.5-mm-long lathlike rods in the axial region.

In longitudinal section (pl. 8, fig. 3) the dissepimentarium consists of 2–5 rows of swollen uparched dissepiments of varying size. The dissepimentarium makes up about half the radius of the corallite. Tabulae are broad flat domes, which are bent downward 30°–45°

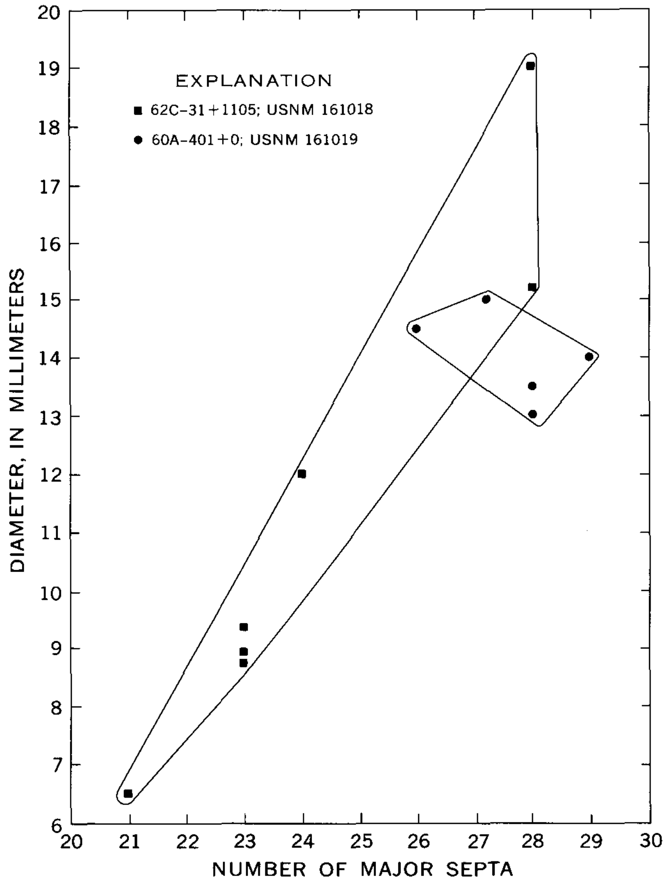

FIGURE 30.—Corallite diameter and number of major septa in *Thysanophyllum orientale* Thomson. Each symbol represents a single corallite.

within a distance of 1–1.5 mm from the dissepimentarium.

The corallite wall is typically 200–300 microns thick, with a central dark-gray calcite band, 20 microns thick, normal to which fibrous calcite has been deposited (pl. 8, fig. 1). The septa in the tabularium are composed of fibrous calcite. The dissepiments and tabulae are 20–30 microns thick and composed of calcite crystals which range in size from 15–20 microns. An immature corallite some 10 mm in diameter has an isolated columella, 1 mm long and 150 microns wide, that appears to be made of fibrous calcite crystals similar to the major septa.

Specimen USNM 161019 (pl. 8, figs. 4, 5; text fig. 31) differs from the above description by having typically 26–29 major septa per corallite and few minor septa.

Occurrence.—Thysanophyllum orientale Thomson, USNM 161018, was collected in about the middle of the Kogruk Formation, section 62C–31, DeLong Mountains (fig. 5). The specimen was found 1,105 feet below the top of the section in poorly sorted crinoid-bryozoan

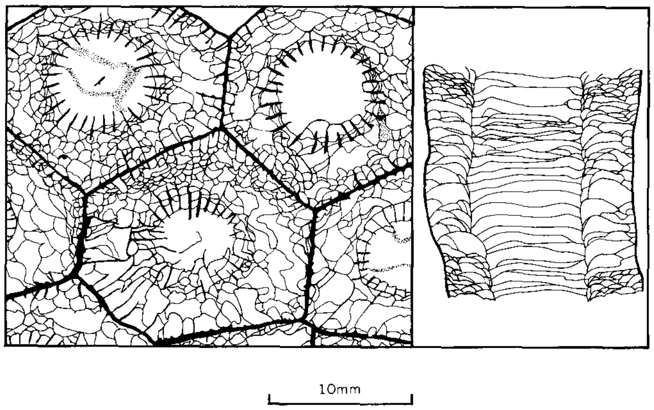

FIGURE 31.—Sections of *Thysanophyllum orientale* Thomson, USNM 161019.

wackestones. It is associated with *Lithostrotion* (*Siphonodendron*) *sinuosum* (Kelly), *Lithostrotion* (*Siphonodendron*) *warreni* Nelson, *Lithostrotionella mclareni* (Sutherland), and *Sciophyllum lambarti* Harker and McLaren.

T. orientale (USNM 161018) was also found in the Kogruk Formation near Trail Creek, DeLong Mountains, in section 60A–400–403 (fig. 7). This section is a continuous exposure of the Kogruk Formation about 1,900 stratigraphic feet thick. The specimen was found about 70 feet below the top, in association with *Lithostrotionella birdi* Armstrong.

The type species of *T. orientale* Thomson occurs in the shales of coral zone 3 age at Aberlady Bay, Scotland (Jull, 1967, p. 623; Hill, 1940, p. 162). Jull (p. 623–624) has collected and illustrated additional topotype material from this location.

Remarks.—The Kogruk Formation specimens of *Thysanophyllum orientale* Thomson compare closely to Hill's (1940, pl. 8, figs. 26, 27) illustrations of the lectotype from the Lower Limestone Series of Scotland (lower Carboniferous).

Thysanophyllum astraeiforme (Warren)

Plate 9, figures 1–6

Diphyphyllum astraeiforme **Warren, 1927, Canada Geol. Survey Mem. 153, p. 44–45, pl. 3, figs. 2, 3; pl. 4, fig. 1.**
Lithostrotionella astraeiformis **(Warren). Kelly, 1942, Jour. Paleontology, v. 16, p. 352, 354.**
Lithostrotionella (Thysanophyllum) astraeiformis **(Warren). Nelson, 1960, Jour. Paleontology, v. 34, p. 115–117, pl. 22, figs. 7–10.**
Lithostrotionella astraeiformis **(Warren). Nelson, 1961, Geol. Assoc. Canada Spec. Paper No. 2, pl. 18, figs. 1–3.**
Thysanophyllum astraeiforme **(Warren). Bamber, 1966, Canada Geol. Survey Bull. 135, p. 23–26, pl. 4, figs. 3, 4.**
Thysanophyllum astraeiforme **(Warren). Armstrong, 1970, U.S. Geol. Survey Prof. Paper 534, p. 37–38, pl. 11, figs. 5–8.**

Material.—Two specimens are available for study, both of which were collected from measured stratigraphic sections. They are preserved as calcite which has retained some of the original microstructure. Specimen USNM 161025 is a 5 by 7 by 7 cm fragment of a corallum from which two transverse and one longitudinal thin sections were made. Specimen USNM 161026 is an 8 by 10 by 10 cm fragment of a corallum from which three transverse and two longitudinal thin sections were made.

Description.—Specimen USNM 161025 is cerioid, and the typical mature corallite is 3.1–6.5 mm in diameter and has 14–16 major septa (figs. 32, 33). In transverse section (pl. 9, fig. 1) the major septa extend one-third to one-half the distance from the inside of the tabularium wall to the axial region. In some corallites, very short (less than 0.2 mm long) minor septa occur between the major septa. Major and minor septa are not developed in the dissepimentarium in the majority of corallites, and where present, they are short ridges on the epitheca wall or short ridges on the upper surfaces of the dissepiments. The dissepimentarium has large lonsdaleoid dissepiments which intercept the loci of 2–8 major septa.

A columella is present in most corallites and is formed by axial ends of the counter and (or) cardinal septa.

In longitudinal section (pl. 9, fig. 3) the dissepimentarium is continuous, one-third to one-half the width of the radius of the corallite, and consists of 1–3 rows of steeply inclined, swollen dissepiments. There are 7–10 dissepiments in 10 mm. Tabulae are inclined 20°–35° near the dissepiments, frequently are flat to slightly domed in the axial region, and in a few specimens are upturned to meet the columella.

Corallite walls are 200–250 microns thick and have a central dark band 20–30 microns thick (pl. 9, fig. 2). The walls are composed of fibrous calcite crystals normal to the central band.

At the tabularium wall the major septa are 50–80 microns thick and are composed of fibers of calcite with a central dark band. The walls of the tabulae and dissepiments are 20–30 microns thick and are formed by crystals of calcite ranging in size from 8 to 12 microns.

Specimens USNM 161026 (pl. 9, fig. 4–6) is cerioid and has corallites which are typically 4.5–6.5 mm in diameter and which have 19–21 major septa. The major septa are best developed within the tabularium, where short minor septa are generally present. Major septa reach one-half to two-thirds the distance to the axial region. A columella is generally present but is not attached to the septa. Major and minor septa are well developed as ridges or projections on epitheca walls, varying from 0.1 to 1 mm in length. The dissepimentarium contains large and numerous lonsdaleoid dissepiments.

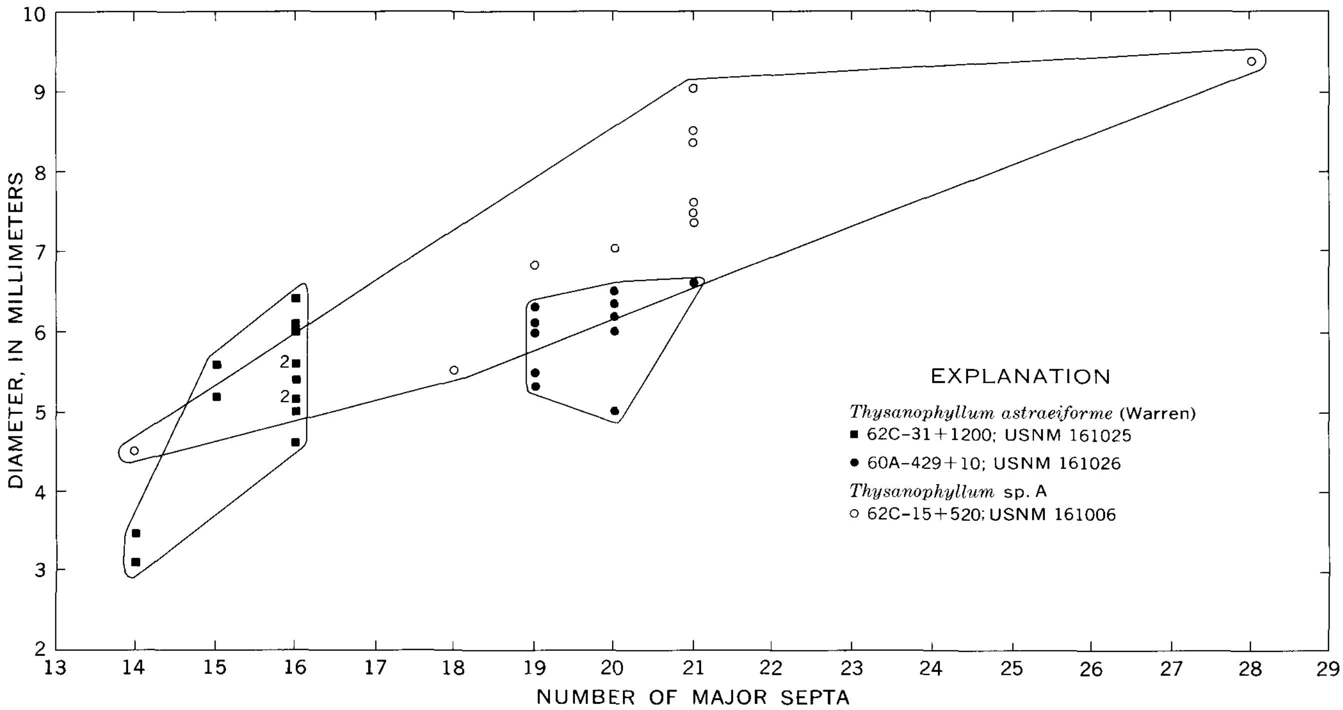

FIGURE 32.—Corallite diameter and number of major septa in *Thysanophyllum astraeiforme* (Warren) and *Thysanophyllum* sp. A. Each unnumbered symbol represents a single corallite; if more than one corallite shows the same diameter and number of septa, the number of similar corallites is shown.

In longitudinal section the dissepimentarium is one-third to one-half the radius of corallite and consists generally of a single row of dissepiments which are large, subquadrate, strongly convex, and steeply inclined. There are 4–6 in 5 mm. Tabulae are complete, dome shaped, and may be slightly uparched near the columella.

Occurrence.—Specimen USNM 161025 was collected 1,200 feet below the top of measured section 62C–31, in the Kogruk Formation, DeLong Mountains. It occurs

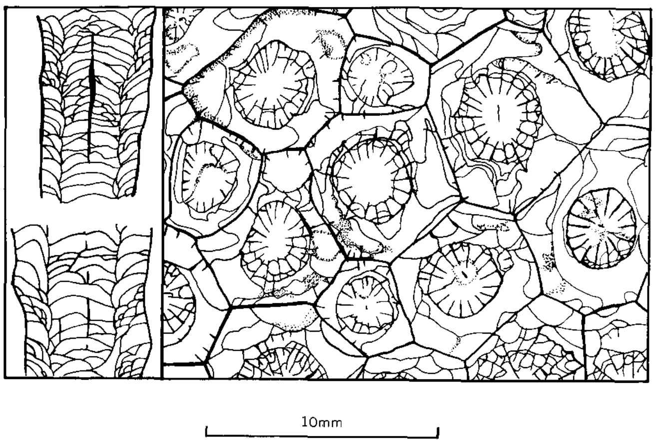

FIGURE 33.—Sections of *Thysanophyllum astraeiforme* (Warren), USNM 161025.

with *Thysanophyllum orientale* Thomson, *Sciophyllum lambarti* Harker and McLaren, *S. alaskaensis* Armstrong, *Lithostrotionella mclareni* (Sutherland), *Lithostrotionella* aff. *L. banffensis* (Warren), and *Lithostrotion* (*Siphonodendron*) *warreni* (Nelson) (fig. 3).

Specimen USNM 161026 was collected in the Cape Thompson Member of the Nasorak Formation south of Nasorak Creek, near Cape Thompson. Here it was found in association with *Lithostrotion* (*Siphonodendron*) *sinuosum* (Kelly), *L.* (*S.*) *warreni* (Nelson), and *Sciophyllum* sp. A.

Armstrong (1970) reports *T. astraeiforme* from the limestone and chert member of the Peratrovich Formation, northwest coast of Prince of Wales Island, southeastern Alaska, in association with a fauna of *Faberophyllum* spp., lithostrotionid corals, and Foraminifera of late Meramec age.

Bamber (1966) reports *T. astraeiforme* (Warren) from the Rundle Group near Banff, Alberta, and in the upper Mount Head Formation of the Rocky Mountains of southern British Columbia and Alberta.

Macqueen and Bamber (1968, p. 264, figs. 7, 8) report *T. astraeiforme* (Warren) from their faunal zones 3 and 4 in the Mount Head Formation, southwestern Alberta.

T. astraeiforme appears to be a common, widespread index fossil to Meramec age rocks in western Canada and Alaska.

Remarks.—Specimen USNM 161025 differs from the lectotype described by Bamber (1966, p. 23–24) by having some corallites which show, in longitudinal section, an additional row of dissepiments. In transverse section specimen USNM 161025 differs from the type specimens by having in corallites of equal diameter 3–4 additional major septa.

Specimen USNM 161026 is with some hesitation placed with the species *Thysanophyllum astraeiforme* (Warren). It differs from the type specimens of the species as described by Bamber (1966) by having in corallites of equal size 4–6 more major septa, by having major and minor septa which are relatively well developed and which are long projections from the epitheca, and by having much smaller and more abundant lonsdaleoid dissepiments.

Thysanophyllum sp. A

Plate 11, figures 1–3

Material.—Specimen USNM 161006 is a 7 by 9 by 10 cm fragment of a corallum collected from 520 feet below the top of section 62C–15. The corallum is preserved as calcite in a limestone matrix. Within the corallum many corallites were crushed before lithification. The specimen was studied in three transverse and four longitudinal thin sections.

Description.—Specimen USNM 161006 (pl. 11, figs. 1–3) is cerioid. In transverse thin section, corallites are from 3.5 to 9.5 mm in diameter, and the dissepimentarium is from 1.5 to 3 mm wide. The major septa are essentially restricted to the tabularium and are 1.25–1.6 mm long. Major septa where developed in the dissepimentarium are short ridges on the epitheca. Minor septa are absent in all corallites studied. The dissepiments are lonsdaleoid.

The majority of corallites lack columellae. Where columellae are present, they are thin and lath shaped and generally not connected to the septa. A few corallites have lens-shaped columellae that are attached to the cardinal and the counter septa (fig. 34).

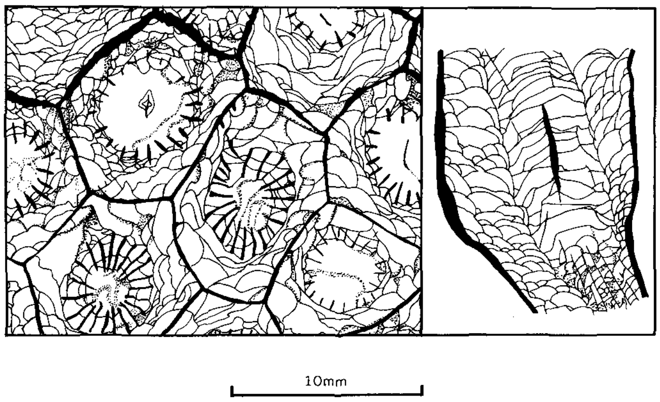

FIGURE 34.—Sections of *Thysanophyllum* sp. A, USNM 161006.

In longitudinal section, corallites with a columella have a dissepimentarium composed (pl. 11, fig. 3) of 2–3 rows of globose dissepiments of which 4–6 occur in 5 mm. Many tabulae are incomplete and dome shaped and are slightly reflexed upward near the columella. The tabulae in the axial region slope downward from the columella 10°–20°, and with 0.5–1.0 mm of the dissepimentarium they are reflexed downward 30°–45°. Corallites which are acolumellate have dome-shaped tabulae in the axial region with steeply inclined margins near the dissepimentarium.

The epitheca (pl. 11, fig. 1) is about 200–300 microns thick and contains a central dark-gray band 30–40 microns thick. The epitheca is composed of fibers of calcite deposited with their long axes normal to the central dark-gray band. Within the tabularium the major septa are 150–170 microns thick at their bases and taper towards the axial region. The septa in transverse section are characterized by a central dark band 10–20 microns thick, on which fibrous calcite crystal are deposited at angles of 35°–40°.

Occurrence.—Only one specimen of *Thysanophyllum* sp. A is known from the Lisburne Group of Alaska. It is represented by specimen USNM 161006, which was collected 520 feet below the top of section 62C–15, Kogruk Formation, DeLong Mountains (fig. 3). It is found in association with *Lithostrotionella banffensis* (Warren), *Lithostrotionella mclareni* (Sutherland), and *Faberophyllum* sp. The coral fauna is of Meramec age.

Remarks.—*Thysanophyllum* sp. A resembles *Thysanophyllum astraeiforme* (Warren) in its development of the septa within the tabularium and in its lonsdaleoid dissepiments in the dissepimentarium. It differs from the latter species by having corallites which are typically 2–3 mm larger in diameter and which have 22–28 major septa (fig. 32).

Thysanophyllum orientale Thomson differs from *Thysanophyllum* sp. A by having corallites of nearly twice the diameter with well-deveoped minor septa.

The description of *Thysanophyllum* sp. A is based on a single fragment of a corallum in which many of the individual corallites were crushed before lithification. The material is considered inadequate for a detailed description of a new species.

Genus SCIOPHYLLUM Harker and McLaren, 1950

Sciophyllum Harker and McLaren, 1950, Canala Geol. Survey Bull. 15, p. 31.

Sciophyllum Harker and McLaren. Hill, 1956, *in* Moore, R. C., ed., Treatise on invertebrate paleontology, part F, Geol. Soc. America, p. F307.

Sciophyllum Harker and McLaren. Sando, 1965, U.S. Geol. Survey Prof. Paper 503–E, p. E29.

Type species.—Sciophyllum lambarti Harker and McLaren (1950 p. 31–33, pl. 4), Mississippian, Canada.

Diagnosis.—Cerioid rugose corals of basaltiform habit, without columella; complete corallum unknown; dissepimentarium of one or more series of dissepiments, the inner margin forming a well-marked inner wall; tabulae strong, well spaced and regular, flat or slightly arched; septa absent or reduced to fine vertical striations on the inner side of the epitheca or inside the inner wall; gemmation laterial (Harker and McLaren, 1950, p. 31).

Sciophyllum lambarti Harker and McLaren

Plate 6, figures 3–6

Sciophyllum lambarti Harker and McLaren, 1950, Canada Geol. Survey Bull. 15, p. 31–33, pl. 4, figs. 1–4.

Material.—Two specimens are available for study, and both are fragments approximately 8 by 8 by 10 cm, collected from two coralla found in measured stratigraphic sections. Specimen USNM 161015 was collected from a dolomitic packstone in section 62C–31. From this specimen two transverse thin sections with 94 corallites and three longitudinal thin sections with 18 corallites were made. Specimen USNM 161017 was collected from the measured section at Cape Thompson, and one transverse thin section with 40 corallites and one longitudinal thin section with five corallites were made.

Description.—Specimen USNM 161015 is cerioid and has prismatic corallites that are typically 3–4 mm in diameter. In transverse section (pl. 6, fig. 6) the traces of 1 or 2 large dissepiments are generally present. Some parts of various corallites are devoid of dissepiment. Where present, the dissepimentarium occupies about one-half the radius of the corallites. Septa are poorly developed and vestigial and on the inside of the tabularium wall as short ridges less than 0.1 mm long (fig. 35).

In longitudinal section (pl. 6, fig. 5) some corallites have a dissepimentarium that consists of a single row of large inflated, steeply inclined dissepiments of which there are 5–8 in 5 mm. Tabulae are essentially flat, and there are 6–8 in 5 mm. In corallites without a dissepimentarium, the tabulae are flat and extend horizontally across the corallites, normal to the epitheca.

The corallite walls are 80–110 microns thick and have a median dark-gray calcite band 20 microns thick. The walls are composed of fibrous calcite deposited normal to the central band. The walls of the dissepiments are thin, only some 15 microns thick, and are formed by very small (10 microns or less) crystals of interlocking calcite. The tabulae have thin walls, only 20–25 microns thick, and are made of crystals of calcite which range in size from 10 to 15 microns.

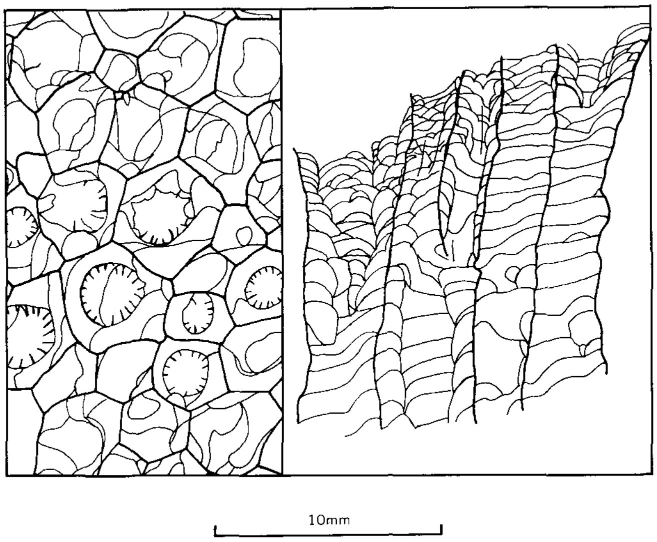

FIGURE 35.—Sections of *Sciophyllum lambarti* Harker and McLaren, USNM 161015.

Specimen USNM 161017 (pl. 6, figs. 3, 4), from the upper member of the Nasorak Formation near Cape Thompson, in transverse section, has corallites which are typically 3–4.5 mm in diameter. The corallites have short septa on the epitheca and on the inside of the tabularium wall. All corallites studied have a dissepimentarium composed of relatively small lonsdaleoid dissepiments. In longitudinal section the dissepimentarium is about half the radius, composed of a single to double row of swollen dissepiments of which 10–14 occur in 5 mm. The tabulae are weakly convex near the dissepiments and nearly horizontal in the axial region, 9–13 tabulae occurring in 5 mm. Microstructure is similar to specimen USNM 161015 which is decribed above.

Occurrence.—S. lambarti, in the Kogruk Formation of the DeLong Mountains and the Nasorak Formation near Cape Thompson, has been collected in beds which contain a diversified coral fauna of Meramec age. Specimen USNM 161015 was collected from the Kogruk Formation, western DeLong Mountains, 1,320 feet below the top of measured section 62C–31 (fig. 5). It occurs in association with *Lithostrotionella mclareni* (Sutherland), *Lithostrotionella* aff. *L. banffensis* (Warren), *Thysanophyllum* sp., *Lithostrotion* (*Siphonodendron*) *sinuosum* (Kelly), and *Lithostrotion* (*Siphonodendron*) *warreni* Nelson.

S. lambarti was collected by the writer in 1962 near Cape Thompson south of Nasorak Creek from the upper member of the Nasorak Formation as defined by Campbell (1967, p. 44–45, pl. 2B) and was found in association with *Lithostrotionella mclareni* (Sutherland) and *Lithostrotionella banffensis* (Warren).

Harker and McLaren's (1950, p. 30–31) holotype of *S. lambarti* is described as having been collected "from the Carboniferous of the Yukon-Alaska boundary, long 141° W., lat 68°48′40″ N." They thought it possibly came "from a Mississippian horizon."

Remarks.—Specimen USNM 161015 from section 62C–31, Kogruk Formation, DeLong Mountains, differs from the illustration and description of the holotype of *S. lambarti* Harker and McLaren (1950) by having a number of corallites which are devoid of dissepiments. Furthermore, in those corallites which have a dissepimentarium, the dissepiments are in only one series and are larger in size. The corallites are devoid of septa in the dissepimentarium and on the epitheca wall. This specimen does conform to the holotype in corallite diameter.

Specimen USNM 161017 from the Nasorak Formation resembles in most respects the holotype of *Sciophyllum lambarti* as defined by Harker and McLaren (1950).

Sando's (1965, p. E29–E31) description of the lectotype of *Sciophyllum adjunctivum* (White) from the Upper Mississippian of southeastern Idaho mentions that corallites are as large as 9 mm in diameter and that most of the tabulae are concave or inclined. *S. adjunctivum* is characterized by a single row of large dissepiments and absence of septa in the dissepimentarium.

Lithostrotionella mclareni (Sutherland) from the Kogruk Formation is exemplified by specimens USNM 161003 (pl. 6, figs. 1, 2) from 520 feet below the top of section 62C–15; USNM 161016 from 1,390 feet below the top of section 62C–31; and USNM 161030 (pl. 6, figs. 8, 9) from 1,100 feet below the top of section 60A–400–403; these specimens have columellae in a majority of the corallites and have septa typical of the genus *Lithostrotionella.* A few corallites within these coralla may have morphology of the genera *Thysanophyllum* and *Sciophyllum.* Furthermore there are clusters of corallites within these coralla which have the morphology of *Sciophyllum lambarti.* Both *L. mclareni* and *S. lambarti* have similar stratigraphic ranges within the Kogruk Formation.

The collection of *L. mclareni* from the Kogruk Formation suggests that *S. lambarti* was possibly derived from the former by elimination of the columella, peripheral withdrawal of the septa, development of large lonsdaleoid dissepiments, and development of horizontal tabulae.

Sciophyllum alaskaensis Armstrong

Plate 10, figures 2–6

Sciophyllum alaskaensis Armstrong, 1970, U.S. Geol. Survey Prof. Paper 534, p. 38, 39, pl. 11, figs. 1–4.

Material.—Fragments of three coralla were collected from two measured sections of the Kogruk Formation in the DeLong Mountains. Each specimen was about 6 by 8 by 8 cm. Three transverse thin sections were made from specimen USNM 161020 and showed 65 corallites. From specimen USNM 161021 the two transverse thin sections made showed 40 corallites, and the three longitudinal thin sections, seven corallites. From specimen USNM 161022 the seven transverse thin sections made showed 43 corallites, and the five longitudinal thin sections, 18 corallites. All the specimens have the corallites preserved as calcite and the internal voids filled with sparry calcite and minor amounts of chalcedony. The microstructure has undergone calcite neomorphism and has also been affected by grain growth and penetrated by sparry calcite crystals.

Description.—Specimen USNM 161020 (pl. 10, figs. 4, 5) has a cerioid corallum. In transverse section the average mature corallite is from 6.0 to 8.7 mm in diameter. The dissepimentarium occupies 25–35 percent of the corallite diameter and consists of lonsdaleoid dissepiments which intercept from 2 to 5 major septa. Short major and minor septa project from the epitheca into the dissepimentarium (pl. 10, fig. 5). The discontinuous major and minor septa may reappear on the inner wall of the tabularium. Here they range in length from 0.1 to 0.5 mm. The development of the major and minor septa varies in different corallites. All corallites studied are devoid of columellae. Corallites with a diameter less than 4 mm have major septa which tend to be persistent in the dissepimentarium from the epitheca to the tabularium wall but which are withdrawn from the axial region of the corallite (fig. 36).

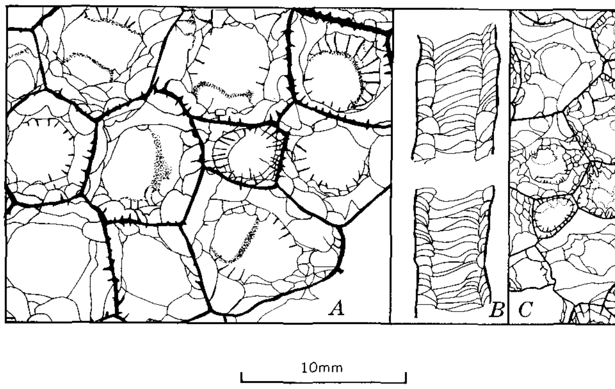

FIGURE 36.—Sections of *Sciophyllum alaskaensis* Armstrong; *A*, USNM 161020; *B*, *C*, USNM 161021.

In longitudinal section the dissepimentarium is a single to double row of large, inflated and steeply inclined dissepiments of which there are 4–6 in 5 mm. The tabulae are complete, flat to slightly concave in the axial region; some are reflexed downward 10°–35° near the dissepimentarium.

Microstructure (pl. 10, fig. 5) is poorly preserved owing to extensive calcite neomorphism—in particular, grain growth of the sparry calcite which fills the internal voids of the corallites. The corallite walls are 150–200 microns thick and have a central band, 20 microns thick, of dark-gray calcite. The epitheca is formed by fibrous calcite deposited at right angles to and on both sides of the dark-gray band. The septa appear to have been thin, less than 100 microns thick. In the tabularium the major septa are 100–120 microns thick and are composed of fibrous calcite. The tabulae and dissepiment walls have been affected by calcite neomorphism but appear to have been very thin, less than 40 microns thick (pl. 10, fig. 5).

Specimen USNM 161021 (pl. 10, figs. 2, 3) has corallites which are typically 4.5–6.5 mm. in diameter and has septa which are irregularly and inconsistently developed on the epitheca and on the inside of the tabularium wall. In other respects it is similar to specimen USNM 161020 (fig. 36).

Specimen USNM 161022 (pl. 10, fig. 6), which is with reservation assigned to this species, has corallites which are 6–8.5 mm in diameter. Minor septa are absent, and the major septa are developed only on the epitheca or in the dissepimentarium of a few corallites. The septa in the tabularium are inconsistently developed on the tabularium wall. The dissepimentarium occupies about half the radius of the corallites, and the dissepiments are large and lonsdaleoid.

Occurrence.—*Sciophyllum alaskaensis* was found in the Kogruk Formation, DeLong Mountains, 515 feet (USNM 161020) and 1,075 feet (USNM 161021) below the top of stratigraphic section 62C–31 (fig. 5). In section 62C–15 it was found about 300 feet (USNM 161022) below the top. *S. alaskaensis* is found in the Kogruk Formation in association with *Faberophyllum* spp., *S. lambarti* Harker and McLaren, *Lithostrotionella mclareni* (Sutherland), *Thysanophyllum astraeiforme* (Warren), *Thysanophyllum orientale* Thomson, and *Lithostrotionella banffensis* (Warren) (fig. 3).

The holotype (Armstrong, 1970) of *S. alaskaensis* was described from the limestone and chert member, Peratrovich Formation, northwest coast, Prince of Wales Island, southeastern Alaska. There the species occurs with *Faberophyllum girtyi* Armstrong, *Faberophyllum williamsi* Armstrong, *L. banffensis*, and *T. astraeiforme*, and a large fauna of Meramec Foraminifera.

Remarks.—*Sciophyllum alaskaensis*, as defined by Armstrong (1970) from material collected from the Peratrovich Formation, northwest side Prince of Wales Island, southeastern Alaska, has a double row of dissepiments. It differs from *S. adjunctivum* (White) as redescribed by Sando (1965, p. E29–E31) and the holotype of *S. lambarti* as described by Harker and McLaren (1950, p. 31–33), both of which have only a single row of dissepiments. Furthermore, *S. adjunctivum* has tabulae which are concave and septa which are inconsistently present on the inner side of the tabularium wall and absent on the corallite wall. *S. lambarti* is distinguished from *S. alaskaensis* by the former's smaller corallite diameter of only 4.6–5.0 mm and less developed septa.

The concept of *S. alaskaensis* is expanded in this study to cover a wider variation of septal degeneration and development of lonsdaleoid dissepiments. Specimen USNM 161020 closely resembles the holotype from southeastern Alaska. Specimen USNM 161021, found 560 feet stratigraphically below specimen USNM 161020 in the Kogruk Formation, is similar in most respects, but typical corallites are about 2 mm smaller in diameter, and the tabulae tend to sag or be concave.

Specimens USNM 161020 and 161021 may have been derived from a *Thysanophyllum astraeiforme* (Warren) lineage, as the holotype of *S. alaskaensis* may have been, by the elimination of the columella and further degeneration of the septa. The holotype and paratypes of the species from the Peratrovich Formation, Prince of Wales Island, southeastern Alaska, also strongly suggest *T. astraeiforme* lineage.

Specimen USNM 161022, from 300 feet below the top of section 61C–15—which is with considerable reservation assigned to this species—probably is of a different phylogenic lineage. It is characterized by very degenerate major septa, large irregularly developed lonsdaleoid dissepiments and irregularly shaped corallites. This specimen may possibly be derived from the *Lithostrotionella birdi* Armstrong lineage. An example of this latter species, specimen USNM 161023, has some corallites (pl. 5, figs. 1, 2) which are strongly suggestive of specimen USNM 161022. (See remarks under *L. birdi.*)

Sciophyllum sp. A

Plate 11, figures 4–7

Material.—Specimen USNM 161029 is the only example of *Sciophyllum* sp. A collected by the writer from the Lisburne Group in Alaska. It is a 6 by 6 by 8 cm, fragment of a corallum.

A significant proportion of the corallites within the corallum were crushed before lithification. The corallum is preserved as calcite and is in a limestone matrix. Thin section studies were made on three transverse thin sections with 12 corallites and two longitudinal thin sections with 5 corallites. (See fig. 37 for transverse and longitudinal section).

Description.—The corallum is cerioid. In transverse thin section (pl. 11, fig. 6) average mature corallites are 12–15 mm in diameter. The dissepimentarium occupies about 50 percent of the corallite diameter and is a series of tightly packed lonsdaleoid dissepiments. Major septa are absent on the epitheca of mature corallites. On the epitheca of corallites under 8 mm in diameter there may be short major septa that are ridges 100–150 microns long. In some corallites major septa may occur on the inside of the tabularium wall as short spikes 100–200 microns long. As many as 20–24 major septa can be developed; minor septa are absent.

In longitudinal section the dissepimentarium is 2–4 rows of inflated, steeply inclined dissepiments of which 6–10 occur in 5 mm. Tabulae are complete, are flat to slightly convex, and have their greatest convexity near their junction with the dissepiments. There are ordinarily 12–15 tabulae in 5 mm (fig. 37).

The epitheca walls in transverse section (pl. 11, fig. 7) are between 350 and 450 microns thick and have a central dark band of calcite 50 microns thick. Fibrous calcite deposited at right angles to the central dark band forms the corallite walls. The spikelike septal ridges on the epitheca are formed by calcite which is in optical continuity with the fibrous calcite of the corallite wall. The short major septa on the inside of the tabularium where present, are also formed by fibrous calcite. In longitudinal section the walls of the dissepimentarium and tabulae are 20–30 microns thick and are composed of interlocking calcite crystals ranging in size from 10 to 20 microns.

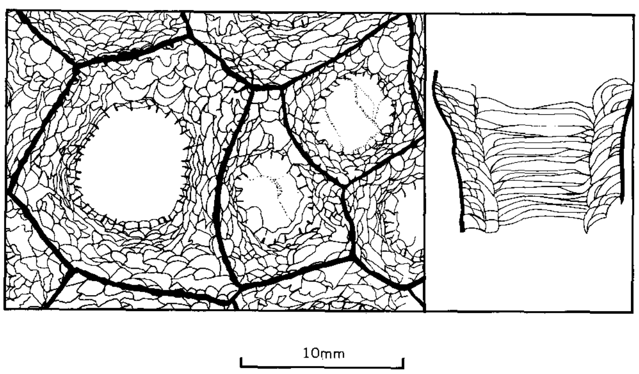

FIGURE 37.—Sections of *Sciophyllum* sp. A, USNM 161029.

The voids within the corallum are filled with 0.2–0.4 mm crystals of sparry calcite.

Occurrence.—The only known example of *Sciophyllum* sp. A was collected in 1962 from the upper 50 feet of the lower member of the Nasorak Formation as defined by Campbell (1967, pl. 2B) south of Nasorak Creek near Cape Thompson. It occurs in association with *Lithostrotion* (*Siphonodendron*) *sinuosum* (Kelly), *L.* (*S.*) *warreni* Nelson, and *Thysanophyllum astraeiforme* (Warren), which indicate a Meramec age.

Remarks.—Specimen 161029, on which the description of *Sciophyllum* sp. A is based, is the only example of this form of *Sciophyllum* known by the writer from the Lisburne Group, and it has many crushed corallites.

Sciophyllum lambarti Harker and McLaren, which occurs in the Lisburne Group, is easily distinguished from *Sciophyllum* sp. A by the former's smaller corallite diameter of 4.5–5 mm and single row of large lonsdaleoid dissepiments.

Sciophyllum alaskaensis Armstrong, which also occurs in the Lisburne Group of northwestern Alaska, is separated from *Sciophyllum* sp. A by the latter's smaller corallite diameter of 6.0–8.5 mm, narrower dissepimentarium, better developed and larger lonsdaleoid dissepiments.

Sciophyllum adjunctivum (White) as redescribed by Sando (1965, p. E29–E31) has concave tabulae, large lonsdaleoid dissepiments, and smaller corallite diameters.

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PLATE 1

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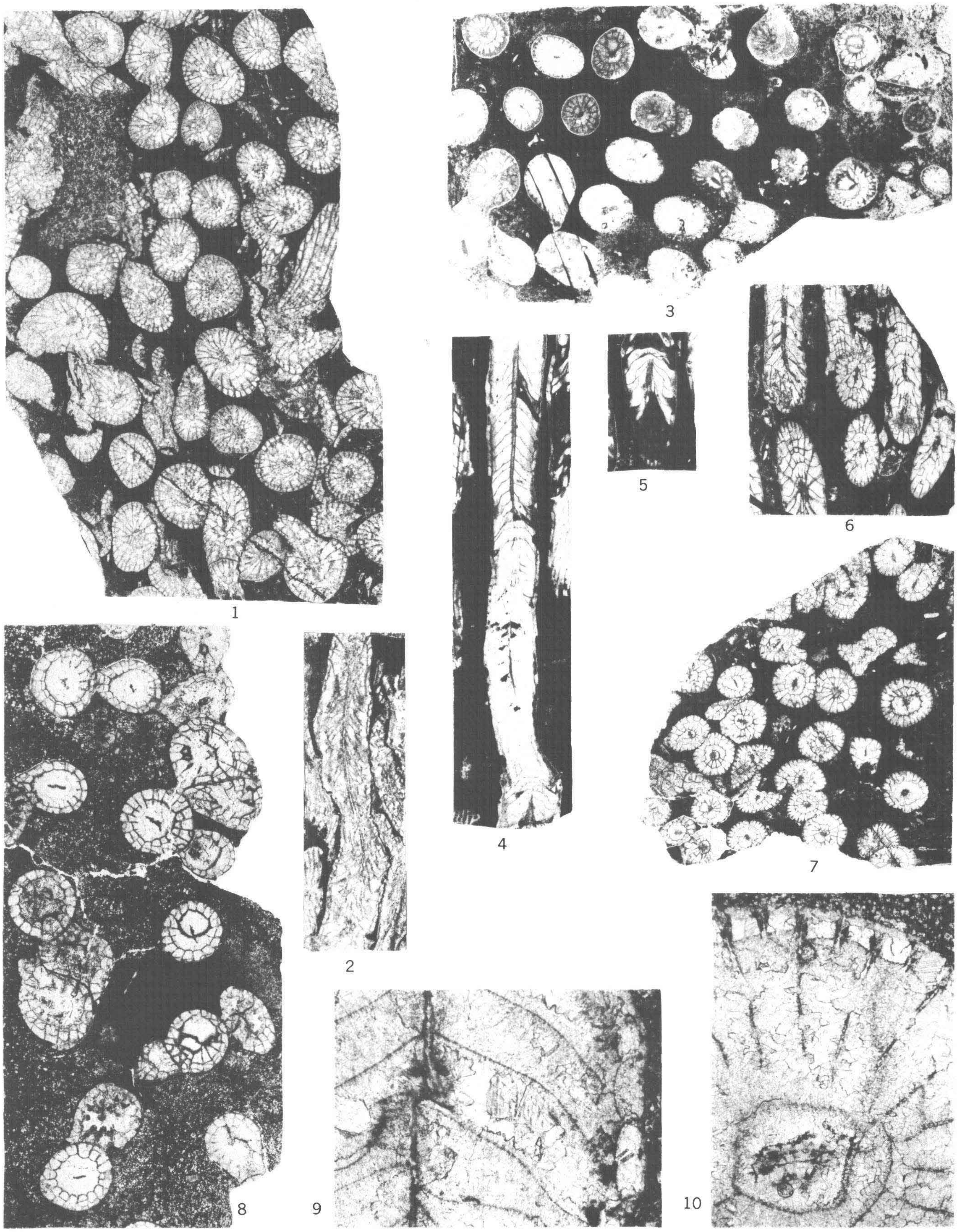

LITHOSTROTION (SIPHONODENDRON) SINUOSUM (Kelly) and
LITHOSTROTION (SIPHONODENDRON) WARRENI Nelson

PLATE 2

FIGURES 1–4. *Lithostrotion* (*Siphonodendron*) *warreni* Nelson (p. 13).

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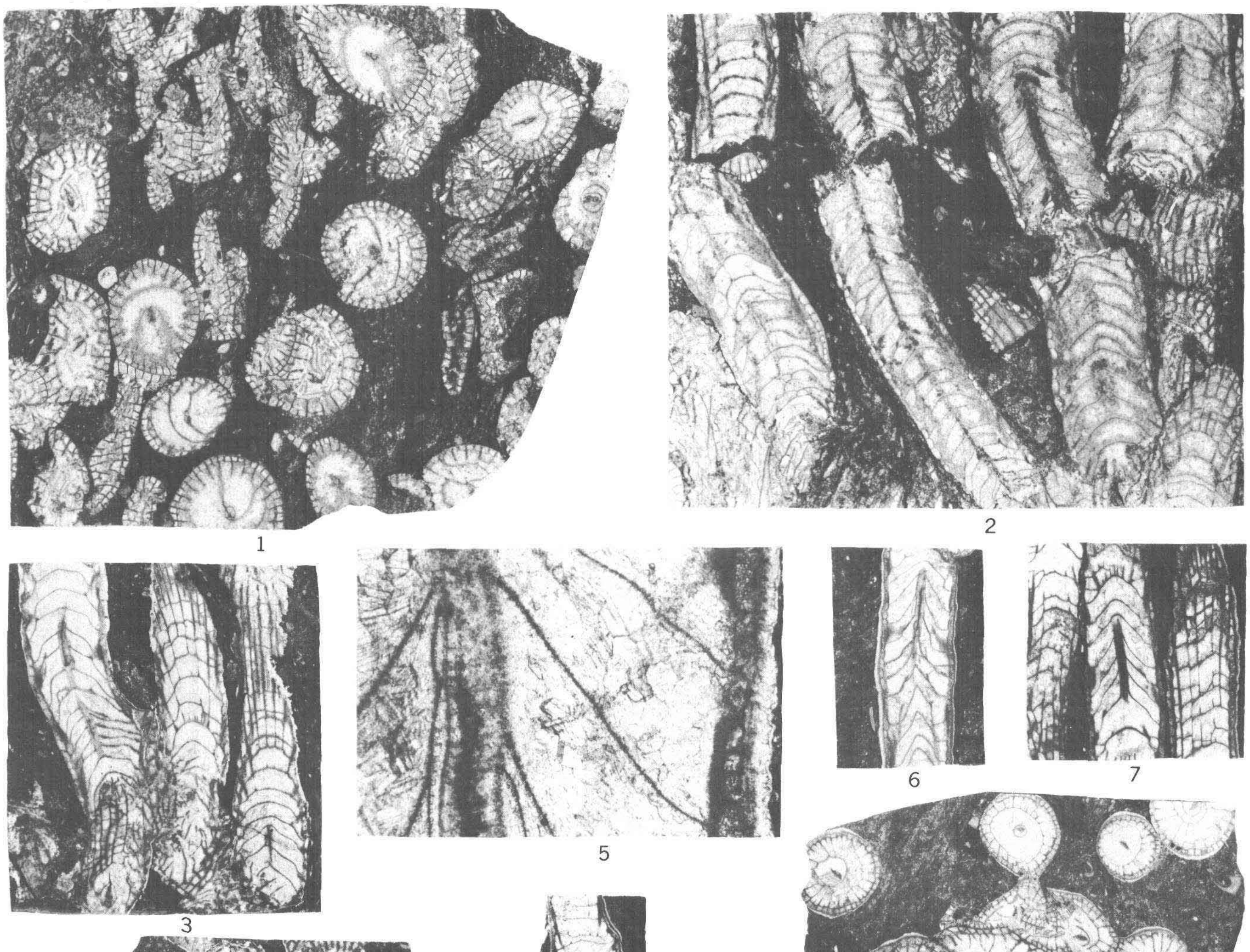

LITHOSTROTION (SIPHONODENDRON) WARRENI (Nelson) and *LITHOSTROTION (SIPHONODENDRON)* sp. A

PLATE 3

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Longitudinal and transverse thin sections, respectively. × 25. USNM 160997; Utukok Formation, Delong Mountains. (See pl. 1, fig. 8 for × 3 transverse thin sections of corallites.)

3, 4. *Lithostrotion* (*Siphonodendron*) *sinuosum* (Kelly) (p. 9).

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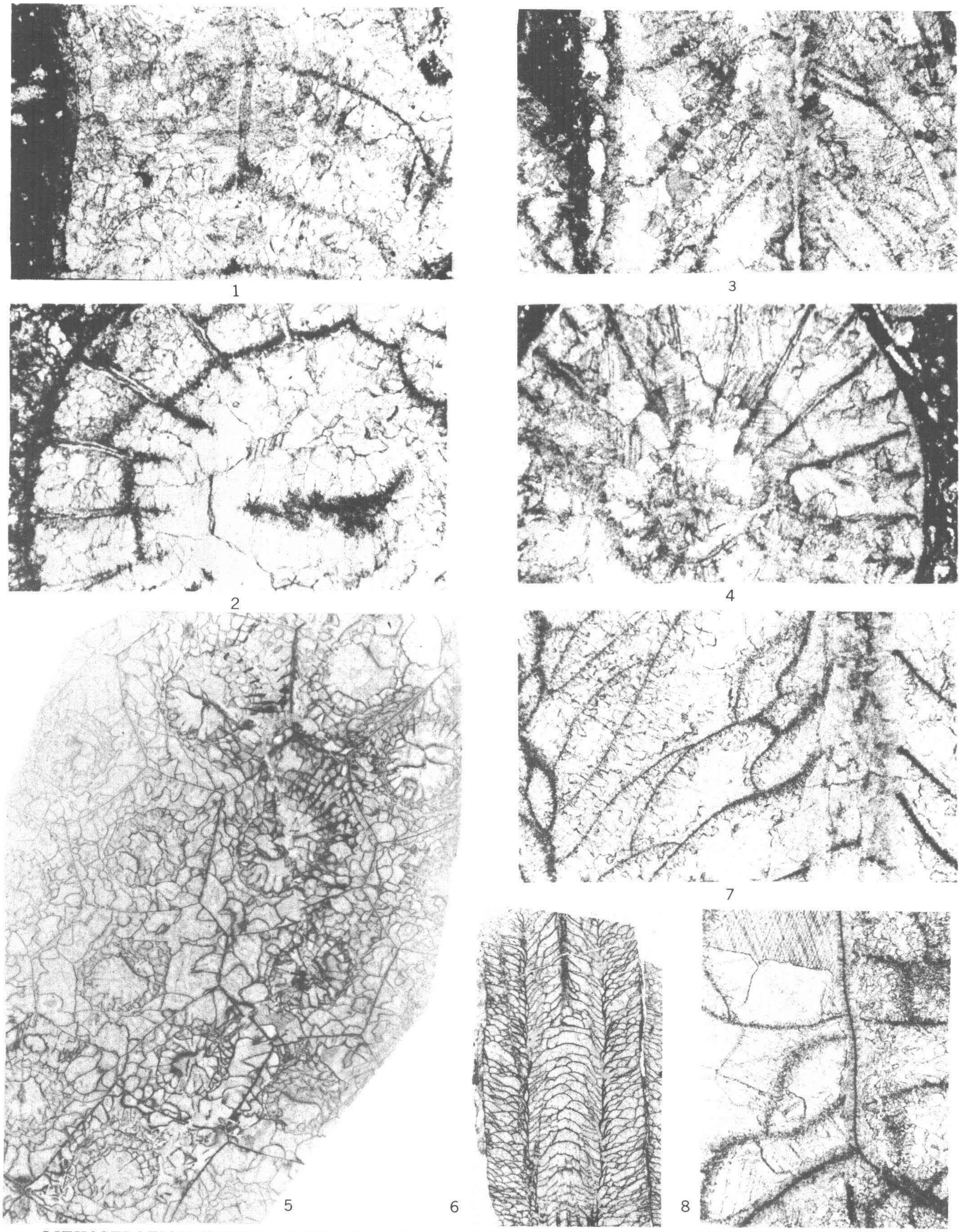
7. Longitudinal thin section of columella, tabulae, dissepiments, and microstructure. × 25.
8. Transverse thin section of wall, dissepiment, microstructure, and sparry calcite void filling. × 25.

USNM 161011; upper member of the Nasorak Formation, Cape Thompson section.



LITHOSTROTION (SIPHONODENDRON) aff. *L. (S.) SINUOSUM* (Kelly), *LITHOSTROTION (SIPHONODENDRON) SINUOSUM* (Kelly), and *LITHOSTROTIONELLA BANFFENSIS* (Warren)

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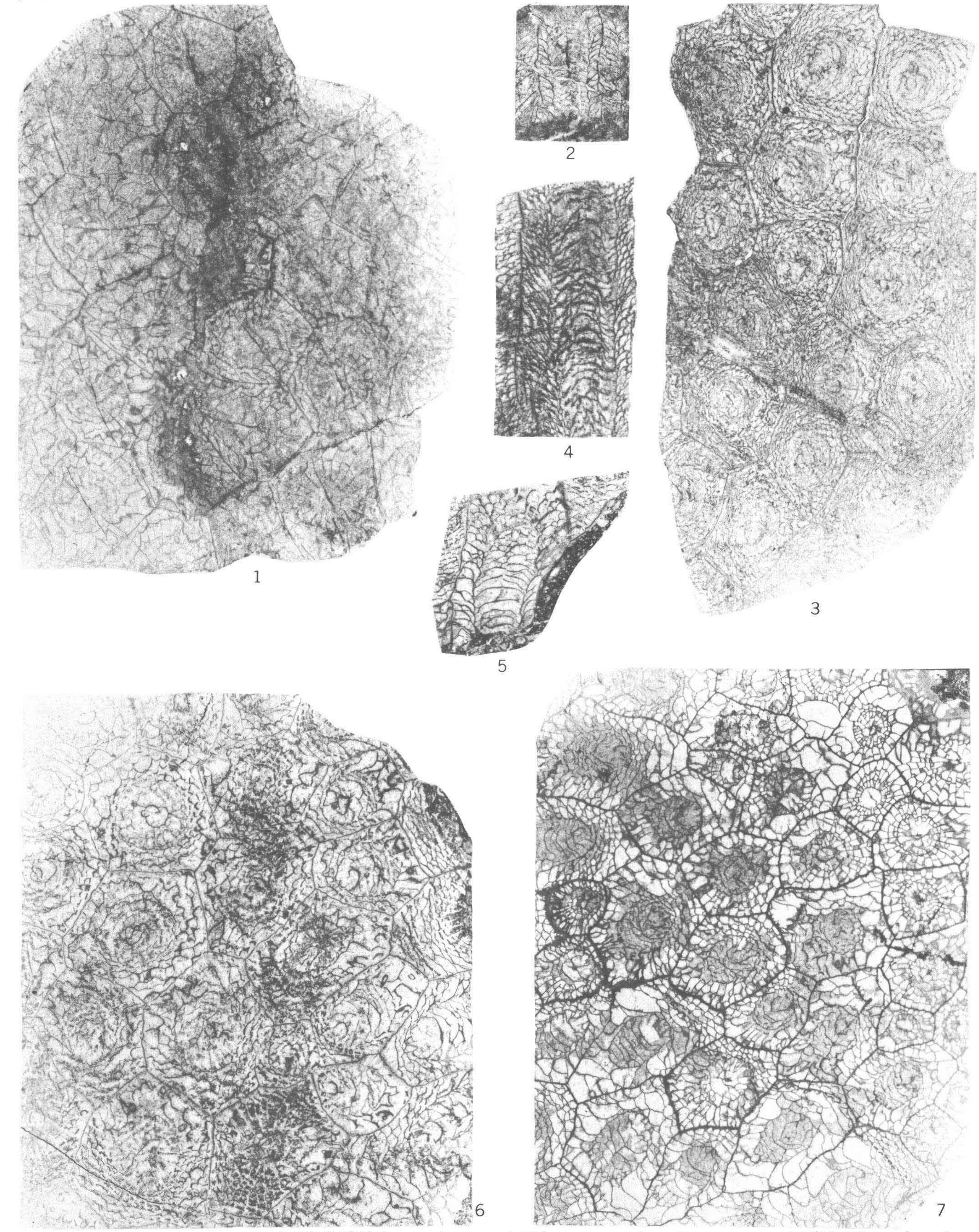
7. *Lithostrotionella birdi* Armstrong (p. 20).

Transverse thin section. × 3. USNM 161024; 100 ft from the top of measured section 60A–400–403, Kogruk Formation, DeLong Mountains. (See pl. 5, figs. 3, 5, for longitudinal views.)



LITHOSTROTIONELLA BANFFENSIS (Warren), *LITHOSTROTIONELLA* aff. *L. BANFFENSIS* (Warren), and *LITHOSTROTIONELLA BIRDI* Armstrong

PLATE 5

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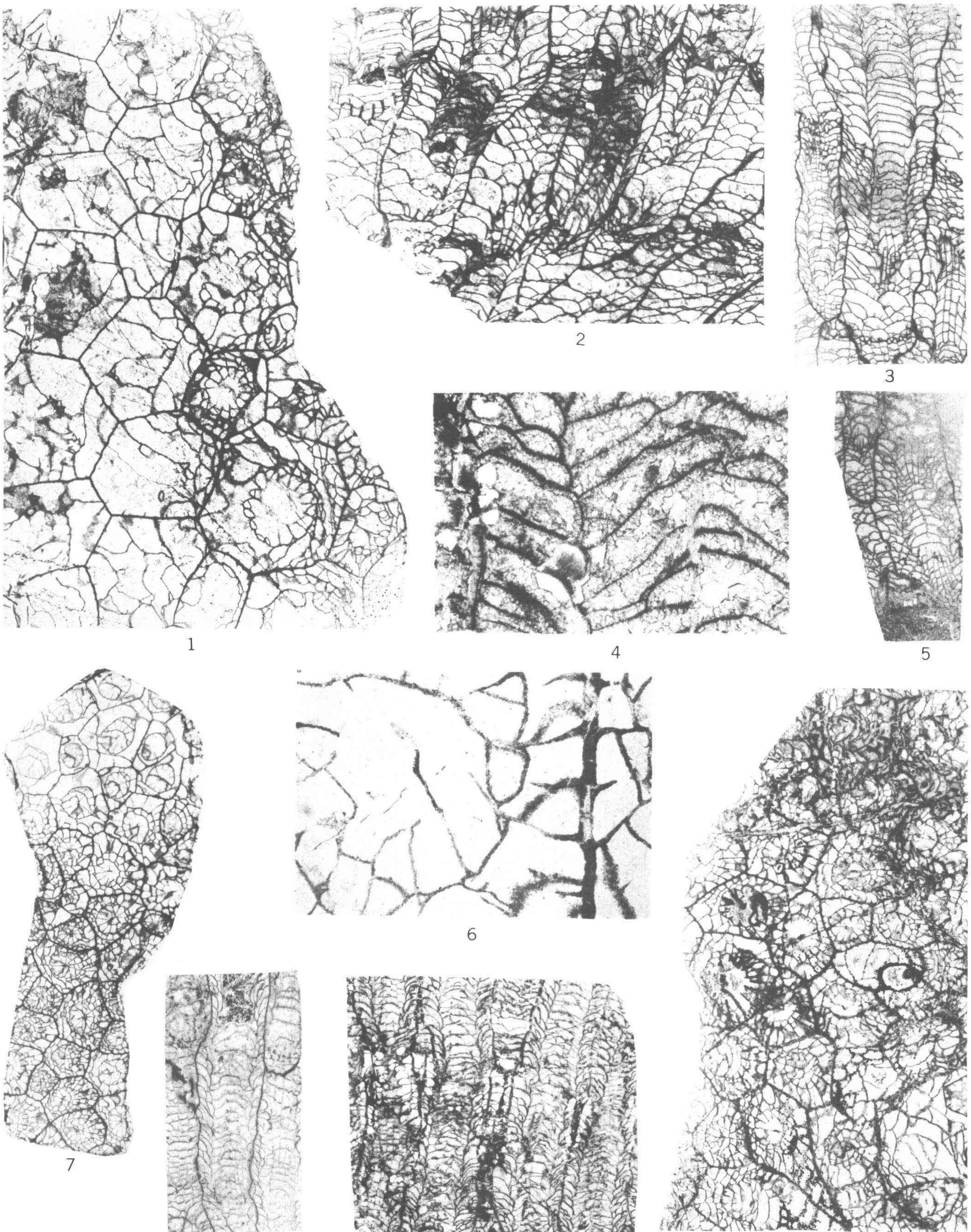

LITHOSTROTIONELLA BIRDI Armstrong and *LITHOSTROTIONELLA MCLARENI* (Sutherland)

PLATE 6

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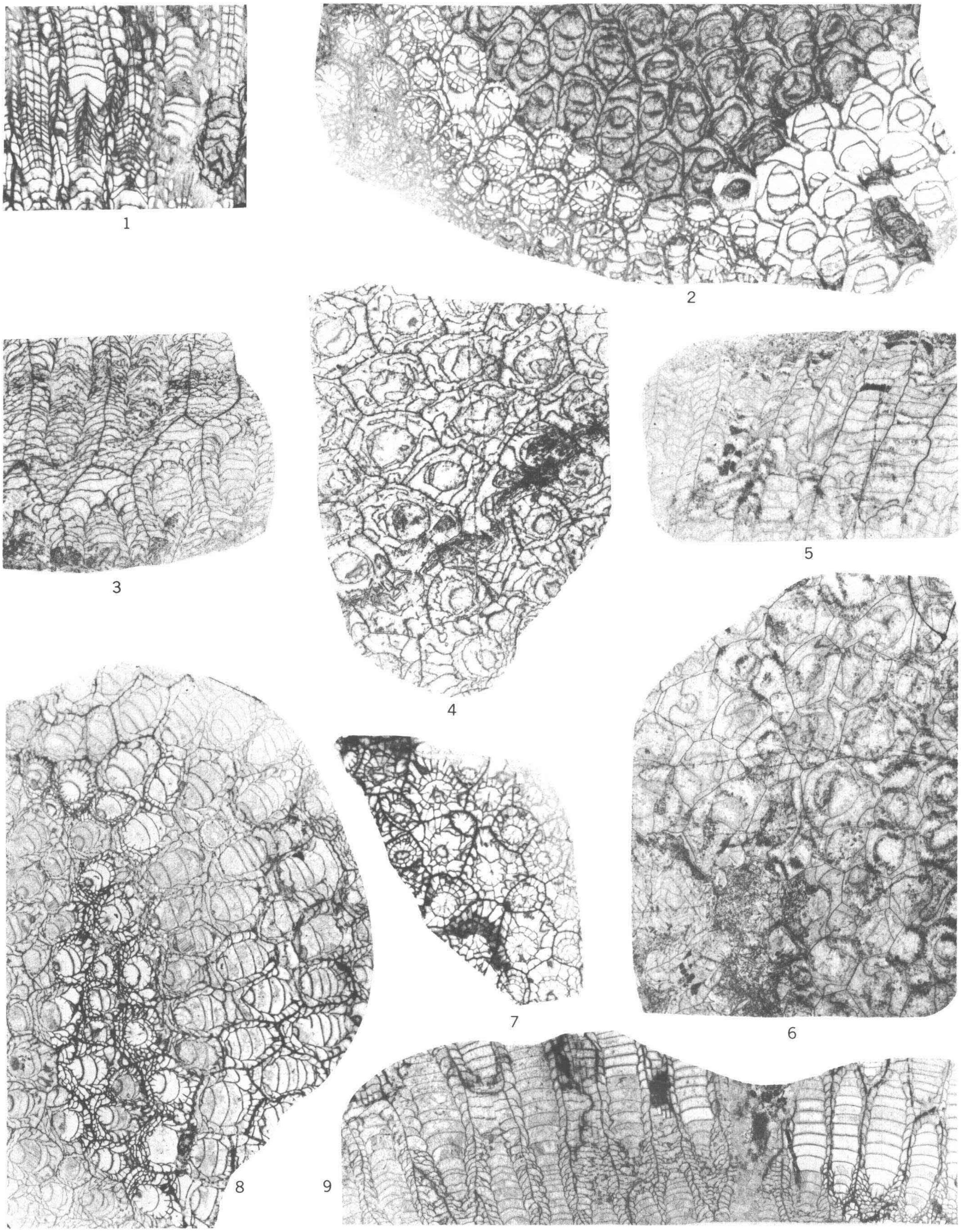

LITHOSTROTIONELLA MCLARENI (Sutherland) and *SCIOPHYLLUM LAMBARTI* Harker and McLaren

PLATE 7

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4. Transverse thin section. × 25.
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9. Transverse thin section. × 25.
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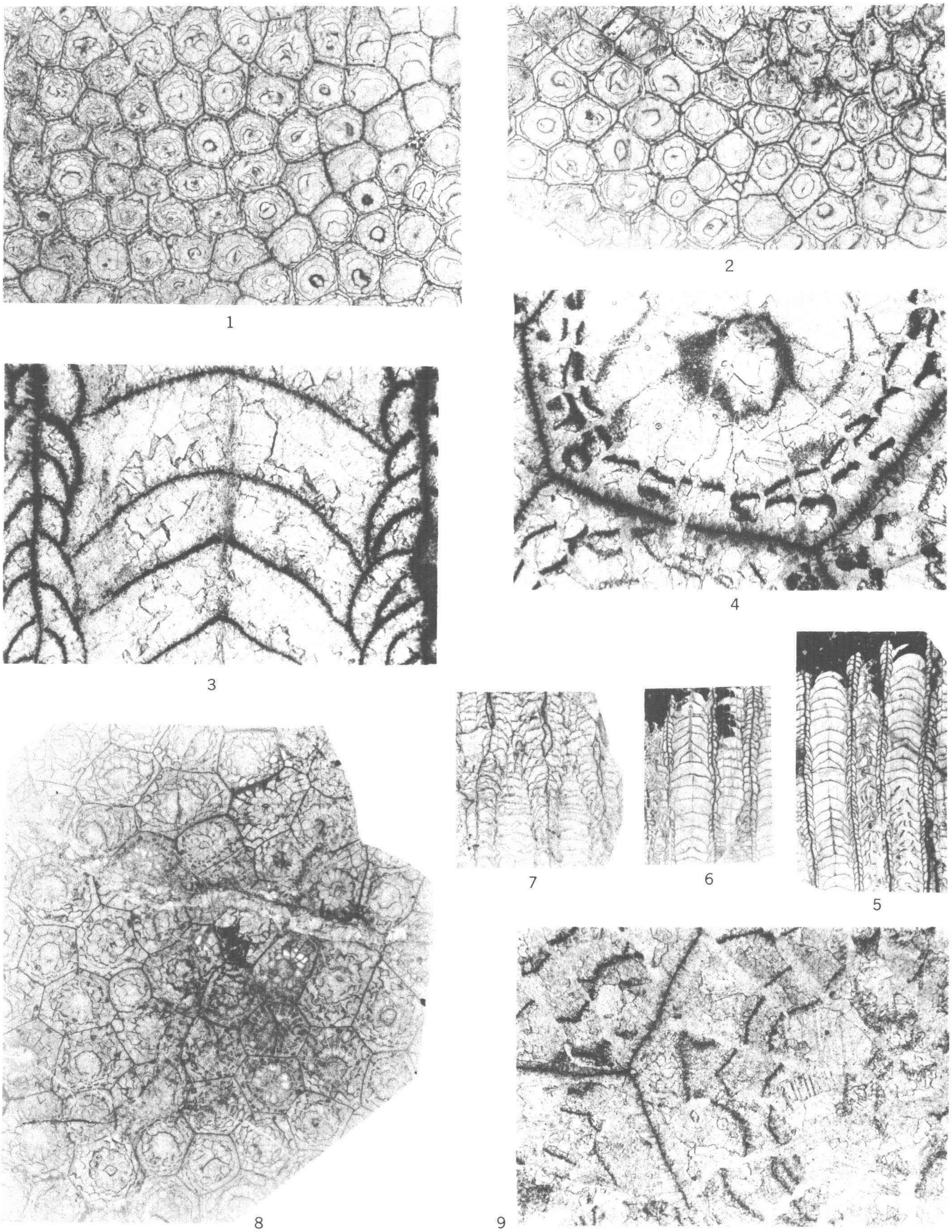

LITHOSTROTIONELLA sp. A. and *LITHOSTROTIONELLA* sp. B

PLATE 8

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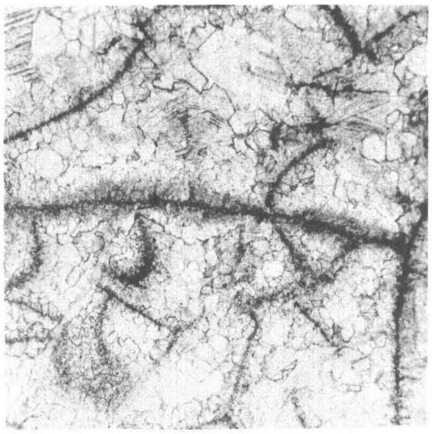
4, 5. Longitudinal and transverrse thin sections, respectively. (× 3). USNM 161019; 70 ft below the top of section 60A–400—403, Kogruk Formation, DeLong Mountains.



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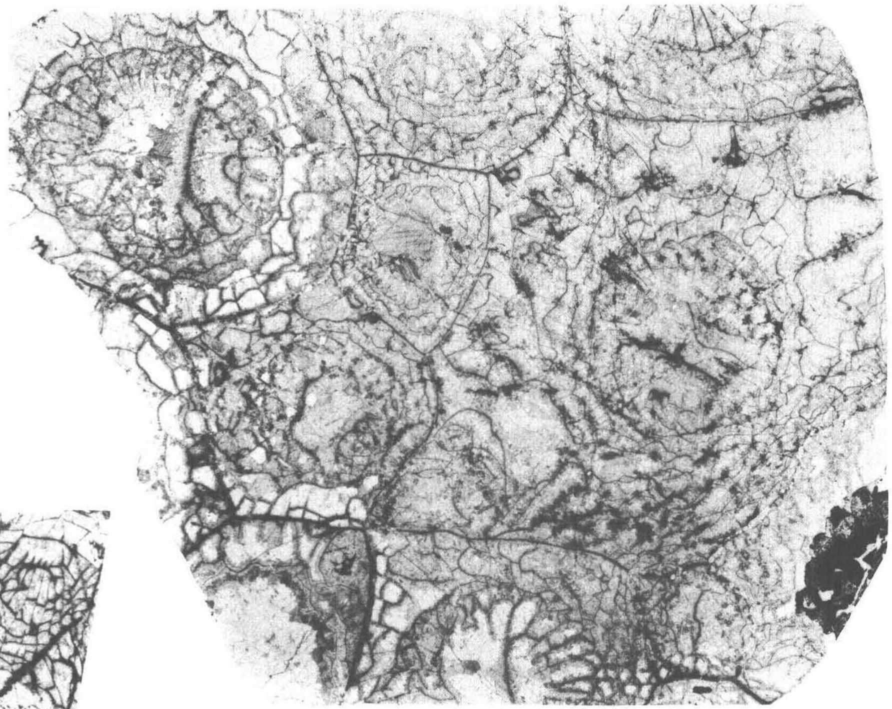

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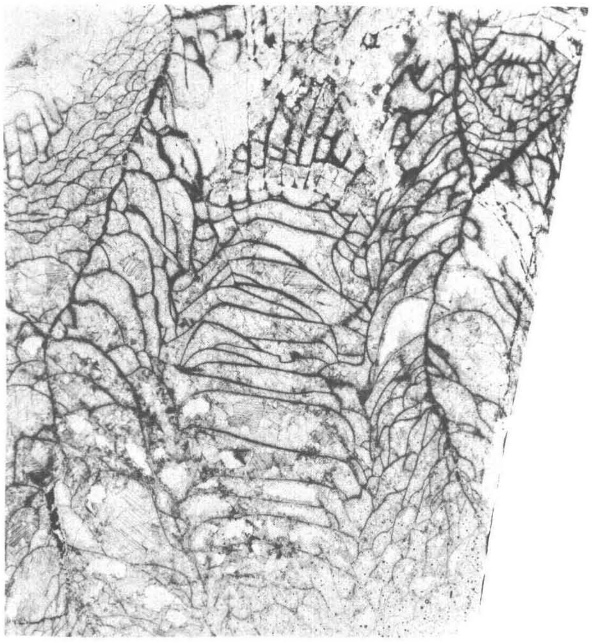

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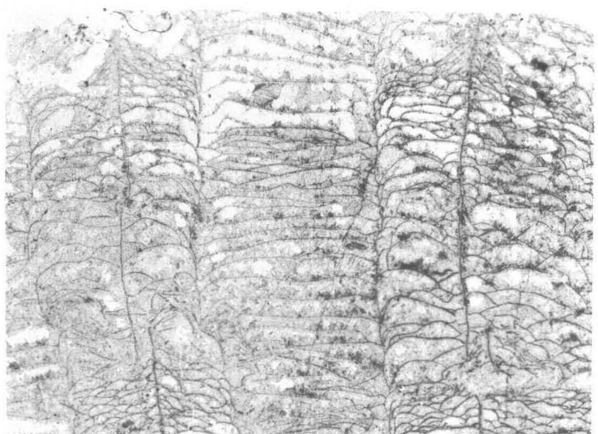

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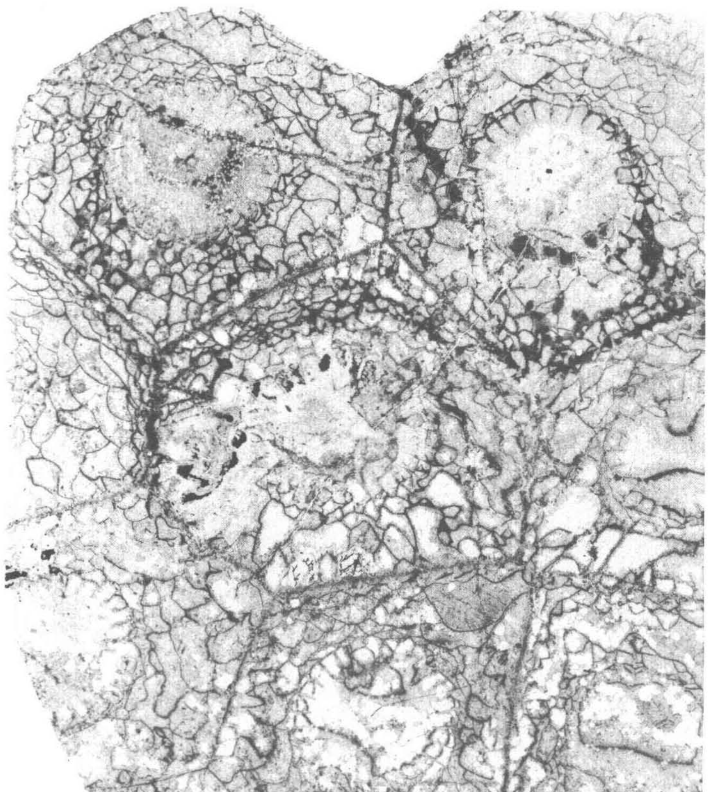

5

THYSANOPHYLLUM ORIENTALE Thomson

PLATE 9

FIGURES 1–6. *Thysanophyllum astraeiforme* (Warren) (p. 28).

1–3. 1, Transverse thin section (× 3); 2, photomicrograph of a tranverse thin section illustrating tabularium wall, major septa, columella, and epitheca (× 25); 3, longitudinal thin section (× 3). USN 161025; 1,200 ft below the top of section 62C–31, Kogruk Formation, DeLong Mountains.

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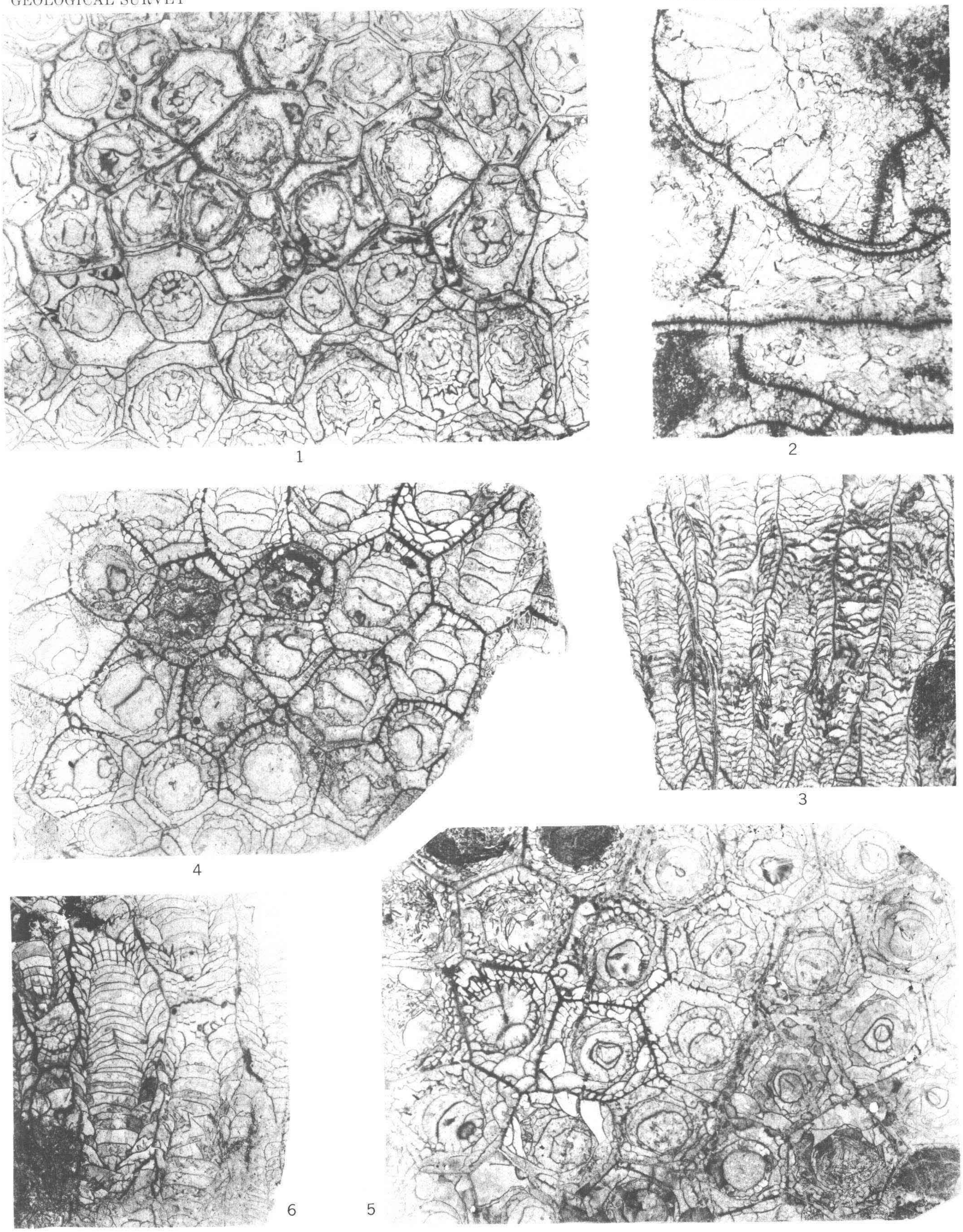

THYSANOPHYLLUM ASTRAEIFORME (Warren)

PLATE 10

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Longitudinal thin section of wall, dissepiments, and septa microstructure preservation. × 25. USNM 161012; 570 ft below the top of section 62C–15, Kogruk Formation, DeLong Mountains. (See pl. 4, figs. 1, 2, for × 3 transverse and longitudinal thin sections of this specimen).

2–6. *Sciophyllum alaskaensis* Armstrong (p. 32).

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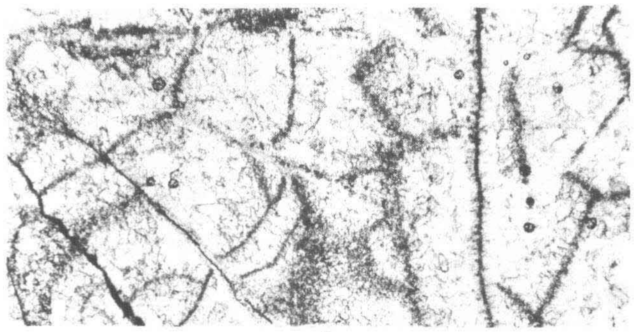
6. Transverse thin section. × 3, USNM 161022; 300 ft below the top of section 62C–15, Kogruk Formation, DeLong Mountains.



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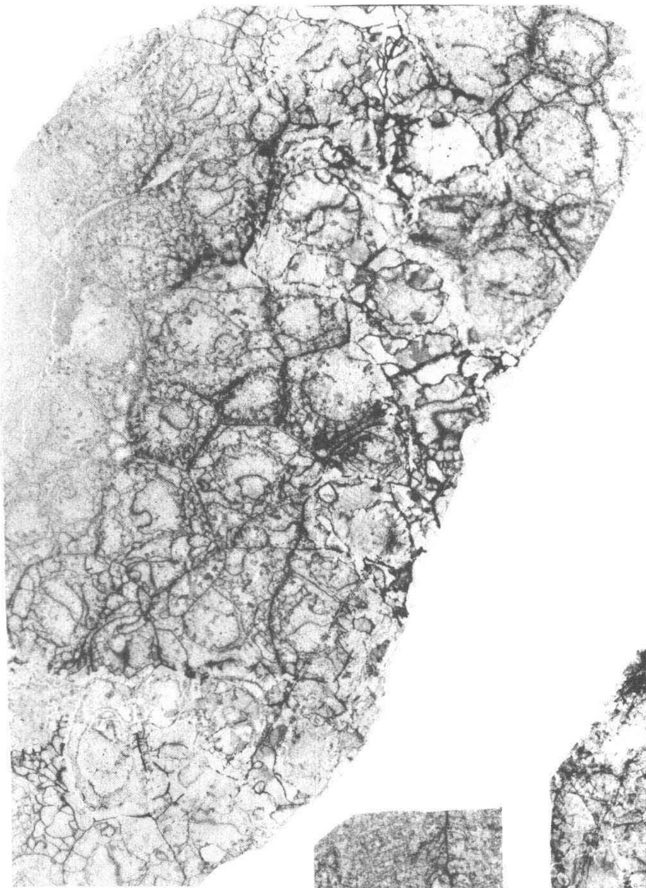

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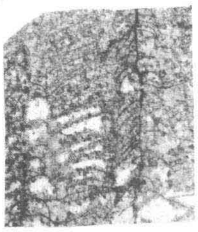

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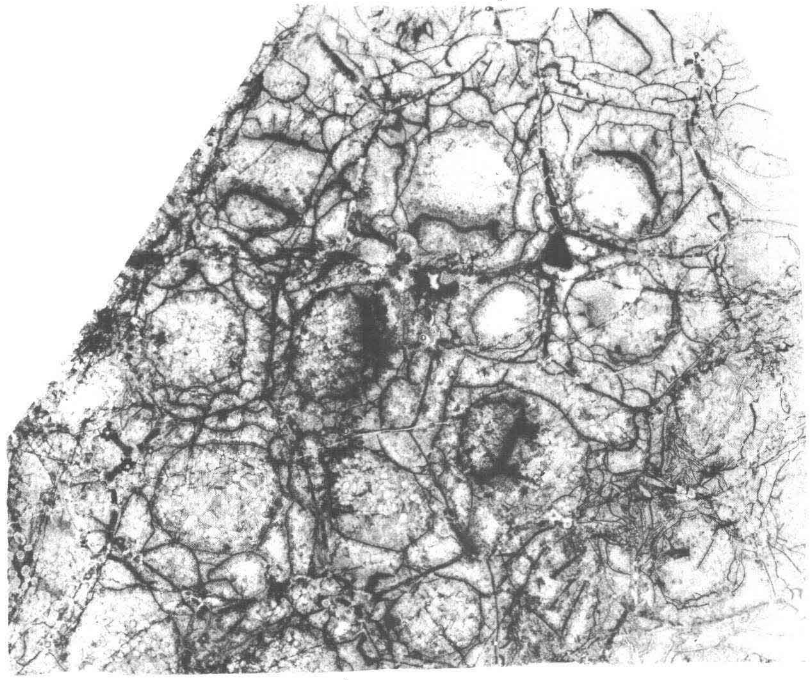

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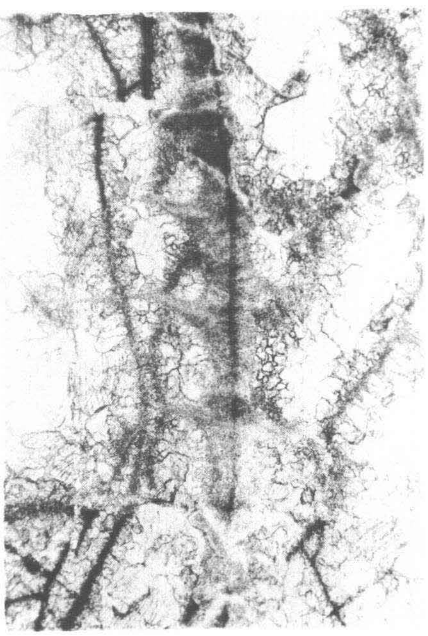

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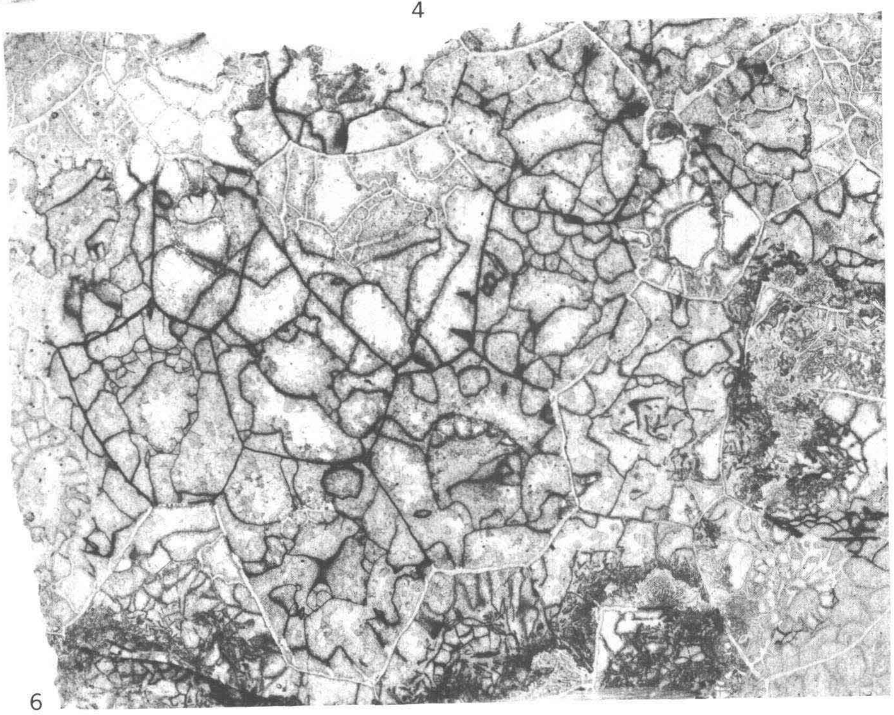


6

LITHOSTROTIONELLA BANFFENSIS (Warren), and *SCIOPHYLLUM ALASKAENSIS* Armstrong

PLATE 11

FIGURES 1–3. *Thysanophyllum* sp. A (p. 30).

1. Photomicrograph of corallite wall in transverse section. × 25.
2. Transverse thin section. × 3.
3. Longitudinal thin section. × 3.

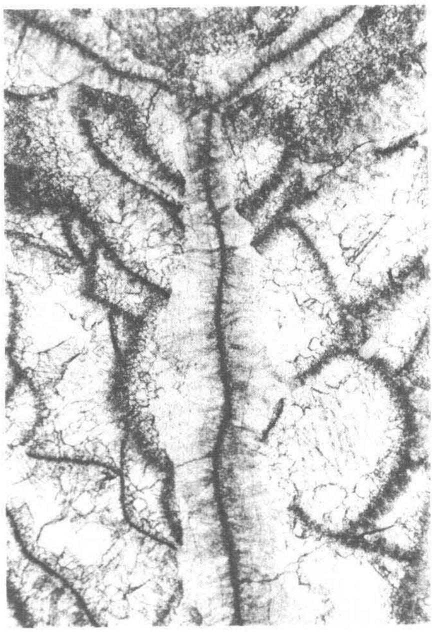
USNM 161006; 520 ft below the top of section 62C–15, Kogruk Formation, DeLong Mountains.

4–7. *Sciophyllum* sp. A (p. 33).

4, 5. Longitudinal thin sections. × 3.

6. Transverse thin section. × 3.
7. Photomicrograph of transverse section of epitheca. × 25.

USNM 161029; upper 50 ft of the lower member of the Nasorak Formation, Cape Thompson.



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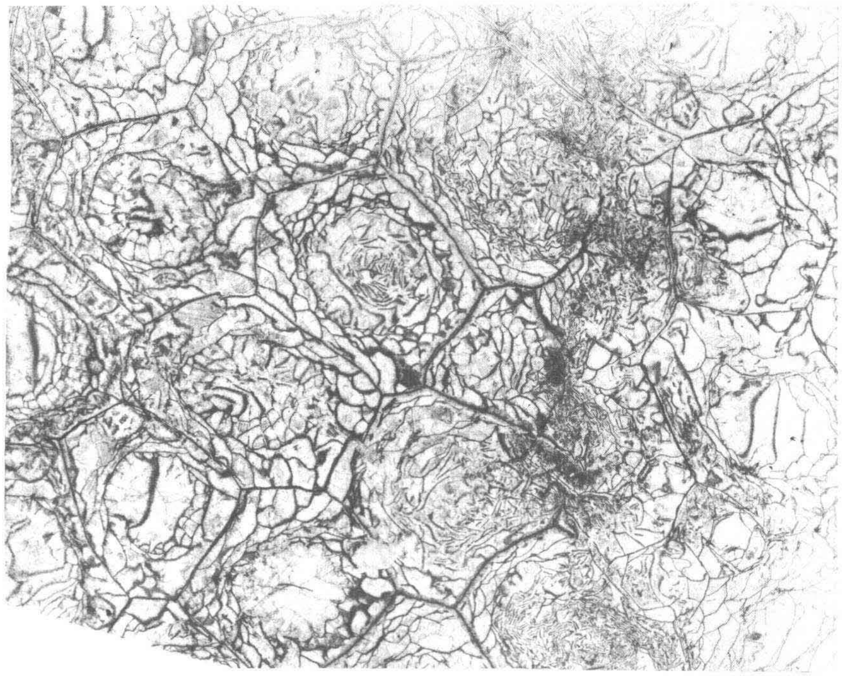

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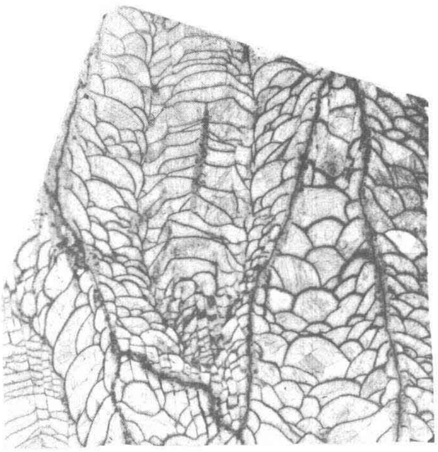

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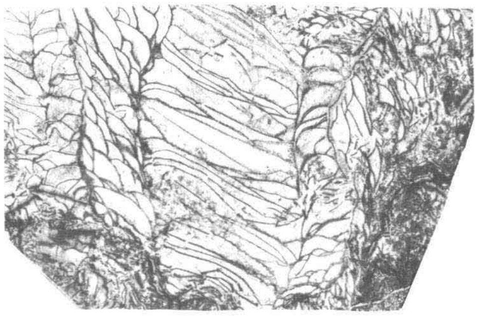

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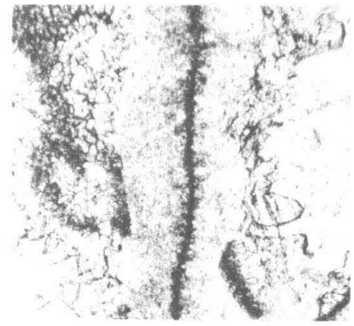

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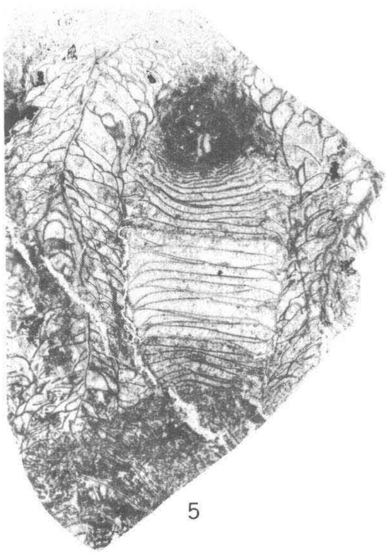

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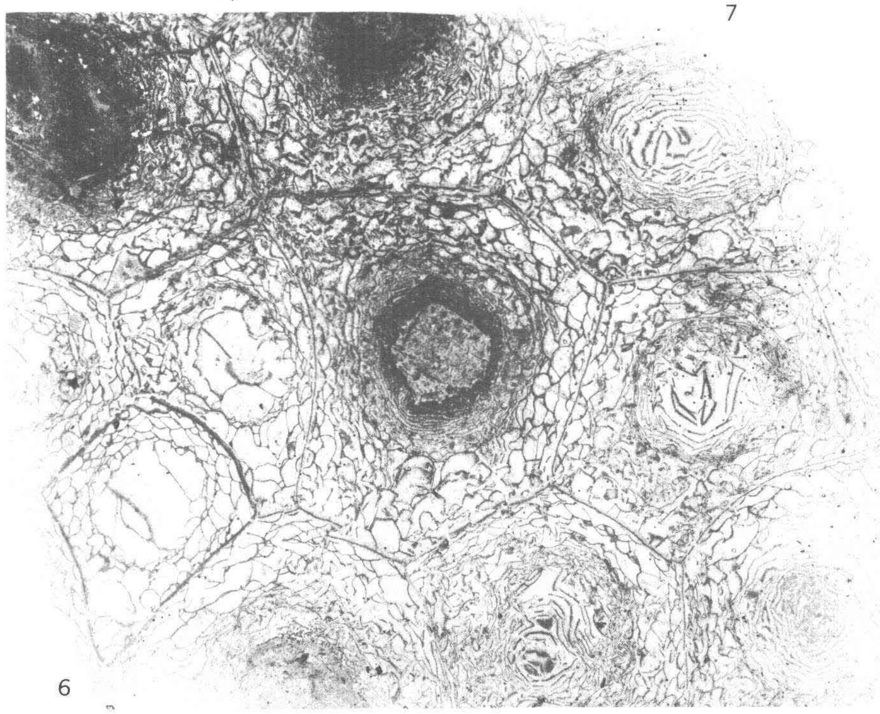


6

THYSANOPHYLLUM sp. A and *SCIOPHYLLUM* sp. A

PLATE 12

FIGURES 1–6. *Lithostrotionella macouni* (Lambe) p. (23).

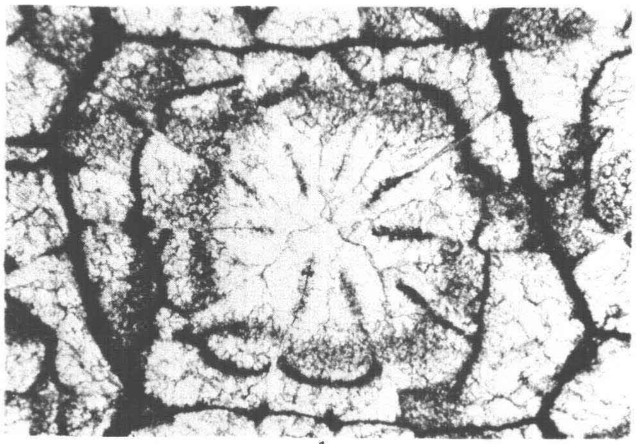
Syntype, Canadian Geologiacl Survey No. 4327, "Fossil Point," Peace River, British Columbia.

1, 2. Transverse thin section (× 25) illustrating microstructure, preservation, and discontinous major septa in dissepimentarium.

3. Longitudinal thin section. × 5.

4. Transverse thin section. × 5.

5, 6. Longitudinal thin section (× 25) illustrating microstructure and preservation.



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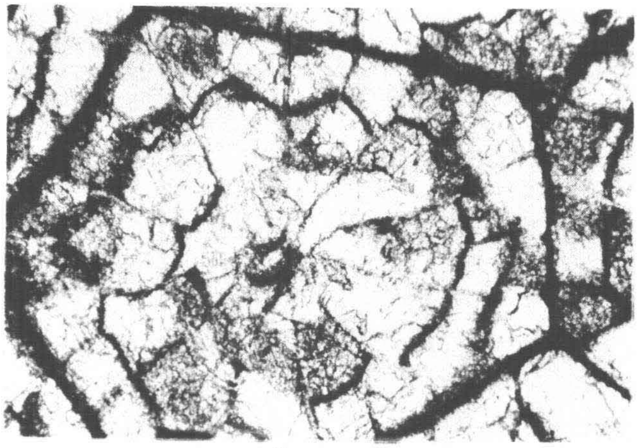

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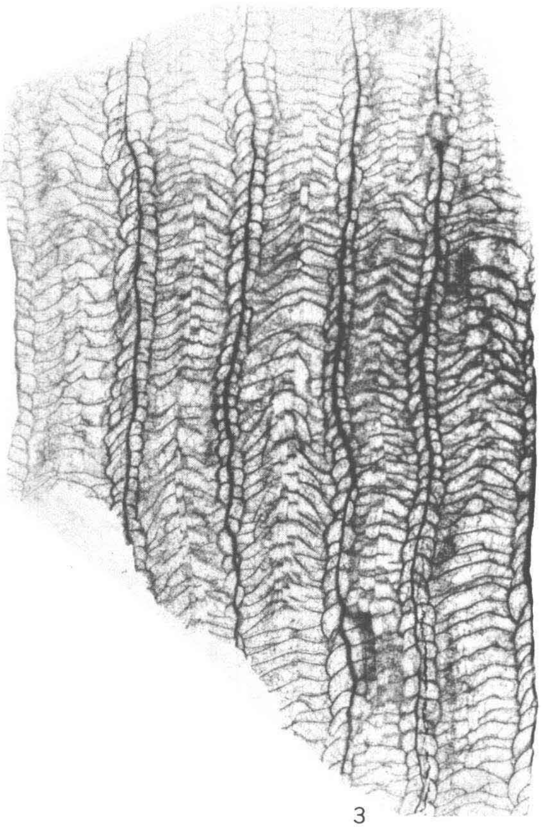

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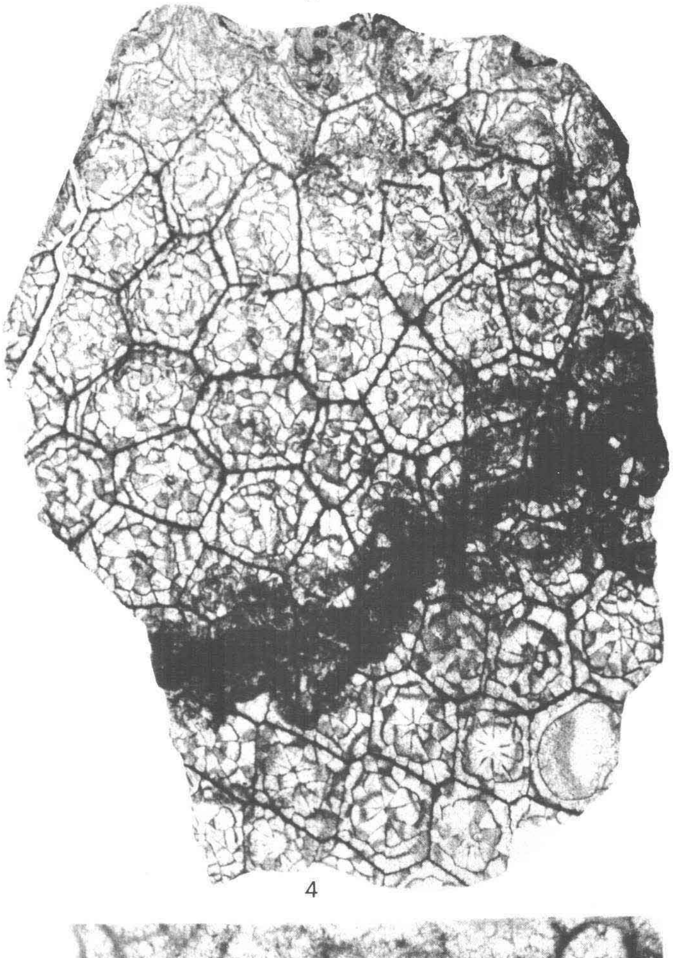

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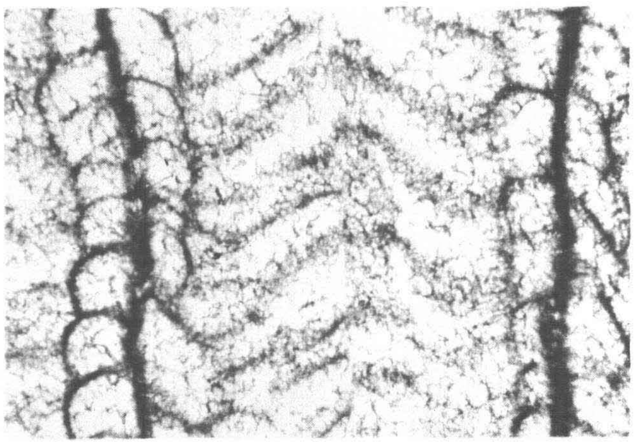

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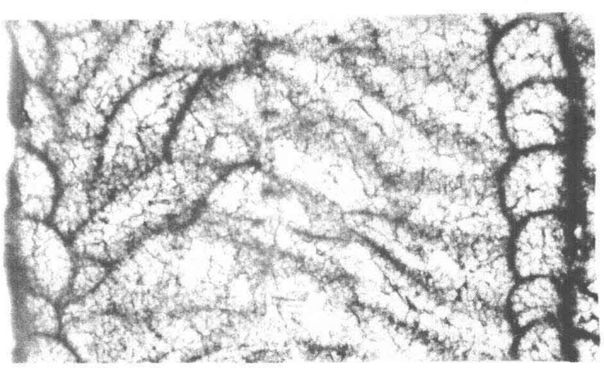

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LITHOSTROTIONELLA MACOUNI (Lambe) syntype

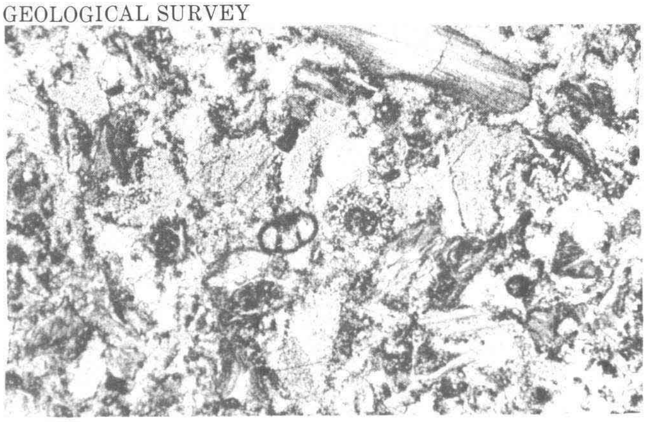
PLATE 13

FIGURES 1–6. Section 62C–15, USGS loc. M1019, Kogruk Formation, DeLong Mountains. (See text fig. 3.)

1. Bryozoan-brachiopod-echinoderm-foraminiferal packstone; most particles are abraded, rounded, and have fair sorting. This carbonate rock type is common in the Kogruk Formation. × 25. 280 ft from top of section.
2. Echinoderm-bryozoan-brachiopod packstone; poorly sorted fossil fragments. Many of the smaller particles are abraded and rounded. This carbonate rock type is very common in the Kogruk Formation. × 25. 520 ft from top of section.
3. Echinoderm-bryozoan-brachiopod packstone; broken and abraded fossil fragments. Some dolomitization of the lime mud; dolomite rhombs range in size from 40 to 80 microns. The dolomite rhombs have generally not affected the fossils but have begun to modify the exterior shape of the pellets. Carbonate rocks with this type of texture are the most abundant within the Kogruk Formation. × 25. 880 ft from the top of section.
4. Echinoderm-bryozoan-foraminiferal packstone; fossil fragments are broken, abraded, and well sorted and are 200–300 microns long. × 25. 1,210 ft below top of section.
5. Algal-echinoderm-bryozoan grainstone; fragments are large, broken, and winnowed. Rock contains abundant fragments of algae of the Solenoporaceae and appears to represent sedimentation in shallow, shoaling water. This carbonate rock type is relatively scarce and is generally found only in the lower 200–300 ft of the Kogruk Formation. × 25. 1,490 ft from top of the section.
6. Bryozoan-foraminiferal-echinoderm ooid grainstone; rounded and sorted fossil fragments have one layer of oolitic coating. Ooid packstones and grainstone of this texture are commonly found in the basal beds of the Kogruk Formation above the Utukok Formation. Environment of deposition is thought to be moderate energy shoaling water. × 25. 1,760 ft from top of section.

7–8. Section 62C–31, USGS loc. M1020, Kogruk Formation, DeLong Mountains. (See text fig. 5.)

7. Bryozoan-foraminiferal-echinoderm ooid packstones to grainstone; rounded and sorted fossil fragments have one layer of oolitic coating. Deposition is believed to be in a shoaling-water environment. × 25. 330 ft from top of section.
8. Bryozoan-echinoderm-foraminiferal packstone; fair to poor sorting, some hard pellets. A typical Kogruk carbonate rock type with initial phase of dolomitization characterized by scattered dolomite rhombs which range in size from 40 to 60 microns. × 25. 980 ft below top of section.



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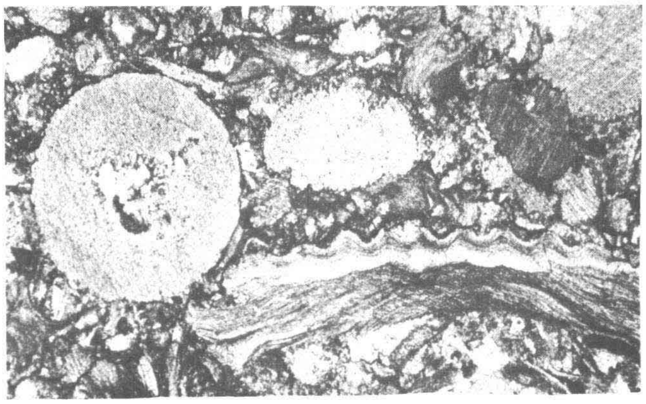

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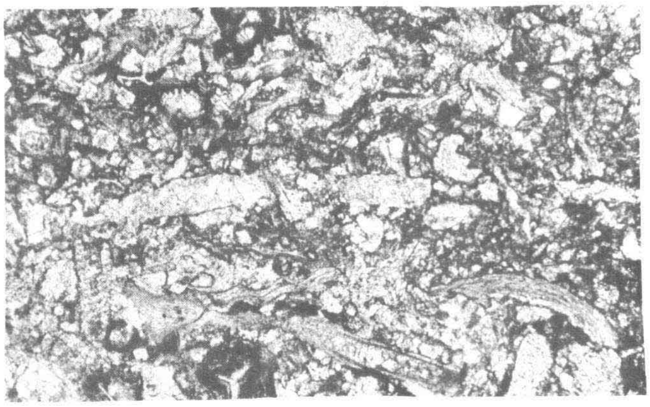

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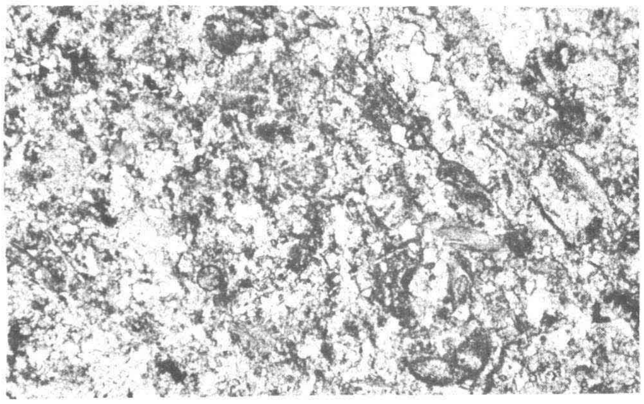

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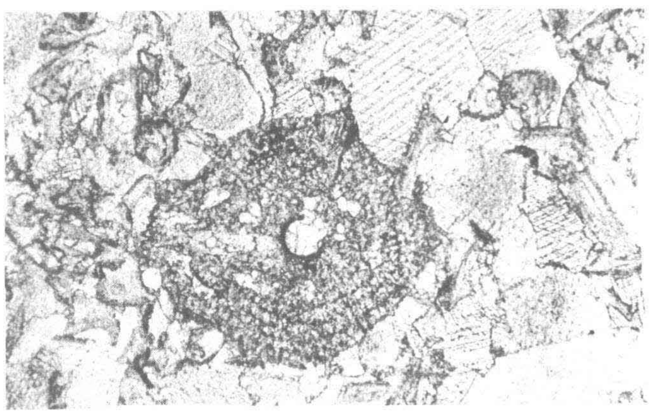

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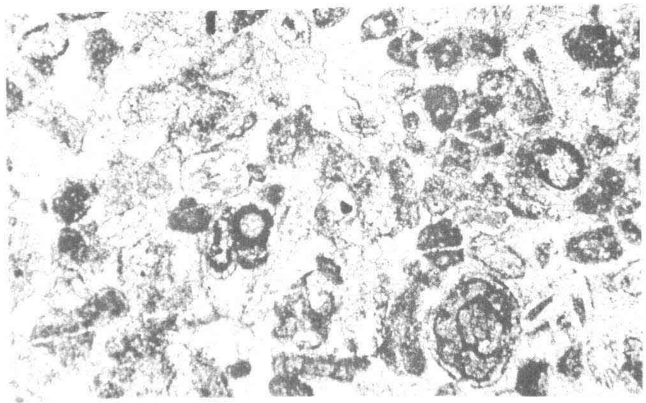

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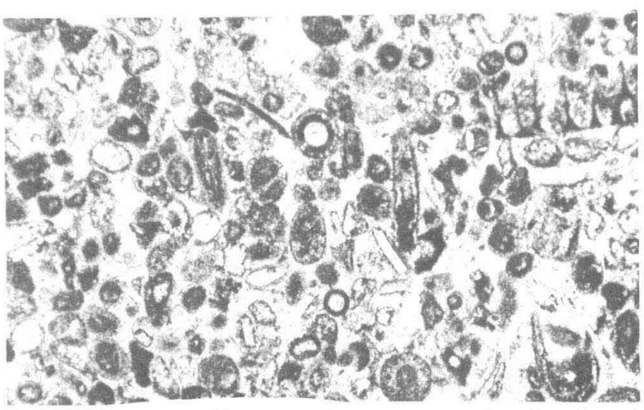

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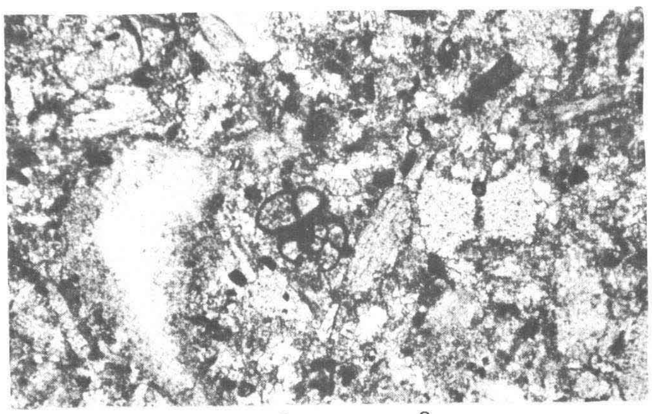

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Photomicrographs of carbonate rock types, sections 62C-15, 62C-31.

PLATE 14

FIGURES 1–3. Section 62C–31, USGS loc. M1020, Kogruk Formation, DeLong Mountains. (See text fig. 5.)

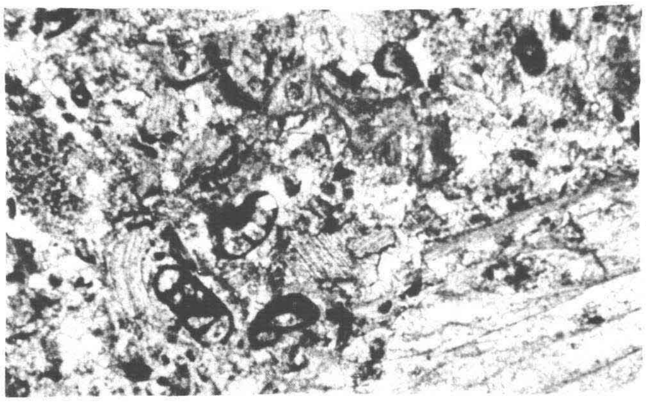
1. Bryozoan-echinoderm-foraminiferal packstone with broken, abraded, poorly sorted fossil fragments. × 25. 1,390 ft from top of section.
2. Lime mudstone to bryozoan-echinoderm wackestone. The lime mudstone is affected in part by calcite neomorphism which has formed crystals of microspar calcite that range in size from 50 to 100 microns. × 25. 1,680 ft from top of section.
3. Bryozoan-echinoderm-pelletoid packstone. Fair to poor sorting of broken and abraded fossil fragments. Much of the lime mud has undergone calcite neomorphism to form microspar calcite between the fossil fragments. × 25. 1,820 ft from top of section.

4–6. Section 60A–400—403, USGS loc. M1021, Kogruk Formation, DeLong Mountains. (See text fig. 7.)

4. Bryozoan-echinoderm packstone; broken and abraded fossil fragments. × 25. 31 ft from top of section.
5. Foraminiferal-echinoderm wackestone. × 25. 330 ft from top of section.
6. Foraminifera-bryozoan-echinoderm wackestone to packstone. Rock has initial phase of dolomitization and is composed of less than 5 percent dolomite. The dolomite rhombs are 50 microns in size. 1,680 ft below top of section.

7–8. Section 62C–34, USGS loc. M1022, Kogruk Formation, Lisburne Hills. (See text fig. 9.)

7. Coarse-grained bryozoan-echinoderm grainstone × 25. 50 ft from top of the section.
8. Oolite-echinoderm-formainiferal packstone to wackestone. × 25. 270 ft from top of section.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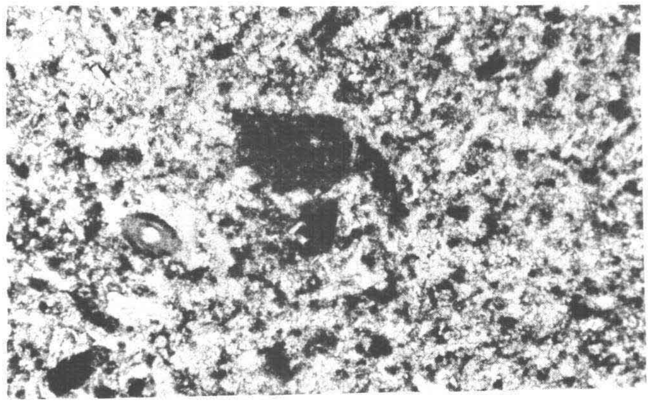
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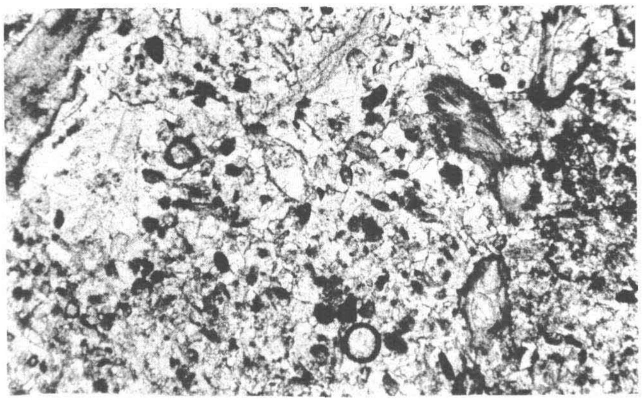
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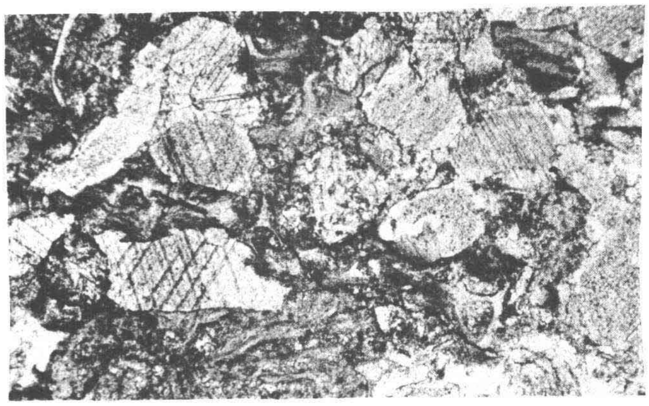
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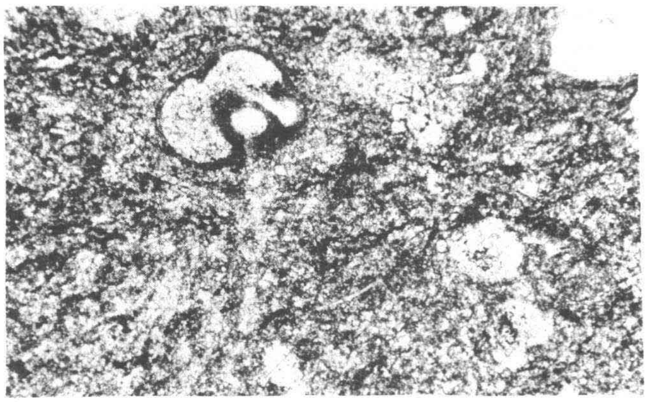
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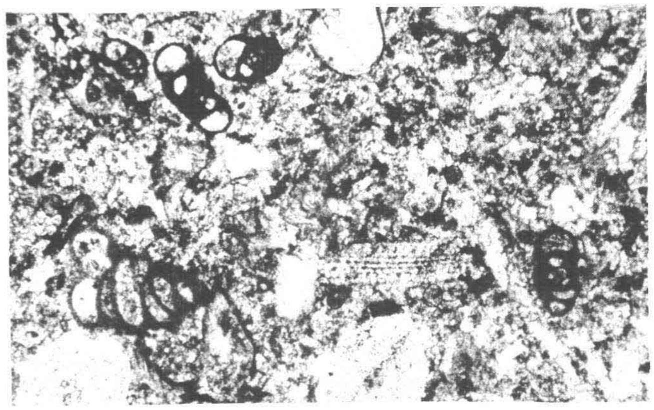
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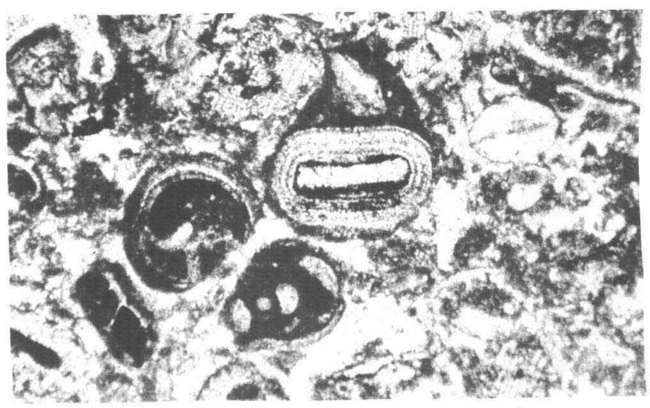
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Photomicrographs of carbonate rock types, sections 62C-31, 60A-400–403, 62C-34.