Biostratigraphy of Mississippian Lithostrotionoid Corals, Lisburne Group, Arctic Alaska

GEOLOGICAL SURVEY PROFESSIONAL PAPER 743-A

BIOSTRATIGRAPHY OF MISSISSIPPIAN LITHOSTROTIONOID CORALS, LISBURNE GROUP, ARCTIC ALASKA

FRONTISPIECE.—Panoramic view to the east, south of Cape Lewis, showing the outcrop of the south Cape Lewis section, 68A–9.

Biostratigraphy of Mississippian Lithostrotionoid Corals, Lisburne Group, Arctic Alaska

By AUGUSTUS K. ARMSTRONG

CONTRIBUTIONS TO PALEONTOLOGY

GEOLOGICAL SURVEY PROFESSIONAL PAPER 743-A

Systematic paleontologic studies of five new species of lithostrotionoid corals from described sections of the Lisburne Group

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1972

UNITED STATES DEPARTMENT OF THE INTERIOR

ROGERS C. B. MORTON, *Secretary*

GEOLOGICAL SURVEY

V. E. McKelvey, *Director*

Library of Congress catalog-card No. 77-188160

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 70 cents (paper cover)
Stock Number 2401-2091

CONTENTS

ILLUSTRATIONS

[Plates follow index]

BIOSTRATIGRAPHY OF MISSISSIPPIAN LITHOSTROTIONOID CORALS, LISBURNE GROUP, ARCTIC ALASKA

By AUGUSTUS K. ARMSTRONG

ABSTRACT

The biostratigraphy of four measured sections of the Lisburne Group is described: South Cape Lewis section, north Niak Creek section, and south Niak Creek section, all in northwestern Alaska; and the west Sadlerochit Mountains section, in northeastern Alaska. In addition, one new species of coral is described from the well-documented Shainin Lake section, in north-central Alaska.

Within the Lisburne Group carbonate rocks, lithostrotionoid corals are known only in Meramec age or younger beds. They are represented by 16 taxa and abundant individuals in strata of Meramec and very earliest Chester age, but they are rare in beds younger than earliest Chester. Middle and late Chester age beds contain only three taxa of lithostrotionoid corals.

Five new species of lithostrotionoid corals are described from the Mississippian part of the Lisburne Group: *Lithostrotionella niakensis* n. sp. and *Lithostrotion* (*Siphonodendron*) *dutroi* n. sp. from middle Meramec age beds, *Lithostrotion* (*Siphonodendron*) *lisburnensis* n. sp. and *Diphyphyllum nasorakensis* n. sp. from late Meramec and earliest Chester age beds, and *Lithostrotion* (*Siphonodendron*) *ignekensis* n. sp. from middle and late Chester age beds.

INTRODUCTION

The most conspicuous macrofaunal elements in much of the Lisburne Group carbonate rocks are the large colonial corals. The primary objective of this study is to describe five new species of lithostrotionoid corals and their stratigraphic ranges.

The system of microfossil assemblage zones developed by Bernard L. Mamet has been applied to the Lisburne Group of arctic Alaska in a series of papers (Armstrong and others, 1970, 1971; Armstrong and Mamet, 1970). The use of these zones has permitted detailed correlation among the surface sections of the Lisburne Group shown in figure 1 and between the Carboniferous type sections of Eurasia and North America (fig. 2).

Most of the corals appear to have stratigraphic ranges that extend through two or more microfossil zones. Plotting the stratigraphic distribution of the lithostrotionoid corals on the microfossil zones chart shows the vertical distribution of the lithostrotionoid corals within the Lisburne Group.

Armstrong's (1970b) study described the biostratigraphy and the lithostrotionoid corals from the Meramec age parts (zones 13–15) of Sable and Dutro's (1961) Kogruk Formation of the DeLong Mountains and Campbell's (1967) Nasorak Formation of the Cape Thompson area. The following taxa were reported: *Lithostrotion (Siphonodendron) sinuosum* (Kelly), *L. (S.) warreni* Nelson, *Lithostrotion (Siphonodendron)* sp. A, *Lithostrotionella banffensis* (Warren), *L.* aff. *L. banffensis* (Warren), *L. birdi* Armstrong, *L. mclareni* (Sutherland), *Lithostrotionella* sp. A, *Lithostrotionella* sp. B, *Thysanophyllum orientale* Thomson, *T. astraeiforme* (Warren), *Thysanophyllum* sp. A, *Sciophyllum lambarti* Harker and McLaren, *S. alaskaensis* Armstrong, and *Sciophyllum* sp. A.

The corals from the Lisburne Hills seacliffs were collected by J. Thomas Dutro, Jr., and myself in July and August 1968. I thank Irvin L. Tailleur, the 1968 field party chief, and Hillard N. Reiser, the 1969 field party chief, for their support of paleontologic and stratigraphic field studies and their stimulating discussions of regional geology and structural and stratigraphic problems.

I also thank the Naval Arctic Research Laboratory (Barrow), Office of Naval Research, for their support of my field activities.

I am most grateful to Dr. Bernard L. Mamet, University of Montreal, for his studies of the microfossils in the carbonate rock thin sections and for his age determinations of the stratigraphic sections.

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

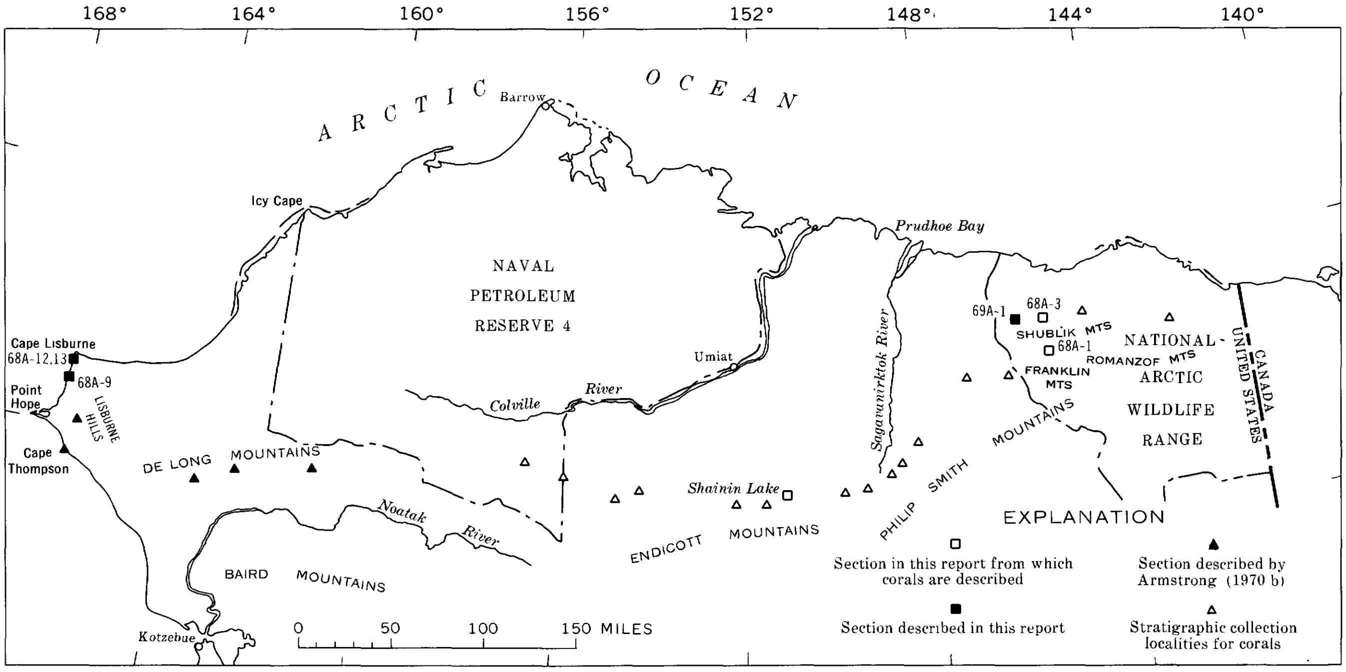


FIGURE 1.—Index map of northern Alaska, showing location of coral collections and stratigraphic sections described and illustrated in this report.

Special thanks are given J. Thomas Dutro, Jr., W. A. Oliver, Jr., and W. J. Sando for their help during preparation of the manuscript and their critical review of the manuscript.

STRATIGRAPHIC SECTIONS

The five new species of lithostrotionoid corals described in this report are from five measured sections of the Lisburne Group (fig. 1). Three sections are in northwestern Alaska: south Cape Lewis, 68A–9; south Niak Creek, 68A–13; and north Niak Creek, 68A–12. The west Sadlerochit Mountains section, 69A–1, is in the Sadlerochit Mountains, northeastern Brooks Range, northeastern Alaska. Bowsher and Dutro's (1957) well-documented Shainin Lake section, central Brooks Range, which yields *Lithostrotion (Siphonodendron) dutroi* n. sp., is not illustrated in this report. All these sections have been carefully sampled for microfossils. The stratigraphic ranges of the new species of corals are plotted with respect to the microfossil assemblage zones in figure 2. The microfaunal assemblage zones are also shown on the illustrations of the stratigraphic sections.

NORTH NIAK CREEK SECTION

The extensively dolomitized carbonate rocks of the Kogruk Formation, of Meramec age, were studied in the seacliff exposures at the north Niak Creek section, 68A–12 (fig. 3). This section, north of Niak Creek, appears to be an allochthonous, rootless thrust sheet and is an incomplete exposure of the Kogruk Formation. The base and top of the section are delineated by fault zones. The lower 25 feet of the section is characterized by an argillaceous dark-gray limestone which contains abundant Foraminifera and lithostrotionoid corals (fig. 4). Corals are present sporadically between 480 and 625 feet from the top of the section, but specific identification is impossible owing to the poor preservation resulting from the extensive dolomitization and from the silicification of the coralla and their internal structures.

SOUTH NIAK CREEK SECTION

The south Niak Creek section 68A–13 (fig. 3), appears to be in an allochthonous thrust sheet overriding the allochthonous carbonate rocks of section 68A–12 (Armstrong and others, 1971, fig. 9). This section, south of Niak Creek, is incomplete because of faulting. It is 215 feet thick and is a partial representation of the lower part of the Nasorak Formation. The rocks are dark-gray shale and argillaceous limestone that contain an abundant lithostrotionoid coral fauna (figs. 5, 6). The microfossils (Armstrong and others, 1971) indicate that the rocks are at the top of zone 15, very near the Meramec-Chester boundary.

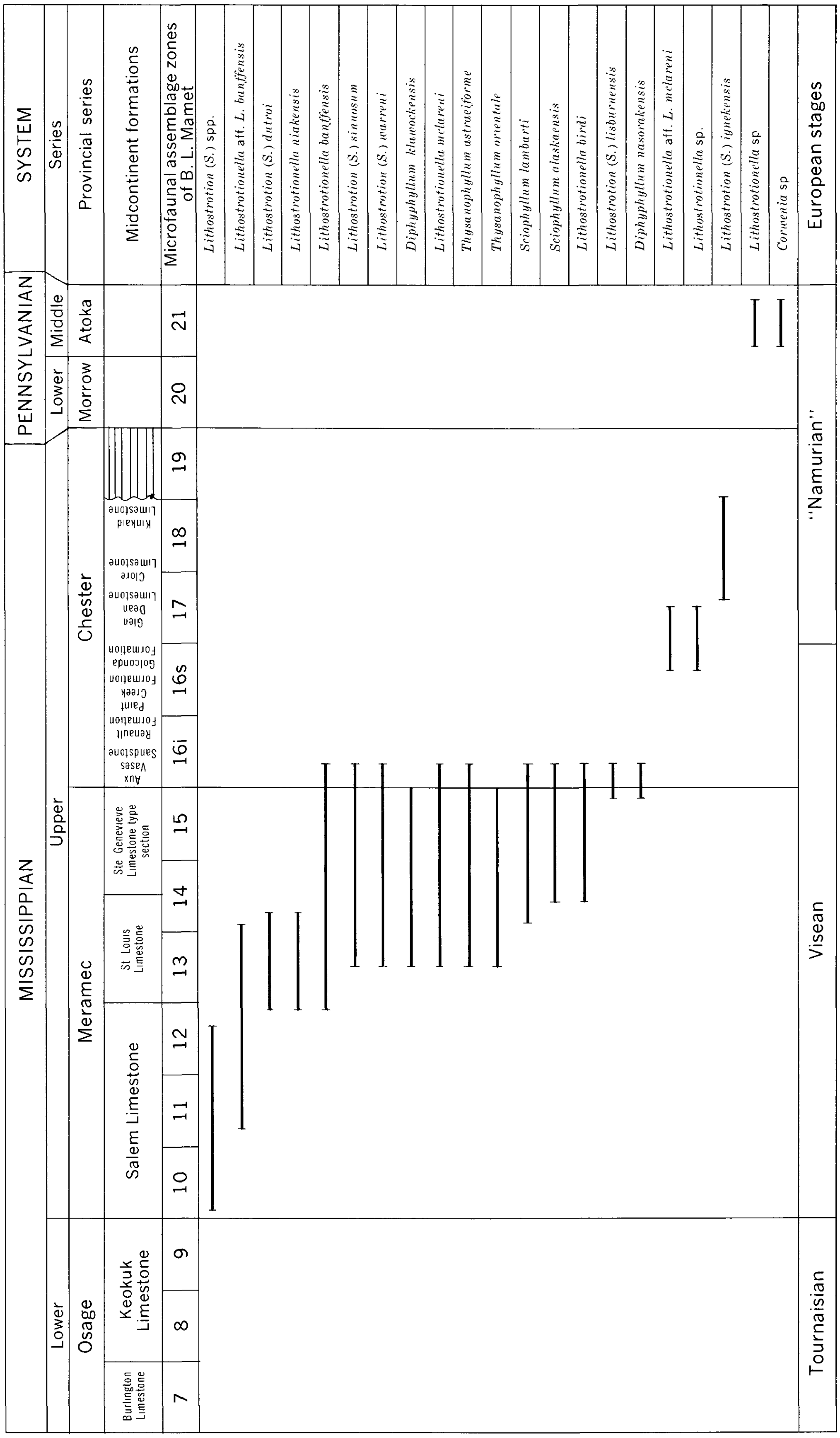


FIGURE 2.—Stratigraphic distribution of colonial rugose corals, Lisburne Group, Brooks Range and Lisburne Hills, arctic Alaska.

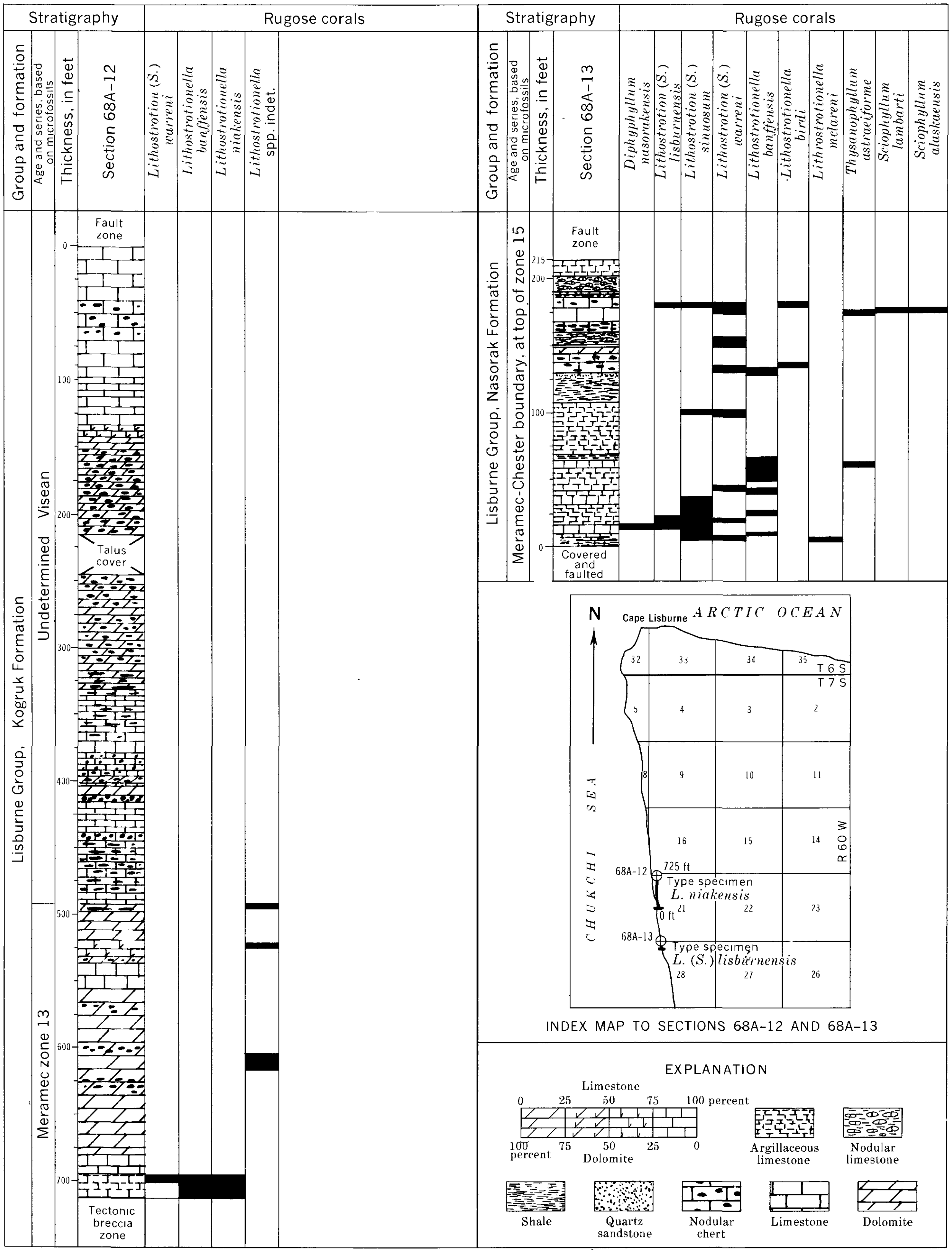


FIGURE 3.—Stratigraphy and coral distribution in the north Niak Creek section, 68A-12, and the south Niak Creek section, 68A-13. Note that section 68A-12 was measured down from the top; 68A-13, up from the bottom.

FIGURE 4.—Lithostrotionoid coral colonies (shown by arrows) at the base of section 68A–12, north of Niak Creek. The bedding surface and the sides of the bed contain numerous coralla. Although coralla are very abundant, only three species of colonial rugose corals are present. (See fig. 3.) Below the 715-foot level is a thick zone of tectonic breccia.

SOUTH CAPE LEWIS SECTION

The south Cape Lewis section, 68A–9 (figs. 7, 8), is also in an allochthonous thrust sheet. The section is magnificently exposed south of Cape Lewis in a series of seacliffs (frontispiece; fig. 9). The lower 1,280 feet of the section is the Nasorak Formation (Chester, zone 16i age) and is composed of dark-gray shale, argillaceous limestone, and cherty limestone. In figures 7 and 9 the dark-gray shale is evident from 0 to 230 feet and from 350 to 650 feet above the base. Corals are abundant from 50 to 325 feet above the base. The fasciculate corals *Lithostrotion (Siphonodendron)* spp. and *Syringopora* spp. are particularly abundant and are the major constituent of many horizons (fig. 10). Fasciculate and cerioid corals form a biostromal bed and possibly also a patch reef that is well exposed at 880–900 feet above the base (fig. 11). Large cerioid coralla which average 1.5–3 feet in diameter are abundant (fig. 12). The location of the biostromal bed and the stratigraphic footage from 900 to 1,500 feet are shown in figure 11.

WEST SADLEROCHIT MOUNTAINS SECTION

The west Sadlerochit Mountains section, 69A–1 (figs. 13, 14), on the west end of the Sadlerochit Mountains in northeastern Alaska, was measured in

FIGURE 5.—Base of section 68A–13; numbers refer to stratigraphic thickness. Beds between 5 and 65 feet contain abundant large coralla. In the foreground is Niak Creek crossing the beach gravel; view is to the south.

beds that are autochthonous. The section comprises the Alapah Limestone, of Late Mississippian age, and the Wahoo Limestone, of Pennsylvanian age in this area (fig. 15). The carbonate rocks range in composition from oolitic limestone and lime mudstone to dolomite and range in age from Chester (zone 16i) to Atoka (zone 21). In general, corals are rare in these carbonates; within Chester age sediments, colonial rugose corals are found only at 1,110–1,120 feet above the base (fig. 15).

BIOSTRATIGRAPHIC DISTRIBUTION OF LISBURNE GROUP LITHOSTROTIONOID CORALS

The stratigraphic distribution of the lithostrotionoid corals from the Lisburne Group (fig. 2) is based on material collected from 27 measured sections (fig. 1). The sections were measured with a jacob staff, and lithologic samples were collected every 5 to 10 feet for petrographic and foraminiferal studies (Armstrong and others, 1970, 1971; Armstrong and Mamet, 1970). Bernard L. Mamet has established microfossil zones for each of these stratigraphic sections.

The known vertical stratigraphic distribution of the lithostrotionoid corals is shown in figure 2 on a geologic time scale based on Mamet's microfossil assemblage zones. Lithostrotionoid corals are not known in pre-Meramec age rocks of the Lisburne Group. On the basis of microfossils, Armstrong, Mamet, and Dutro (1970) reported that the oldest known carbonates in the central and eastern Brooks Range are early Keokuk, Osage age (zone 8), and Mamet (oral commun., 1970) reported that the oldest known carbonates in the Kogruk Formation of the DeLong Mountains are also Osage (zone 8). Present knowledge indicates that carbonate deposition in the Lisburne Group began after the decline and extinction of the widespread Cordilleran lithostrotionoid coral fauna of late Kinderhook and earliest Osage age (zone 7) consisting of *Lithostrotionella microstylum* (White), *L. micra* Kelly, and *L. lochmanae* Armstrong. An abundant and widespread coral assemblage developed in the Lisburne carbonate facies during latest early, middle, and late Meramec time and very earliest Chester time (top of zone 12 through lower part of zone 16i). The lithostrotionoids then declined markedly in earliest Chester time (zone 16i).

Stratigraphic and taxonomic studies of the lithostrotionoid corals from the Lisburne Group indicate that none of the species of the 12 taxa shown in figure 2, which are characteristic of the late Meramec age carbonates, persist very far stratigraphically into zone 16i of early Chester. Furthermore, in the Chester no great number of new species or numbers of individuals replace the Meramec corals. The thick sequence of Chester age carbonates in the region from Itkillik River east to the Sadlerochit Mountains (Armstrong and others, 1970) contains very few colonial rugose corals. A relatively rare coral species in these Chester age beds is *Lithostrotion (Siphonodendron) ignekensis* n. sp., from zones 17 and 18 of the Alapah Limestone in the Sadlerochit Mountains. At Cape Lewis, the very poorly preserved colonial rugose corals found in zones 16s and 17, in the Chester age beds, appear to be two new rather rare species of *Lithostrotionella* (Armstrong and others, 1971).

The abrupt and spectacular decline (fig. 2) of the Lisburne Group lithostrotionoid corals in the upper part of zone 15 and the lowest part of zone 16i probably represents a shift in ecological conditions in latest Meramec time over a large part of arctic Alaska. The open-marine carbonate facies of zones 14 and 15 of the Kogruk Limestone in the western Brooks Range and of the Alapah Limestone in the

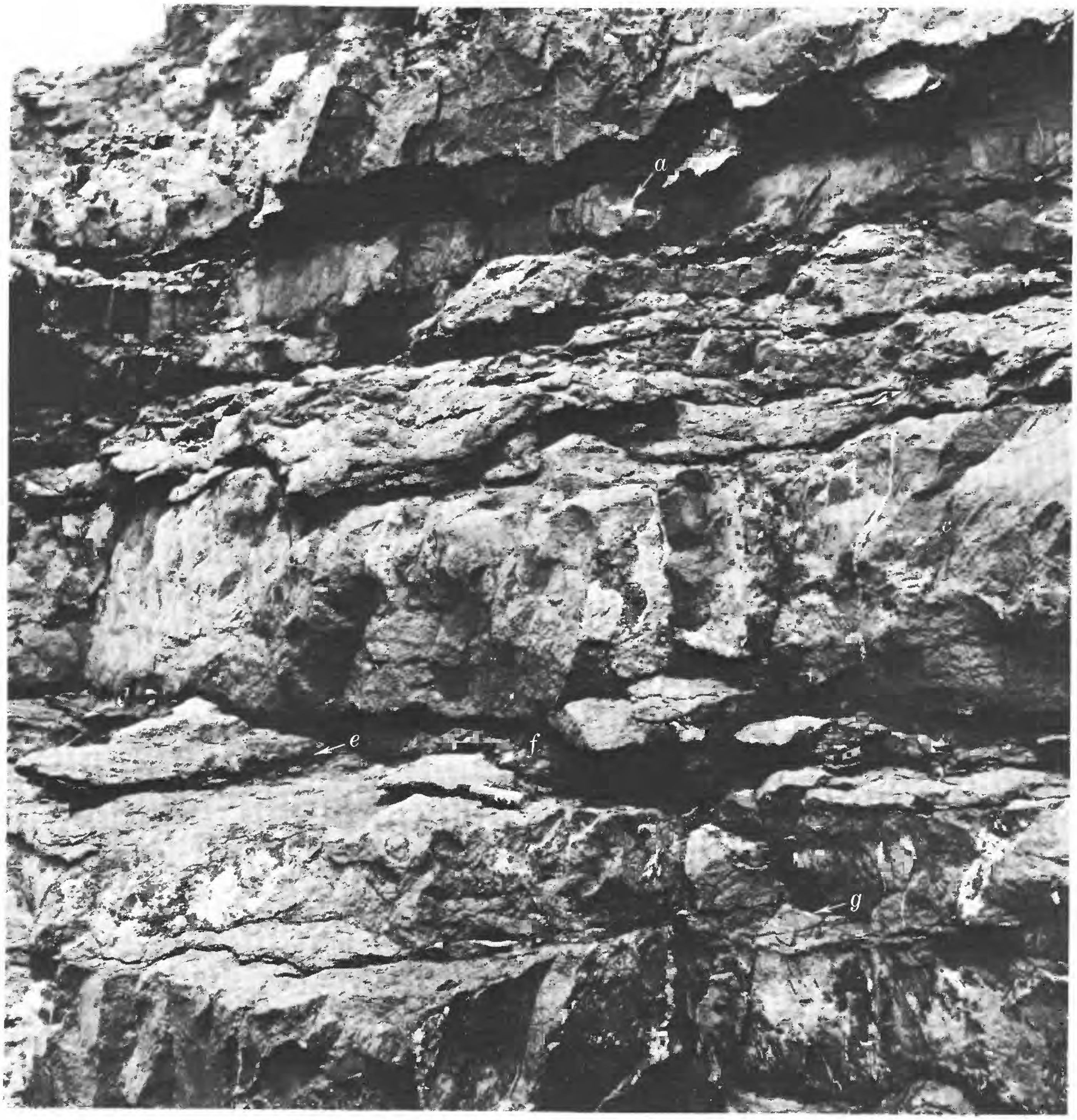


FIGURE 6.—Lithostrotionoid biostrome in section 68A–13. Letters *a* and *g* are colonies of *Lithostrotionella*; *b* is a biostromal zone, 6 inches to 2 feet thick, of *Lithostrotion* (*Siphonodendron*) *sinuosum* and *L.* (*S.*) *warreni*; *c*, *d*, *e*, and *f* are colonies of *L.* (*S.*) *lisburnensis*. The biostrome is approximately 140–146 feet above the base of the section.

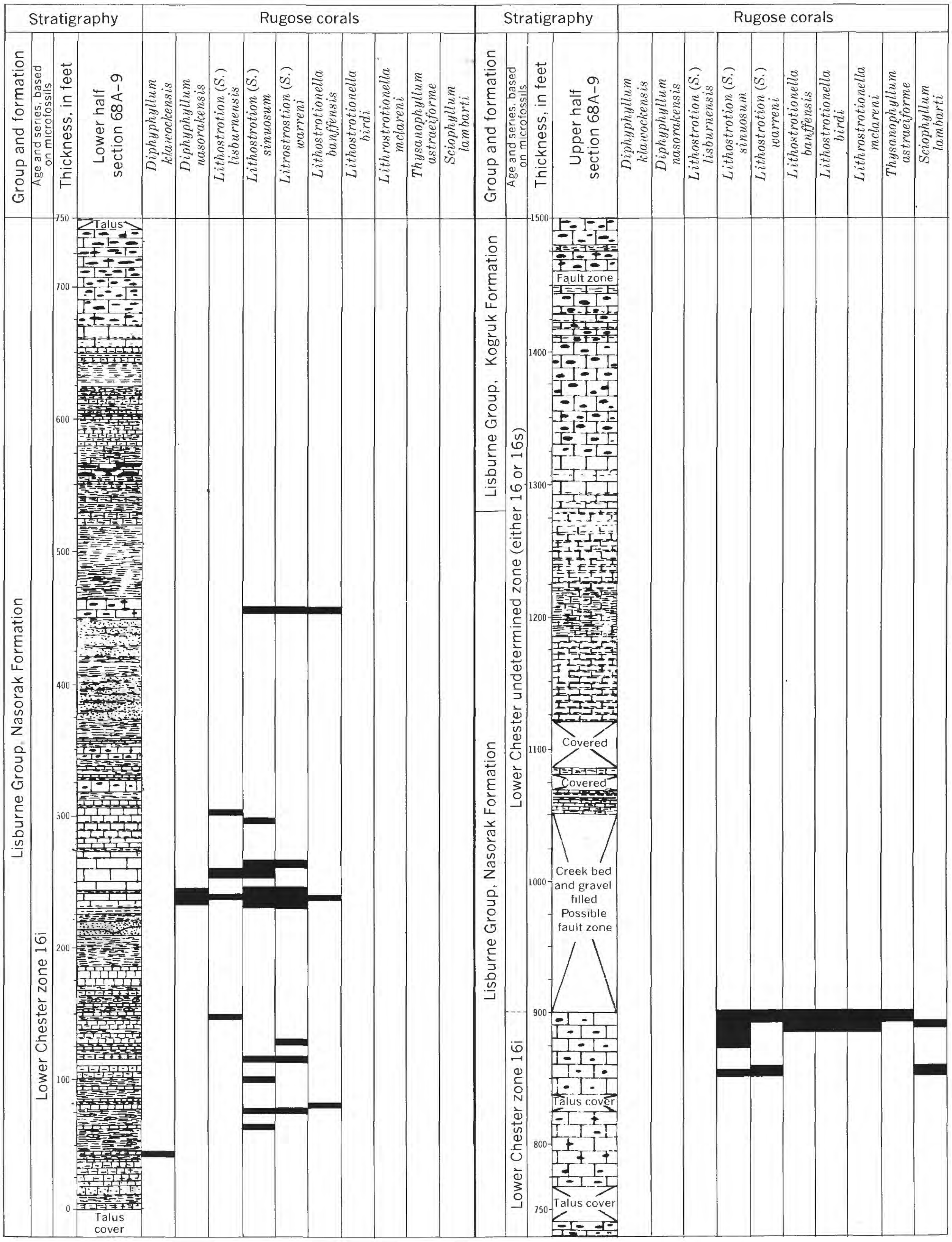


FIGURE 7.—Stratigraphy and coral distribution in the south Cape Lewis section, 68A–9.

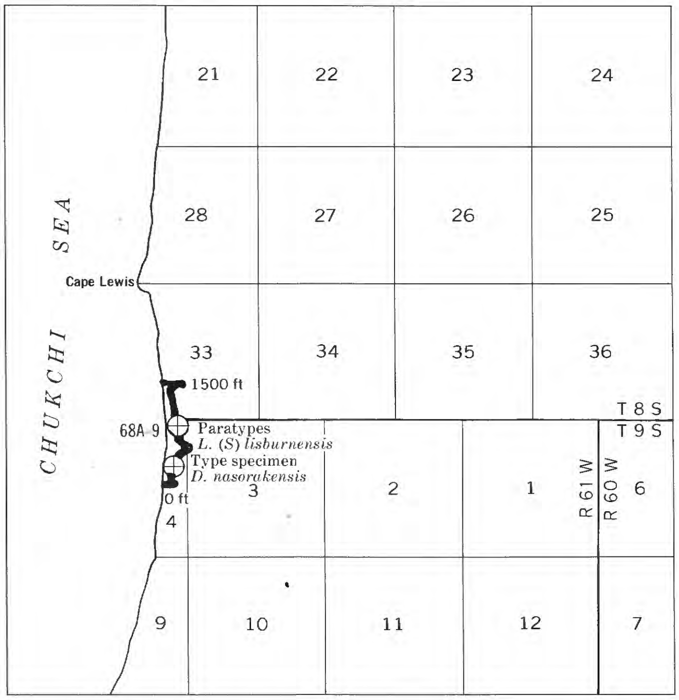


FIGURE 8.—Index map of section 68A–9 and location of type specimen of *Diphyphyllum nasorakensis* and paratypes of *Lithostrotion* (*Siphonodendron*) *lisburnensis*. See figures 9 and 11 for photographs of the outcrops and for locations of the fossils.

central eastern Brooks Range contains abundant lithostrotionoid corals, but corals are rare in essentially similar carbonate facies of the upper part of zone 16i and above.

The factors which caused the decline of the lithostrotionoid corals at or slightly above the Meramec-Chester boundary are not known. No sudden change in environment of deposition is portrayed in the carbonate rock types across this boundary. The Chester age Lisburne carbonate beds are primarily crinoid-bryozoan packstones and wackestones and lime mudstones and are lithologically similar to the underlying coral-rich Meramec age beds. These Meramec and Chester age beds are supposedly facies equivalents and represent similar environments. I provisionally suggest that subtle changes in the regional temperature and (or) salinity of the water altered conditions for lithostrotionoid coral growth and development but did not markedly change the living conditions required for prolific echinoderm and bryozoan life.

The Meramec age (zones 13–15) Lisburne Group coral fauna contains the following species in common with the Peratrovich Formation on Prince of Wales Island, southeastern Alaska (Armstrong, 1970a): *Lithostrotion (Siphonodendron) warreni* Nelson, *Lithostrotionella birdi* Armstrong, *L. banffensis* (Warren), *Thysanophyllum astraeiforme* (Warren), *Sciophyllum alaskaensis* Armstrong, and *Diphyphyllum klawockensis* Armstrong.

The Lisburne Group corals which occur in microfaunal assemblage zone 14 correspond approximately to Macqueen and Bamber's (1968) faunal zone 3 for the Mississippian rocks of Alberta, Canada. The corals which are found in microfaunal zone 15 in the Lisburne Group correspond approximately to Macqueen and Bamber's faunal assemblage zone 4 for Alberta.

Macqueen and Bamber's (1968) faunal list for the Mount Head Formation, southwestern Alberta, shows only three species that are conspecific with the Lisburne Group lithostrotionoids. They are *Lithostrotion (Siphonodendron) warreni* Nelson, *Lithostrotionella mclareni* (Sutherland), and *Thysanophyllum astraeiforme* (Warren).

Sando, Mamet, and Dutro's (1969, p. E7) list of lithostrotionoids from the Mississippian of the northern Cordilleran of the United States shows no species in common with those from the Lisburne Group.

SYSTEMATIC PALEONTOLOGY

Oliver (1968, p. 27) considered that, for Paleozoic corals, a sample of 20 corallites adequately characterizes a corallum and that a sample of 20 coralla can be considered representative of a local population from one environment over a limited area. Although the criterion for numbers of coralla was not met in describing the new species, fairly large numbers of coralla were available for study. Morphological terminology follows that of Hill (1956, p. F234–F251).

Conventional treatment has been followed in the taxonomic hierarchy above the species level. The classification is generally that of Hill (1956), but some minor changes have been made. 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, ed., Treatise on invertebrate paleontology, Part F, Geol. Soc. America, p. F282.

Type species.—(Opinion 117, International Commission of Zoological Nomenclature) *Lithostrotion*

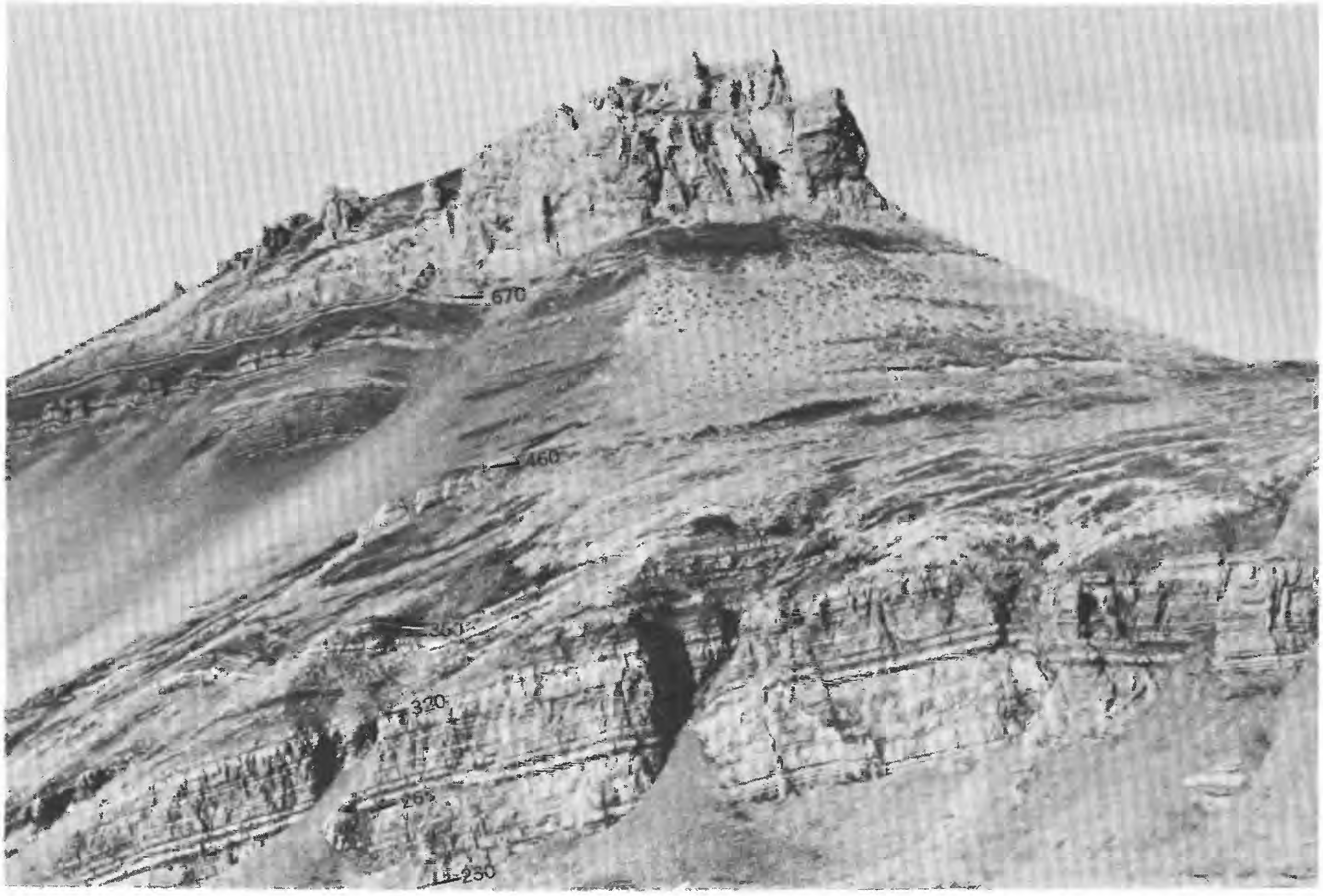


FIGURE 9.—Section 68A–9, showing stratigraphic footage along line of transverse. Between 230 and 320 feet, fasciculate colonial corals are very abundant. View is to the east.

striatum Fleming, Lower Carboniferous, British Isles.

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

Diagnosis.—Phaceloid or cerioid corallum; typically with columella, long major septa, and large conical tabulae that are 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 corallum is fasciculate.

Lithostrotion (Siphonodendron) lisburnensis n. sp.

Plate 1, figures 1–5; plate 2, figures 1–7

Material.—Fragments, each approximately 10×10×10 cm (centimeters), of 17 coralla were collected by J. T. Dutro, Jr., and myself within carefully measured and sampled stratigraphic sections. A minimum of one transverse and one longitudinal 2- by 3-inch thin section was cut of each corallum. The 17 coralla are well preserved and are type material. Approximately 30 corallites were studied and measured in each corallum. Most coralla are preserved by calcite, with only minor amounts of silica, and in general the preservation of microstructure is good to excellent.

Description.—The holotype, USNM 161064 (pl. 1, figs. 1–4), is a dendroid corallum with offsets that arise by lateral increase. In transverse thin section, corallites are 0.5–4 mm (millimeters) apart. Corallites are 2.3–2.8 mm in diameter and have 14–16 long major septa (figs. 16, 17). The major septa are 0.7–1.0 mm long and commonly reach the columella. Minor septa are well developed and are 0.2–0.4 mm long. The corallite wall is 40–60 microns thick, and the major septa are 50–60 microns thick at the periphery of the corallum and taper axially. The microstructure of the septa, walls, and dissepiments appears to be formed of fibrous calcite and is similar to Kato's (1963, fig. 17c) fibrous structure. The septa in the tabularium are commonly recrystallized into a mosaic of 5- to 10-micron calcite crystals and are not uncommonly silicified. Well-preserved specimens indicate that the microstructures of the corallite wall and septa are very similar (pl. 1, figs. 2, 3). The columella is lens shaped in cross section, 0.5 mm long and 0.25 mm wide, and is commonly continuous with the counter septa. Some diphymorphic corallites are present.

In longitudinal section the tabulae are generally complete and slope away from the columella for a distance of approximately 0.8 mm at an angle of about 45° from the horizontal before bending downward to an angle of about 80° adjacent to the dissepiments. Ten to twelve tabulae occur in a vertical distance of 5 mm. A dissepimentarium is generally present and consists of slightly globose, elongated dissepiments (fig. 17). Microscopic examination of the junction of the tabulae and the columella clearly indicates that the tabulae do not contribute to the structure of the columella (pl. 1, fig. 3).

Paratype USNM 161056 (pl. 2, fig. 5) is similar to the holotype in most morphological features, but it differs in having slightly smaller corallites with a diameter of 1.5–2.4 mm, 11–13 major septa (fig. 16), and dissepiments which are somewhat more globose.

Paratypes USNM 161060 (not figured) and 161061 (pl. 2, figs. 2, 3) are similar to the holotype except that the dissepimentarium is less well developed and occasionally absent, as shown by longitudinal sections of the corallites.

The remaining paratypes do not differ from the above material in any significant morphological features.

FIGURE 10.—A persistent *Lithostrotion* (*Siphonodendron*) *sinuosum* bed in section 68A–9. The bed is 6–10 inches thick and is approximately 235 feet above the base of the section. Between 230 and 265 feet this species, *L.* (*S.*) *warreni*, and *Diphyphyllum nasorakensis* are very common. Cerioid colonial corals are rare.

Occurrence.—The holotype, USNM 161064, was collected south of Niak Creek approximately 13 feet above the base of measured section 68A–13 (figs. 3, 5). Three paratypes were also collected from this section: USNM 161065, at 15 feet above the base; USNM 161066, at 21 feet; and USNM 161067, at 180 feet. The corals are associated with a microfauna (Armstrong and others, 1971) of latest Meramec age (upper part of zone 15) and earliest Chester age (zone 16i). Other colonial corals found in association are *Lithostrotion (Siphonodendron) sinuosum* (Kelly), *L. (S.) warreni* Nelson, *Diphyphyllum nasorakensis* n. sp., *Lithostrotionella banffensis* (Warren), *Sciophyllum lambarti* Harker and McLaren, and *S. alaskaensis* Armstrong.

FIGURE 11.—Cape Lewis and upper part of section 68A–9, showing biostromal bed (arrow) at 880- to 900-foot level. Line of traverse and stratigraphic footage are also shown. View is to the north.

Section 68A–9, south of Cape Lewis (figs. 7, 11), has yielded 13 paratypes of *L. (S.) lisburnensis*. These occur in beds of earliest Chester age (zone 16i) and are found associated with the above coral fauna (fig. 9). These paratypes are:

USNM No.	*Feet above base of section 68A–9*
161063	899
161062	899
161061	895
161060	890
161059	885
161058	878
161057	878
161056	855
161055	303
161054	257
161053	263
161052	241
161051	147

L. (S.) lisburnensis n. sp. is known only from sections 68A–9 and 68A–13 in the Lisburne Peninsula region of arctic Alaska. No corals similar to this species are reported from the Meramec age carbonates of the Kogruk Formation, DeLong Mountains (Armstrong, 1970b), and *L. (S.) lisburnensis* has not been found in the coral collections made from the Lisburne Group of the central and northeastern Brooks Range.

Remarks.—*Lithostrotion (Siphonodendron) lisburnensis* n. sp. is very similar morphologically to the European Viséan species *Lithostrotion junceum* (Fleming) as redescribed by Hill (1940, p. 171–173), except that in the Viséan species "dissepiments are never developed" (p. 172), and diphymorphic corallites may occur. *L. (S.) lisburnensis* always has a single row of dissepiments, and the major and minor septa are generally longer than in *L. junceum* (Fleming).

FIGURE 12.—Large *Thysanophyllum* sp. corallum in biostrome beds 895 feet above the base of section 68A–9. Note pencil for scale; coralla of this size are common.

The Chinese species, *Lithostrotion irregulare* Phillips var. *asiatica* Yabe and Hayasaka, as originally described (1916, p. 57–60), has corallites with diameters of 3.5 mm, 16–18 long major septa, and a single row or occasionally a double row of dissepiments. Yü (1933, p. 95–96, pl. 19, figs. 3, 4, and pl. 30, fig. 1; 1937, p. 39–40, pl. 9, fig. 4) illustrated and redescribed this Viséan species from China. He (1937, p. 39) stated that "the columella is stout but inpersistent and irregular so that at some levels the corallites show diphyphylloid characters" and "the dissepimental area is wide and forms one-third the radius, and consists of two series of small and well arched dissepiments." *L. (S.) lisburnensis* n. sp. differs from the Chinese *L. (S.) irregularis* var. *asiatica* in always having one row of dissepiments, a consistently smaller corallite diameter, and a well-developed persistent columella.

Lithostrotion (Siphonodendron) genevievensis Easton (1957, p. 616–622, pl. 71, figs. 5–12) from the Ste. Genevieve Limestone of the Ohio River Valley is somewhat similar to *L. (S.) lisburnensis*,

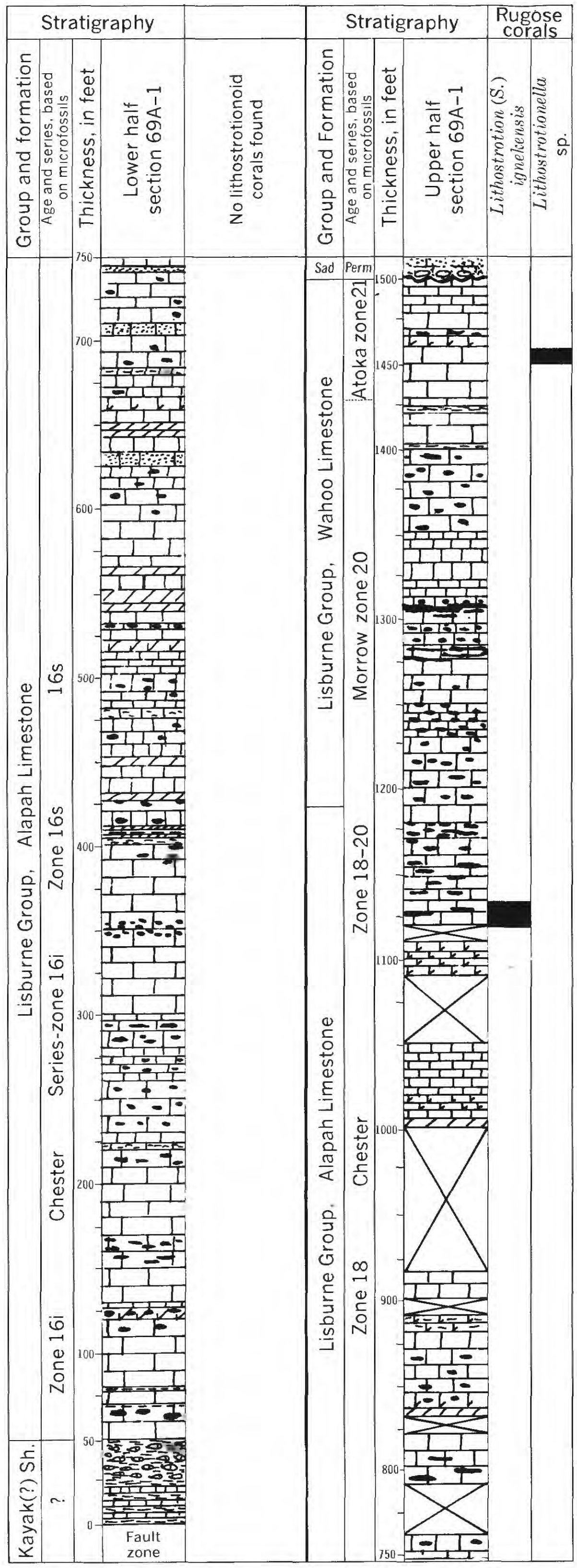


FIGURE 13.—Stratigraphy and coral distribution in the west Sadlerochit Mountains section, 69A–1.

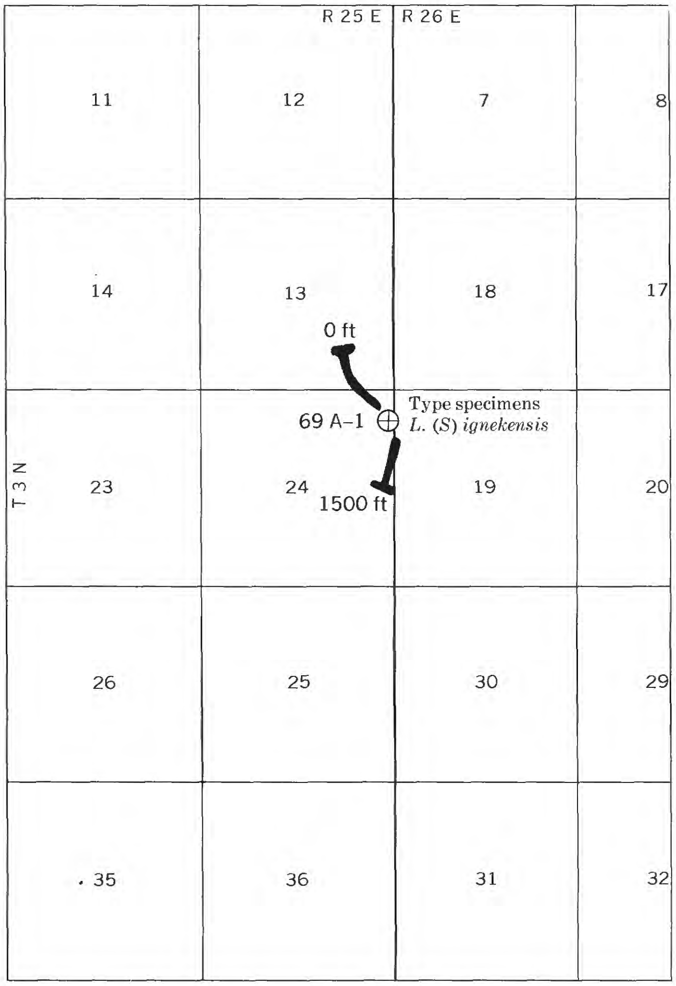


FIGURE 14.—Index map of section 69A–1 and location of type specimens of *Lithostrotion* (*Siphonodendron*) *ignekensis.*

except that *L. (S.) genevievensis* has a slightly larger corallite diameter (4.5 mm) and no minor septa.

Lithostrotion (*Siphonodendron*) *dutroi* n. sp. (pl. 3, figs. 1–7) from the lower part of the Alapah Limestone, Lisburne Group, Shainin Lake, and the lower part of the Lisburne Group, Hulahula River, Romanzof Mountains, is easily distinguished from *L. (S.) lisburnensis* by corallites that are 1.0–2.1 mm in diameter and that have 9–13 long major septa, all of which reach the columella, and a corallite spacing of 0.2–0.5 mm.

The Lisburne Group *Lithostrotion (Siphonodendron) ignekensis* n. sp. (pl. 5, figs. 1–5) of middle and late Chester age from the Sadlerochit Mountains is distinguished from *L. (S.) lisburnensis* n. sp. by its larger corallite diameter (3–5 mm), higher septal count (14–18), long sinuous counter septa, and thin columella.

Lithostrotion (Siphonodendron) sinuosum (Kelly, 1942) is readily distinguished from *L. (S.) lisburnensis* n. sp., which occurs abundantly in the same beds, by its larger corallite diameter of 3–4.5 mm, its 16–19 major septa, and its tendency to have amplexoid major septa in some corallites. Coralla which are morphologically transitional between *L. (S.) lisburnensis* n. sp. and *L. (S.) sinuosum* have not been found in the large collections made at the south Niak Creek section (68A–13) or at the south Cape Lewis section (68A–9).

Name.—*L. (S.) lisburnensis* is derived from the Lisburne Hills, which form the seacliffs of northwestern Alaska.

Lithostrotion (Siphonodendron) dutroi n. sp.

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

Material.—Fragments, each approximately 10×10×15 cm, of six coralla were available for study. Two transverse and two longitudinal thin sections were cut from the holotype, and one transverse and one longitudinal thin section were cut from each of the five paratypes. Approximately 200–400 corallites from each colony were studied in thin section. The coralla are preserved by calcite, and preservation of the microstructure is good.

Description.—The holotype, USNM 161085 (pl. 3, figs. 1–7), is a dendroid corallum, but commonly two or more corallites may be in contact for some distance. When two or more corallites are in contact, the corallite walls have three to six straight to slightly curved sides. Typically the corallites are cylindrical and are commonly in contact, but they may be separated from each other by a distance of 200–500 microns.

In transverse section the corallites of the holotype are 1–1.7 mm in diameter and have nine to 12 long major septa (figs. 18, 19). The corallite walls are 60–100 microns thick. The major septa are 50–60 microns thick at the periphery of the corallite, taper toward the axis, and are generally fused with the columella. The lens-shaped columella is formed by the axial ends of the cardinal and counter septa. The minor septa are 200–300 microns long and extend into the tabularium. Both classes of septa are continuous through the narrow (100–250 microns wide), discontinuous dissepimentarium.

No diphymorphic corallites were seen in the holotype.

In transverse section the walls and septa are composed of fibrous calcite similar to the fibrous calcite of Kato's (1963, fig. 17c) wall structure (pl. 3, figs.

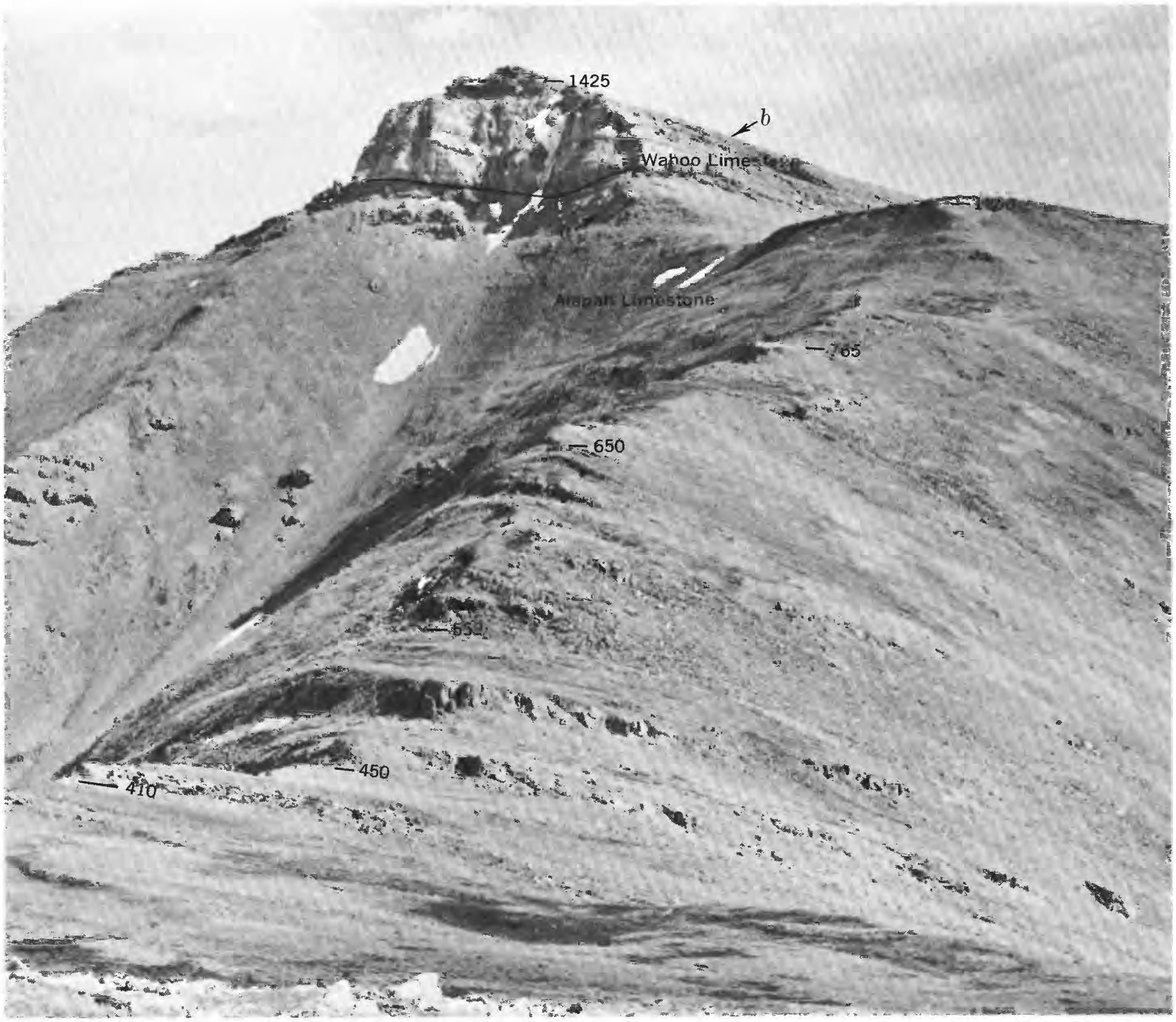


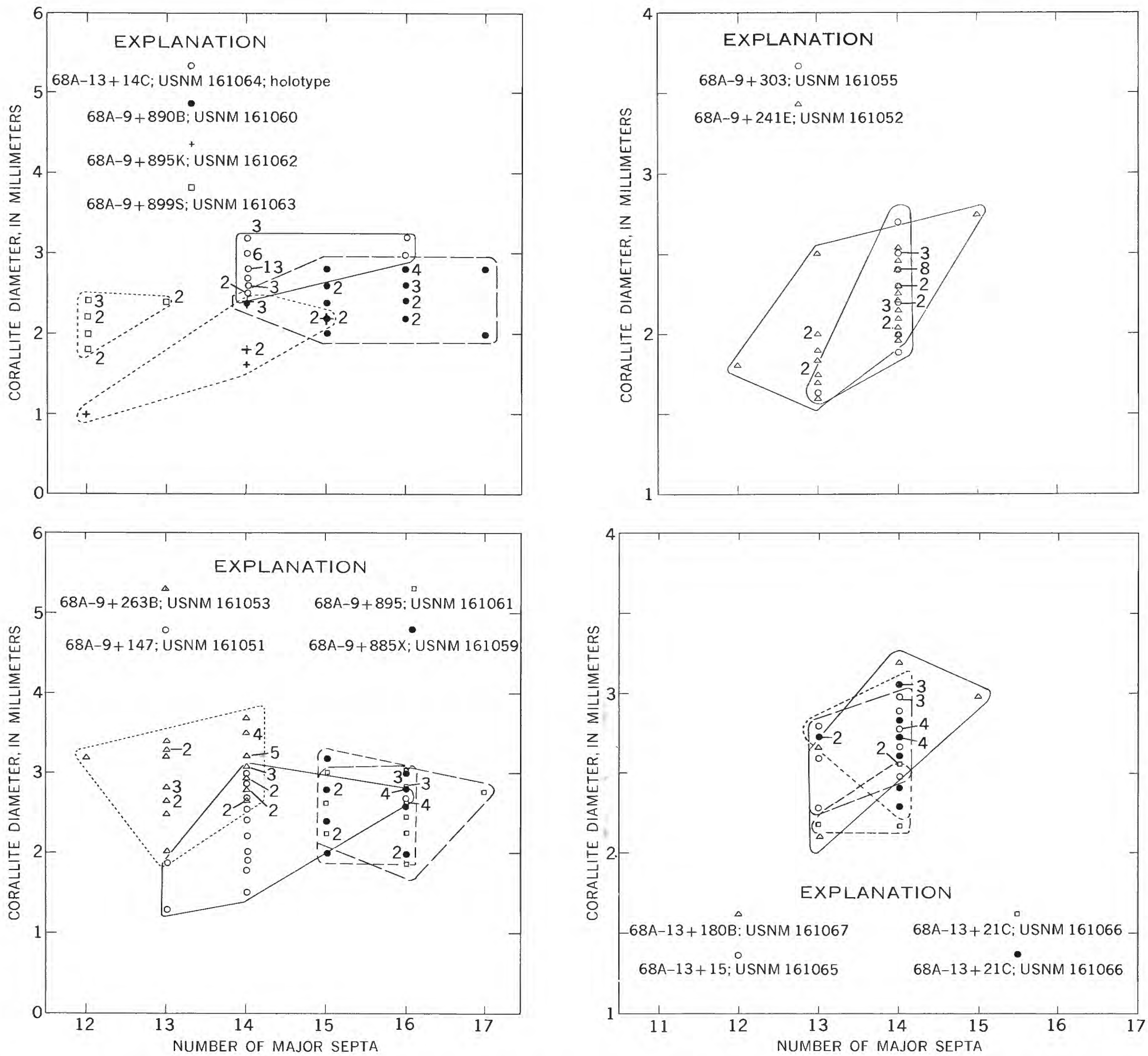
FIGURE 15.—Upper part of section 69A–1, showing stratigraphic footage along line of traverse. Arrow *a* points to locality of the holotype of *Lithostrotion* (*Siphonodendron*) *ignekensis* n. sp. Arrow *b* shows locality in upper beds of Wahoo Limestone where Atoka age *Lithostrotionella* sp. was collected. View is to the south.

1, 2, 5, 6). The corallite wall in many well-preserved specimens shows an outer, dark layer 20–30 microns thick and an inner, lighter fibrous layer 30–40 microns thick.

In longitudinal section the tabulae are generally complete and slope away from the columella at angles of 40°–50° from the horizontal. Approximately 10–12 tabulae occur in a vertical distance of 5 mm. The discontinuous dissepimentarium is composed of a single row of globose dissepiments. There are 16–20 dissepiments in a distance of 5 mm. The columella is slightly sinuous, is thick, and is formed by the axial ends of the major septa. The tabulae and dissepiments are 10–20 microns thick and are formed by crystals of fibrous calcite less than 5 microns in size.

The five paratypes, USNM 161086–161090, are nearly identical morphologically with the holotype (pl. 4, figs. 1, 3–5). No diphymorphic corallites were found in the paratypes.

Occurrence.—The holotype, USNM 161085, was collected by the writer in 1964 from Bowsher and



Dutro's (1957) type section of the Alapah Limestone at Shainin Lake. A detailed description and illustrations of this section can be found in their report. The corallum was collected from a bed 185 feet above the base of the Alapah Limestone and was found in association with *Lithostrotion (Siphonodendron) warreni* Nelson, *Lithostrotionella banffensis* (Warren), *Lithostrotionella mclareni* (Sutherland), *Thysanophyllum astraeiforme* (Warren), and *Sciophyllum* sp. The microfauna associated with the holotype is of middle Meramec age (zone 13) (Armstrong and others, 1970).

The five paratypes, USNM 161086–161090, were collected in 1969 by J. Thomas Dutro, Jr., and myself from outcrops of the Alapah Limestone, Lisburne Group, on the west bank of the west fork of the Hulahula River in sec. 2, T. 5 S., R. 31 E., arctic Alaska. The paratypes were found associated with a coral and foraminiferal fauna of Meramec age.

Field studies in 1970 revealed *L. (S.) dutroi* to be a common coral in the Meramec age beds of the Lisburne Group in the Franklin and Romanzof Mountains, Brooks Range, northeastern Alaska.

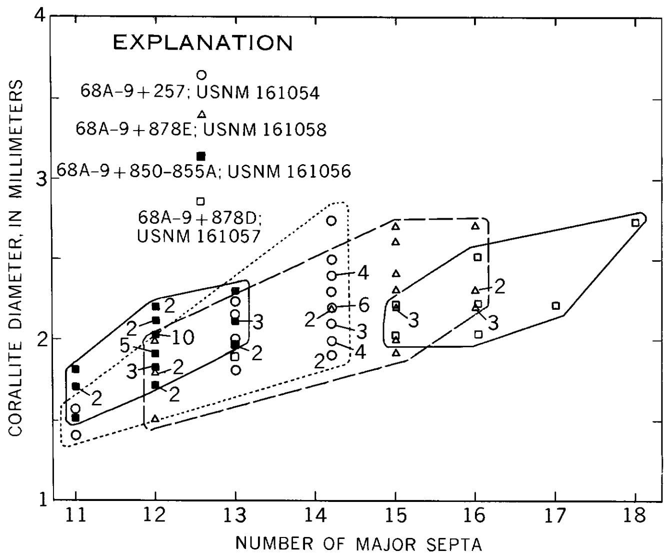


FIGURE 16.—Corallite diameter and number of major septa in *Lithostrotion* (*Siphonodendron*) *lisburnensis* n. sp. Each unnumbered symbol represents a single corallite; if more than one corallite shows the same diameter and number of septa, the number of similar corallites is shown.

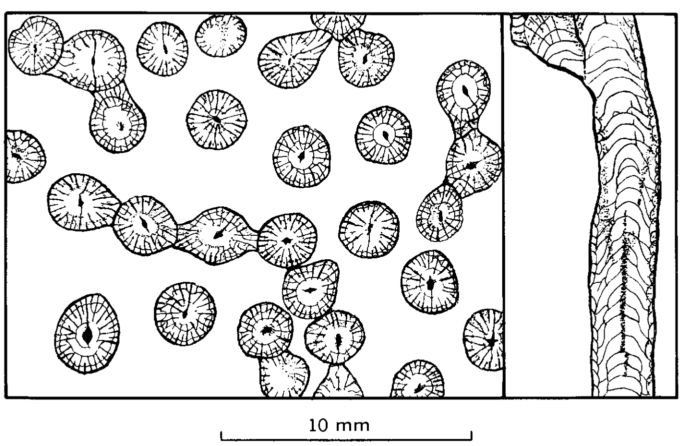


FIGURE 17.—Sections of *Lithostrotion* (*Siphonodendron*) *lisburnensis* n. sp. (USNM 161064).

This species was not reported from the Kogruk Formation of the DeLong Mountains (Armstrong, 1970b), and it is not known from the Lisburne Group exposures in the Lisburne Hills, which form the seacliffs of northwestern Alaska.

Remarks.—*Lithostrotion* (*Siphonodendron*) *dutroi* n. sp. is sharply delineated from all other species of *Lithostrotion (Siphonodendron)* found in the Lisburne Group of arctic Alaska by its small corallite diameter of 1.0–2.1 mm, nine to 13 long major septa, and well-developed minor septa and columella. In hand specimen the corallum is distinctive

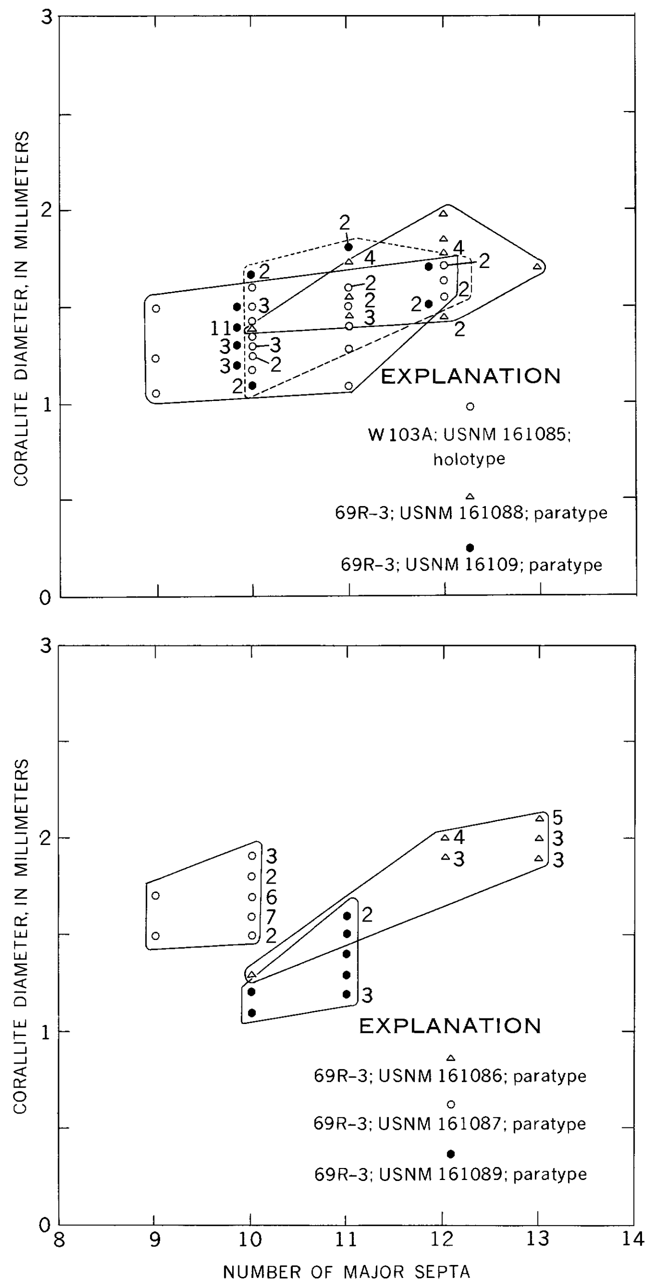


FIGURE 18.—Corallite diameter and number of major septa in *Lithostrotion* (*Siphonodendron*) *dutroi* n. sp. Each unnumbered symbol represents a single corallite; if more than one corallite shows the same diameter and number of septa, the number of similar corallites is shown.

and is characterized by the close corallite spacing of 0.2–0.5 mm.

The only species within the Lisburne Group that remotely resembles *L. (S.) dutroi* n. sp. is *Lithostrotion (Siphonodendron) lisburnensis* n. sp., which has larger diameter corallites (1.5–2.8 mm) and

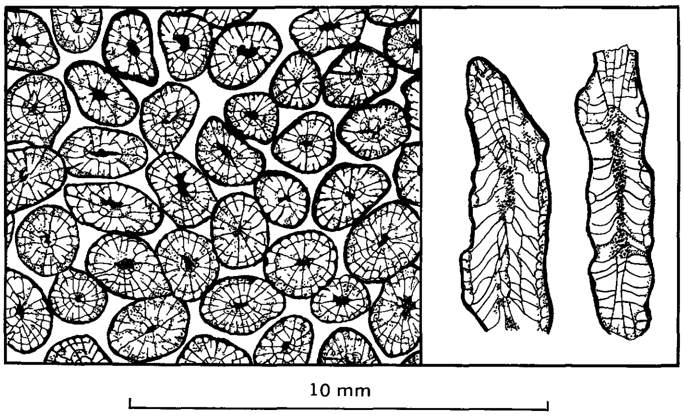


FIGURE 19.—Sections of *Lithostrotion* (*Siphonodendron*) *dutroi* n. sp. (USNM 161085).

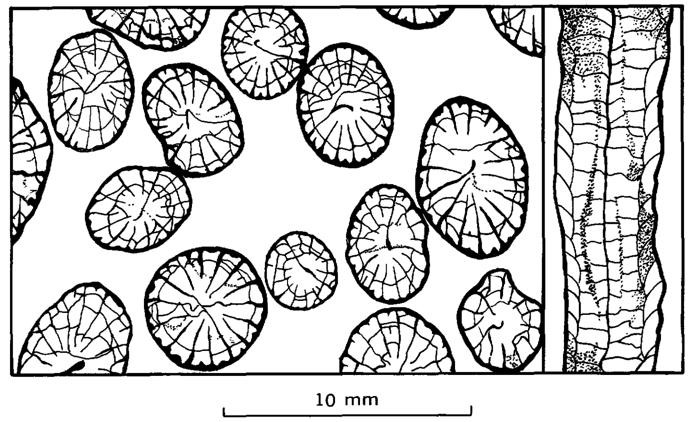


FIGURE 21.—Sections of *Lithostrotion* (*Siphonodendron*) *ignekensis* n. sp. (USNM 160520).

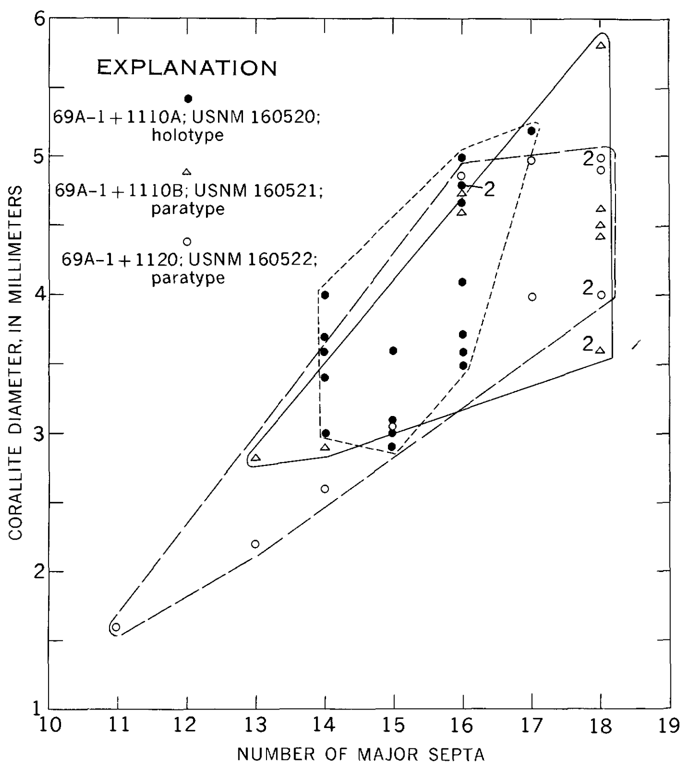


FIGURE 20.—Corallite diameter and number of major septa in *Lithostrotion* (*Siphonodendron*) *ignekensis* n. sp. Each unnumbered symbol represents a single corallite; if more than one corallite shows the same diameter and number of septa, the number of similar corallites is shown.

more major septa (11–16) (fig. 16). It is also characterized by corallites which are more widely spaced and tabulae that are more strongly arched toward the columella and then are reflexed to a lower angle near the dissepimentarium (fig. 17). The two species also appear to have different stratigraphic ranges. *L. (S.) lisburnensis* n. sp. is known only from beds of latest Meramec (upper part of zone 15) and earliest Chester age (lower part of zone 16i), whereas *L. (S.) dutroi* n. sp. has been found in beds of middle and late Meramec age (zone 13 and lower part of 14).

Lithostrotion irregulare Phillips var. *asiatica* from China as described by Yabe and Hayasaka (1916, p. 57–60) and redescribed and illustrated by Yü (1933, p. 95–96) has relatively larger corallites with a diameter of 3.5 mm, 14–16 major septa, and a persistent single or a rare double row of dissepiments in the dissepimentarium. Furthermore, the Chinese species is distinguished from *L. (S.) dutroi* n. sp. by its shorter major septa, flatter tabulae, and occasionally diphymorphic corallites.

Lithostrotion junceum (Fleming) as redescribed by Hill (1940, p. 171–173, pl. 9, figs. 3–8) is somewhat similar to *L. (S.) dutroi* n. sp. but differs in a number of significant ways. It has a corallite diameter of 2.5–3.8 mm, 14–18 major and 14–18 short minor septa, and no dissepiments. Hill stated diphymorphic corallites may occur.

Dobroljubova (1958, p. 283, pl. 18, 19) described "narrow-tubed colonies" of *Lithostrotion junceum* (Fleming) from the Lower Carboniferous of the Russian Platform which have corallites with a diameter of 1.5–2 mm, 12–13 major septa, and no dissepiments; also, diphymorphic corallites are found within the corallum.

Easton's (1957, p. 616–622, pl. 71, figs. 5–12) species *Lithostrotion (Siphonodendron) genevievensis*, from late Meramec age rocks of the Ohio River valley, is distinguished from *L. (S.) dutroi* n. sp. by its large corallite diameter of 4.5 mm, typically 16 thin major septa, and no minor septa. The species does contain a single row of dissepiments in the dissepimentarium.

Name.—The species is named in honor of J. Thomas Dutro, Jr., paleontologist and geologist, U.S. Geological Survey.

Lithostrotion (Siphonodendron) ignekensis n. sp.

Plate 5, figures 1–5

Material.—Fragments of five colonies were collected from measured stratigraphic sections of the Alapah Limestone, Lisburne Group, northeastern Alaska. All specimens were studied in transverse and longitudinal thin sections. Three specimens from section 69A–1 have good preservation and are preserved by calcite (USNM 160520–160522). Specimen USNM 160523, from section 68A–3, was in part crushed before lithification. Specimen USNM 160524, from section 68A–1, is from a tectonically stressed limestone and is distorted.

Description.—The holotype, USNM 160520, is a fasciculate corallum. In transverse section, corallites have a spacing of 1–4 mm, a diameter of 2.9–5.2 mm, and 14–17 long major septa (figs. 20, 21). Minor septa are generally developed as low ridges on the inside of the corallite wall and may extend 0.2–0.4 mm into the dissepimentarium. The minor septa, commonly reappear on the axial side of the tabularium wall. Major septa are continuous through the dissepimentarium and taper from the periphery toward the axis of the corallite.

The columella is formed by the axial extensions of the counter septa (pl. 5, figs. 1, 4). In a number of corallites the counter and cardinal septa are continuous through the columella.

The corallite walls are approximately 200 microns thick and are formed by fibrous calcite, as are the major septa, which are 75–100 microns thick at their outer ends.

The preservation of the microstructure is good. The corallite walls are formed by dense fibrous calcite deposited normal to the exterior of the corallite. The septa are also made of fibrous calcite deposited nearly parallel to the length of the septa. The crystals of fibrous calcite are very small, less than 5 microns wide and not over 10 microns long. The dissepiments are composed of a denser, dark calcite; their wall thickness is 10–30 microns (pl. 5, figs. 1, 2).

In longitudinal section the holotype (pl. 5, fig. 3) has a dissepimentarium formed by one row of globose dissepiments (500–750 microns wide), of which there are 10–12 in a vertical distance of 10 mm. The tabulae are nearly flat and abut against the dissepimentarium and columella at nearly 90°. The columella is persistent and slightly sinuous. Study of the microstructure of the columella and the tabulae shows that the tabulae do not contribute to the structure of the columella (pl. 5, fig. 2).

Paratypes.—Specimens USNM 160521 and 160522 are similar in mode of preservation and morphology to the holotype except that the two paratypes have corallites with as many as 18 major septa (fig. 20).

Occurrence.—The holotype was collected from the upper part of the Alapah Limestone, 1,120 feet above the base of section 69A–1 (figs. 13–15), at the west end of the Sadlerochit Mountains. The paratypes USNM 160521 and 160522 were collected 1,110–1,120 feet above the base of the same section. The beds containing the corals have a small fauna of Foraminifera. Bernard L. Mamet (written commun., 1970) assigned a Chester-Morrow age (zones 18–20) to the Foraminifera. A better foraminiferal fauna was found with the corals (Armstrong and others, 1970) collected from section 68A–3 (specimen USNM 160523). Here the microfauna indicates that the corals are Chester age (zones 17 and 18). Specimen USNM 160524, collected at 810 feet from the top of section 68A–1, in the Franklin Mountains, also occurs with a microfauna of Chester age (zones 17 and 18).

The microfaunal evidence reported by Armstrong, Mamet, and Dutro (1970) indicates that *L. (S.) ignekensis* n. sp. occurs in zones 17 and 18, of middle and late Chester age (fig. 13).

The species is known only from the upper part of the Alapah Limestone of northeastern Alaska. It has not been found in Chester age rocks of the central or western Brooks Range.

Remarks.—*Lithostrotion (Siphonodendron) genevievensis* Easton (1957, p. 616–622, pl. 71, figs. 5–12) from the Fredonia Oolite Member of the Ste. Genevieve Limestone of the Ohio River valley is similar to *L. (S.) ignekensis* is corallite diameter and number of major septa. *L. (S.) ignekensis* differs in having well-developed minor septa, less sinuous major septa, and flatter tabulae. In *L. (S.) genevievensis* the axial ends of the counter septa which form the columella are thicker, or swollen, in contrast to the more simple columella in *L. (S.) ignekensis* n. sp. In addition to the morphological differences between the two species, there is a significant stratigraphic separation. *L. (S.) genevievensis* Easton occurs in the late Meramec age Ste. Genevieve Limestone (zone 15), and *L. (S.) ignekensis* occurs in the Lisburne Group in rocks of Chester age (zones 17 and 18).

Hill (1940) redescribed the European Lower Carboniferous species *Lithostrotion (Siphonodendron) pauciradiale* (McCoy), which has a similar corallite diameter and a higher number of major septa (22) but differs from *L. (S.) ignekensis* n. sp. primarily in having conical tabulae.

Hill (1940, p. 172) also redescribed *Lithostrotion junceum* (Fleming), which is similar to the Alaskan species but in which "dissepiments are never developed" and diphymorphic corallites may occur. These morphological characteristics have not been found in any colonies of *L. (S.) ignekensis* n. sp.

Lithostrotion volkovae Dobroljubova (1958, p. 153–155, pl. 22, figs. 1, 2) from the Russian Platform is fasciculate and has corallites with diameters of 4–5 mm and 17–18 major septa. However, it differs from *L. (S.) ignekensis* n. sp. in a number of significant ways. It has a broad rounded or ellipsoidal columella, long minor septa, tabulae strongly arched to meet the columella, and a double row of dissepiments.

Lithostrotion (Siphonodendron) sinuosum (Warren, 1927), which is abundant in Meramec and Chester age (lower part of zone 16i) carbonates of the Lisburne Group, is similar in size and number of corallites to *L. (S.) ignekensis*. *L. (S.) sinuosum* (Warren) is readily recognized by its ellipsoidal columella, longer and thicker major and minor septa, and tabulae which are strongly arched to meet the columella (Armstrong, 1970b, fig. 12).

Name.—*L. (S.) ignekensis* is derived from Ignek Creek, which flows between the Shublik and Sadlerochit Mountains into the Canning River. Ignek in Eskimo means "fire" (Orth, 1967, p. 445).

Genus DIPHYPHYLLUM Londsdale, 1845

Diphyphyllum Lonsdale, 1845, in Murchison and others, Geology of Russia and the Ural Mountains, v. 1, p. 622.

Diphyphyllum Lonsdale. Thomson, 1883, Royal Philos. Soc. Glasgow Proc., v. 10, p. 381.

Diphyphyllum Lonsdale. Thomson, 1887, Geol. Soc. London Quart. Jour., v. 43, p. 33.

Lithostrotion Fleming, genomorph [*Diphyphyllum* Lonsdale]. Smith and Lang, 1930, Annals and Mag. Nat. History, v. 5, p. 180.

Depasophyllum Yü, 1933, Palaeontologica Sinica, v. 12, p. 86.

Lithostrotion Fleming, genomorph [*Diphyphyllum* Lonsdale]. Hill, 1940, Palaeontographical Soc., v. 94, p. 180–182.

Diphyphyllum Lonsdale. Minato, 1955, Hokkaido Univ. Fac. Sci. Jour., v. 9, no. 2, p. 80, 81.

Diphyphyllum Lonsdale. Hill, 1956, in Moore, ed., Treatise on invertebrate paleontology, Part F, Geol. Soc. America, p. F283.

Depasophyllum Yü. Minato and Kato, 1957, Hokkaido Univ. Fac. Sci. Jour., ser. 4, v. 9, no. 4, p. 480.

Diphyphyllum Lonsdale. Dobroljubova, 1958, Akad. Nauk SSSR Paleont. Inst. Trudy, v. 70, p. 180–183.

Type species.—*Diphyphyllum concinnum* Lonsdale, 1845, Carboniferous, Ural Mountains, U.S.S.R. Smith and Lang (1930, p. 180) state that the type *D. concinnum* is lost, and they base *Diphyphyllum* on *D. lateseptatum* McCoy, which, if not conspecific, is certainly congeneric with *D. concinnum.*

Diagnosis.—Fasciculate corallum; columella undeveloped; septa continuous in dissepimentarium, amplexoid in tabularium; tabulae domed or flattened axilly, downturned peripherally (modified after Hill, 1965, p. F283).

Remarks.—Smith (1928, p. 114) and later Hill (1940, p. 181) divided the species of *Diphyphyllum* into two groups on the basis of the structure of the tabulae. The majority of the described species of *Diphyphyllum,* including the type species, have inner tabulae which are strongly arched, and each arch rests upon the arch below. The smaller group comprises *Diphyphyllum* species that have complete tabulae with broad flat tops and downturned edges that extend to the dissepimentarium without touching the lower tabulae. *Diphyphyllum venosum* Armstrong and *D. klawockensis* Armstrong from the Mississippian of the west coast of Prince of Wales Island, southeastern Alaska, both belong to the latter, smaller group of the species, as does the new species from the Lisburne Group, *D. nasorakensis.*

Diphyphyllum nasorakensis n. sp.

Plate 6, figures 1–6; plate 7, figures 1–6

Material.—The four specimens available for study were collected by J. T. Dutro, Jr., and myself from carefully measured and sampled stratigraphic sections. All specimens are fragments of coralla. The specimens are preserved in blocks or beds of limestone, and the exterior of the corallites or coralla was not available for study. The size of the fragments of each colony is approximately:

USNM 161044, holotype	20×25×25 cm
USNM 161045, paratype	15×15×15 cm
USNM 161047, paratype	8×9×10 cm
USNM 161068, paratype	5×7×7 cm

Several transverse and longitudinal 2- by 3-inch thin sections were cut of each corallum. A number of polished slabs were made, and these were studied by reflected light. Specimens USNM 161046 and 161069 have badly crushed corallites, and measurements of diameter and septa cannot be made.

Description.—The holotype, USNM 161044 (pl.

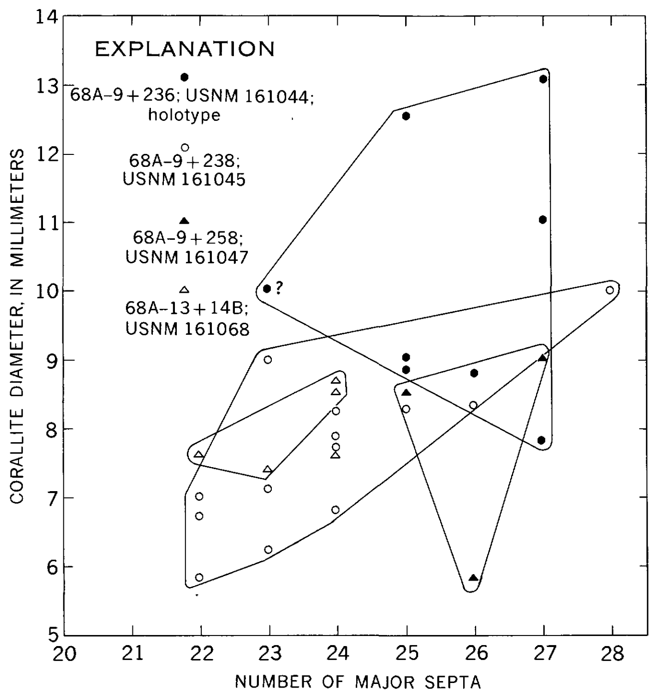


FIGURE 22.—Corallite diameter and number of major septa in *Diphyphyllum nasorakensis* n. sp. Each unnumbered symbol represents a single corallite; if more than one corallite shows the same diameter and number of septa, the number of similar corallites is shown.

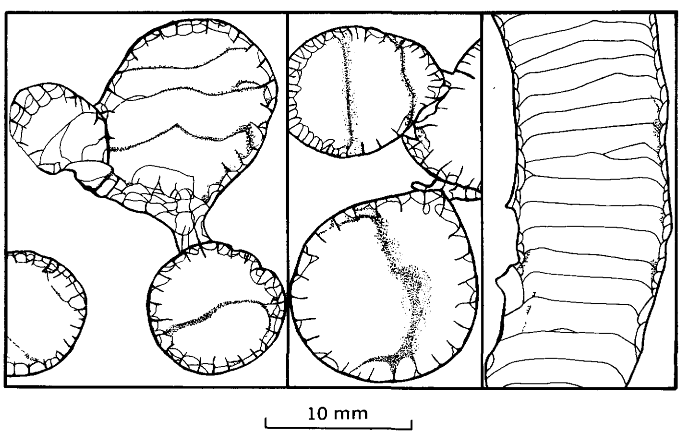


FIGURE 23.—Sections of *Diphyphyllum nasorakensis* n. sp. (USNM 161044).

6, figs. 1–6), is a fasciculate corallum. Spacing between corallites is typically 2–5 mm but may range from 0.5 to 12 mm. In transverse section the corallites are 7.9–13.1 mm in diameter and have 23–27 major septa (figs. 22, 23). The major septa are short, 0.8–1.2 mm in length, and 100–150 microns thick at their outer ends. The corallite wall is 100–200 microns thick. The majority of corallites are devoid of minor septa; where present, the minor septa are 0.2–0.3 mm long and 50–70 microns thick at their outer ends. The corallite walls and septa appear to be composed of a mosaic of calcite crystals 10 microns or less in size. The microstructure is poorly preserved, having been affected by calcite recrystallization, grain growth, and selective silicification of internal structures. Petrographic studies reveal that the corallite walls are composed of an outer, dark layer, approximately 20 microns thick, formed by interlocking calcite crystals 5 microns in size. The inner part of the corallite walls is 60–120 microns thick and is formed by dense fibrous to granular calcite. The septa appear to be made of fibrous calcite deposited nearly parallel to the length of the septa, although they are now commonly granular calcite (recrystallized) or are replaced by chalcedony (pl. 6, figs. 4–6). The corallites are acolumellate.

In general the major septa are continuous throughout the dissepimentarium except in some specimens where the dissepimentarium may widen in a parent corallite adjacent to an offset (fig. 23).

Longitudinal sections of the corallites show the tabulae to be complete; they are flat to very gently convex upward. At a distance of 1–1.5 mm from the corallite walls the tabulae are reflexed downward at angles of 20°–45° from the horizontal. Generally a single row of dissepiments is present, but the dissepiments are commonly discontinuous. Dissepiments are 0.2–0.5 mm wide and 0.5–1.3 mm long. The walls of the tabulae and dissepiments are 40–70 microns thick and are composed of crystals of calcite 5–15 microns in size.

Paratypes USNM 161045, 161047, and 161068 are, except for a slightly smaller corallite diameter, similar in all respects to the holotype. All specimens are acolumellate.

Occurrence.—Diphyphyllum nasorakensis n. sp. was found south of Cape Lewis in the Nasorak Formation, Lisburne Group (figs. 7, 9), at 236 feet above the base of section 68A–9 (USNM 161044), at 238 feet (USNM 161045), and at 241 feet (USNM 161047). The foraminiferal fauna in these beds is earliest Chester in age (zone 16i) (Armstrong and others, 1971), and the coral fauna consists of the following species: *Lithostrotion (Siphonodendron) lisburnensis* n. sp., *L. (S.) sinuosum* (Kelly), *L. (S.) warreni* Nelson, and *Lithostrotionella banffensis* (Warren).

The two specimens collected from the Lisburne Group south of Niak Creek, section 68A–13 (figs. 3, 5), were from 14 feet (USNM 161068) and 103 feet

(USNM 161069) above the base of the section. The foraminiferal fauna from these beds, according to Armstrong, Mamet, and Dutro (1971), is latest Meramec (upper part of zone 15) and earliest Chester (zone 16i) age. In addition to the associated coral species found with *D. nasorakensis* in section 68A–9, *Lithostrotionella birdi* Armstrong, *L. mclareni* (Sutherland), *Thysanophyllum astraeiforme* (Warren), *Sciophyllum lambarti* Harker and McLaren, and *S. alaskaenis* Armstrong have been found in section 68A–13.

The known range of *D. nasorakensis* is latest Meramec (boundary between zones 15 and 16i) and earliest Chester (zone 16i).

Coral collections made by Armstrong (1970b) from the Meramec and possibly early Chester age parts of the Kogruk Formation in the DeLong Mountains do not have any forms which could be referred to the genus *Diphyphyllum.* This genus is also absent from my collections of Meramec and Chester age coral faunas from the Lisburne Group in the Endicott Mountains.

Diphyphyllum nasorakensis n. sp. has not been found in the Lisburne Group in the Franklin or Romanzof Mountains, northeastern Alaska. The stratigraphic range of the very closely related species *D. klawockensis* Armstrong appears to be somewhat older; this species is abundant in beds of Meramec age (primarily in zones 13 and 14).

The type specimen of *D. klawockensis* Armstrong (1970a) from the limestone and chert member of the Peratrovich Formation, Prince of Wales Island, southeastern Alaska, is found in beds which contain a large foraminiferal fauna of Meramec (zones 13 and 14) age in association with *D. venosum* Armstrong, *Lithostrotionella banffensis* (Warren), *L. pennsylvanica* (Shimer), *L. birdi* Armstrong, *Thysanophyllum astraeiforme* (Warren), and *Sciophyllum alaskaensis* Armstrong.

Diphyphyllum klawockensis has been found in the Lisburne Group at 45 feet above the base of the South Cape Lewis section (68A–9) (figs. 7, 9) in beds of earliest Chester age (zone 16i). *D. klawockensis* is common in Meramec (zones 13 and 14) beds of the Kayak (?) Shale and the Lisburne Group of the Franklin and Romanzof Mountains of northeastern Alaska.

Remarks.—The examples of *Diphyphyllum nasorakensis* n. sp. from the Lisburne Group at Cape Lewis and south of Niak Creek differ from the type material of *D. klawockensis* Armstrong (1970a) from the Peratrovich Formation, Prince of Wales Island, southeastern Alaska, in having very few minor septa between the major septa. The holotype and the paratypes of *D. klawockensis* Armstrong (1970a, pl. 5, figs. 2–6) are characterized by having 0.3-mm-long minor septa between the major septa. Except for the slightly shorter major septa and the diminutive to absent minor septa, *D. nasorakensis* is very similar morphologically to *D. klawockensis* Armstrong.

Diphyphyllum venosum Armstrong (1970a, pl. 6, figs. 1–7, and pl. 9, figs. 4, 5) from the Meramec age beds of the Peratrovich Formation, Prince of Wales Island, southeastern Alaska, is distinguished from *D. nasorakensis* and *D. klawockensis* by its larger corallite diameter of 10–12 mm, 25–34 major septa, and three or four rows of dissepiments.

Diphyphyllum furcatum Thomson from the Viséan of Scotland as described by Hill (1940, p. 185–186) is similar in corallite diameter and in number and length of major septa to *D. klawockensis. D. furcatum* differs in having two or three rows of dissepiments and in having tabulae which are in two series, an inner series consisting of very broad, flattened domes whose downturned edges abut on the lower dome and an outer series that is narrow and consists of small concave plates (Hill, 1940, pl. 11, fig. 1).

Diphyphyllum vermiculare (Stuckenberg) as described by Dobroljubova (1958, p. 195–197, pl. 33, fig. 3) is similar in corallite diameter and in number and development of septa to *D. klawockensis.* The Russian species differs in having (p. 195) "trapeziform tabulae which make contact with the underlying tabulae or with the dissepiments" and in having one to three rows of dissepiments.

Name.—*D. nasorakensis* refers to the Nasorak Formation (Campbell, 1967), from which the type material was collected.

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, ed., Treatise on invertebrate paleontology, Part F, Geol. Soc. America, p. F306–307.

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

Diagnosis.—Cerioid corallum; prismatic corallites; columella a persistent vertical lath frequently continuous with counter and cardinal septa; lonsdaleoid dissepiments; major septa intermittently reach wall along tops of dissepiments; minor septa short; tabulae commonly complete, conical. (Summarized from Yabe and Hayasaka, 1915, p. 94.)

Lithostrotionella niakensis n. sp.

Plate 4, figures 2, 6; plate 8, figures 1–3; plate 9, figures 1–6

Lithostrotionella sp. A. Armstrong, 1970b, U.S. Geol. Survey Prof. Paper 664, p. 25, 26, pl. 7, figs. 1–6.

Material.—The five speciments available for study were collected by J. Thomas Dutro, Jr., and myself from measured stratigraphic sections. The specimens are preserved in blocks of limestone, and the exterior of the coralla cannot be seen. All specimens are fragments of coralla. The approximate size of each fragment is:

USNM 161074	7×7×7 cm
USNM 161075 (badly broken)	7×7×12 cm
USNM 161076	9×10×12 cm
USNM 161077	4×10×10 cm
USNM 161078	4×8×9 cm

A transverse and a longitudinal 2- by 3-inch thin section were cut of each corallum. About 100 corallites per corallum were studied in thin section.

Description.—The holotype, USNM 161074 (pl. 4, figs. 2, 6; pl. 8, fig. 3; pl. 9, figs. 5, 6), is a cerioid corallum and in transverse section has prismatic corallites that are typically 2.5–3.5 mm in diameter and have 11–14 major septa (figs. 24, 25). In some corallites the major septa are 1–1.5 mm long, and the minor septa are 0.5–0.7 mm long. The major septa are generally continuous through the dissepimentarium. In the larger corallites, which have a columella and a diameter in excess of 3.5 mm, the dissepiments are generally lonsdaleoid and may intercept the loci of the majority of the major septa. Except for the cardinal and counter septa, which may reach the columella, the major septa are withdrawn from the axial region. Serial transverse thin sections reveal that the corallites are acolumellate at various levels, and typically the major septa extend ¼–¾ the distance to the axial region as short ridges on the upper surfaces of the tabulae. Where the columella is well developed, the major septa commonly extend into the axial region and may even reach the columella. The weaker the development of the columella, the more amplexoid are the septa. In acolumellate corallites the major septa extend only a short distance beyond the tabularium wall into the axial region (fig. 25).

Transverse sections show the dissepimentarium to be present throughout the length of the corallite and to be formed by a single row, and in some spec-

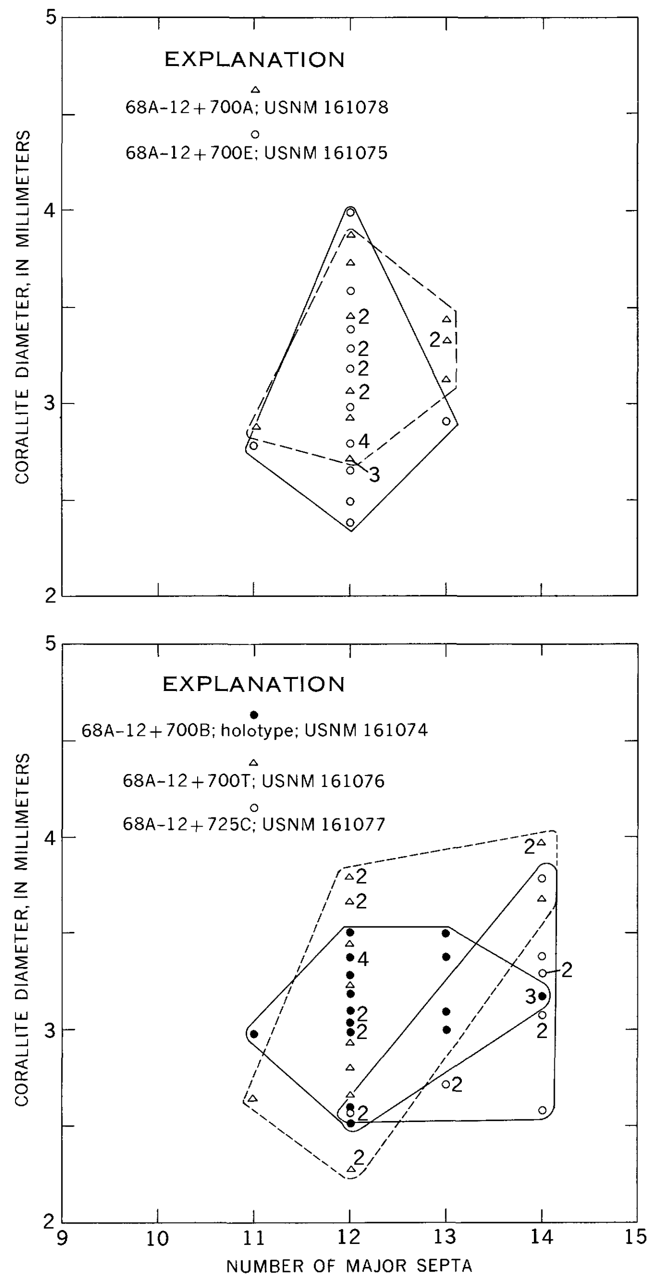


FIGURE 24.—Corallite diameter and number of major septa in *Lithostrotionella niakensis* n. sp. Each unnumbered symbol represents a single corallite; if more than one corallite shows the same diameter and number of septa, the number of similar corallites is shown.

imens a double row, of globose dissepiments, of which nine to 11 occur in 5 mm. The dissepimentarium is 0.5–0.9 mm wide. The columella may be well developed at certain levels and absent at other levels of the corallite. Where the columella is well developed, the dissepimentarium tends to be formed by two rows of dissepiments, and the tabulae are complete. The tabulae are nearly horizontal to a

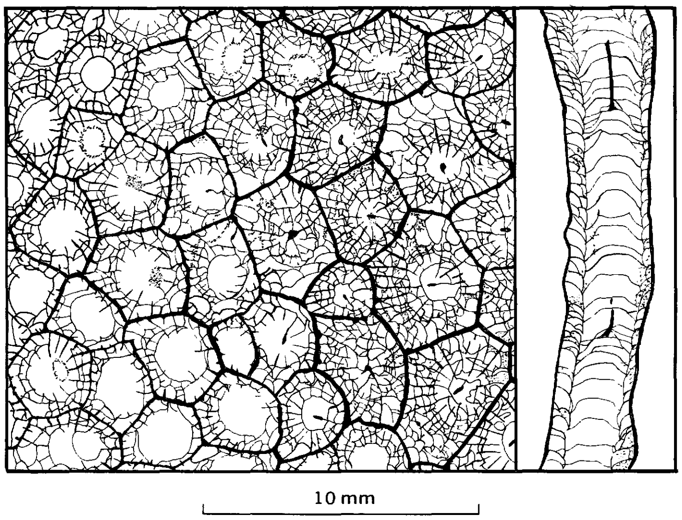


FIGURE 25.—Sections of *Lithostrotionella niakensis* n. sp. (USNM 161074).

distance of 0.5–0.7 mm from the columella, and then they are reflexed downward at angles of 45°–65° from the horizontal. The tabulae are reflexed at a lower angle before reaching the dissepiments (pl. 4, fig. 2; pl. 9, fig. 6). In acolumellate corallites the tabulae are complete and dome shaped (pl. 9, fig. 5).

The corallite wall in transverse section is 100–150 microns thick, and its center is marked by a dark calcite band 30 microns thick (pl. 4, figs. 2, 6). The corallite wall is composed of fibrous calcite deposited normal to this dark band. The microstructure of the septa is fibrous calcite deposited at angles at 20°–25° from the axis of the septum. In longitudinal section, the tabulae and dissepiment walls are 30 microns thick, and their microstructure is a mosaic of crystals of calcite 5–10 microns in size.

Paratype USNM 161077 (pl. 8, figs. 1, 2) differs from the holotype in having a corallite diameter of 2.5–3.8 mm and 12–14 major septa. Furthermore, some of the corallites are characterized by a very massive and thick columella and by major septa that are long and commonly extend to and join the columella. Adjacent corallites may have a columella which is less massive, and some corallites are diphymorphic.

Paratypes USNM 161075, 161076, and 161078 are all from the same bed (fig. 4) and do not differ in any significant morphological characteristics from the holotype (fig. 24).

Occurrence.—The type material for *Lithostrotionella niakensis* was collected north of Niak Creek in the Lisburne Group, at 700 feet below the top of section 68A–12 (figs. 3, 4) (USNM 161074, 161075, 161076, 161078) and at 725 feet below the top of this section (USNM 161077). Armstrong, Mamet, and Dutro (1971) reported that the associated Foraminifera indicate a middle Meramec age (zone 13). The Foraminifera are archaediscids, *Archaediscus* of the group *A. krestovnikovi* Rauzer-Chernoussova; endothyrids, *Eoendothyranopsis* of the group *E. pressa* Grozdilova, in Lebedeva, and *Globoendothyra* sp.; eoforschiids, *Eoforschia;* and primitive bradyinids, *Endothyranopsis.* The associated coral fauna consists of *Lithostrotion* (*Siphonodendron*) *warreni* Nelson and *Lithostrotionella banffensis* (Warren).

Lithostrotionella sp. A described by Armstrong (1970b, p. 25) is assigned to the species *L. niakensis.* It was collected from the Kogruk Formation in a river cutbank of the Kukpuk River in the Lisburne Hills region, where it was found in association with a foraminiferal and coral fauna of Meramec age.

Present knowledge of the stratigraphic distribution of *L. niakensis* suggests that the species is characteristic of rocks of Meramec age (zones 13 and 14) within the Lisburne Group.

Remarks.—*Lithostrotionella mclareni* (Sutherland) is similar in corallite diameter and in number of major septa to *L. niakensis* but differs in having major septa that are better developed and thicker and that tend to be dilated in the tabularium, and in having few corallites in which the septa are well developed within the dissepimentarium. Further, if the columella is weakly developed or absent, then the septa are more strongly amplexoid, the dissepiments tend to be strongly lonsdaleoid, and the septa are very poorly developed or absent in the dissepimentarium. In contrast, *L. niakensis,* in acolumellate sections of the corallites, generally has major septa that are relatively well developed and persistent in the dissepimentarium. In *L. niakensis* those sections of a corallite which contain a columella have tabulae that are complete and horizontal and are not bent or arched to join the columella. *L. mclareni,* however, has strongly arched tabulae which are more sharply bent upward before joining the columella.

The syntype of the Meramec age *Lithostrotionella macouni* (Lambe) as redescribed by Nelson (1960) and Armstrong (1970b) differs from *L. niakensis* n. sp. in having corallites with a diameter of 2–3 mm and 9 to 11 major septa. The major septa are long and commonly join the columella. The tabulae may be complete or incomplete and are arched to meet the columella.

Lithostrotion trimorphum Groot (1963, p. 49–51, pl. 6, figs. 1, 2) from the Perapertu Formation of Palencia, Spain, is similar in size and number of corallites to *L. niakensis* n. sp. The Spanish species has wide variation in the morphology of the corallites and displays within a single corallum the traits of the genera *Lithostrotion*, *Lithostrotionella*, and *Thysanophyllum*. Although it is morphologically very similar to *L. niakensis*, *L. trimorphum* differs in having corallites with a persistent columella and slightly arched and domed tabulae. In addition, the dissepimentarium is somewhat wider and has a stronger trend toward the development of a double row of dissepiments.

Name.—*L. niakensis* is from Niak Creek south of the collection locality. According to Orth (1967, p. 685), Niak may mean "head" in Eskimo.

REFERENCES CITED

Armstrong, A. K., 1970a, Mississippian rugose corals, Peratrovich Formation, west coast of Prince of Wales Island, southeastern Alaska: U.S. Geol. Survey Prof. Paper 534, 43 p., 13 pls., 30 figs.

——— 1970b, Carbonate facies and the lithostrotionoid corals of the Mississippian Kogruk Formation, DeLong Mountains, northwestern Alaska: U.S. Geol. Survey Prof. Paper 664, 38 p., 14 pls., 37 figs.

Armstrong, A. K., and Mamet, B. L., 1970, Biostratigraphy and dolomite porosity trends of the Lisburne Group, *in* Adkison, W. L., and Brosgé, M. M., eds., Proceedings of the geological seminar on the North Slope of Alaska: Los Angeles, Pacific Sec. Am. Assoc. Petroleum Geologists, p. N1–N16, 12 figs.

Armstrong, A. K., Mamet, B. L., and Dutro, J. T., Jr., 1970, Foraminiferal zonation and carbonate facies of Carboniferous (Mississippian and Pennsylvanian) Lisburne Group, central and eastern Brooks Range, Arctic Alaska: Am. Assoc. Petroleum Geologists Bull., v. 54, no. 5, p. 687–698, 4 figs.

——— 1971, Lisburne Group, Cape Lewis–Niak Creek, northwestern Alaska, *in* Geological Survey research 1971: U.S. Geol. Survey Prof. Paper. 750–B, p. B23–B34.

Bowsher, A. L., and Dutro, J. T., Jr., 1957, The Paleozoic section in the Shainin Lake area, central Brooks Range, Alaska: U.S. Geol. Survey Prof. Paper 303–A, p. 1–39, 6 pls., 4 figs.

Campbell, R. H., 1967, Areal geology in the vicinity of the Chariot site, Lisburne Peninsula, northwestern Alaska: U.S. Geol. Survey Prof. Paper 395, 71 p., 1 pl., 28 figs.

Dobroljubova, T. A., 1958, Nizhnekamennogol'nye kolonial'nye chetyrekhluchevye korally Russkoi platformy [Lower Carboniferous colonial tetracorals of the Russian Platform]: Akad. Nauk SSSR Paleont. Inst. Trudy, v. 70, 216 p., 38 pls., 34 figs.

Easton, W. H., 1957, On the tetracoral *Lithostrotion harmodites* Milne-Edwards and Haime: Jour. Paleontology, v. 31, no. 3, p. 616–622, pl. 71.

Groot, G. E. de, 1963, Rugose corals from the Carboniferous of northern Palencia (Spain): Leidse Geol. Mededel., pt. 29, 123 p., 26 pls., 39 figs.

Hill, Dorothy, 1938–41, A monograph on the Carboniferous rugose corals of Scotland: Palaeontographical Soc. [London], 1938, pt. 1, p. 1–78 (v. 91), 2 pls., 2 figs.; 1939, pt. 2, p. 79–114 (v. 92), 3 pls.; 1940, pt. 3, p. 115–204 (v. 94); 1941, pt. 4, p. 205–213 (v. 95).

——— 1956, Rugosa, *in* Moore, R. C., ed., Treatise on invertebrate paleontology, Part F, Coelenterata: Geol. Soc. America and Kansas Univ. Press, p. F233–F324.

Kato, Makoto, 1963, Fine skeletal structures in rugose: Hokkaido Univ. Fac. Sci. Jour., ser. 4, v. 11, no. 4, p. 571–630, 3 pls., 19 text figs.

Kelly, W. A., 1942, Lithostrotiontidae in the Rocky Mountains: Jour. Paleontology, v. 16, no. 3, p. 351–361, pls. 50 and 51, 1 text fig.

Macqueen, R. W., and Bamber, E. W., 1968, Stratigraphy and facies relationships of the Upper Mississippian Mount Head Formation, Rocky Mountains and foothills, southwestern Alberta: Bull. Canadian Petroleum Geology, v. 16, no. 3, p. 225–287, 11 figs.

Nelson, S. J., 1960, Mississippian lithostrotionid zones of the southern Canadian Rocky Mountains: Jour. Paleontology, v. 34, no. 1, p. 107–125, pls. 21–25, 3 text figs.

Oliver, W. A., 1968, Some aspects of colony development in corals, *in* Paleobiological aspects of growth and development—A symposium: Paleont. Soc. Mem. 2, Jour. Paleontology, v. 42, no. 5, supp. p. 16–34, 6 figs.

Orth, D. J., 1967, Dictionary of Alaska place names: U.S. Geol. Survey Prof. Paper 567, 1084 p.

Sable, E. G., and Dutro, J. T., Jr., 1961, New Devonian and Mississippian Formations in DeLong Mountains, northern Alaska: Am. Assoc. Petroleum Geologists Bull., v. 45, no. 5, p. 585–593, 4 figs.

Sando, W. J., Mamet, B. L., and Dutro, J. T., Jr., 1969, Carboniferous megafaunal and microfaunal zonation in the northern Cordillera of the United States: U.S. Geol. Survey Prof. Paper 613–E, 29 p., 7 figs.

Smith, Stanley, 1928, The Carboniferous coral *Nemistium edmondsi* gen. et sp. n.: Annals and Mag. Nat. History, ser. 10, v. 1, p. 112–120, 1 pl.

Smith, Stanley, and Lang, W. D., 1930, Description of the type-specimens of some Carboniferous corals of the genera "*Diphyphyllum*," "*Stylastracea*," *Aulophyllum* and *Chaetetes*: Annals and Mag. Nat. History, ser. 10, v. 5, no. 26, p. 177–194, 2 pls.

Warren, P. S., 1927, Banff area, Alberta: Canada Geol. Survey Mem. 153, 94 p., 7 pls.

Yabe, Hisakatsu, and Hayasaka, Ichiro, 1915, Palaeozoic corals from Japan, Korea, and China: Geol. Soc. Tokyo Jour., v. 22, no. 264, p. 93–109.

——— 1916, Palaeozoic corals from Japan, Korea, and China: Geol. Soc. Tokyo Jour., v. 23, no. 271, p. 57–62.

Yü, C. C., 1933, Lower Carboniferous corals of China: China Geol. Survey, Palaeontologica Sinica, ser. B, v. 12, pt. 3, 211 p., 24 pls.

——— 1937, The Fenginian corals of south China: Acad. Sinica, Inst. Geology and Paleontology, Chi-K'an Mem., no. 16, 111 p., 13 pls.

INDEX

[Italic page numbers indicate both major references and descriptions]

PLATES 1-9

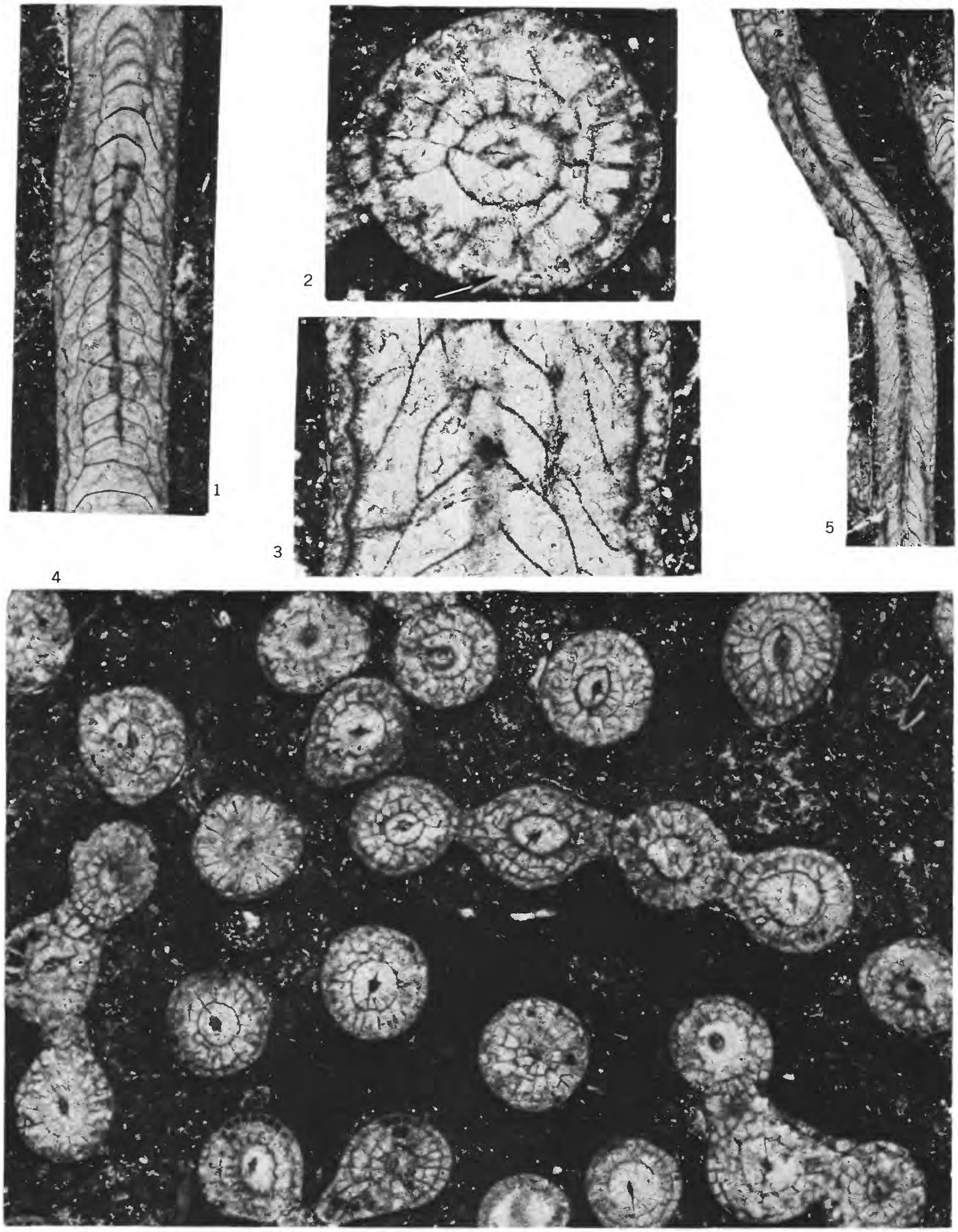
Contact prints of each fossil plate in this publication are available at cost from the Library, U.S. Geological Survey, Federal Center, Denver, Colorado 80225.

PLATE 1

FIGURE 1–5. *Lithostrotion* (*Siphonodendron*) *lisburnensis* n. sp. Nasorak Formation, south Niak Creek section, 68A–13.

1–4. 1, Longitudinal thin section (× 9). 2, Transverse photomicrograph (× 25), illustrating microstructure and preservation. Corallite and matrix are preserved by calcite, except for chalcedony replacement in parts of the corallite wall and adjacent dissepimentarium; arrow points to a small area replaced by chalcedony. 3, Longitudinal photomicrograph (× 25), showing dark granular calcite of the dissepiments and the very thin tabulae. 4, Transverse thin section (× 9). Holotype, USNM 161064.

5. Longitudinal thin section (× 4). Paratype, USNM 161065.



LITHOSTROTION (SIPHONODENDRON) LISBURNENSIS N. SP.

PLATE 2

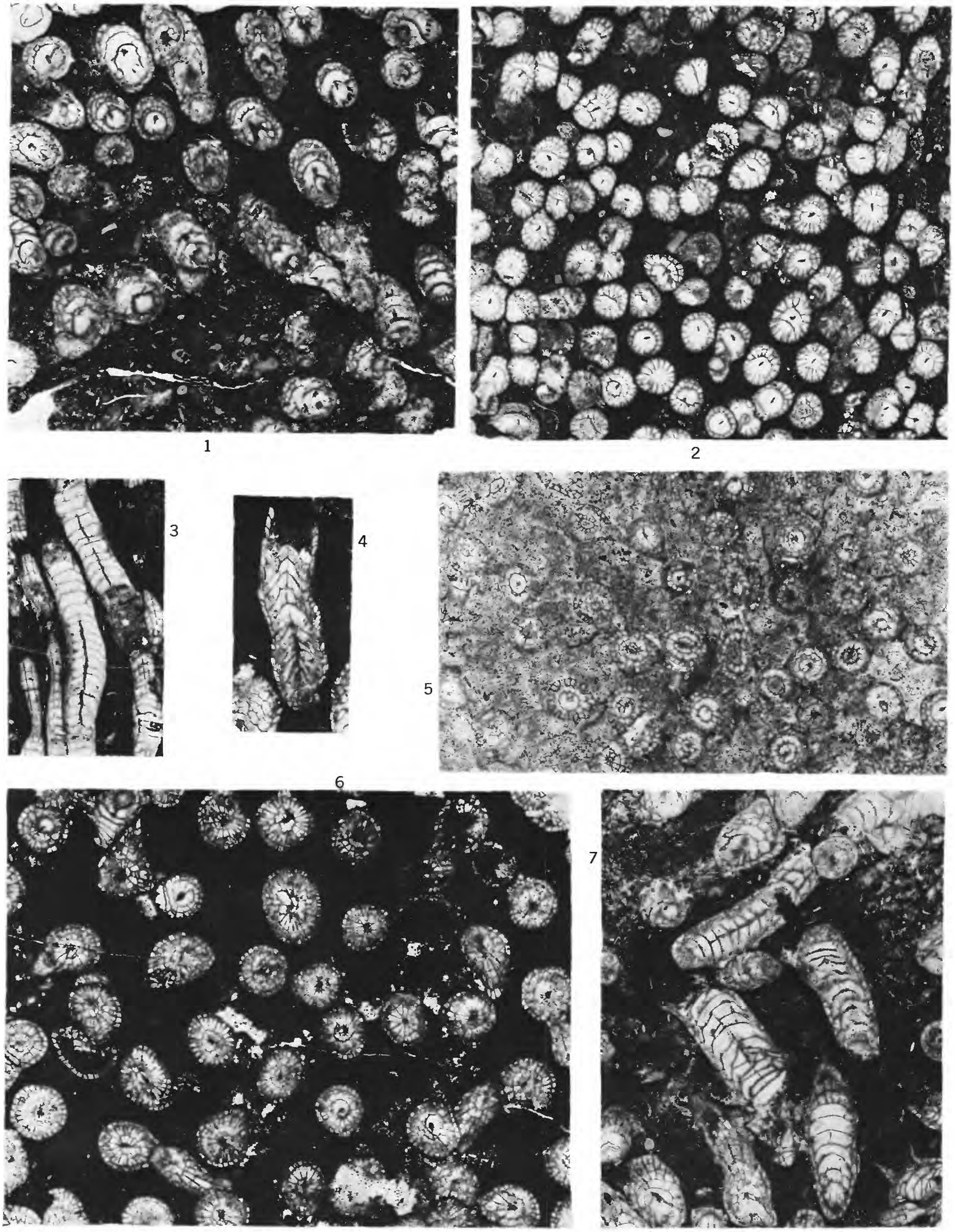
FIGURES 1–7. *Lithostrotion* (*Siphonodendron*) *lisburnensis* n. sp., south Cape Lewis section, 68A–9.

1, 7. 1, Transverse; 7, longitudinal oblique thin section (× 4). Paratype, USNM 161052.

2, 3. 2, Transverse; 3, longitudinal thin section (× 4). Paratype, USNM 161061.

4, 6. 4, Longitudinal; 6, transverse thin section (× 4). Paratype, USNM 161053.

5. Transverse thin section (× 4); matrix surrounding corallite is extensively replaced by chalcedony. Paratype, USNM 161056.



LITHOSTROTION (SIPHONODENDRON) LISBURNENSIS N. SP.

PLATE 3

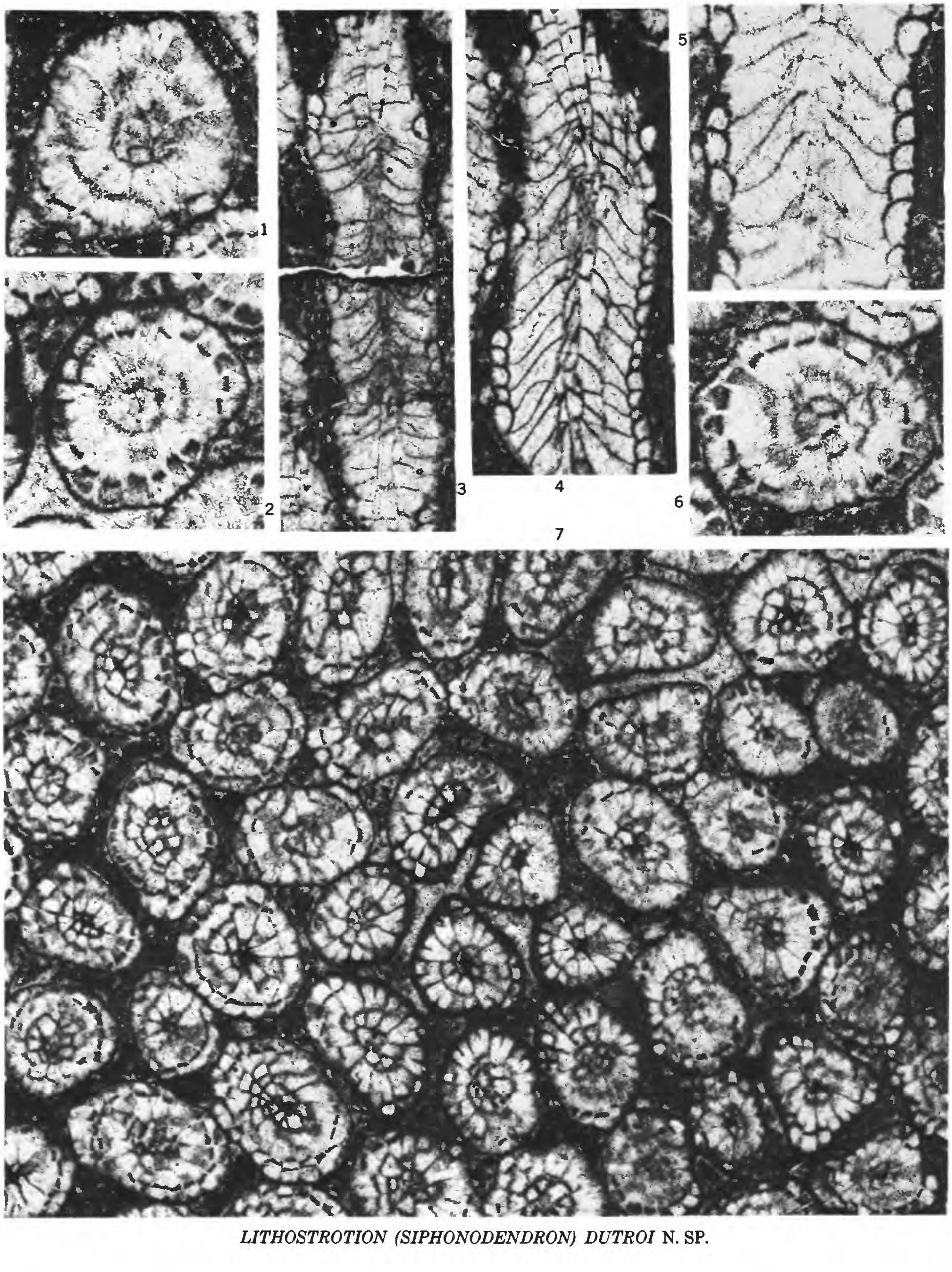
FIGURES 1–7. *Lithostrotion* (*Siphonodendron*) *dutroi* n. sp. Holotype, USNM 161085, 185 feet above the base of the Alapah Limestone, type section, Shainin Lake, Alaska.

1, 2, 6. Transverse photomicrographs (× 25), illustrating microstructure; corallites and matrix are preserved by calcite; figure 2 shows the dark outer band on the corallite wall.

3, 4. Longitudinal thin sections (× 15).

5. Longitudinal photomicrograph (× 25), illustrating the dark wall structure and dissepiments.

7. Transverse thin section (× 15).



LITHOSTROTION (SIPHONODENDRON) DUTROI N. SP.

PLATE 4

FIGURES 1, 3–5. *Lithostrotion* (*Siphonodendron*) *dutroi* n. sp. Alapah Limestone, west fork Hulahula River.

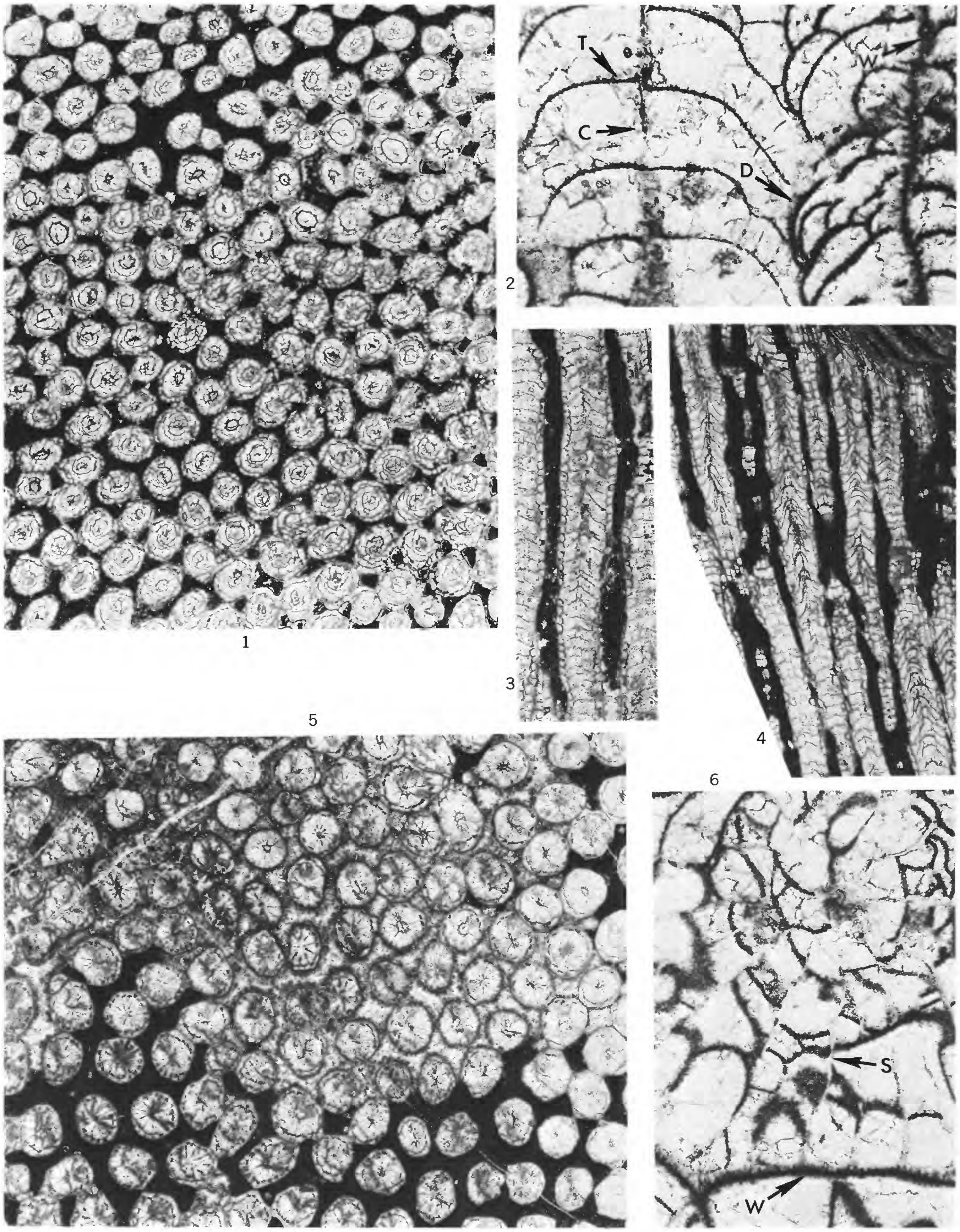
1, 4. 1, Transverse; 4, longitudinal thin section (× 4). Paratype, USNM 161090.

3, 5. 3, Longitudinal; 5, transverse thin section (× 4). Paratype, USNM 161087.

2, 6. *Lithostrotionella niakensis* n. sp. Holotype, USNM 161074, Kogruk Formation, north Niak Creek section, 68A–12.

2. Longitudinal photomicrograph (× 25), illustrating the fibrous microstructure of the columella and corallite wall; dark central band in the corallite wall is shown. T, tabulae; C, columella; D, dissepiments; W, wall; S, septa.

6. Transverse photomicrograph (× 25), illustrating the fibrous microstructure of the corallite walls with their dark central band, and the granular microstructure of the tabulae and dissepiments.



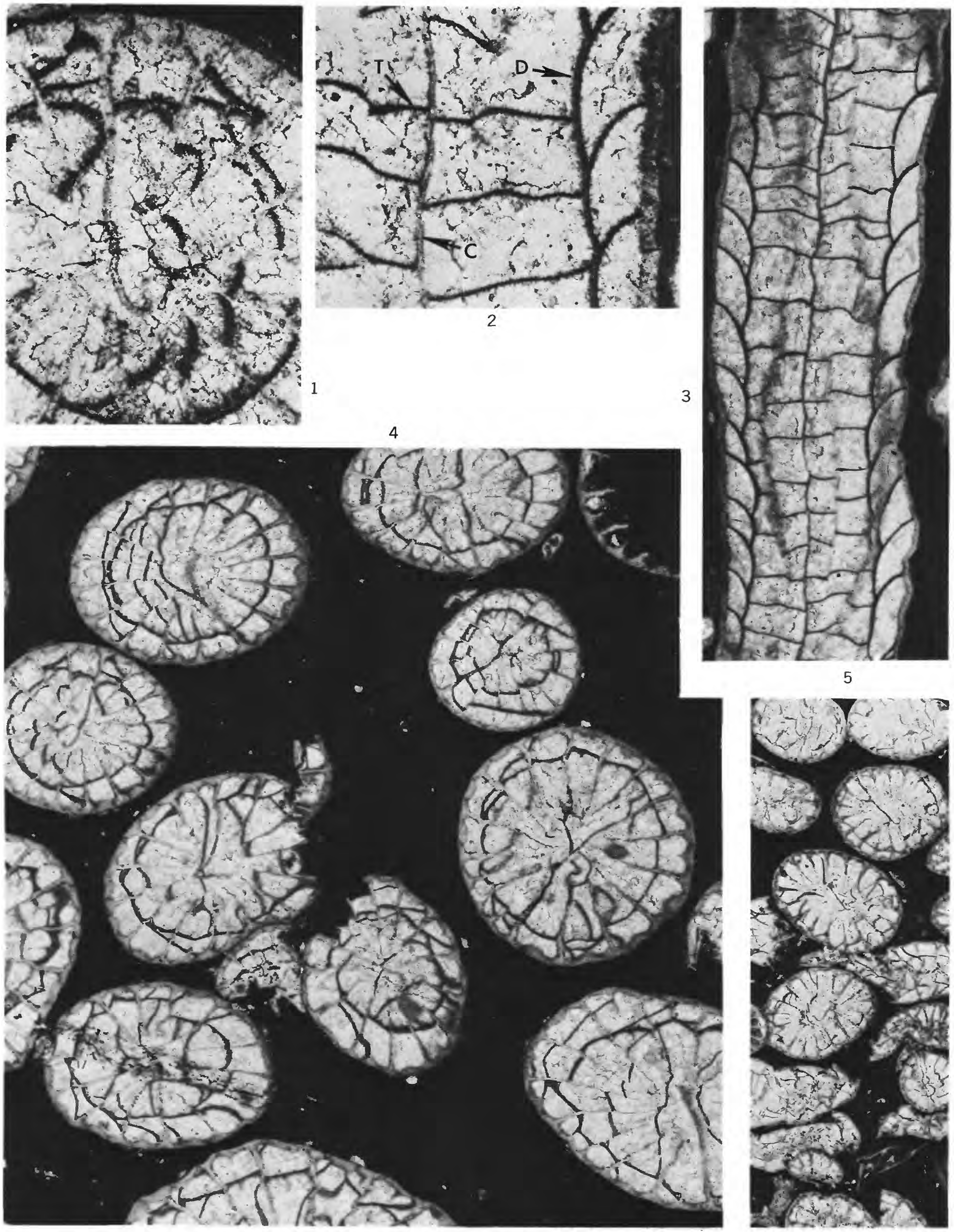
LITHOSTROTION (SIPHONODENDRON) DUTROI N. SP. AND
LITHOSTROTIONELLA NIAKENSIS N. SP.

PLATE 5

FIGURES 1–5. *Lithostrotion* (*Siphonodendron*) *ignekensis* n. sp. Holotype, USNM 160520, Alapah Limestone, west Sadlerochit Mountains section, 69A–1.

1, 2. 1, Transverse photomicrograph (× 25), illustrating microstructure of the wall, major septa, long counter septum, and columella. The darker color and texture of the dissepiments and tabulae are in contrast to the microstructure of the septa and wall. 2, Longitudinal photomicrograph (× 25); T, tabulae; C, columella; D, dissepiment. Microstructure of the columella and corallite wall contrasting with that of the dissepiments and tabulae is shown.

3–5. 3, Longitudinal; 4, transverse thin section (× 9); 5, transverse thin section (× 4).



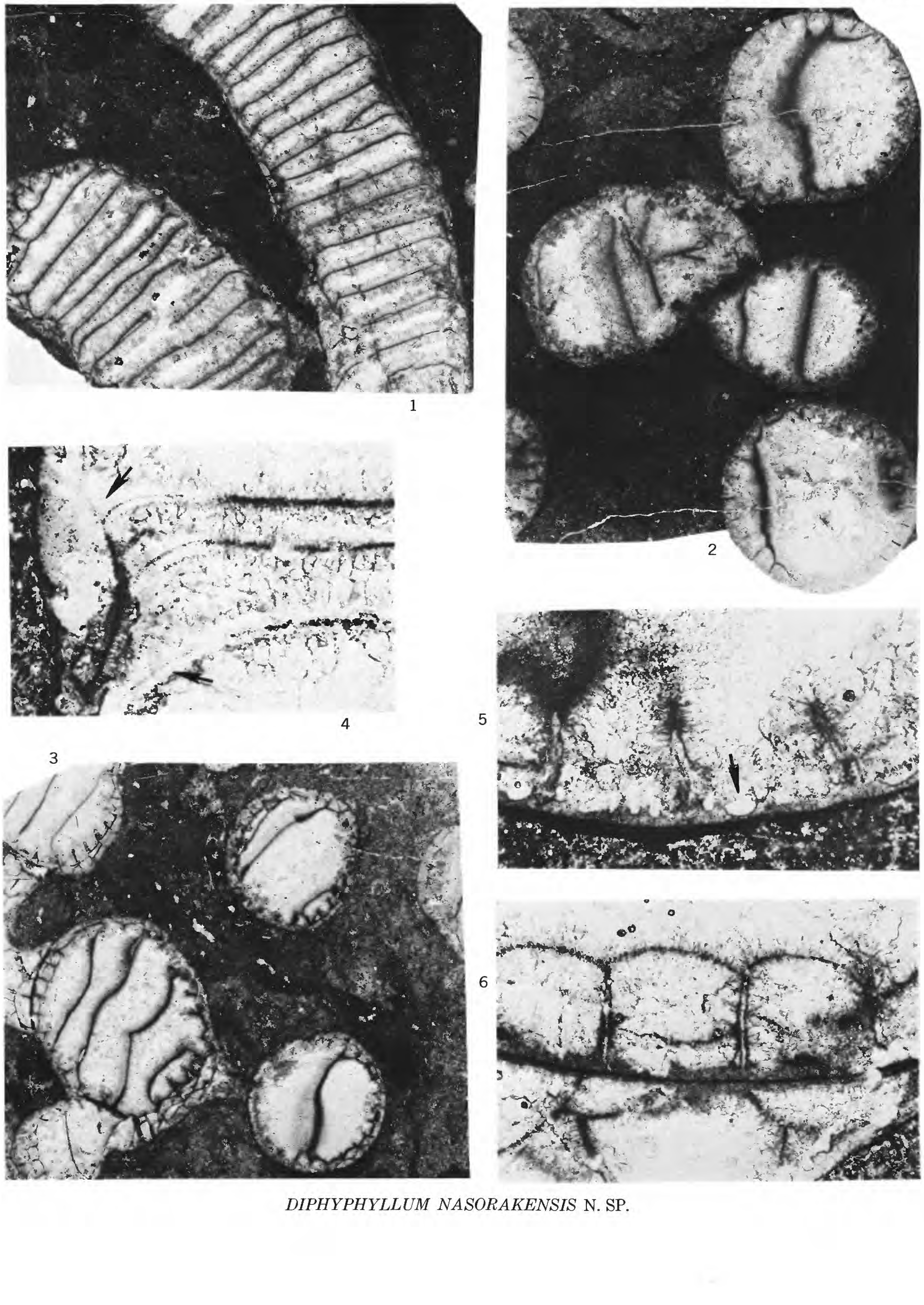
LITHOSTROTION (SIPHONODENDRON) IGNEKENSIS N. SP.

PLATE 6

FIGURES 1–6. *Diphyphyllum nasorakensis* n. sp. Holotype, USNM 161044, Nasorak Formation, south Cape Lewis section, 68A–9.

1–3. 1, Longitudinal; 2, 3, transverse thin sections (× 3).

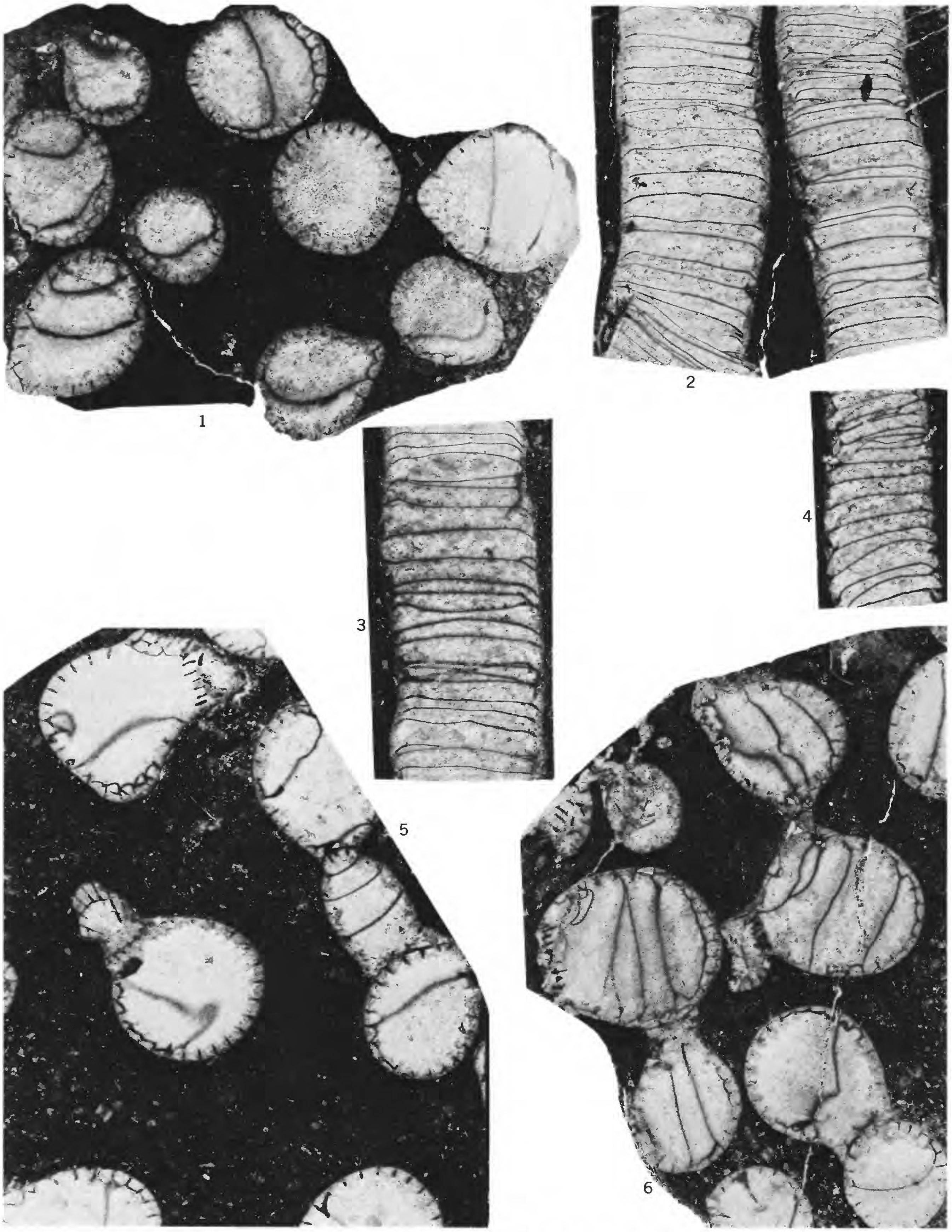
4–6. 4, Longitudinal; 5, 6, transverse photomicrographs (× 25), illustrating wall structure and preservation; the matrix and most of the corallum and interior is calcite, although most areas near the corallite walls have been selectively silicified. Arrows point to locations where chalcedony has penetrated the walls, septa, and dissepiments. Figure 4 shows where chalcedony has selectively destroyed much of the tabulae.



DIPHYPHYLLUM NASORAKENSIS N. SP.

PLATE 7

FIGURES 1–6. *Diphyphyllum nasorakensis* n. sp. Nasorak Formation, south Cape Lewis section, 68A–9.
1–3, 6. 1, 6, Transverse; 2, 3, longitudinal thin sections (× 3). Paratype, USNM 161045.
4, 5. 4, Longitudinal; 5, transverse thin section (× 3). Paratype, USNM 161047.

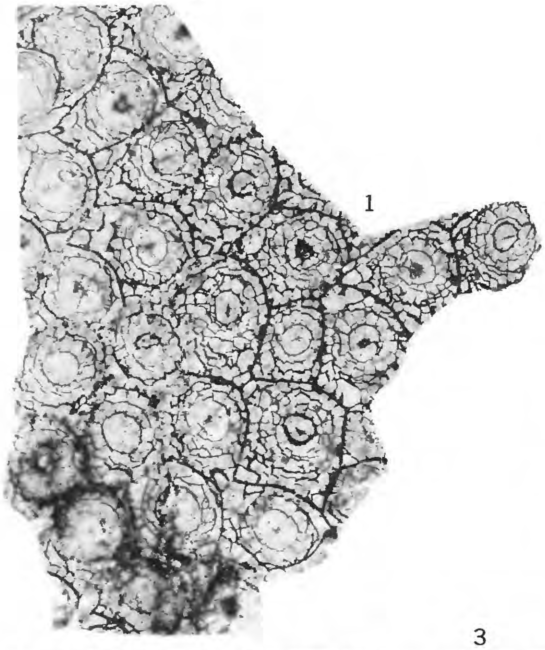


DIPHYPHYLLUM NASORAKENSIS N. SP.

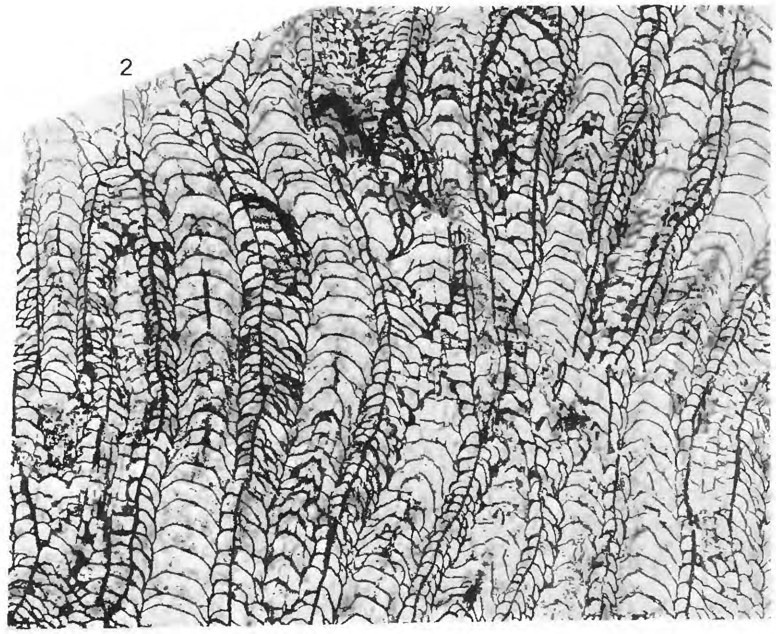
PLATE 8

FIGURES 1–3. *Lithostrotionella niakensis* n. sp. Kogruk Formation, north Niak Creek section, 68A–12.
1, 2. 1, Transverse; 2, longitudinal thin section (× 4). Paratype, USNM 161077.
3. Transverse thin section (× 9). Holotype, USNM 161074.

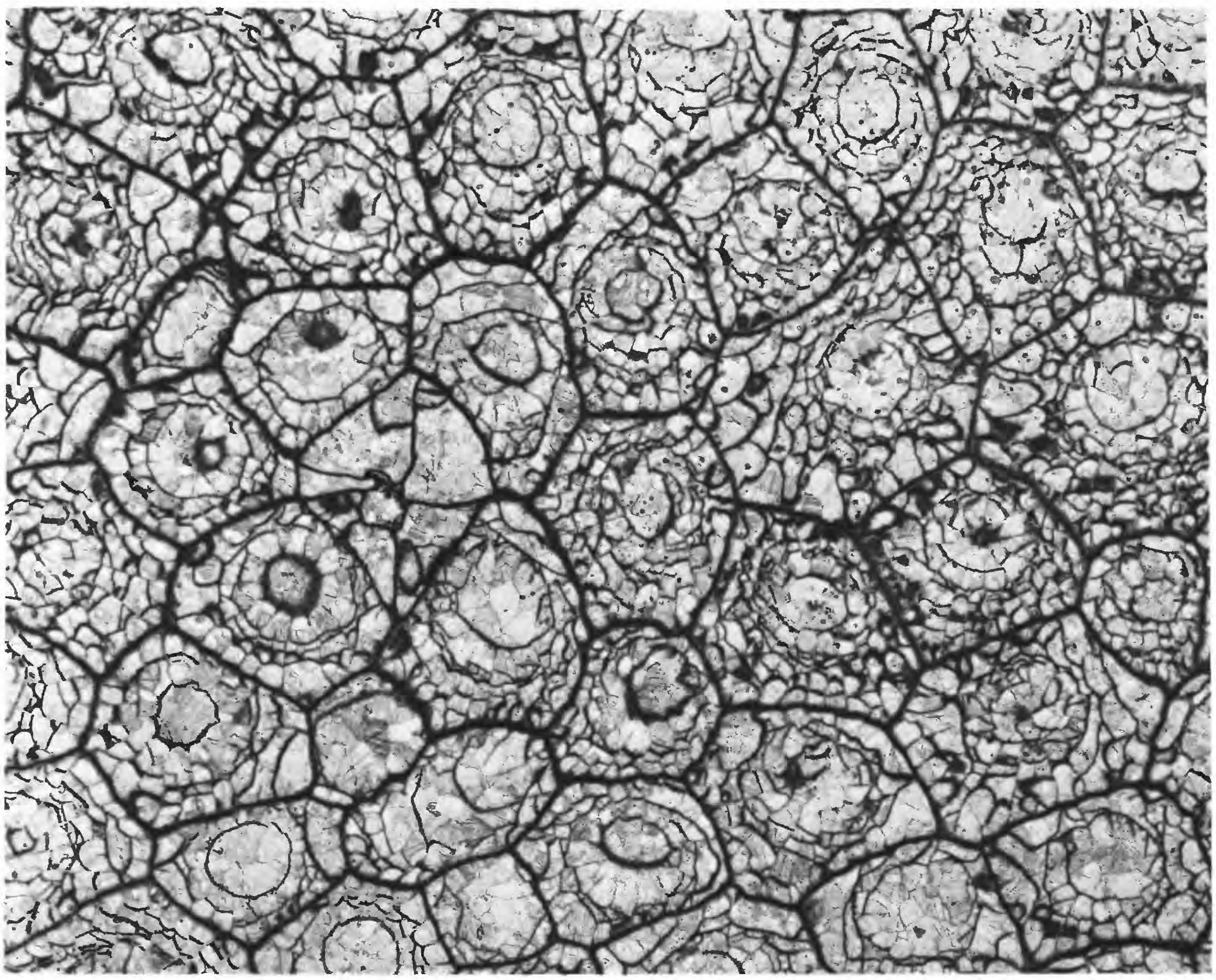
1



2



3



LITHOSTROTIONELLA NIAKENSIS N. SP.

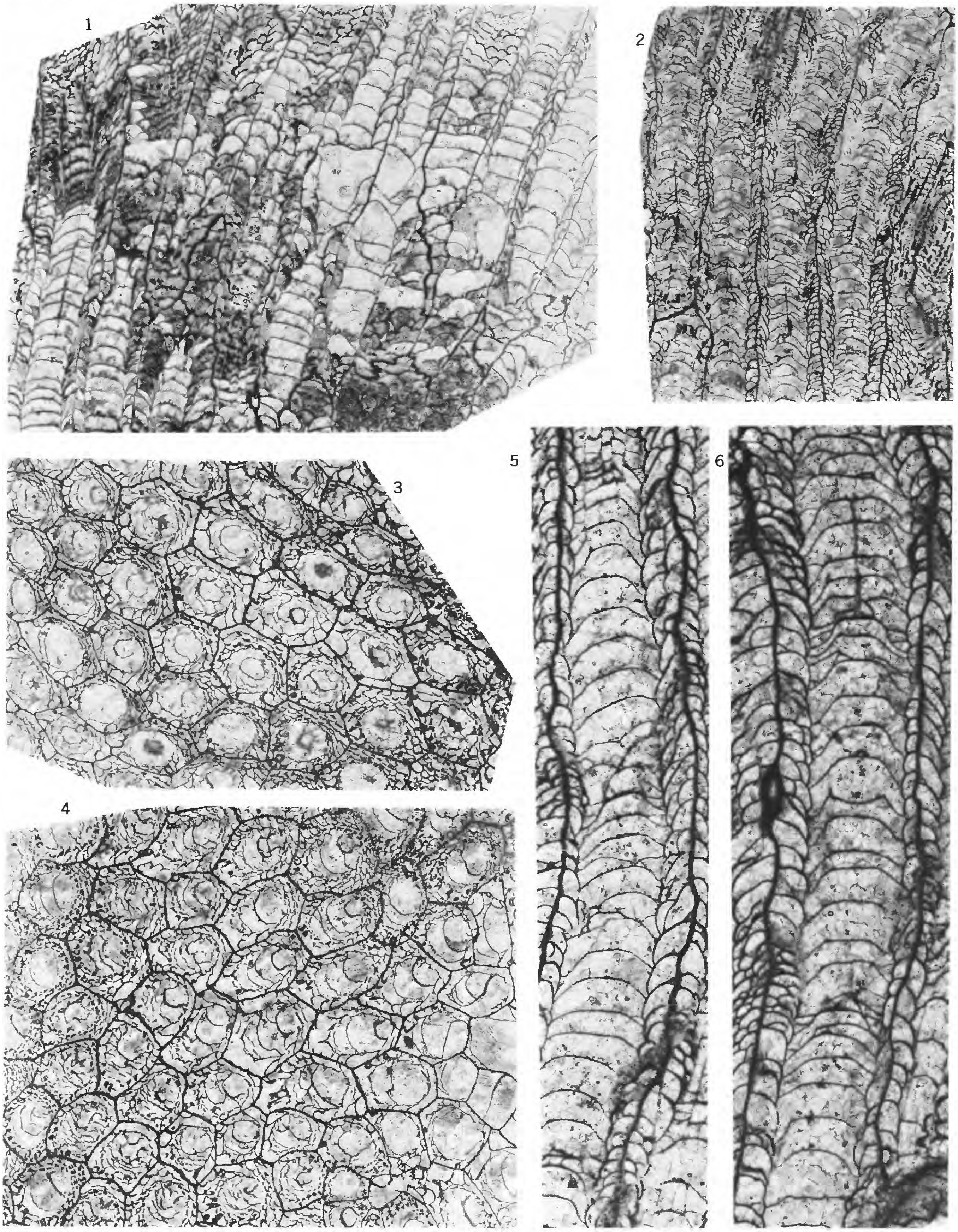
PLATE 9

FIGURES 1–6. *Lithostrotionella niakensis* n. sp. Kogruk Formation, north Niak Creek section, 68A–12.

1, 3. 1, Longitudinal; 3, transverse thin section (× 4). Paratype, USNM 161076.

2, 4. 2, Longitudinal; 4, transverse thin section (× 4). Paratype, USNM 161078.

5, 6. Longitudinal thin sections (× 9). Holotype, USNM 161074.



LITHOSTROTIONELLA NIAKENSIS N. SP.

U. S. GOVERNMENT PRINTING OFFICE : 1972 O - 456-832