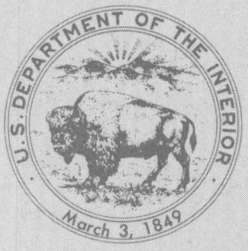
Revision of *Lithostrotionella* (Coelenterata, Rugosa) from the Carboniferous and Permian

GEOLOGICAL SURVEY PROFESSIONAL PAPER 1247



Revision of *Lithostrotionella* (Coelenterata, Rugosa) from the Carboniferous and Permian

By WILLIAM J. SANDO

GEOLOGICAL SURVEY PROFESSIONAL PAPER 1247

A revision of colonial rugose corals based on restudy of Hayasaka's North American species and the literature on other species referred to Lithostrotionella

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1983

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, *Secretary*

GEOLOGICAL SURVEY

Dallas L. Peck, *Director*

Library of Congress Cataloging in Publication Data

Sando, William Jasper.
Revision of Lithostrotionella (Coelenterata, Rugosa) from the Carboniferous and Permian.

(Geological survey professional paper ; 1247)
"A revision of colonial rugose corals based on restudy of Hayasaka's North American species and the literature on other species referred to Lithostrotionella."
Includes bibliographical references and index.
Supt. of Docs. no.: I 19.16:
1. Lithostrotionidae. 2. Paleontology–Carboniferous. 3. Paleontology–Permian. I. Title. II. Series.
QE778.S24 563'.6 81-607828
AACR2

**For sale by the Distribution Branch, U.S. Geological Survey,
604 South Pickett Street, Alexandria, VA 22304**

CONTENTS

ILLUSTRATIONS

[Plates follow index]

TABLE

REVISION OF *LITHOSTROTIONELLA* (COELENTERATA, RUGOSA) FROM THE CARBONIFEROUS AND PERMIAN

By WILLIAM J. SANDO

ABSTRACT

Species of predominantly massive colonial rugose corals from the Carboniferous and Permian that were referred previously to *Lithostrotionella* Yabe and Hayasaka are reassigned to the following genera: *Acrocyathus* d'Orbigny (including probable junior synonym *Lithostrotionella* Yabe and Hayasaka), *Stelechophyllum* Tolmachev (including junior synonym *Eolithostrotionella* Zhizhina), *Petalaxis* Milne-Edwards and Haime (including junior synonyms *Hillia* de Groot and *Eastonoides* Wilson and Langenheim), *Aulostylus* Sando, *Kleopatrina* McCutcheon and Wilson, *Lonsdaleia* McCoy (subgenus *Actinocyathus* d'Orbigny), and *Thysanophyllum* Nicholson and Thomson. One of the species referred to *Cystolonsdaleia* Fomichev is reassigned to *Petalaxis*.

Stelechophyllum and *Aulostylus* are referred to the Family Lithostrotionidae d'Orbigny. A new family, the Acrocyathidae, is created for the genus *Acrocyathus*. *Petalaxis* is placed in the Family Petalaxidae Fomichev, *Thysanophyllum* and *Lonsdaleia* are referred to the Family Lonsdaleiidae Chapman, and *Kleopatrina* is assigned to the Family Durhaminidae Minato and Kato.

The principal lithostrotionelloid genera are *Stelechophyllum, Aulostylus, Acrocyathus,* and *Petalaxis*. *Stelechophyllum* ranges in age from Late Devonian(?) into the late Viséan and is represented in the Carboniferous by 15 nominal species allocated to five species groups; the genus occurs in the U.S.S.R., U.S.A., Canada, and Mexico. *Aulostylus* is represented by two middle Tournaisian species in the U.S.A. and Canada and a possible species from the Viséan of China. *Acrocyathus* is represented by 14 nominal species (one new) from the lower to upper Viséan of the U.S.S.R., U.S.A., Canada, and China. *Petalaxis* is represented by 41 nominal species (six new) allocated to five species groups that range from the upper Viséan into the Permian; the genus occurs in the U.S.S.R., U.S.A., Canada, Spain, Japan, and possibly China and Spitzbergen.

Stelechophyllum may have been derived from *Endophyllum* in the Devonian. *Aulostylus, Acrocyathus,* and *Petalaxis* are regarded as offshoots from the *Stelechophyllum* stock in the Carboniferous. *Lonsdaleia, Thysanophyllum,* and *Kleopatrina* do not seem to be closely related to *Stelechophyllum* and its derivatives.

Hayasaka's type specimens of *Lithostrotionella* species from North America are reassigned to *Acrocyathus, Stelechophyllum, Petalaxis,* and *Aulostylus* and are revised specifically. Three new species and two new subspecies are based on specimens studied by Hayasaka.

INTRODUCTION

Inadequate description of taxa is one of the principal deterrents to progress in paleontology. The study of fossil corals has been particularly plagued by this problem because many taxa were proposed before thin-section techniques became widely used and thus were founded largely or entirely on external skeletal features. Until these extant taxa are redescribed and adequately understood, new taxa cannot be proposed without risk of duplication.

In North America, massive colonial rugose corals originally referred to *Lithostrotion* Fleming and later to *Lithostrotionella* Yabe and Hayasaka are noteworthy examples of inadequate description. After the genus *Lithostrotionella* was founded by Yabe and Hayasaka (1915, 1920) on material from the Carboniferous of China, Hayasaka studied North American corals in the large U.S. Geological Survey collection of fossils (now housed in the U.S. National Museum of Natural History in Washington, D.C.). Although Hayasaka's visit to the United States was in 1927, his monograph on North American *Lithostrotionella* was not published until 1936. Hayasaka prepared thin sections from all the holotypes of his North American species, but the thin sections were small and only a few paratypes were sectioned. Consequently, Hayasaka's species concepts were based largely on the holotypes, and many paratypes were incorrectly identified. Moreover, the geologic ages of these specimens were poorly known at the time the study was made. Subsequently, the name *Lithostrotionella* came into wide use for Carboniferous and Permian colonial Rugosa throughout the world.

I became acquainted with the problem of Hayasaka's type specimens some years ago during the course of investigations of North American Mississippian coral faunas. Easton's (1973) study of *Acrocyathus* and his conclusion that *Lithostrotionella* is a junior synonym lent impetus to a restudy of the Hayasaka material. All Hayasaka's type specimens were sectioned and restudied in detail except for four paratypes that could not be found; most of Hayasaka's specimens are illustrated in this report. Other described and undescribed specimens of Carboniferous and Permian age in the collections of the U.S. National Museum of Natural History were also investigated in order to broaden the base for taxonomic conclusions. All locality data were rechecked

and were revised as necessary on the basis of the latest available information (see locality register on p. 40).

As work proceeded on the Hayasaka material, it became apparent that the classification of this material had broader implications concerning the validity of *Lithostrotionella* as a taxonomic concept and concerning the scope and phylogeny of other genera. Accordingly, the present study was expanded to include an evaluation of all corals that have been described under the name of *Lithostrotionella*; this evaluation was based on a study of the systematic literature on these corals as of the end of 1978. I found that most of the specimens originally referred to *Lithostrotionella* by Hayasaka (1936) should be reassigned to *Stelechophyllum*, *Aulostylus*, *Acrocyathus*, and *Petalaxis* (table 1). Corals assigned by other authors to *Lithostrotionella* also belong in these genera, but a few are assigned to *Thysanophyllum*, *Kleopatrina*, and *Lonsdaleia*.

ACKNOWLEDGMENTS

I am indebted to P. M. Kier and R. E. Grant of the U.S. National Museum of Natural History for making Hayasaka's types and other specimens available to me for study. I am also grateful to P. Semenoff-Tian-Chansky of the Muséum National d'Histoire Naturelle in Paris and to N. V. Kabakovich and T. A. Sayutina of the Paleontologic Institute of the U.S.S.R. Academy of Sciences in Moscow for courtesies extended to me during visits to study material in their care. Many of the ideas expressed in this paper were discussed with colleagues at the Eighth International Congress of Carboniferous Stratigraphy and Geology in Moscow and the Third International Symposium on Fossil Corals in Paris, 1975; N. P. Vasilyuk, E. W. Bamber, M. Minato, M. Kato, P. K. Sutherland, and J. Fedorowski provided useful suggestions and criticisms. M. Minato and M. Kato provided me with photographs of the holotype of the type species of *Lithostrotionella* and translations of some of Hayasaka's short papers in Japanese. E. C. Wilson provided information on some Pacific Coast localities and specimens. B. L. Mamet identified foraminifers in some collections. I am also indebted to the following for searching collections in their care for type material: J. A. Stitt, University of Missouri; L. S. Kent, Illinois Geological Survey; H. R. Cramer, Emory University; A. Horowitz, Indiana University; D. B. Macurda, University of Michigan; and R. R. Shrock, Massachusetts Institute of Technology. K. R. Moore and H. I. Saunders searched the collections of the U.S. Geological Survey and U.S. National Museum of Natural History for specimens used in this study. K. R. Moore also made thin sections and photographs of the specimens.

THE STATUS OF *LITHOSTROTIONELLA*

Yabe and Hayasaka (1915, p. 94–96, 133–134) originally proposed *Lithostrotionella* as a subgenus of *Lithostrotion* for a cerioid coral having a lamellar columella and differing from true *Lithostrotion* by having a lonsdaleoid dissepimentarium. They described, but did not illustrate, the type species (by monotypy) *Lithostrotion* (*Lithostrotionella*) *unicum* from the Carboniferous(?) of Yun-nan Province, China. They suggested that *Petalaxis* Milne-Edwards and Haime might be a senior synonym but concluded that *Petalaxis* is identical with true *Lithostrotion*. In 1920, the same authors (Yabe and Hayasaka, p. 11, pl. 9, figs. 12a, b) illustrated two thin sections of the type species, but both thin sections were cut obliquely with respect to the axes of the corallites, making it difficult to interpret internal structures.

Chi (1931, p. 28–29) raised the name to generic rank for a species from the Middle Carboniferous Weiningian System of Kuechow Province, China, and Yü (1933, p. 101–102) described two species of *Lithostrotionella* from the Lower Carboniferous of Kuechow Province. Dobrolyubova (1935b, p. 10–20) described species from the Middle Carboniferous of the Moscow Basin and, later (1936a, p. 9, 28, 66), from the Upper Carboniferous of the Urals. This early work set the stage for Hayasaka's (1936) monograph of *Lithostrotionella* in North America.

Meanwhile, *Stelechophyllum* Tolmachev was ignored, even by Soviet students, until Hill (1956, p. F286) treated it as a distinct genus and Dobrolyubova and Kabakovich (1962) used the name for corals from the Kuznetsk Basin. The interpretation of *Petalaxis* Milne-Edwards and Haime at that time was based on an erroneous designation of *Petalaxis portlocki* Milne-Edwards and Haime as type species by Hill (1940, p. 165, 166), who had overlooked Roemer's (1883, p. 387, 388) designation of *P. maccoyanus* Milne-Edwards and Haime as type species. *P. portlocki* is a *Lithostrotion*, whereas *P. maccoyanus* has a lonsdaleoid dissepimentarium and cannot be referred to *Lithostrotion*.

Recent work has not unequivocally resolved the morphology of the type species or the most practical limits of the generic concept. Easton (1973) revived *Acrocyathus* d'Orbigny, redescribed the type specimen of its type species, and concluded that *Lithostrotionella* is a junior synonym. By this action, Easton simply transferred the highly variable group of corals previously referred to *Lithostrotionella* to *Acrocyathus*.

Minato and Kato (1974, p. 67–75) restudied the holotype of *Lithostrotionella unicum*. All that remains of the original type material is one of the oblique thin sections originally illustrated by Yabe and Hayasaka (1920, pl. 19, fig. 12a). Minato and Kato concluded that

TABLE 1.—*Hayasaka (1936) type specimens of* Lithostrotionella

Hayasaka species identification	Kind of type specimen	Revised identification	USNM No.	USGS Loc. No.	Revised stratigraphic level, age, and and location (see Register of USGS Localities (p. 40) for detailed data)	Plate and page
americana ___	Holotype _____	*Acrocyathus floriformis floriformis* d'Orbigny	120240	2333-PC	St. Louis Limestone, Late Mississippian (Viséan), Kentucky.	Pl. 5; p. 17
	Paratype _____	*Acrocyathus floriformis floriformis* d'Orbigny?	120241	1211B-PC	St. Louis Limestone, Late Mississippian (Viséan), Missouri.	Pl. 6; p. 17
	____do _____	*Acrocyathus floriformis floriformis* d'Orbigny?	162001	498-PC	St. Louis Limestone, Late Mississippian (Viséan), Illinois.	Pl. 6; p. 17
	____do _____	Indet. lithostrotionelloid coral	174371	3858-PC (green label)	McCloud Limestone, Early Permian, California.	_____
	____do _____	*Stelechophyllum banffense* (Warren)?	174372	7130B-PC	Alapah Limestone(?), Late Mississippian (Viséan), Alaska.	Pl. 3; p. 13
	____do _____	Indet. lithostrotionelloid coral	174373	3890-PC (green label)	McCloud Limestone, Early Permian, California.	_____
	____do _____	*Stelechophyllum banffense* (Warren)?	174374	970-PC	Alapah Limestone(?), Late Mississippian (Viséan), Alaska.	Pl. 3; p. 13
	____do _____	*Stelechophyllum banffense* (Warren)?	174375	3024-PC	Little Flat Formation, Late Mississippian (Viséan), Idaho.	Pl. 4; p. 13
	____do _____	*Acrocyathus floriformis floriformis* d'Orbigny	174376	499-PC	St. Louis Limestone, Late Mississippian (Viséan), Illinois.	Pl. 5; p. 17
castelnaui ____	Holotype _____	*Acrocyathus floriformis floriformis* d'Orbigny	120235	499-PC	St. Louis Limestone, Late Mississippian (Viséan), Illinois.	Pl. 7; p. 17
	Paratype _____	*Acrocyathus floriformis hemisphaericus* (Hayasaka)	120236	3282-PC	Hillsdale Member of Greenbrier Limestone, Late Mississippian (Viséan), West Virginia.	Pl. 14; p. 00
	____do _____	*Acrocyathus floriformis floriformis* d'Orbigny	161989	2226-PC	St. Louis Limestone, Late Mississippian (Viséan), Illinois.	Pl. 9; p. 17
	____do _____	*Acrocyathus floriformis floriformis* d'Orbigny	161990	346C-PC	Residual chert from Tuscumbia Limestone, Late Mississippian (Viséan), Alabama.	Pl. 8; p. 17
	____do _____	*Acrocyathus floriformis floriformis* d'Orbigny	161991	643-PC	St. Louis Limestone(?), Late Mississippian (Viséan), Missouri.	Pl. 8; p. 17
	____do _____	*Acrocyathus floriformis hemisphaericus* (Hayasaka)	161992	2020A-PC	Greenbrier Limestone, Late Mississippian (Viséan), Virginia.	Pl. 14; p. 00
	____do _____	*Acrocyathus floriformis floriformis* d'Orbigny	161993	3159-PC	Newman Limestone, Late Mississippian (Viséan), Virginia.	Pl. 10; p. 17
	____do _____	*Acrocyathus floriformis floriformis* d'Orbigny	161994	2013B-PC	Greenbrier Limestone, Late Mississippian (Viséan), Virginia.	Pl. 9; p. 17
	____do _____	*Acrocyathus floriformis floriformis* d'Orbigny?	174377	3946-PC (green label)	Unknown, probably St. Louis Limestone, Mississippi Valley region.	Pl. 7; p. 17
floriformis ___	Holotype _____	*Stelechophyllum banffense* (Warren)	120242	3760-PC	Peratrovich Formation, Late Mississippian (Viséan), Alaska.	See Armstrong (1970a)
girtyi _____	____do _____	*Acrocyathus girtyi* (Hayasaka)	120243	4801H-PC (green label)	Little Flat Formation, Late Mississippian (Viséan), Utah.	Pl. 17, p. 21
	Paratype _____	*Petalaxis exiguus* n. sp.	162002A, B	3856-PC (green label)	McCloud Limestone, Early Pemian, California.	Pl. 19; p. 28
	____do _____	*Stelechophyllum microstylum* (White)?	162003	3864-PC	Lodgepole Limestone, Early Mississippian (Tournaisian), Montana.	Pl. 2; p. 11
	____do _____	*Acrocyathus pilatus* n. sp.	162004	499-PC	St. Louis Limestone, Late Mississipian (Viséan), Illinois.	Pl. 17; p. 19
	____do _____	Specimen lost	_____	2111-PC	Meridian Range, Montana.	_____
	____do _____	____do_____	_____	5077A-PC (green label)	Weber Canyon, Utah.	_____
	____do _____	____do_____	_____	_____	Granitville, Utah.	_____
hemisphaerica	Holotype _____	*Acrocyathus floriformis hemisphaericus* (Hayasaka)	120237	1148-PC	St. Louis Limestone, Late Mississippian (Viséan), Illinois.	Pl. 12; p. 19
	Paratype _____	*Acrocyathus floriformis floriformis* d'Orbigny	120238	3283-PC	Hillsdale Member of Greenbrier Limestone, Late Mississippian (Viséan), West Virginia.	Pl. 11; p. 17
	____do _____	*Stelechophyllum* sp. indet.	120239	5892-PC	Madison Limestone, Early Mississippian (Tournaisian), Utah.	Pl. 4; p. 15
	____do _____	*Acrocyathus floriformis floriformis* d'Orbigny	161995	83-PC	Newman Limestone, Late Mississippian (Viséan), Kentucky.	Pl. 11; p. 17
	____do _____	*Stelechophyllum microstylum* (White)	161996	1439-PC	Lodgepole Limestone, Early Mississippian (Tournaisian), Idaho.	Pl. 2; p. 11
	____do _____	*Acrocyathus floriformis floriformis* d'Orbigny	161997	2020-PC	Greenbrier Limestone, Late Mississipian (Viséan), Virginia.	Pl. 10; p. 17
	____do _____	*Acrocyathus floriformis hemisphaericus* (Hayasaka)	161998	932A-PC	St. Louis Limestone, Late Mississippian (Viséan), Missouri.	Pl. 12; p. 19
	____do _____	*Acrocyathus floriformis hemisphaericus* (Hayasaka)	161999	2222A-PC	St. Louis Limestone, Late Mississippian (Viséan), Illinois.	Pl. 13; p. 19
	____do _____	*Acrocyathus floriformis hemisphaericus* (Hayasaka)?	162000	2222C-PC	St. Louis Limestone, Late Mississippian (Viséan), Illinois.	Pl. 13; p. 19
multiradiata _	Holotype _____	*Stelechophyllum microstylum* (White)	120244	490-PC	Lodgepole Limestone, Early Mississipian (Tournaisian, Utah.	Pl. 1; p. 11
	Paratype _____	*Stelechophyllum microstylum* (White)	162005	104-PC	Lodgepole Limestone, Early Mississippian (Tournaisian), Idaho.	Pl. 1; p. 11
simplex _____	Holotype _____	*Petalaxis simplex* (Hayasaka)	120249	5893-PC	Little Flat Formation, Late Mississippian (Viséan), Utah.	Pl. 18; p. 26
	Paratype _____	*Petalaxis wyomingensis* n. sp.	120675	7452-PC (green label)	"Wells" Formation, Late Mississippian or Early Pennsylvanian (Namurian), Wyoming.	Pl. 18; p. 26
tabulata _____	Holotype _____	*Petalaxis tabulatus* (Hayasaka)	120246	1476-PC	Aspen Range Formation, Late Mississippian (Viséan), Idaho.	Pl. 19; p. 26
tubifera _____	____do _____	*Aulostylus tubiferus tubiferus* (Hayasaka)	120247	5894-PC	Mission Canyon Limestone, Early Mississippian (Tournaisian), Montana	See Sando (1976)
	Paratype _____	*Aulostylus tubiferus eotubiferus* Sando	120248	3290-PC	Lodgepole Limestone, Early Mississippian (Tournaisian), Montana.	See Sando (1976)
vesicularis ___	Holotype _____	*Stelechophyllum banffense (Warren)*	120245	3747C-PC	Peratrovich Formation, Late Mississippian (Viséan), Alaska.	See Armstrong (1970a)
	Paratype _____	Specimen lost	_____	970-PC(?)	Porcupine-Arctic section, Alaska(?)	_____

the geologic age of the type specimen is probably Carboniferous. According to these writers, *Lithostrotionella* and *Acrocyathus* are distinct and separate genera, *Stelechophyllum* is a junior synonym of *Lithostrotionella*, *Eolithostrotionella* is a junior synonym of *Acrocyathus*, and *Petalaxis* is a junior synonym of *Lithostrotion*.

The single surviving thin section of the holotype (Minato and Kato, 1974, pl. 15, fig. 1) does not permit an unequivocal evaluation of all the critical internal characters of the type species of *Lithostrotionella*. However, the corallite in the upper left-hand corner of the slide has what appear to be conical tabulae like those of *Acrocyathus* and shows no peripheral tabellae. The tabularium is certainly not that of *Stelechophyllum* or *Petalaxis*. Although none of the corallites show clearly defined septal lamellae, septal lamellae are not present in all corallites of some species of *Acrocyathus*.

I conclude that the type species of *Lithostrotionella* is most likely a species of *Acrocyathus*; therefore, I regard *Lithostrotionella* as a probable junior synonym of *Acrocyathus*. This action, although debatable, is the most practical solution to the nomenclatural problem because both *Acrocyathus* and *Stelechophyllum* are founded on well-described and well-illustrated specimens whose ages are well documented. Although the holotype of the type species of *Petalaxis* is lost and a neotype remains to be selected, the species is well established on topotypes (Sutherland, 1977).

CLASSIFICATION

Species that have been referred previously to *Lithostrotionella* Yabe and Hayasaka are reassigned to the following genera in this report: *Acrocyathus* d'Orbigny (including probable junior synonym *Lithostrotionella* Yabe and Hayasaka), *Stelechophyllum* Tolmachev (including junior synonym *Eolithostrotionella* Zhizhina), *Petalaxis* Milne-Edwards and Haime (including junior synonyms *Hillia* de Groot and *Eastonoides* Wilson and Langenheim), *Aulostylus* Sando, *Kleopatrina* McCutcheon and Wilson, *Lonsdaleia* McCoy (subgenus *Actinocyathus* d'Orbigny), and *Thysanophyllum* Nicholson and Thomson. One of the species referred to *Cystolonsdaleia* Fomichev is reassigned to *Petalaxis*.

Recent classification of the generic taxa recognized herein is in a state of flux, and there has been little agreement on their familial relations. *Acrocyathus* was referred to the Family Lonsdaleiidae Chapman by Hill (1956) (as a questionable senior synonym of *Lithostrotionella*), Easton (1973), and by Ivanovskiy (1975) (as a junior synonym of *Lonsdaleia*). Dobrolyubova and Kabakovich (1962) regarded *Acrocyathus* as a questionable junior synonym of *Lithostrotion* and referred it to the Family Lithostrotionidae d'Orbigny.

Lithostrotionella was referred to the Family Lonsdaleiidae by Hill (1956), Easton (1973) (as a junior synonym of *Acrocyathus*), de Groot (1964), Armstrong (1970a, b; 1972a, b), and Ivanovskiy (1975). It was placed in the Family Lithostrotionidae by Easton and Gutschick (1953) (as a junior synonym of *Lithostrotion*) and by Dobrolyubova and Kabakovich (1962). Easton (1958) placed *Lithostrotionella* in the Family Lithostrotionidae Grabau. The genus was placed in Family Petalaxidae Fomichev by Pyzh'anov (1964) (as a junior synonym of *Petalaxis*) and by Onoprienko (1970, 1976).

Stelechophyllum was referred to the Family Lithostrotionidae by Hill (1956) and to the Family Lonsdaleiidae by Ivanovskiy (1975) (as a junior synonym of *Lithostrotionella*). Dobrolyubova and Kabakovich (1962, 1966) placed this genus in the Family Endophyllidae Torley because of its inferred derivation from *Endophyllum*, a Devonian genus that they recognized as ranging into the Lower Carboniferous.

Eolithostrotionella was referred to the Family Lithostrotionidae by Zhizhina (1956) and in Bul'vanker and others (1960), by Vasilyuk (1960), and by Dobrolyubova and Kabakovich (1962) (as a junior synonym of *Lithostrotionella*). It was placed in the Family Lonsdaleiidae by Easton (1973) (as a questionable junior synonym of *Acrocyathus*), by Degtyarev (1973), and by Ivanovskiy (1975) (as a junior synonym of *Lithostrotionella*). Dobrolyubova and Kabakovich (1966) regarded it as a junior synonym of *Stelechophyllum* and placed it in the Family Endophyllidae. Pyzh'anov (1964), Onoprienko (1970), and Kozyreva (1974) placed this genus in the Family Petalaxidae. Fedorowski and Gorianov (1973) placed it in the Family Lonsdaleiidae.

Petalaxis was referred by Hill (1956) (as a junior synonym of *Lithostrotion*) and by Ivanovskiy (1975) (as a junior synonym of *Lithostrotion*) to the Family Lithostrotionidae, on the basis of an erroneous type-species designation. Fomichev (1953), Dobrolyubova and Kabakovich (1962), Pyzh'anov (1964), Onoprienko (1970), and Kozyreva (1974) placed this genus in the Family Petalaxidae. Fedorowski and Gorianov (1973) placed it in the Family Lonsdaleiidae.

Hillia was referred to the Family Lonsdaleiidae by de Groot (1964) (as a subgenus of *Lithostrotionella*) and by Easton (1973) (questionably). Ivanovskiy (1975) regarded it as a questionable junior synonym of *Lithostrotion* and placed it in the Family Lithostrotionidae.

Eastonoides was referred to the Family Lonsdaleiidae by Wilson and Langenheim (1962).

Aulostylus was placed in the Family Lithostrotionidae by Sando (1976).

Kleopatrina was referred to the Family Durhaminidae Minato and Kato by Minato and Kato (1965) and by Ivanovskiy (1975).

Lonsdaleia was placed in the Family Lonsdaleiidae by Hill (1956), Vasilyuk (1960), Dobrolyubova and Kabakovich (1962), de Groot (1964), and Ivanovskiy (1975).

Thysanophyllum was referred to the Family Lonsdaleiidae by Hill (1956), Armstrong (1970a, b), Degtyarev (1973), and Ivanovskiy (1975). Dobrolyubova and Kabakovich (1962) placed it in the Family Lithostrotionidae. Pyzh'anov (1964) and Onoprienko (1970, 1976) referred it to the Family Petalaxidae.

In this report, the following classification is used:

Order Rugosa Milne-Edwards and Haime, 1850
- Suborder Columnariina Rominger, 1876
  - Family Lithostrotionidae d'Orbigny, 1851
    - Genus *Stelechophyllum* Tolmachev, 1933 (junior synonym *Eolithostrotionella* Zhizhina in Fomichev, 1955)
      - *S. ascendens* species group
        - *S. ascendens* (Tolmachev, 1924)
          - *S. ascendens simplex* Dobrolyubova in Dobrolyubova and Kabakovich, 1966
          - *S. ascendens ascendens* (Tolmachev, 1924)
        - *S. megalum* (Tolmachev, 1924)
        - *S. grande* (Tolmachev, 1924)
        - *S. venukoffi* (Tolmachev, 1924)
          - *S. venukoffi venukoffi* (Tolmachev, 1924)
          - *S. venukoffi altaicum* (Tolmachev, 1924)
      - *S. microstylum* species group
        - *S. microstylum* (White, 1880a)
        - *S. circinatum* (Easton and Gutschick, 1953)
        - *S. longiseptatum* (Lisitsyn, 1925)
        - *S. banffense* (Warren, 1927)
      - *S. micrum* species group
        - *S. micrum* (Kelly, 1942)
        - *S. lochmanae* (Armstrong, 1962)
        - *S. ergunjaicum* (Onoprienko, 1976)
      - *S.? mclareni* species group
        - *S.? mclareni* (Sutherland, 1958)
        - *S.? birdi* (Armstrong, 1970a)
        - *S.? niakensis* (Armstrong, 1972a)
      - *S.? macouni* species group
        - *S.? macouni* (Lambe, 1899)
      - *S.* sp. indet.
      - *S.?* sp. indet.
    - Genus *Aulostylus* Sando, 1976
      - *A. tubiferus* (Hayasaka, 1936)
        - *A. tubiferus tubiferus* (Hayasaka, 1936)
        - *A. tubiferus eotubiferus* Sando, 1976
        - *A.?* sp.
  - Family Acrocyathidae new family
    - Genus *Acrocyathus* d'Orbigny, 1849a (?junior synonym *Lithostrotionella* Yabe and Hayasaka, 1915)
      - *A. floriformis* d'Orbigny, 1849a
        - *A. floriformis floriformis* d'Orbigny, 1849a
        - *A. floriformis hemisphaericus* (Hayasaka, 1936)
      - *A. pilatus* n. sp.
      - *A. proliferus* (Hall in Hall and Whitney, 1858)
      - *A. girtyi* (Hayasaka, 1936)
      - *A. pennsylvanicus* (Shimer, 1926)

Order Rugosa – Continued
- Suborder Columnariina – Continued
  - Family Acrocyathidae – Continued
    - Genus *Acrocyathus* – Continued
      - *A. utkae* (Degtyarev, 1973)
      - *A. rotai* (Zhizhina in Bul'vanker and others, 1960)
      - *A. cystosus* (Zhizhina in Bul'vanker and others, 1960)
      - *A. lissitzini* (Zhizhina in Bul'vanker and others, 1960)
      - *A. hsujiulingi* (Yoh, 1961)
      - *A.? unicus* (Yabe and Hayasaka, 1915)
      - *A.? shimeri* (Crickmay, 1955)
      - *A.? grechovkae (Degtyarev, 1973)*
      - *A.? zhizhinae* (Vasilyuk, 1960)
      - *A.* spp. indet.
  - Family Petalaxidae Fomichev, 1953
    - Genus *Petalaxis* Milne-Edwards and Haime, 1852 (junior synonyms *Hillia* de Groot, 1963, and *Eastonoides* Wilson and Langenheim, 1962)
      - *P. simplex* species group
        - *P. simplex* (Hayasaka, 1936)
        - *P. wyomingensis* n. sp.
        - *P. tabulatus* (Hayasaka, 1936)
        - *P. bailliei* (Nelson, 1960)
      - *P. flexuosus* species group
        - *P. flexuosus* (Trautschold, 1879)
        - *P. donbassicus* (Fomichev, 1939)
        - *P. mokomokensis* (Easton, 1960)
        - *P. exiguus* n. sp.
        - *P. brokawi* (Wilson and Langenheim, 1962)
        - *P. monocyclicus* (de Groot, 1963)
        - *P. sexangulus* (de Groot, 1963)
        - *P. taishakuensis* (Yokoyama, 1957)
        - *P. immanis* Kozyreva, 1974
        - *P. belinskiensis* Fomichev, 1953
        - *P. major* (de Groot, 1963)
        - *P. fomichevi* n. sp.
        - *P. grootae* n. sp.
      - *P. wagneri* species group
        - *P. wagneri* (de Groot, 1963)
        - *P. perapertuensis* (de Groot, 1963)
        - *P. radians* (de Groot, 1963)
        - *P. santaemariae* (de Groot, 1963)
        - *P. cantabricus* (de Groot, 1963)
        - *P. orboensis* (de Groot, 1963)
        - *P. occidentalis* (Merriam, 1942)
      - *P. vesiculosus* species group
        - *P. vesiculosus* (Dobrolyubova, 1935a)
        - *P. lisitschanskensis* (Fomichev, 1953)
        - *P. exilis* Kozyreva, 1974
        - *P. confertus* Kozyreva, 1974
        - *P. persubtilis* Kozyreva, 1974
        - *P. korkhovae* Kozyreva, 1974
        - *P. mirus* Kozyreva, 1974
        - *P. evidens* Kozyreva, 1974
      - *P. maccoyanus* species group
        - *P. maccoyanus* Milne-Edwards and Haime, 1851
        - *P. stylaxis* (Trautschold, 1879)
        - *P. mohikanus* (Fomichev, 1939)
        - *P. celadensis* (de Groot, 1963)

Order Rugosa–Continued
Suborder Columnariina–Continued
Family Petalaxidae–Continued
Genus *Petalaxis*–Continued
P. maccoyanus species group–Continued
P. elyensis (Wilson and Langenheim, 1962)
P. dobrolyubovae n. sp.
P. donetsensis n. sp.
P. ivanovi (Dobrolyubova, 1935a)
P.? spp., indet.
Family Lonsdaleiidae Chapman, 1893
Genus *Thysanophyllum* Nicholson and Thomson, 1876
T. astraeiforme (Warren, 1927)
Genus *Lonsdaleia* McCoy, 1849
Subgenus *Actinocyathus* d'Orbigny, 1849a
L. (*A.*) *berthiaumi* (Merriam, 1942)
L. (*A.*) *peratrovichensis* (Armstrong, 1970a)
Family Durhaminidae Minato and Kato, 1965
Genus *Kleopatrina* McCutcheon and Wilson, 1963
Subgenus *Kleopatrina* McCutcheon and Wilson, 1963
K. (*K.*)? *dilatata* (Easton, 1960)
K. (*K.*)? *uralica* (Dobrolyubova, 1936a)
K. (*K.*)? *wahooensis* (Armstrong, 1972b)
Undetermined lithostrotionelloid corals

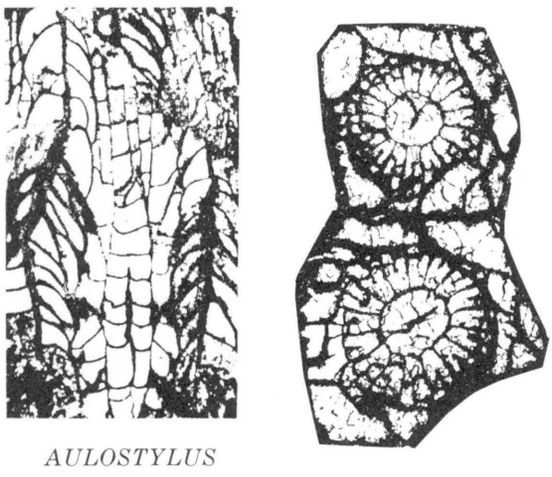
The foregoing classification of lithostrotionelloid corals follows Hill (1956) at the ordinal and subordinal level. Placement of *Stelechophyllum* in the Family Lithostrotionidae also follows Hill (1956). *Aulostylus* is placed in the Lithostrotionidae because of its close relationship to *Stelechophyllum*. The recognition of Family Petalaxidae including only *Petalaxis* and *Cystolonsdaleia* conforms to Fomichev's (1953) original definition and the subsequent acceptance by Dobrolyubova and Kabakovich (1962). A new family, the Acrocyathidae, is proposed to include only the genus *Acrocyathus*, which appears to have been derived from *Stelechophyllum*. Only a few species are allocated to *Thysanophyllum*, *Lonsdaleia* (*Actinocyathus*), and *Kleopatrina* (*Kleopatrina*), which are not closely related to the main stock of lithostrotionelloid corals. *Thysanophyllum* and *Lonsdaleia* are placed in the Family Lonsdaleiidae following Hill (1956), and *Kleopatrina* is placed in the Family Durhaminidae following Minato and Kato (1965).

PHYLOGENY

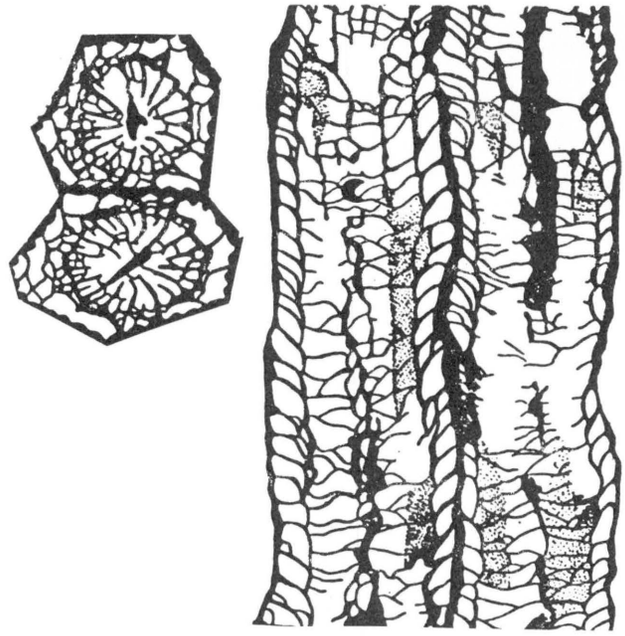
Hill's (1938, p. 35) statement that "little is known of the phylogeny of the Rugosa" is still valid today. In the absence of general agreement on the composition of families, it is very difficult to sketch out even the main phylogenetic lines. Hill (1938, p. 35–36) listed five methods of approach to the phylogeny of genera and species in Rugosa: (1) morphologic comparison without strict attention to detailed stratigraphic chronology; (2) the adult "Formenreihe" method used by Vaughan in his studies of the Rugosa, in which adult characters are traced through a stratigraphic sequence of species; (3) the "Formenreihe" method used by Carruthers in his classic studies of *Zaphrentis*, in which Haeckel's law of recapitulation is used on a stratigraphic succession of species; (4) deduction of phylogeny of individual species from their ontogeny and checking this against stratigraphic evidence; and (5) deduction of phylogeny of individual species from ontogeny without detailed stratigraphic evidence. Unfortunately, few studies have been made of colonial Rugosa in the Carboniferous by any of these methods. Nevertheless, it is useful to speculate on how the lithostrotionelloid corals are related phylogenetically.

The lithostrotionelloid corals may be divided into two groups of genera, those that seem to be closely related phylogenetically, and those that seem to be independent unrelated forms. In the first group are species allocated to *Stelechophyllum*, *Aulostylus*, *Acrocyathus*, and *Petalaxis* (fig. 1), which are characterized by a lonsdaleoid dissepimentarium, tabulae that range from tent-shaped to conical to horizontal, and an axial structure that ranges from a simple axial plate ordinarily connected to the counter septum to a complex spider-web structure made up of axial plate, vertical axial tabellae, and septal lamellae.

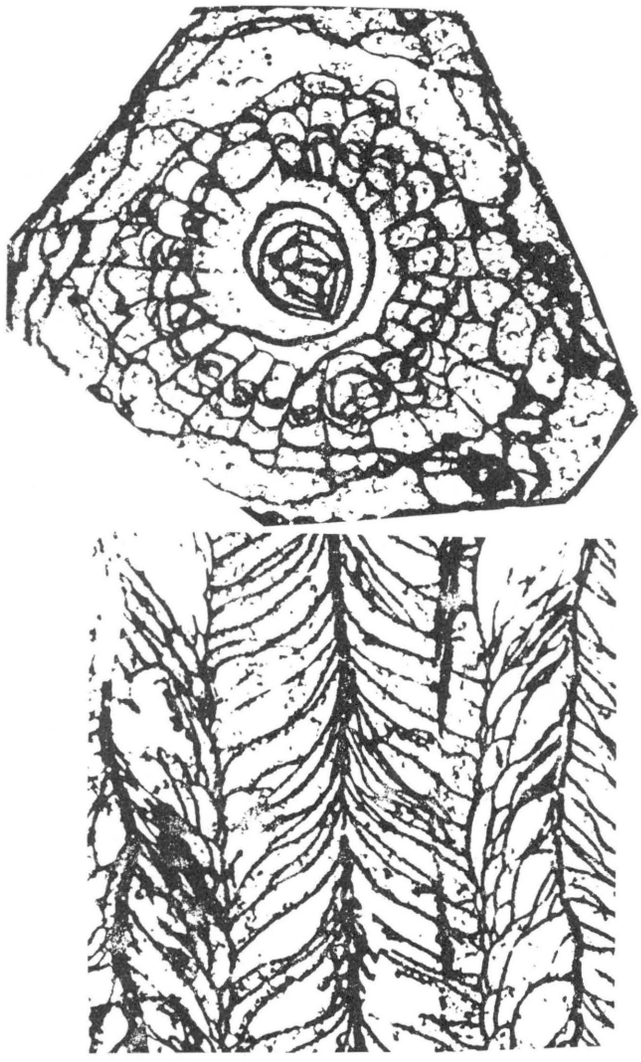
The origin of the first group of lithostrotionelloid corals is uncertain. The earliest member of this group is *Stelechophyllum*, which has a lonsdaleoid dissepimentarium, a simple columella, and tent-shaped tabulae. According to Soshkina, Dobrolyubova, and Kabakovich (1962, p. 342), *Stelechophyllum* was derived from *Endophyllum* Milne-Edwards and Haime, a Middle Devonian coral that they considered to range into the Tournaisian of Novaya Zemlya. The occurrence of *Endophyllum* in the Carboniferous apparently was based on Gorskiy's (1935, p. 49–56; 1938, p. 21–24) description of species from the Etroeungtian beds of Novaya Zemlya, which Gorskiy regarded as lower Tournaisian (most Carboniferous and Devonian stratigraphers now regard the Etroeungtian as latest Devonian). True Middle Devonian *Endophyllum* has a lonsdaleoid dissepimentarium, major septa that approach the axis of the corallites but do not meet or form a columella, and flat tabulae that have down-turned margins (see Jones, 1929). Gorskiy's (1935, 1938) colonial species are more like *Stelechophyllum* than *Endophyllum* in the nature of their tabulae but do not have a columella. Some species of *Stelechophyllum* have a poorly developed columella (for example, *S. ascendens*, *S. megalum*, and *S. grande*). It seems more reasonable to refer Gorskiy's species



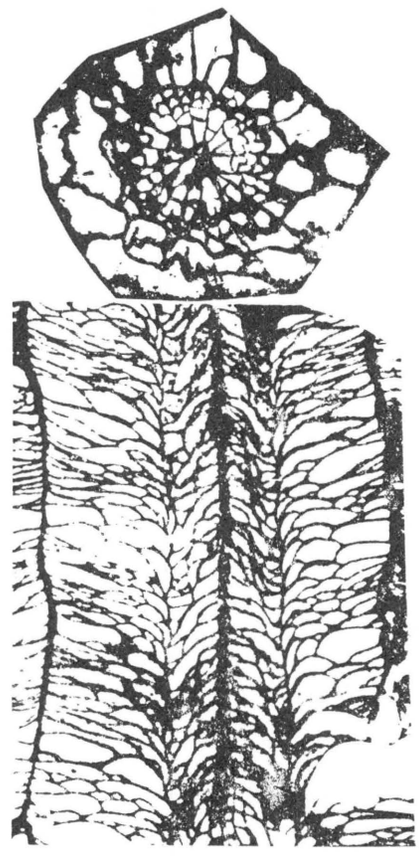
AULOSTYLUS



PETALAXIS



ACROCYATHUS



STELECHOPHYLLUM

FIGURE 1.–Morphology of the type species of the principal lithostrotionelloid genera. *Acrocyathus*: longitudinal and transverse thin sections (× 4) of *A. floriformis floriformis* d'Orbigny (USNM 120235). *Stelechophyllum*: longitudinal and transverse thin section (× 4) of *S. venukoffi altaicum* (Tolmachev) (from Dobrolyubova and Kabakovich, 1966). *Petalaxis*: longitudinal and transverse thin sections (× 4) of *P. maccoyanus* Milne-Edwards and Haime (from Fedorowski and Gorianov, 1973). *Aulostylus*: longitudinal and transverse thin sections (× 6) of *A. tubiferus tubiferus* (Hayasaka) (from Sando, 1976).

questionably to *Stelechophyllum* and to regard them as possible derivatives of the Middle Devonian *Endophyllum*.

If the Famennian forms in Novaya Zemlya are referred questionably to *Stelechophyllum*, then there is a gap until the middle Tournaisian, when true *Stelechophyllum* appears and ranges into the upper Viséan (fig. 2). In the middle and upper Tournaisian, the axial structure was modified to an aulos in *Aulostylus*, which is a closely related offshoot of *Stelechophyllum*. Increased complexity of the axial structure and the formation of conical tabulae took place in *Acrocyathus*, which ranges through most of the Viséan. *Acrocyathus* seems to be an offshoot of *Stelechophyllum* rather than a member of the Lonsdaleiidae, although it may have been the ancestor of *Lonsdaleia* (*Actinocyathus*). The earliest species of *Petalaxis*, which occur in the upper Viséan, are similar to *Stelechophyllum* in the morphology of their septa and columella, but they have horizontal tabulae. *Petalaxis* continues upward to the top of the Middle Carboniferous (Moscovian), but there is a gap in its record of occurrence in the Upper Carboniferous before it is seen again in the Permian. The Permian species are very similar to Middle Carboniferous species. The significance of the gap is not now understood; the Permian forms may be merely homeomorphs in an unrelated phylogenetic stock.

The second group of lithostrotionelloid corals includes two phylogenetic stocks that do not seem to be related to *Stelechophyllum*. Some species previously assigned to *Lithostrotionella* are herein placed in *Lonsdaleia* and *Thysanophyllum*, which are members of the Family Lonsdaleiidae. The origin of *Lonsdaleia*, which first appears at the top of the Tournaisian (Hill, 1940, p. 151), has been variously linked to *Clisiophyllum* (Vaughan, 1905, p. 184), *Carcinophyllum* (Vaughan, 1906, p. 148), and *Thysanophyllum* (Carruthers, in Garwood, 1912, p. 563; Smith, 1916, p. 235). However, E. W. Bamber (written commun., 1980) has pointed out that *Acrocyathus pennsylvanicus* and *A. shimeri* have axial structures and tabulation similar to those of the North American species of *Lonsdaleia* (*Actinocyathus*), that is, *L.* (*A.*) *stelcki* and *L.* (*A.*) *peratrovichensis*. Although these similarities suggest derivation of *Lonsdaleia* (*Actinocyathus*) from *Acrocyathus* in the Viséan of North America, they are inconsistent with the earliest occurrence of *Lonsdaleia* in the upper Tournaisian of Great Britain. *Thysanophyllum* is characterized by a discontinuous axial structure and may be polyphyletic (Hill, 1940, p. 161). For the present, the origins of *Lonsdaleia* and *Thysanophyllum* and their possible relationships to the *Stelechophyllum* stock remain obscure.

Other Carboniferous corals previously assigned to *Lithostrotionella* are placed herein in *Kleopatrina*, a predominantly Permian genus. According to Minato and Kato (1965, test-fig. 4), *Kleopatrina* was derived from *Durhamina*, and all the members of the Durhaminidae were ultimately derived from the Lithostrotionidae in the Lower Carboniferous. Hence, *Kleopatrina* does not seem to be closely related to the main stock of lithostrotionelloid corals.

SYSTEMATIC PALEONTOLOGY

Morphologic terminology is generally that of Hill (1956). The term "tent-shaped" refers to tabulae that slope peripherally from their intersection with the columella at a slight angle to a distinct rounded shoulder, where they are vertical (see *Stelechophyllum* in fig. 1). These tabulae ordinarily terminate peripherally at a zone of horizontal tabellae without reaching the inner margin of the dissepimentarium and rest one upon the other. The term "conical" refers to tabulae that slope peripherally from their intersection with the columella at a moderate to steep angle without distinct shoulders and reach the inner margin of the dissepimentarium (see

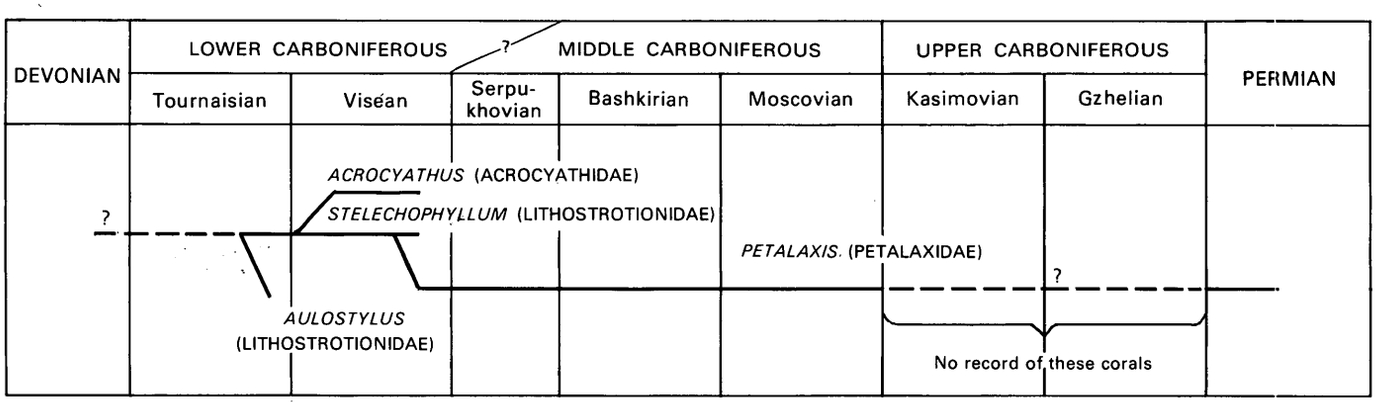


FIGURE 2. – Postulated phylogeny of the principal genera of lithostrotionelloid corals.

Acrocyathus in fig. 1). Convex or bell-shaped tabulae are like tent-shaped tabulae but are horizontal at the top where they intersect the columella. All types of tabulae are commonly seen in the same specimen, but ordinarily one type dominates. Sections that are not in the plane of the axis show tabulae that appear to be progressively flatter as one approaches the periphery of the tabularium.

Because skeletal microstructure has not been described in most of the species diagnosed herein, no attempt is made to include it in the diagnoses of genera. Septal microstructure is described according to the classification of Kato (1963) only in descriptions of type material of new species and subspecies.

The repositories for material studied by the author are the U.S. National Museum of Natural History, Washington, D.C. (USNM), and the Muséum National d'Histoire Naturelle, Paris, France (MNHN, FL). Other material referred to is in the Rijksmuseum van Geologie en Mineralogie at Leiden, The Netherlands (RGM).

Occurrence data are limited to information taken from descriptive studies given in the synonymies of the taxa concerned, unless otherwise indicated. No attempt was made to search out all occurrences in faunal lists or other similar citations of the taxa.

Order RUGOSA Milne-Edwards and Haime, 1850
Suborder COLUMNARIINA Rominger, 1876
Family LITHOSTROTIONIDAE d'Orbigny, 1851

Genus STELECHOPHYLLUM Tolmachev, 1933

Stylophyllum Tolmachev, 1924, p. 316; 1931, p. 606; Fomichev, 1931, p. 43, 72 (not Reuss, 1854).

Stelechophyllum Tolmachev, 1933, p. 287 (replacement name for *Stylophyllum* Tolmachev); Soshkina, Dobrolyubova, and Kabakovich, 1962, p. 342; Dobrolyubova and Kabakovich, 1962, p. 122; 1966, p. 130; Minato and Kato, 1974, p. 69.

Eolithostrotionella Zhizhina in Fomichev, 1955, p. 303, 304; Zhizhina, 1956, p. 40.

Lonsdaleia McCoy. Lisitsyn, 1925, p. 68.

Lithostrotion Fleming. White, 1880a (1883), p. 159 [part]; Keyes, 1894, p. 124; Lambe, 1899, p. 220; 1901, p. 176; Tolmachev, 1924, p. 314 [part]; Warren, 1927, p. 46 [part]; Easton, 1944, p. 53; McLaren and Sutherland, 1949, p. 631; Bassler 1950, p. 213; Crickmay, 1955 (1961), p. 12 [part]; Nelson, 1960, p. 122 [part].

Lithostrotion [*Lithostrotionella*]. Bassler, 1950, p. 221; Easton and Gutschick, 1953, p. 19.

Lithostrotionella Yabe and Hayasaka. Hayasaka, 1936, p. 61, 62, 64, 65, 67, 68 [part]; Kelly, 1942, p. 354, 356, 357 [part]; Easton, 1958, p. 31; Nelson, 1960, p. 112, 113, 119, [part]; 1962, p. 170; Bamber, 1961, p. 107 [part]; 1966, p. 9, 14, 17 [part]; Armstrong, 1962, p. 38, 39 [part]; 1970a, p. 29, 32, 35 [part]; 1970b, p. 16, 19, 20, 21 25, 26; Easton, 1963, p. 297; Sando, 1969, p. 309; Onoprienko, 1976, p. 29 [part].

Lithostrotion [*Lithostrotionella*] [*Thysanophyllum*] Sutherland, 1958, p. 95.

Type species.—*Stylophyllum venukofi* Tolmachev, 1924, p. 318, pl. 19, figs. 9, 10 and 1931, p. 607, pl. 23, fig. 2 (by designation of Tolmachev, 1933, p. 287). Lower Carboniferous (Tournaisian), Kuznetsk Basin, U.S.S.R..

Diagnosis.—Cerioid corals with tabular to hemispherical growth form. Septa of two orders. Major septa thin, ordinarily extending across tabularium to columella but discontinuous or absent in dissepimentarium. Minor septa absent to variably developed. Columella ordinarily a simple, smooth or serrated, strong, continuous axial rod or plate that may have been derived from one or more septa, but thysanophylloid variants are known. Tabularium ordinarily consisting of an axial series of bell-shaped to tent-shaped complete tabulae resting one upon the other and a weak peripheral series of horizontal or inclined, concave-upward tabellae ("split tabulae" of Soviet authors). Dissepimentarium lonsdaleoid, commonly showing traces or crests of discontinuous septa in transverse section. Increase axial, peripheral, and intermural.

Discussion.—Tolmachev's (1924, 1931) original diagnosis of this genus described a coral similar to cerioid *Lonsdaleia* but without an axial plate and having a false columella formed by arched tabulae. Some of Tolmachev's figures of transverse sections suggest that an axial rod is present, but the point is ambiguous. Hill (1940, p. 164; 1956, p. 286) and Cotton (1973, p. 195) followed the original diagnosis. However, Fomichev (1931, p. 43, 72) restudied Tolmachev's types and concluded that Tolmachev's longitudinal sections are cuts that do not intersect the axes of the corallites. Fomichev found a columella like that of *Lithostrotion* in Tolmachev's transverse sections. These observations were confirmed by Fomichev's study of topotypes. Subsequent study by Dobrolyubova and Kabakovich (1962, 1966) on specimens from the Kuznetsk Basin confirmed Fomichev's findings and also showed that the Kuznetsk Basin species form a genetic series from weakly to strongly columellate forms.

Most authors (Hill, 1956, p. F286; Soshkina, Dobrolyubova, and Kabakovich, 1962, p. 342; Dobrolyubova and Kabakovich, 1962, p. 122–124; 1966, p. 130–157; Cotton, 1973, p. 195) regarded *Stelechophyllum* as a distinct genus, but Wang (1950, p. 212), Ivanovskiy (1967, p. 34), and Minato and Kato (1974, p. 69–71) regarded it as a junior synonym of *Lithostrotionella* Yabe and Hayasaka. In my opinion, *Stelechophyllum* is a distinct genus and *Lithostrotionella* is a probable junior synonym of *Acrocyathus* d'Orbigny.

Stelechophyllum is differentiated from *Acrocyathus* and *Petalaxis* by the nature of its axial structure and tabularium (fig. 1). In *Stelechophyllum*, the axial structure consists of a simple columella in the form of a rod or plate unmodified by septal lamellae or axial tabellae. The major septa may or may not join the columella, and the columella may be slightly serrated where the septa fall short of it. The tabularium in *Stelechophyllum* con-

sists of an axial series of convex to tent-shaped tabulae with well-defined shoulders that rest one upon the other and a weak peripheral zone of more or less horizontal, ordinarily concave-upward tabellae. *Acrocyathus* has a complex axial structure composed of an axial plate, axial lamellae, and steeply inclined tabulae or tabellae. The major septa seldom extend to the axial complex. The tabulae are essentially conical and ordinarily extend without shoulders to the periphery of the tabularium; peripheral tabellae are rare. *Petalaxis* has an essentially simple columella like that of *Stelechophyllum,* although some species have impersistently developed axial tabellae. The tabulae in *Petalaxis* are essentially horizontal.

Eolithostrotionella Zhizhina was proposed for corals that differ from *Lithostrotion* by having lonsdaleoid dissepiments and from *Lithostrotionella* by having arched, rather than horizontal, tabulae. Although the morphology of the type species of *Lithostrotionella* is in doubt, it seems to have conical tabulae like those of *Acrocyathus*; at any rate, the tabulae are not horizontal. The type species of *Eolithostrotionella* has an axial structure identical with the type species of *Stelechophyllum* and is here placed in the synonymy of *Stelechophyllum.*

Species of *Stelechophyllum* are distinguished on differences in mature corallite diameter, number of major septa at maturity, presence or absence and length of minor septa (weak or strong), development of the columella (absent, weak, or strong), major septal extensions into the tabularium (weak or strong), major septal extensions in the dissepimentarium (weak or strong), shape of the axial tabulae (flat, tent-shaped, convex), spacing of the tabulae, development of peripheral tabellae (absent, weak, or strong), number of rows of dissepiments, size and shape of dissepiments (large, small, inflated, flattened), and ratio of tabularium width to corallite diameter.

The species of *Stelechophyllum* fall into five major groups:

1. *S. ascendens* group, including *ascendens, megalum, grande,* and *venukoffi.* This group is characterized by its large corallites, moderate number of major septa, and by having a variably developed columella. The group is exclusively Tournaisian.
2. *S. microstylum* group, including *microstylum, circinatum, longiseptatum,* and *banffense.* This group is characterized by its large corallites, large number of major septa, and well developed columella. The group is Tournaisian and Viséan.
3. *S. micrum* group, including *micrum, lochmanae,* and *ergunjaicum.* This group is characterized by its small corallites and small number of major septa. The group is Tournaisian and Viséan.
4. *S.? mclareni* group, including *mclareni, birdi,* and *niakense.* This group is characterized by its strongly polymorphic corallites. The group is exclusively Viséan.
5. *S.? macouni* group, including only *S.? macouni* from the Viséan. This group is characterized by its weakly lonsdaleoid dissepimentarium.

Occurrence.—Upper Devonian (Famennian)(?) and Lower Carboniferous, middle Tournaisian to upper Viséan. U.S.S.R., Canada, U.S.A., Mexico.

Stelechophyllum ascendens species group

Stelechophyllum ascendens (Tolmachev)

Stylophyllum ascendens Tolmachev, 1924, p. 319, pl. 19, figs. 14, 15; 1931, p. 608, pl. 23, fig. 4.

Stelechophyllum ascendens (Tolmachev). Dobrolyubova and Kabakovich, 1962, p. 123, pl. C–5, fig. 11, pl. C–6, figs. 1a, b; 1966, p. 136.

Diagnosis.—*Stelechophyllum* with corallite diameter 7 to 12 mm and 13 to 17 major septa that seldom extend into the dissepimentarium. Major septa join the columella or end a short distance from it or from the axis when a columella is absent. Minor septa weakly developed or absent. Columella weakly developed or absent from some corallites. Dissepimentarium composed of a single row of large inflated dissepiments. Axial tabulae flat to strongly convex, spaced 0.5 to 1 mm apart. Peripheral tabellae absent or weakly developed. Ratio of tabularium width to corallite diameter 0.5 to 0.6. Increase is peripheral.

Discussion.—This species is distinguished by its weak development of minor septa and columella.

Occurrence.—Lower Carboniferous, upper Tournaisian. Nizhnetersin Horizon, Kuznetsk Basin, U.S.S.R.

Stelechophyllum ascendens simplex Dobrolyubova, in Dobrolyubova and Kabakovich

Stelechophyllum ascendens simplex Dobrolyubova, in Dobrolyubova and Kabakovich, 1966, p. 137, pl. 23, figs. 1, 2, text-fig. 7.

Diagnosis.—*Stelechophyllum ascendens* in which most of the corallites are without a columella and have tabulae that range from flat (without columella) to tent-shaped (with columella).

Description of holotype.—See Dobrolyubova and Kabakovich (1966, p. 137).

Discussion.—This form is the most primitive in the Russian *Stelechophyllum* sequence (Dobrolyubova and Kabakovich, 1966, p. 134).

Occurrence.—Lower Carboniferous, Tournaisian. Nizhnetersin Horizon, Kuznetsk Basin, U.S.S.R.

Stelechophyllum ascendens ascendens (Tolmachev)

Stelechophyllum ascendens ascendens (Tolmachev). Dobrolyubova and Kabakovich, 1966, p. 139, pl. 24, figs. 1, 2; pl. 25, figs. 1, 2; pl. 28, fig. 3; text-figs. 8, 9.

Diagnosis.—*Stelechophyllum ascendens* in which most of the corallites have a columella and axial tabulae and peripheral tabellae are present.

Description of lectotype.—See Tolmachev (1924, p. 319).

Occurrence.—Lower Carboniferous, upper Tournaisian. Nizhnetersin Horizon, Kuznetsk Basin, U.S.S.R.

Stelechophyllum megalum (Tolmachev)

Stylophyllum megalum Tolmachev, 1924, p. 319, pl. 19, figs. 11, 12; 1931, p. 608, pl. 23, fig. 3.

Stelechophyllum megalum (Tolmachev). Dobrolyubova and Kabakovich, 1962, p. 123, pl. C–5, fig. 1; 1966, p. 143, pl. 26, figs. 1a–c, 2, text-fig. 10.

Diagnosis.—*Stelechophyllum* with corallite diameter 7 to 14 mm and 13 to 19 major septa that most commonly extend from the columella across the tabularium and into the dissepimentarium. Minor septa generally well developed. Columella variable in form and thickness, commonly thick and lenticular, in some corallites replaced by ends of one or more major septa, absent from many corallites. Dissepimentarium consists of 1 to 3 poorly defined rows of large and small inflated dissepiments. Axial tabulae tent-shaped, spaced about 5 in 1 mm. Peripheral tabellae well developed. Ratio of tabularium width to corallite diameter about 0.4. Increase is peripheral.

Description of lectotype.—See Tolmachev (1924, p. 319).

Occurrence.—Lower Carboniferous, upper Tournaisian. Nizhnetersin Horizon, Kuznetsk Basin, U.S.S.R.

Stelechophyllum grande (Tolmachev)

Lithostrotion grande Tolmachev, 1924, p. 315, pl. 19, fig. 13; 1931, pl. 22, fig. 6.

Stelechophyllum grande (Tolmachev) Dobrolyubova and Kabakovich, 1966, p. 146, pl. 27, figs. 1, 2; text-figs. 11–14.

Diagnosis.—*Stelechophyllum* with corallite diameter 9 to 18 mm and 13 to 20 major septa that most commonly extend from the columella across the tabularium but seldom extend into the dissepimentarium. Minor septa absent to weakly developed. Columella variable in form and thickness, commonly thick and lenticular, in some corallites replaced by ends of one or more major septa, absent from some corallites. Dissepimentarium consists of 1 to 4 rows of small to large dissepiments. Tabulae spaced 0.5 to 1 mm apart, variable in form. Peripheral tabellae poorly developed. Ratio of tabularium width to corallite diameter about 0.4 . Increase is peripheral.

Description of lectotype.—See Tolmachev (1924, p. 315).

Occurrence.—Lower Carboniferous, upper Tournaisian. Nizhnetersin Horizon, Kuznetsk Basin, U.S.S.R.

Stelechophyllum venukoffi (Tolmachev)

See subspecies below for synonymy.

Diagnosis.—*Stelechophyllum* with corallite diameter 5.5 to 15 mm and 12 to 20 major septa that ordinarily extend from the columella across the tabularium but seldom extend into the dissepimentarium. Minor septa absent to well developed. Columella absent to very thick. Dissepimentarium composed of 1 to 4 rows of small to large dissepiments. Axial tabulae convex to tent-shaped, spaced about 0.5 mm apart. Peripheral tabellae poorly to well developed. Ratio of tabularium width to corallite diameter about 0.3 to 0.4. Increase is peripheral, axial, or intermural.

Stelechophyllum venukoffi venukoffi (Tolmachev)

Stylophyllum venukoffi Tolmachev, 1924, p. 318, pl. 19, figs. 9, 10; 1931, pl. 23, fig. 2.

Stelechophyllum venukoffi (Tolmachev). Dobrolyubova and Kabakovich, 1962, p. 124.

Stelechophyllum venukoffi venukoffi (Tolmachev). Dobrolyubova and Kabakovich, 1966, p. 156, pl. 28, figs. 1, 2, text-fig. 15.

Diagnosis.—*Stelechophyllum venukoffi* with minor septa absent or weakly developed and predominantly large dissepiments.

Description of lectotype.—See Tolmachev (1924, p. 318).

Occurrence.—Lower Carboniferous, upper Tournaisian. Nizhnetersin Horizon, Kuznetsk Basin, U.S.S.R.

Stelechophyllum venukoffi altaicum (Tolmachev)

Lithostrotion altaicum Tolmachev, 1924, p. 314, pl. 19, figs. 7, 8; 1931, pl. 23, fig. 1.

Stelechophyllum venukoffi altaicum (Tolmachev). Dobrolyubova and Kabakovich, 1966, p. 157, pl. 29, figs. 1-3, pl. 30, fig. 1.

Diagnosis.—*Stelechophyllum venukoffi* with minor septa well developed and variable, predominantly small dissepiments.

Description of lectotype.—See Tolmachev (1924, p. 314).

Discussion.—This subspecies is similar to *Stelechophyllum microstylum* (White) but has fewer major septa, fewer extensions of the septa in the dissepimentarium, and a lower ratio of tabularium width to corallite diameter.

Occurrence.—Lower Carboniferous, upper Tournaisian. Nizhenetersin Horizon, Kuznetsk Basin, U.S.S.R.

Stelechophyllum microstylum species group

Stelechophyllum microstylum (White)

Plates 1 and 2

Lithostrotion microstylum White, 1880a (1883), p. 159, pl. 40, fig. 7a; Keyes, 1894, p. 124; Easton, 1944, p. 53, pl. 13, figs. 1–3, pl. 17, fig. 1; Bassler, 1950, p. 213, Nelson, 1962, p. 170.

Lithostrotionella microstyla (White). Bamber, 1961, p. 110, pl. 8, figs. 4a, b, pl. 9, figs. 1a–h; Bowsher, 1961, pl. 110, figs. 4, 5a–c; Carlson, 1964, p. 663, pl. 110, figs. 4, 6.

?*Lithostrotionella* cf. *microstyla* (White). Bamber, 1961, p. 121, pl. 9, figs. 2a–e.

Lithostrotionella microstylum (White). Easton, 1963, p. 297; Bamber, 1966, p. 9, pl. 1, figs. 5a–g, pl. 2, figs. 1–3, pl. 3, figs. 1–3.

Lithostrotionella jasperensis Kelly, 1942, p. 356, pl. 51, figs. 3, 6; Nelson, 1960, p. 112, pl. 21, figs. 1–4; 1961, pl. 1, figs. 1–3; 1962, p. 170; Stensaas and Langenheim, 1960, p. 184, text-figs. 9a, b, 10a, b; Easton, 1963, p. 297.

Lithostrotion [*Lithostrotionella*] *jasperensis* (Kelly). Bassler, 1950, p. 221.

Lithostrotionella confluens Easton, 1958, p. 31, pl. 1, fig. 12, pl. 2, figs. 8, 9; Armstrong, 1962, p. 39, text-fig. 18, pl. 4, figs. 1–5, Nelson, 1962, p. 170; Easton, 1963, p. 297.

?*Lithostrotionella girtyi* Hayasaka, 1936, p. 65 [part].

Lithostrotionella hemisphaerica Hayasaka, 1936, p. 61 [part].

Lithostrotionella multiradiata Hayasaka, 1936, p. 67.

Diagnosis.—*Stelechophyllum* with corallite diameter 4 to 17 mm and 15 to 22 major septa that most commonly extend across the tabularium from the columella and into the dissepimentarium. Minor septa well developed. Columella ordinarily very well developed. Dissepimentarium composed of 1 to 10 rows (ordinarily 5 rows) of small to large, commonly flattened dissepiments. Axial tabulae convex to tent-shaped, spaced 2 to 4 in 1 mm. Peripheral tabellae well developed. Ratio of tabularium width to corallite diameter 0.4 to 0.5. Increase is intermural(?).

Description of neotype.—According to Easton (1944, p. 54), the holotype of *S. microstylum* was probably lost in a fire. USNM specimen 66838, described and illustrated by Bamber (1961, p. 110, pl. 8, figs. 4a, b, pl. 9, figs. 1a–h; 1966, p. 10–11, pl. 1, figs. 5a–g, pl. 2, figs. 3a, b), is here designated neotype for this species.

Discussion.—This is the most widespread species of *Stelechophyllum* in North America, ranging from the Mississippi Valley area to western Canada, where its occurrence is exclusively middle and upper Tournaisian (upper Kinderhookian and lower Osagean). *S. microstylum* is distinguished from the Russian species *S. megalum* by its greater maximum corallite diameter, more numerous major septa, ordinarily stronger columella, and more numerous, generally less inflated dissepiments. It is separated from *S. banffense* by its greater maximum corallite diameter, stronger minor septa, more numerous septal extensions into the tabularium, less flattened axial tabulae, and less inflated dissepiments.

Bamber (1966, p. 12-14) has discussed the synonymy of *Lithostrotionella jasperensis* Kelly and *Lithostrotionella confluens* Easton with *S. microstylum*, on the basis of study of the type material of these taxa. Three of Hayasaka's (1936) specimens are here referred definitely to *S. microstylum*. These are the holotype and paratype of *Lithostrotionella multiradiata* Hayasaka, USNM 120244 and 162005, respectively, and a paratype of *L. hemisphaerica* Hayasaka, USNM 161996. A fourth specimen, a paratype of *L. girtyi* Hayasaka, USNM 162003, is referred questionably to *S. microstylum*. These specimens are all illustrated herein.

Occurrence.—Lower Carboniferous, middle and upper Tournaisian. Chouteau Limestone and Northview Shale, Missouri, U.S.A.; Gilmore City Limestone, Iowa, U.S.A.; Lodgepole Limestone, Montana(?), Idaho, and Utah, U.S.A.; Joana Limestone, Nevada, U.S.A.; Keating Formation and Lake Valley Limestone, New Mexico, U.S.A.; Represo and Venada Formations, Sonora, Mexico; Banff and Pekisko Formations, Alberta, Canada.

Stelechophyllum circinatum (Easton and Gutschick)

Lithostrotion (Lithostrotionella) circinatus Easton and Gutschick, 1953, p. 19, pl. 3, figs. 5, 6 [part].

Lithostrotionella circinatus (Easton and Gutschick). Nelson, 1962, p. 170; Easton, 1963, p. 297; Sando, 1969, p. 309, pl. 38, figs. 1–7.

Diagnosis.—*Stelechophyllum* with corallite diameter 9 to 13 mm and 21 to 30 major septa that most commonly extend from the columella across the tabularium but seldom extend into the dissepimentarium. Minor septa absent to poorly developed. Columella absent to very well developed. Dissepimentarium composed of 1 to 4 rows of small to large, commonly flattened dissepiments. Axial tabulae flat to tent-shaped, spaced 4 in 1 mm. Peripheral tabellae well developed. Ratio of tabularium width to corallite diameter 0.4 to 0.5. Increase is peripheral.

Description of type specimens.—See Easton and Gutschick (1953, p. 19).

Discussion.—This species is similar to *S. microstylum* but differs in having more major septa, a columella that is variably developed, and fewer extensions of the major septa into the dissepimentarium. *S. circinatum* occurs at a slightly higher stratigraphic level than *S. microstylum*.

Occurrence.—Lower Carboniferous, upper Tournaisian. Redwall Limestone, Arizona, U.S.A.

Stelechophyllum longiseptatum (Lisitsyn)

Lonsdalia longiseptata Lisitsyn, 1925, p. 68, p. 1, fig. 4.

Eolithostrotionella longiseptata (Lisitsyn). Zhizhina, 1956, p. 40, pl. 9, figs. 1a, b.

Diagnosis.—*Stelechophyllum* with corallite diameter 15 to 20 mm and 24 to 32 major septa that most commonly extend from the columella across the tabularium and into the dissepimentarium. Minor septa well developed. Columella well developed. Dissepimentarium composed of 2 to 5 rows of small to large inflated dissepiments. Axial tabulae convex to tent-shaped, spaced 0.2 to 1 mm apart. Peripheral tabellae well developed(?). Ratio of tabularium width to corallite diameter 0.4 to 0.5. Mode of increase unknown.

Description of holotype.—See Zhizhina (1956).

Discussion.—This species is similar to *S. circinatum* but differs in having larger corallites, more major septa, a stronger columella, and in having the major septa commonly extending into the dissepimentarium.

Occurrence.—Lower Carboniferous, middle Viséan. Zone $C_1^{\gamma}d$ Donetz Basin, U.S.S.R.

Stelechophyllum banffense (Warren)

Plate 3; plate 4, figures 1, 2

Lithostrotion banffensis Warren, 1927, p. 46, pl. 3, figs. 5, 6, pl. 5; Crickmay, 1955, 1961, p. 12, pl. 1, figs. 13, 14.

Lithostrotionella banffensis (Warren). Kelly, 1942, p. 354; Bamber, 1966, p. 17, pl. 3, fig. 5; Armstrong, 1970a, p. 29, pl. 10, figs. 1–8, pl. 13, figs. 1-7; 1970b, p. 16, pl. 3, figs. 5-8, pl. 4, figs. 1–4, pl. 10, fig. 1.

Lithostrotionella banffense (Warren). Nelson, 1960, p. 119, pl. 23, figs. 4, 5; 1961, pl. 17, figs. 1, 2.

Lithostrotionella cf. *banffensis* (Warren). Bamber, 1961, p. 133, pl. 10, figs. 3a–d.

Lithostrotionella floriformis Hayasaka, 1936, p. 64, pl. 17, figs. 1a, b.

Lithostrotionella vesicularis Hayasaka, 1936, p. 68, pl. 14, figs. 3a, b.

?*Lithostrotionella americana* Hayasaka, 1936, p. 62 [part].

?*Lithostrotionella* aff. *L. banffensis* (Warren). Armstrong, 1970b, p. 19, pl. 4, figs. 5, 6.

Diagnosis.—*Stelechophyllum* with corallite diameter 6 to 13 mm and 19 to 26 major septa of variable length that seldom join the columella and seldom extend into the dissepimentarium. Minor septa absent to poorly developed. Columella well developed. Dissepimentarium composed of 1 to 6 rows of small to large inflated dissepiments. Axial tabulae ordinarily broadly tent-shaped, spaced 2 to 4 in 1 mm. Peripheral tabellae poorly to well developed. Ratio of tabularium width to corallite diameter 0.5 to 0.6. Increase is peripheral.

Description of lectotype.—See Nelson (1960) and Bamber (1966).

Discussion.—This highly variable species is common in rocks of early and middle Viséan age in western Canada and Alaska. It appears to have been derived from *S. microstylum*, from which it differs in having smaller corallites, weaker major and minor septa, somewhat flattened tabulae that are variable in form, ordinarily fewer rows of dissepiments, and a larger ratio of tabularium width to corallite diameter.

Armstrong (1970a, p. 29–31) has discussed the synonymy of *Lithostrotionella floriformis* Hayasaka and *Lithostrotionella vesicularis* Hayasaka with *S. banffense* on the basis of study of the type material. Hayasaka's type specimens are illustrated in Armstrong's paper. Three paratypes of *Lithostrotionella americana* (USNM 174372, 174374, and 174375) are here referred to the species with query and are illustrated herein.

Occurrence.—Lower Carboniferous, lower and middle Viséan. Mount Head Formation, Alberta, Canada; Prophet Formation, British Columbia, Canada; Peratrovich, Nasorak, Kogruk, and Alapah(?) Formations, Alaska, U.S.A.; Little Flat Formation, Idaho, U.S.A.(?).

Stelechophyllum micrum species group

Stelechophyllum micrum (Kelly)

Lithostrotionella micra Kelly, 1942, p. 357, pl. 50, fig. 7; Nelson, 1960, p. 113, pl. 21, figs. 5, 6; 1961, pl. 6, figs. 1–3; Bamber, 1966, p. 14, pl. 3, figs. 4a–e.

Lithostrotion [*Lithostrotionella*] *micra* (Kelly). Bassler, 1950, p. 221.

Lithostrotion micra (Kelly). Brindle, 1960, pl. 10, fig. 2.

Diagnosis.—*Stelechophyllum* with corallite diameter 2 to 6 mm and 10 to 15 major septa that most commonly extend from the columella across the tabularium but seldom extend into the dissepimentarium. Minor septa poorly developed. Columella poorly to well developed. Dissepimentarium composed of 1 to 2 rows of large inflated dissepiments. Axial tabulae convex, spaced 2 in 1 mm. Peripheral tabellae poorly developed. Ratio of tabularium width to corallite diameter about 0.6. Increase is peripheral(?).

Description of holotype.—See Kelly (1942) and Bamber (1961).

Discussion.—This species is similar to *Stelechophyllum lochmanae* and *S. ergunjaicum*. *S. lochmanae* has larger corallites and stronger major septa. *S. ergunjaicum* has slightly more major septa and only one row of dissepiments.

Occurrence.—Lower Carboniferous, upper Tournaisian. Pekisko and Shunda Formations, Alberta, Canada.

Stelechophyllum lochmanae (Armstrong)

Lithostrotionella lochmanae Armstrong, 1962, p. 38, pl. 4, figs. 6–8, text fig. 17.

Diagnosis.—*Stelechophyllum* with corallite diameter 5 to 8 mm and 13 to 15 major septa that most commonly extend from the columella across the tabularium and into the dissepimentarium. Minor septa well developed. Columella well developed. Dissepimentarium composed of 1 to 2 rows of large inflated dissepiments. Axial tabulae convex, spaced 3 in 1 mm. Peripheral tabellae poorly developed. Ratio of tabularium width to corallite diameter about 0.6. Mode of increase unknown.

Description of type material.—See Armstrong (1962).

Discussion.—This species is similar to *S. micrum* and *S. ergunjaicum*. *S. micrum* has smaller corallites and weaker minor septa, and *S. ergunjaicum* has weaker minor septa and fewer extensions of the major septa into the dissepimentarium.

Occurrence.—Lower Carboniferous, middle Tournaisian. Keating Formation and Lake Valley Limestone, New Mexico and Arizona, U.S.A.

Stelechophyllum ergunjaicum (Onoprienko)

Lithostrotionella ergunjaicum Onoprienko, 1976, p. 29, pl. 11, figs. 3, 4.

Diagnosis.—*Stelechophyllum* with corallite diameter 4 to 6 mm and 15 to 16 major septa that most commonly extend from the columella across the tabularium but seldom extend into the dissepimentarium. Minor septa poorly developed. Columella well developed. Dissepimentarium composed of a single row of large inflated dissepiments. Axial tabulae convex to tent-shaped, spaced 0.1–1.2 mm apart. Peripheral tabellae well developed. Ratio of tabularium width to corallite diameter 0.5 to 0.6. Mode of increase unknown.

Description of type material.—See Onoprienko (1976).

Discussion.—This species is similar to the North American species *S. lochmanae* and *S. micrum*. *S. ergunjaicum* differs from *S. micrum* by having convex to tent-shaped tabulae, better developed peripheral tabellae, and only one row of dissepiments. The Russian species differs from *S. lochmanae* by having smaller corallites, weaker minor septa, fewer extensions of the major septa into the dissepimentarium, and only one row of dissepiments.

Occurrence.—Lower Carboniferous, upper Viséan. Utaveem Suite, East Chukotka, Chegitun' River basin, U.S.S.R.

Stelechophyllum? mclareni species group

Stelechophyllum? mclareni (Sutherland)

Lithostrotion sp. McLaren and Sutherland, 1949, p. 631, pl. 103, figs. 1–9.

Lithostrotion [*Lithostrotionella*] [*Thysanophyllum*] *mclareni* Sutherland, 1958, p. 95, pl. 33, figs. 1a–g.

Lithostrotionella mclareni (Sutherland). Armstrong, 1970b, p. 21, pl. 5, figs. 4, 7, 8–10, pl. 6, figs. 1, 2, 7–9.

?*Lithostrotionella* aff. *L. mclareni* Sutherland. Armstrong, 1970a, p. 35, pl. 8, figs. 8, 9.

Diagnosis.—*Stelechophyllum*? with corallite diameter 3.5 to 4.4 mm and 12 to 15 major septa of variable length that may or may not join the columella and may or may not extend into the dissepimentarium. Minor septa absent to well developed. Columella weakly developed (or discontinuous) to strongly developed. Dissepimentarium composed of 1 to 3 rows of small to large inflated dissepiments. Axial tabulae flat to tent-shaped, depending on strength of columella, spaced 2 in 1 mm Peripheral tabellae absent to poorly developed. Ratio of tabularium width to corallite diameter about 0.5. Increase is peripheral.

Description of holotype.—See McLaren and Sutherland (1949).

Discussion.—McLaren and Sutherland (1949), Sutherland (1958), and Armstrong (1970b) have discussed in detail the extreme morphologic variability in this species. According to E. W. Bamber (written commun., 1980), who has studied the species, serial sections of the corallites show vertical discontinuity of the septa in the dissepimentarium and vertical discontinunity of the columella so that some sections have the appearance of *Sciophyllum* in corallites that are mainly characterized by the *Stelechophyllum* structure. The amount of variation is notable in this species.

S.? *mclareni* is similar to *S.*? *birdi* and *S.*? *niakense*, from which it differs in corallite diameter, in number of major septa, and in the degree to which the major septa extend into the dissepimentarium Armstrong's (1970a) *Lithostrotionella* aff. *L. mclareni* has characters that place it close to *S.*? *birdi* and is here referred to *S.*? *mclareni* with query.

Occurrence.—Lower Carboniferous, Viséan. Prophet Formation, British Columbia, Canada; Kogruk Formation, Alaska, U.S.A.

Stelechophyllum? birdi (Armstrong)

Lithostrotionella birdi Armstrong, 1970a, p. 32, pl. 7, figs. 1–4, pl. 8, figs. 1–7; 1970b, p. 20, pl. 4, fig. 1, pl. 5, figs 1–3, 5, 6.

Diagnosis.—*Stelechophyllum*? with corallite diameter 3.5 to 7.5 mm and 15 to 20 major septa of variable length that seldom join the columella and may or may not extend into the dissepimentarium. Minor septa absent to poorly developed. Columella absent to weakly developed. Dissepimentarium composed of 1 to 2 rows of mostly large inflated dissepiments. Axial tabulae flat to flattened tent-shaped, spaced 2 in 1 mm. Peripheral tabellae absent to poorly developed. Ratio of tabularium width to corallite diameter about 0.6. Increase is peripheral.

Description of holotype.—See Armstrong (1970a).

Discussion.—This species shows intracolony variation similar to that of *S.*? *mclareni* (see discussion of *S.*? *mclareni*). It is distinguished from *S.*? *mclareni* by its larger corallites and larger number of major septa. Its extreme morphologic variation makes generic placement questionable.

Occurrence.—Lower Carboniferous, Viséan. Peratrovich and Kogruk Formations, Alaska, U.S.A.

Stelechophyllum? niakense (Armstrong)

Lithostrotionella sp. A. Armstrong, 1970b, p. 25, pl. 7, figs. 1–6.

Lithostrotionella sp. B. Armstrong, 1970b, p. 26, pl. 7, figs. 7–9.

Lithostrotionella niakensis Armstrong, 1972a, p. A23, pl. 4, figs. 2, 6, pl. 9, figs. 1–3, pl. 9, figs. 1–6.

Diagnosis.—*Stelechophyllum*? with corallite diameter 2.5 to 4.7 mm and 9 to 14 major septa of variable length that seldom extend from the columella across the tabularium but commonly extend into the dissepimentarium. Minor septa poorly to well developed. Columella absent to poorly developed. Dissepimentarium composed of 1 to 2 rows of mostly large inflated dissepiments. Axial tabulae flat to tent-shaped, spaced 2 in 1 mm. Peripheral tabellae absent to poorly developed. Ratio of tabularium width to corallite diameter about 0.6. Increase is probably peripheral.

Description of holotype.—See Armstrong (1972a).

Discussion.—*S.? niakense* is similar to *S.? mclareni* but differs in having fewer major septa, more extensions of the major septa into the dissepimentarium, and less polymorphic variation between corallites. *S.? niakense* differs from *S.? macouni* in having larger corallites, more major septa, and fewer extensions of the major septa to the columella.

Occurrence.—Lower Carboniferous, Viséan. Kogruk Formation, Alaska, U.S.A.

Stelechophyllum macouni species group

Stelechophyllum? macouni (Lambe)

Lithostrotion macouni Lambe, 1899, p. 220; 1901, p. 176, pl. 14, figs. 11, 11a, 11b.

Lithostrotion? macouni Lambe. Nelson, 1960, p. 122, pl. 23, figs. 1, 2 [part].

Lithostrotionella macouni (Lambe). Armstrong, 1970b, p. 23, pl. 12, figs. 1–6.

Diagnosis.—*Stelechophyllum*? with corallite diameter 1.9 to 2.8 mm and 9 to 11 major septa that commonly extend from the columella across the tabularium and into the dissepimentarium. Minor septa absent to poorly developed. Columella ordinarily well developed. Dissepimentarium composed of a single row of small inflated dissepiments. Axial tabulae nearly flat to conical, spaced 3 in 1 mm. Peripheral tabellae poorly developed. Ratio of tabularium width to corallite diameter 0.7. Mode of increase unknown.

Description of lectotype.—GSC 4327 is here designated lectotype for this species. See Nelson (1960) and Armstrong (1970b) for description of this specimen.

Discussion.—This species is distinguished from all other species of *Stelechophyllum* by its smaller corallite diameter, fewer major septa, and very weakly developed lonsdaleoid dissepimentarium. Its morphology approaches that of *Lithostrotion* (*Lithostrotion*), which is unknown in North America

Occurrence.—Lower Carboniferous, Viséan. Prophet Formation, British Columbia, Canada.

Stelechophyllum sp. indet.

Plate 4, figures 3, 4

Lithostrotionella hemisphaerica Hayasaka, 1936, p. 61 [part].

Discussion.—An indeterminate species of *Stelechophyllum* is represented by USNM 120239, which is a paratype of *Lithostrotionella hemisphaerica* Hayasaka. This specimen has corallites 9 to 12 mm in diameter, 18 to 20 major septa, and an impersistent columella, but the corallites are too badly crushed to permit evaluation of all specific characters.

Occurrence.—Lower Carboniferous, Tournaisian. Madison Limestone, Utah, U.S.A.

Stelechophyllum? sp. indet.

Lithostrotionella sp. Bamber, 1961, p. 129, pl. 10, figs. 2a–d.

Discussion.—Bamber's (1961) specimen has corallites 4 to 8 mm in diameter, 19 to 21 major septa, a simple columella, and tabulae that appear to be of the *Stelechophyllum* type. Formal recognition of this species is deferred pending discovery of more specimens.

Occurrence.—Lower Carboniferous, Viséan. Prophet Formation, British Columbia, Canada.

Genus AULOSTYLUS Sando, 1976

Aulostylus Sando, 1976, p. 427.

Type species.—*Lithostrotionella tubifera* Hayasaka, 1936, p. 69, pl. 16, figs. 1a, b, 2. Lower Carboniferous (Tournaisian), Montana.

Diagnosis.—See Sando (1976).

Discussion.—This genus was established for lithostrotionelloid corals that have an aulos and a weak columella. Two middle Tournaisian species from the U.S.A. and Canada and a possible representative from the Viséan of China are the only described species. The species formerly referred to *Lithostrotionella* are listed below; pertinent information on them has been given by Sando (1976).

Aulostylus tubiferus (Hayasaka)

Lithostrotionella tubifera Hayasaka, 1936, p. 69, pl. 16, figs. 1a, b, 2; Smith and Yü, 1943, p. 42; Sando, 1963, p. 1076.

Lithostrotion [*Lithostrotionella*] *tubifera* (Hayasaka). Bassler, 1950, p. 220.

Aulina tubifera (Hayasaka). Hill, 1940, p. 190; Bamber, 1961, p. 161, pl. 12, figs. 3a–d.

Aulostylus tubiferus (Hayasaka). Sando, 1976, p. 428, figs. 3, 4.

Description of holotype.—See Sando (1976).

Diagnosis.—See Sando (1976).

Discussion.—Sando (1976) recognized two subspecies, *A. tubiferus tubiferus* and *A. tubiferus eotubiferus*. The holotype of *A. tubiferus tubiferus* is probably from the lower part of the Mission Canyon Limestone in Montana rather than from the Woodhurst Member of the Lodgepole Limestone as stated by Sando (1976).

Aulostylus? sp.

Lithostrotionella sp. A Lo and Chao, 1962, p. 184, pl. 19, fig. 1.

Aulostylus? sp. Sando, 1976, p. 431.

Family ACROCYATHIDAE new family

Diagnosis.—Cerioid and fasciculate colonial Rugosa that have two orders of septa, a columella that ranges from a simple axial plate joined to the counter septum to a complex spiderweb structure made up of axial plate, septal lamellae, and axial tabellae; ordinarily complete conical tabulae; and a lonsdaleoid dissepimentarium.

Type genus.—The type and only included genus is *Acrocyathus* d'Orbigny, 1849.

Genus ACROCYATHUS d'Orbigny, 1849

Astraea Castelnau, 1843, p. 45 (not Fischer von Waldheim, 1830, pl. 31, fig. 3).

Acrocyathus d'Orbigny, 1849a, p. 12; 1850, p. 160; 1852, p. 184; Thevenin in Boule and others, 1906, expl. pl. 6; 1907, p. 90; 1923, p. 90; Easton, 1973, p. 130, 132 [part]; Minato and Kato, 1974, p. 70 [part].

Lithostrotion Fleming. Milne-Edwards and Haime, 1851, p. 433, 483 [part]; Owen, 1852, expl. pl. 4; Hall in Hall and Whitney, 1858, p. 667; Milne-Edwards, 1860, p. 423 [part]; Owen, 1862, p. 364; Rominger, 1876, p. 111; White, 1880a (1883), p. 159 [part]; 1880b, p. 506; 1882, p. 401; Weller, 1898, p. 329 [part]; Ulrich, 1905, p. 33; Butts, 1917, p. 46; 1926, p. 176; 1941, p. 239; Shimer, 1926, p. 27 [part]; Morse, 1930, p. 104; Weller, 1931, p. 274; Kelly, 1942, p. 361 [part]; Allen and Lester, 1954, p. 101.

?*Lithostrotion* (*Lithostrotionella*) Yabe and Hayasaka, 1915, p. 133, 1920, p. 11; Bassler, 1950, p. 217, 221.

Lithostrotionella Yabe and Hayasaka. Hayasaka, 1936, p. 58, 61, 62, 65 [part]; Kelly, 1942, p. 352 [part]; Parks, 1951, p. 180; Weller and others, 1952, p. 84; Allen and Lester, 1954, p. 101; Nelson, 1960, p. 117, 118 [part]; 1961, pl. 17 [part]; Yoh, 1961, p. 8; Bamber, 1961, p. 107 [part]; 1966, p. 19 [part]; Armstrong, 1962, p. 39 [part]; 1970a, p. 31 [part]; Wu in Yü and others, 1963, p. 86; Nations, 1963, p. 1257; Minato and Kato, 1974, p. 72 [part].

Lonsdaleia McCoy. Crickmay, 1955, 1961, p. 13.

Eolithostrotionella Zhizhina. Vasilyuk, 1960, p. 95; Zhizhina in Bul'vanker and others, 1960, p. 250, 251, 252; Degtyarev, 1973, p. 192, 193.

Type species.—*Acrocyathus floriformis* d'Orbigny, 1849, p. 12 (by monotypy). Lower Carboniferous (Viséan), Indiana, U.S.A.

Diagnosis.—Ordinarily cerioid colonial corals with tabular to hemispherical growth form; one fasciculate species is known and cerioid-fasciculate coralla are rare. Septa of two orders. Major septa thin, seldom extending across tabularium to columella and ordinarily discontinuous or absent in dissepimentarium. Cardinal septum short and situated in a fossula formed by downwarped tabulae in some species. Counter septum commonly long and extending to columella. Minor septa ordinarily absent or poorly developed. Columella ranging from a simple axial plate joined to counter septum to a complex spiderweb structure made up of an axial plate, septal lamellae, and axial tabellae or upturned edges of tabulae. Tabulae ordinarily complete, conical, without well-defined shoulders, but may be nearly horizontal in some species. Peripheral tabellae rare. Dissepimentarium lonsdaleoid, commonly showing traces or crests of discontinuous septa in transverse section. Increase peripheral.

Discussion.—d'Orbigny's (1849a) original proposal and subsequent citations (1849b, 1852) of *Acrocyathus* provided only brief diagnoses of the genus, and Thevenin's (*in* Boule, 1906, 1907, 1923) reinvestigation of the type specimen added only illustrations of the exterior of the specimen. Most earlier authors (Milne-Edwards and Haime, 1851, p. 432, 433; 1852, p. 192; Lindstrom, 1883, p. 5, 11; de Koninck, 1872, p. 26; Thevenin, *in* Boule, 1907, 1923, p. 90; Sanford, 1939, p. 405; Soshkina and others, 1962, p. 336) regarded *Acrocyathus* as a junior synonym of *Lithostrotion* Fleming, although de Fromentel (1861, 304) thought it was a *Diphyphyllum* Lonsdale, and Wang (1950, p. 212) placed it in synonymy with *Lonsdaleia* McCoy. More recently, some authors (Hill, 1956, p. F307; Ivanovskiy, 1967, p. 34, and Cotton, 1973, p. 12) linked it questionably with *Lithostrotionella* Yabe and Hayasaka.

Easton (1973) redescribed in detail the type specimen and illustrated thin sections of it, thus providing the first adequate basis for a determination of the morphology and affinities of the type species. Easton regarded *Acrocyathus* as a senior synonym of *Lithostrotionella* and espoused a broad generic concept that included species placed herein in *Stelechophyllum* Tolmachev and *Petalaxis* Milne-Edwards and Haime. Minato and Kato (1974, p. 70–71) regarded *Acrocyathus* as a distinct genus distinguished from *Lithostrotionella* by having a complex axial structure rather than a simple axial plate.

In my opinion, *Acrocyathus* is a distinct genus separated from *Stelechophyllum* and *Petalaxis* by its complex axial structure and complete conical tabulae. It is distinguished from *Lithostrotion* by its lonsdaleoid dissepimentarium and complex axial structure and from *Lonsdaleia* by its lack of a distinct separation of axial and peripheral series of tabellae. Although the morphology of the type species of *Lithostrotionella* is in doubt, *Lithostrotionella* is regarded as a probable junior synonym (see p. 4).

Eolithostrotionella is included in the synonymy of *Acrocyathus* because some of the Russian species were referred to that genus. The type species of *Eolithostrotionella* is a *Stelechophyllum.*

Species of *Acrocyathus* are distinguished on differences in mature corallite diameter, number of major septa at maturity, development of major septa, development of minor septa, complexity of the columella, shape and spacing of the tabulae, size and number of dissepiments, number of rows of dissepiments, and ratio of tabularium width to corallite diameter. Most of the species of *Acrocyathus* have a cerioid corallum, but one fasciculate species, *A. proliferus*, is included here because of its internal morphologic similarity to cerioid species and the presence of transitional forms. Cerioid species included here are the abundantly represented *A. floriformis* from the Eastern United States; *A. pilatus* from the Mississippi Valley; *A. girtyi* from the Western United States; *A. pennsylvanicus* from western Canada; *A. utkae, A. rotai, A. cystosus*, and *A. lissitzini* from the U.S.S.R.; and *A. hsujiulingi* from China. Questionable forms include *A.? unicus* and *A.? zhizhinae*, whose morphology is in doubt, and *A.? shimeri* and *A.? grechovkae*, which have essentially horizontal tabulae like *Petalaxis* but have a complex columella characteristic of *Acrocyathus.*

Occurrence.—Lower Carboniferous, lower to upper Viséan. U.S.S.R., U.S.A., Canada, China.

Acrocyathus floriformis d'Orbigny

Plates 5–14, 16

Not *Astraea mamillaris* Fischer von Waldheim, 1830, pl. 31, fig. 3
Astraea mamillaris Castelnau, 1843, p. 45, pl. 24, fig. 5.
Acrocyathus floriformis d'Orbigny, 1849a, p. 12; 1850, p. 160; 1852, p. 184; Thevenin in Boule and others, 1906, expl. pl. 6, pl. 6, figs. 1, 2; 1907, p. 90; 1923, p. 90, expl. pl. 6, pl. 6, figs. 1, 2; Easton, 1973, p. 130, pl. 1, figs. 1a–f.
Acrocyathus sp. Easton, 1973, p. 132, pl. 1, figs. 2a–b.
Not *Axinura canadensis* Castelnau, 1843, p. 49, pl. 24, fig. 4.
Lithostrotion mamillare Milne-Edwards and Haime, 1851, p. 433, pl. 13, fig. 1 [part]; Hall in Hall and Whitney, 1858, p. 667, pl. 24, figs. 5a, b; Rominger, 1876, p. 111, pl. 55, upper-right figure [part].
Lithostrotion mamillare (Castelnau). White, 1880a (1883), p. 159, pl. 40, figs. 6a, b; 1880b, p. 506, pl. 6, figs. 1, 2; 1882, p. 401, pl. 52, fig. 3.
Not *Lithostrotion mamillare*(?) Meek, 1864, p. 5, pl. 1, figs. 4–4b.
Lithostrotion canadense Milne-Edwards and Haime, 1851, p. 483, pl. 13, fig. 1 [part]; Milne-Edwards, 1860, p. 423; Owen, 1862, p. 364, fig. 6; Butts, 1926, p. 176, pl. 58, figs. 12, 13; Morse, 1930, p. 104, pl. 9; Weller, 1931, p. 274, pl. 36, figs. 1a, b.
Lithostrotion canadense (Castelnau). Weller, 1898, p. 329 [part].
Lithostrotion? canadense Ulrich, 1905, p. 33, pl. 3, figs. 1, 2.
Lithostrotion "canadensis" (Castelnau). Butts, 1941, p. 239, pl. 129, fig. 3.
Lithostrotion basaltiforme Owen, 1852, expl. pl. 4, pl. 4, figs. 5, 6; Butts, 1917, p. 46, pl. 11, figs. 1, 2.
Lithostrotionella castelnaui Hayasaka, 1936, p. 58, pl. 11, figs. 1, 2 [part]; Weller and others, 1952, p. 84, pl. 1, figs. 6, 7; Allen and Lester, 1954, p. 101, pl. 26, fig. 1.
Lithostrotion [Lithostrotionella] castelnaui (Hayasaka). Bassler, 1950, p. 217 [part].
Lithostrotionella americana Hayasaka, 1936, p. 62, pl. 14, figs. 1, 2 [part].
Lithostrotion [Lithostrotionella] americanum Bassler, 1950, p. 217 [part].
Lithostrotionella hemisphaerica Hayasaka, 1936, p. 61, pl. 12, fig. 1, pl. 13, figs. 1, 2 [part].
Lithostrotion [Lithostrotionella] hemisphericum (Hayasaka). Bassler, 1950, p. 217 [part].
Not *Lithostrotionella floriformis* Hayasaka, 1936, p. 64, pl. 17, fig. 1.

Material studied.—MNHN 1140 (holotype), FL 411; USNM 756, 3779, 8211, 13669, 15526, 17071, 17848, 37466, 39654, 42695, 42766, 71646, 98102, 120235, 120236, 120237, 120238, 120240, 120241, 135092, 135094, 135096, 135097, 135172, 135173, 135174, 135177, 135179, 135300, 135301, 135302, 136704, 161989, 161990, 161991, 161992, 161993, 161994, 161995, 161997, 161998, 161999, 162000, 162001, 166604, 166605, 174376, 174377, 216198, 216199, 216200, 216202, 216203, 216204, 216205, 216206, 216207, 216208, 216210, 216211, 216212, 216214.

Diagnosis.—Predominantly cerioid *Acrocyathus* with corallite diameter 10 to 30 mm and 20 to 40 major septa that are ordinarily short and do not extend across the tabularium to the columella and seldom extend into the dissepimentarium. Cardinal fossula ordinarily well developed. Counter septum commonly joined to columella. Minor septa weakly developed as crests on dissepiments. Columella highly variable, ranging from a simple axial plate joined to the counter septum to a complex spiderweb structure made up of an axial plate, septal lamellae, and axial tabellae or upturned edges of tabulae; thysanophylloid variants are known. Dissepimentarium composed of 1 to 5 rows of large and small, ordinarily inflated dissepiments. Tabulae complete, conical, sharply deflected upward at columella and without shoulders or with poorly defined shoulders and spaced about 1 mm apart. Peripheral tabellae rare. Axial tabellae common. Ratio of tabularium width to corallite diameter 0.4 to 0.6. Increase is peripheral.

Description of holotype.—See Easton (1973).

Discussion.—This species is characterized by the highly variable structure of the columella and the great range in corallite diameter and number of major septa (fig. 3). The variation in the latter two characters appears to be continuous and does not permit recognition of separate species or subspecies. The species has been divided into two subspecies on the basis of the complexity of the columella (see below). Similarities between *Acrocyathus floriformis* and the fasciculate species *A. proliferus* are discussed under *A. proliferus*.

Occurrence.—*A. floriformis* is abundant in and characteristic of the St. Louis Limestone and correlative formations in the Southeastern Province of Sando and others (1975, 1977). Data on its occurrence are noted under the two subspecies of the species.

Acrocyathus floriformis floriformis d'Orbigny

Plates 5–11; plate 16, figure 2

Not *Astraea mamillaris* Fischer von Waldheim, 1830, pl. 31, fig. 3.
Astraea mamillaris Castelnau, 1843, p. 45, pl. 24, fig. 5.
Acrocyathus floriformis d'Orbigny, 1849a, p. 12; 1850, p. 160; 1852, p. 184; Thevenin in Boule, 1906, expl. pl. 6, pl. 6, figs. 1, 2; 1907, p. 90; 1923, p. 90, expl. pl. 6, pl. 6, figs. 1, 2; Easton, 1973, p. 130, pl. 1, figs. 1a–f.
?*Lithostrotion mamillare* Milne-Edwards and Haime, 1851, p. 433, pl. 13, fig. 1 [part]; Rominger, 1876, p. 111, pl. 55, upper right figure [part].
Not *Lithostrotion mamillare* (Castelnau). White, 1880a (1883), p. 159, pl. 40, figs. 6a, b; 1880b, p. 506, pl. 6, figs. 1, 2; 1882, p. 401, pl. 52, fig. 3.
Not *Lithostrotion mamillare*(?) Meek, 1864, p. 5, pl. 1, figs. 4–4b.
?*Lithostrotion canadense* Milne-Edwards and Haime, 1851, p. 483, pl. 13, fig. 1 [part].
Lithostrotion canadense Butts, 1926, p. 176, pl. 58, figs. 12, 13.
Lithostrotion? canadense Ulrich, 1905, p. 33, pl. 3, figs. 1, 2.
?*Lithostrotion basaltiforme* Owen, 1852, expl. pl. 4, pl. 4, figs. 5, 6.
Lithostrotion basaltiforme Owen. Butts, 1917, p. 46, pl. 11, figs. 1, 2.
Lithostrotionella castelnaui Hayasaka, 1936, p. 58, pl. 11, figs. 1, 2.
Lithostrotion [Lithostrotionella] castelnaui (Hayasaka). Bassler, 1950, p. 217.
Lithostrotionella americana Hayasaka, 1936, p. 62, pl. 14, figs. 1, 2 [part].

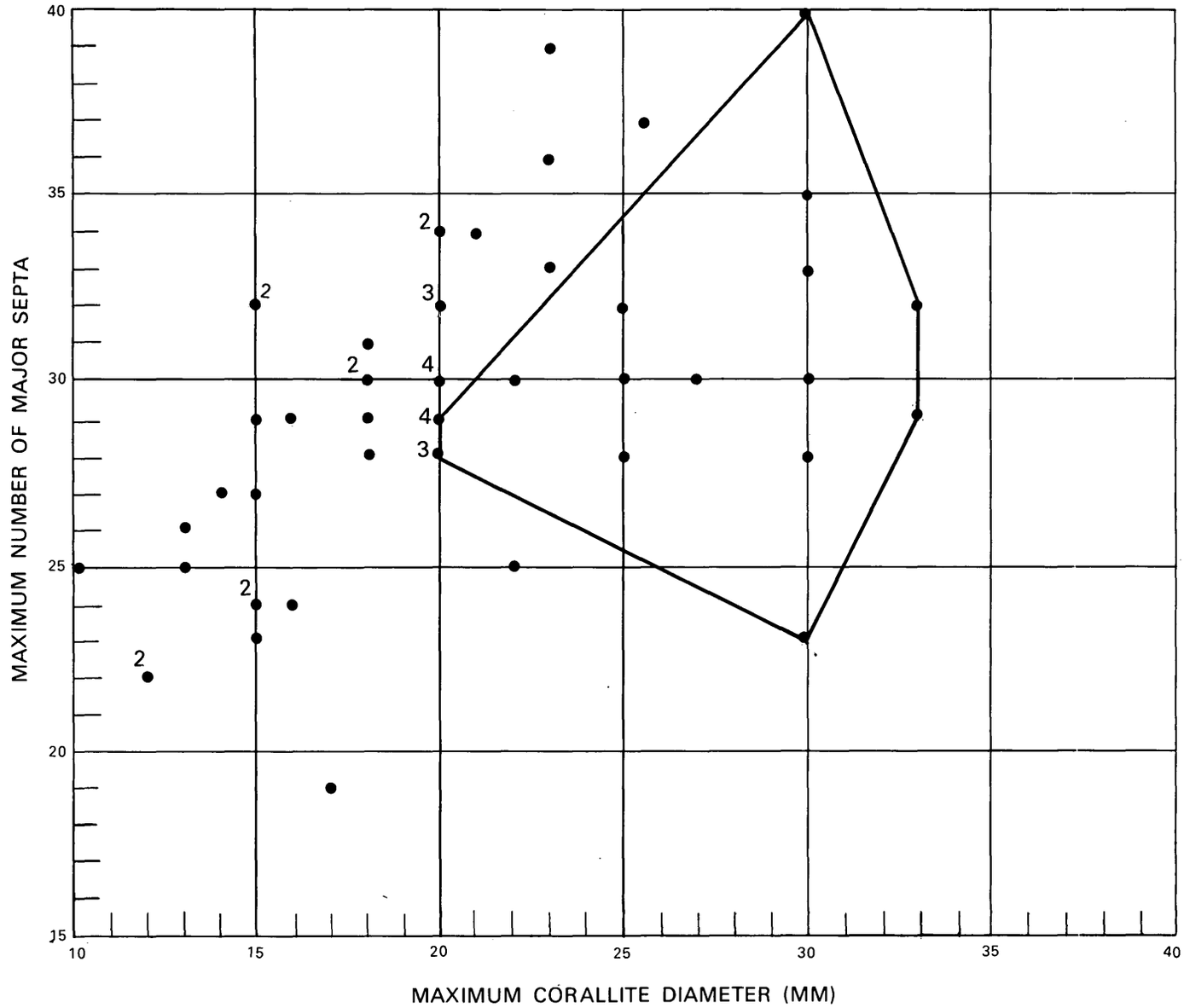


FIGURE 3.–Variation in maximum number of major septa and maximum corallite diameter in 56 coralla of *Acrocyathus floriformis*. Polygon defines field of variation of coralla from one locality (Livingston, Tenn.). Numbers beside dots indicate more than one corallum.

Lithostrotion [*Lithostrotionella*] *americanum* Bassler, 1950, p. 217.
Lithostrotionella hemisphaerica Hayasaka, 1936, p. 61, pl. 12, fig. 1, pl. 13, figs. 1, 2 [part].
Lithostrotion [*Lithostrotionella*] *hemisphericum* (Hayasaka). Bassler, 1950, p. 217 [part].
Not *Lithostrotionella floriformis* Hayasaka, 1936, p. 64, pl. 17, fig. 1.

Description of holotype.–See Easton (1973).

Material studied.–MNHN 1140 (holotype), FL 411; USNM 13669, 71646, 120235, 120238, 120240, 120241(?), 161989, 161990, 161991, 161993, 161994, 161995, 161997, 162001(?), 174376, 174377(?), 216205(?), 216206.

Diagnosis.–*Acrocyathus floriformis* having an axial structure ranging from a simple axial plate to a complex structure composed of an axial plate, a few axial lamellae, and a few concentric intercepts of axial tabellae or upturned edges of axial tabulae in transverse section.

Discussion.–This predominant subspecies of the widespread species *A. floriformis* is distinguished from *A. floriformis hemisphaericus* by its less complex columella. The two subspecies occur in the same formations in the same geographic areas.

Occurrence.—Lower Carboniferous, middle or upper Viséan. St. Louis Limestone, Indiana, Illinois, Iowa, Kentucky, Missouri, Tennessee, U.S.A.; Greenbrier Limestone and Newman Limestone, Virginia, U.S.A.; Hillsdale Member of Greenbrier Limestone, West Virginia, U.S.A.; Newman Limestone, Kentucky, U.S.A.; Tuscumbia Limestone, Alabama, U.S.A.

Acrocyathus floriformis hemisphaericus (Hayasaka)

Plates 12–14

Lithostrotion mamillare (Castelnau). White, 1880a, p. 159, pl. 40, figs. 1a, b.

Lithostrotion "canadensis" (Castelnau). Butts, 1941, p. 239, pl. 129, fig. 3.

Lithostrotion castelnaui Hayasaka, 1936, p. 58 [part].

Lithostrotion [Lithostrotionella] castelnaui (Hayasaka). Bassler, 1950, p. 217 [part].

Lithostrotionella hemisphaerica Hayasaka, 1936, p. 61, pl. 12, 13, figs. 2a, b. [part].

Lithostrotion [Lithostrotionella] hemisphericum (Hayasaka). Bassler, 1950, p. 217.

Material studied.—USNM 8211, 98102, 120236, 120237 (holotype), 161992, 161998, 161999, 162000(?).

Diagnosis.—*Acrocyathus floriformis* having an axial structure ranging from a simple axial plate to a very complex structure composed of an axial plate, many axial lamellae, and many concentric intercepts of axial tabellae or upturned edges of axial tabulae in transverse section.

Description of holotype.—The specimen is a fragment of a large, silicified, cerioid, hemispherical colony. It is about 15 cm high and was more than 18 cm in diameter. Internal structures are poorly preserved.

Corallites are polygonal, have straight double-layered walls as much as 0.25 mm thick, and range from 10 to 15 mm in diameter at maturity. Increase is peripheral. The major septa seldom extend to the columella but commonly extend into the dissepimentarium. The cardinal septum is shorter than the other major septa, and the counter septum commonly joins the columella. There are 26 to 32 major septa at maturity. Minor septa are relatively well developed at the corallite walls and as crests on the dissepiments. The columella ranges from a simple axial plate joined by a few septal lamellae in young corallites to a very complex structure composed of an axial plate, many septal lamellae, and as many as 4 concentric traces of axial tabellae; the columella is as much as 2.5 mm in diameter. Tabulae are ordinarily complete, conical, curved upward to the columella, and spaced 0.25 to 1 mm apart. The dissepimentarium is weakly lonsdaleoid and consists of 2 to 3 rows of inflated to flattened dissepiments of varying sizes. There are ordinarily 2 or 3 dissepiments in 1 mm. The ratio of the tabularium width to the corallite diameter is about 0.6 to 0.7. Septal microstructure has been destroyed by silicification.

Discussion.—This subspecies is distinguished by its compact, very complex columella. The holotype (pl. 12, figs. 1, 2) is a poor example of the species because of the poor preservation of internal structures. A paratype, USNM 161998, is a much better example. This specimen pl. 12, figs. 3, 4) has as many as 5 tabellar rings around the medial plate. The other paratypes have fewer tabellar rings than USNM 161998, but all have a more complex columella than is found in *A. floriformis floriformis.*

The transverse section of this subspecies mimics that of *Lonsdaleia (Actinocyathus)* because of its complex columella and lonsdaleoid dissepimentarium. It is readily distinguished from *Lonsdaleia (Actinocyathus)* in longitudinal section by lacking a distinct continuous separation of axial and peripheral tabellae. The longitudinal section (pl. 12, fig. 3) also shows that the complexity of the columella ranges from a simple structure like that of *A. floriformis floriformis* to a complex structure in the same corallite.

Occurrence.—Lower Carboniferous, middle or upper Viséan. St. Louis Limestone, Illinois, Indiana, and Missouri, U.S.A.; Newman Limestone and Greenbrier Limestone, Virginia, U.S.A.; Hillsdale Mamber of Greenbrier Limestone, West Virginia, U.S.A.

Acrocyathus pilatus n. sp.

Plate 17, figures 1, 2

Lithostrotionella girtyi Hayasaka, 1936, p. 65 [part].

Material studied.—USNM 162004 (holotype).

Description of holotype.—The specimen is a fragment of a small, cerioid, hemispherical corallum. It was more than 4.5 cm high and more than 8 cm in diameter. The outer part of the specimen is silicified.

Corallites are polygonal, have straight, double-layered, beaded walls 0.25-0.5 mm thick, and range from 8 to 11 mm in diameter at maturity. Increase is peripheral. The major septa most commonly extend to the columella and may or may not extend into the dissepimentarium. The cardinal septum is elongated in some corallites. There are 17 to 19 major septa at maturity. Minor septa are poorly developed as spines on the corallite walls. The columella is complex, composed of a medial plate, septal lamellae, and conical axial tabellae and is as much as 2 mm in diameter; it is ordinarily thickened by stereoplasm. Tabulae are ordinarily complete, conical, uncurved, and spaced about 0.7 to 0.8 mm apart. The dissepimentarium is weakly lonsdaleoid and consists of 1 or 2 rows of inflated dissepiments of variable size. There are ordinarily 2 or 3 dissepiments in 1 mm. The ratio of the tabularium width to the corallite diameter is about 0.6 to 0.7. Septal microstructure is obscured by recrystallization, seemingly diffusotrabecular.

Discussion.—This species is most similar to *Acrocyathus floriformis hemisphaericus* by virtue of its complex columella but is distinguished by having fewer tabellar rings and by the stereoplasmic thickening of the columella.

Occurrence.—Lower Carboniferous, middle Viséan. St. Louis Limestone, Illinois, U.S.A.

Acrocyathus proliferus (Hall in Hall and Whitney)

Plate 15; plate 16, figures 1, 3, 4

Lithostrotion mamillare Milne-Edwards and Haime, 1851, p. 433, pl. 13, figs. 1a, b. [part]; Rominger, 1876, p. 111, pl. 55 [part].

Lithostrotion canadense Milne-Edwards and Haime, 1851, p. 483, pl. 13, figs. 1a, b. [part].

Lithostrotion canadense Castelnau. Weller, 1898, p. 329 [part].

Lithostrotion proliferum Hall in Hall and Whitney, 1858, p. 668, pl.24, figs. 6a–c; Rominger, 1876, p. 111, pl. 55; Butts, 1917, p. 45, pl. 10, figs. 15–17; 1926, p. 176, pl. 58, fig. 14; Morse, 1930, p. 102, pl. 8; Weller, 1931, p. 276, pl. 37, figs. 1a, b; Kelly, 1942, p. 361, pl. 51, figs. 1, 4; Allen and Lester, 1954, p. 101, pl. 26, fig. 2; not Davis, 1956, p. 31, pl. 2, figs. 3a, b.

Lithostrotion? proliferum Hall. Ulrich, 1905, p. 32, pl. 3, figs. 3–7.

Lithostrotionella prolifera (Hall). Butts, 1941, p. 239, pl. 129, figs. 1, 2; Weller and others, 1952, p. 84, pl. 1, fig. 5.

Lithostrotion [*Lithostrotionella*] *proliferum* (Hall). Bassler, 1950, p. 217.

Material studied.—USNM 841 (neotype), 4587, 37469, 37470, 37471, 39655, 42667, 42705, 42714, 42845, 49941, 52681, 60306, 71647, 135085, 135087, 135091, 135095, 135098, 135168, 135176, 216201, 216207, 216209, 216213, 239233.

Diagnosis.—Fasciculate *Acrocyathus* with corallite diameter 10 to 25 mm and 26 to 49 major septa. Internal morphology like that of *Acrocyathus floriformis*, but dissepimentarium is consistently weakly lonsdaleoid. Increase is peripheral.

Description of neotype.—I have been unable to locate the specimens originally described and illustrated by Hall (*in* Hall and Whitney, 1858). I have therefore selected USNM 841, from the St. Louis Limestone, Hardin County, Ill., as neotype for the species.

The neotype is a fragment of a large phaceloid corallum. The specimen is about 12 mm high and 17 × 9 mm in diameter.

Corallites are cylindrical, have single-layered walls about 0.2 mm thick, and range from 12 to 15 mm in diameter at maturity. Increase is peripheral. The major septa do not extend to the columella but do extend into the dissepimentarium, most commonly reaching the corallite wall. There are 26 to 29 major septa at maturity. The cardinal septum is slightly shorter than the other major septa and is in a fossula formed by downwarped tabulae. Minor septa are poorly developed as spines on the corallite walls. The columella ranges from a simple axial plate to a structure made up of axial plate, a few axial lamellae, and a few concentric traces of axial tabellae in transverse section. Tabulae are ordinarily complete, conical, curved upward at the columella, and spaced about 1 mm apart. The dissepimentarium is weakly lonsdaleoid and consists of 1 to 3 rows of inflated dissepiments of variable size. There is ordinarily 1 dissepiment in 2 mm. The ratio of the tabularium width to the corallite diameter is about 0.6 to 0.8. Septal microstructure is diffusotrabecular.

Discussion.—Colonies of the fasciculate *A. proliferus* show the same range in variation of internal structures, such as the columella and tabulae, as the cerioid *A. floriformis*. Both forms have a shortened cardinal septum and commonly a long counter septum. The only consistent internal difference is in the dissepimentarium, where the fasciculate forms have fewer rows of dissepiments, and the dissepimentarium is only weakly lonsdaleoid. Increase in both the fasciculate and cerioid forms is peripheral. In the fasciculate forms, the offsets tend to arise in clusters of several new individuals at levels of rejuvenation of the parent corallite.

Form variation was studied in 263 USNM specimens from the St. Louis Limestone and equivalent beds in Alabama, Indiana, Illinois, Iowa, Kentucky, Missouri, Tennessee, Virginia, West Virginia, Georgia, and Michigan. Of these specimens, 154 are cerioid *A. floriformis* and 95 are fasciculate *A. proliferus*. Both forms occur together at two localities. Ordinarily cerioid and fasciculate forms are discrete colonies, but 14 specimens show both growth forms in the same colony (pl. 16). In most of these, cerioid corallites gave rise to fasciculate corallites, but in one colony, a fasciculate form became cerioid at a later stage.

The form variation noted above presents problems in taxonomic treatment of these corals. Some authors (for example, Hill, 1940, p. 151, 166) place cerioid and fasciculate forms of *Lithostrotion* and *Lonsdaleia* in the same genus. Others (for example, Kato, 1966, p. 100–101; Sando, 1975, p. C20) regard the two growth forms as subgenera. The evidence with respect to form variation in "*Lithostrotionella*" *floriformis* and "*Lithostrotion*" *proliferum* suggests a strong genetic relationship between the two forms. Indeed, the basic similarities in internal structure and the presence of transitional forms might lead to the conclusion that the two forms are merely ecologic variants of the same biologic species. However, the rarity of transitional forms, the lack of detailed information on geographic and stratigraphic distribution of the morphotypes, and the obvious practicality of recognizing the two growth forms as separate entities lead me to maintain them as separate species. The treatment is different from my treatment of *Lithostrotion* and *Lonsdaleia*, because in North America, *Lithostrotion* is represented almost entirely by the fasciculate form (*Siphonodendron*), and fasciculate and cerioid *Lonsdaleia* are separated from

each other in different faunal provinces. Furthermore, no transitional forms are known between the subgenera of either *Lithostrotion* or *Lonsdaleia* in North America.

Occurrence.—Lower Carboniferous, middle or upper Viséan. St. Louis Limestone and equivalent strata, Illinois, Georgia, Kentucky, Tennessee, Alabama, and Michigan, U.S.A.

Acrocyathus girtyi (Hayasaka)

Plate 17, figures 3, 4

Lithostrotionella girtyi Hayasaka, 1936, p. 65, pl. 13, figs. 3a, b.
?*Lithostrotionella* sp. Parks, 1951, p. 180, pl. 29, figs. 2a, b.

Material studied.—USNM 120243 (holotype).

Description of holotype.—The specimen is a fragment of a large hemispherical corallum. It was more than 15 cm in diameter and attained a height of more than 8 cm. The outer part of the specimen is silicified.

Corallites are polygonal, have straight double-layered walls as much as 0.3 mm thick, and range from 8 to 11 mm in diameter at maturity. Increase is peripheral. Except for the counter septum, the major septa are short and do not extend to the columella and seldom extend into the dissepimentarium. There are 18 to 21 major septa at maturity. Minor septa are absent or poorly developed. The columella is a simple axial plate connected to the counter septum in young corallites but is composed of an axial plate, septal lamellae, and upturned edges of tabulae in mature corallites. The columella is ordinarily thickened by stereoplasm and attains a maximum diameter of 2 mm. Tabulae are ordinarily complete, conical, turned up at the columella, and spaced 0.5 to 1 mm apart. The dissepimentarium is strongly lonsdaleoid and consists of a single row of large inflated dissepiments. There are ordinarily 1 or 2 dissepiments in 2 mm. The ratio of the tabularium width to the corallite diameter is about 0.6 to 0.7. Septal microstructure is fibronormal.

Discussion.—This species has a columella and corallite diameter like that of *A. pilatus* but is distinguished from the latter by its strongly lonsdaleoid dissepimentarium, single row of dissepiments, and septa that seldom extend to the columella. The specimen illustrated by Parks (1951) from the "Brazer Limestone" in Utah may belong here, but the lack of information on morphological details prevents certain identification.

Occurrence.—Lower Carboniferous, middle or upper Viséan. Little Flat Formation, Utah, U.S.A.

Acrocyathus pennsylvanicus (Shimer)

Lithostrotion pennsylvanicum Shimer, 1926, p. 27, pl. 5, figs. 3–5 [part].
Lithostrotionella pennsylvanica (Shimer). Kelly, 1942, p. 352, pl. 50, figs. 1, 2, 5, 6, 8; Bamber, 1961, p. 145, pl. 11, figs. 1b, c, 3a–f; 1966, p. 19, pl. 4, figs. 1a–c, 2a–c.
Lithostrotion [*Lithostrotionella*] *pennsylvanicum* (Shimer). Bassler, 1950, p. 221.
Lonsdaleia pennsylvanica (Shimer). Crickmay, 1955, 1961, p. 13, pl. 1, figs. 11, 12.
Lithostrotionella pennsylvanicum (Shimer). Nelson, 1960, p. 117, pl. 22, figs. 4-6; 1961, pl. 17, figs. 3, 4.

Diagnosis.—Cerioid *Acrocyathus* with corallite diameter 10 to 17 mm and 18 to 23 major septa that ordinarily approach the columella but do not reach it and seldom extend into the dissepimentarium. Minor septa weakly developed. Columella complex, composed of an axial plate, septal lamellae, and axial tabellae or upturned edges of tabulae. Dissepimentarium composed of 1 to 3 rows of large and small inflated dissepiments. Tabulae complete, conical, sharply deflected upward at columella, without shoulders or with poorly defined shoulders, and spaced about 0.5 mm apart. Ratio of tabularium width to corallite diameter 0.5 to 0.8. Mode of increase unknown.

Description of lectotype.—See Nelson (1960) and Bamber (1966).

Discussion.—This species falls within the range of *Acrocyathus floriformis* on corallite diameter and number of major septa. *A. pennsylvanicus* is distinguished from *A. floriformis* by lacking differentiation of the cardinal and counter septa, by having fewer rows of dissepiments, and by its larger ratio of tabularium width to corallite diameter.

Occurrence.—Lower Carboniferous, middle or upper Viséan. Mount Head Formation, Alberta, Canada; Prophet Formation, British Columbia, Canada.

Acrocyathus utkae (Degtyarev)

Eolithostrotionella utkae Degtyarev, 1973, p. 192, pl. 1, figs. 1a, b.

Diagnosis.—Cerioid *Acrocyathus* with corallite diameter 1 to 15 mm and 22 to 25 major septa that approach the columella but ordinarily do not reach it and seldom extend into the dissepimentarium. Minor septa absent. Columella composed of a thickened axial plate commonly joined by counter and cardinal septa, septal lamellae, and concentric traces of upturned tabulae in transverse section. Dissepimentarium composed of 1 to 3 rows of large inflated dissepiments. Tabulae complete, conical to nearly horizontal, and spaced about 0.5 mm apart. Ratio of tabularium width to corallite diameter about 0.6. Mode of increase unknown.

Description of holotype.—See Degtyarev 1973).

Discussion.—This species is similar to *A.*? *grechovkae* but differs in having larger corallites, more major septa, a more complex columella, and conical tabulae.

Occurrence.—Lower Carboniferous, lower or middle Viséan. Zapadnouralsk Horizon, Ural Mountains, U.S.S.R.

Acrocyathus rotai (Zhizhina in Bul'vanker and others)

Eolithostrotionella rotai Zhizhina in Bul'vanker and others, 1960, p. 251, pl. 61, figs. 2a, b.

Diagnosis.—Cerioid *Acrocyathus* with corallite diameter 15 to 20 mm and 22 to 26 major septa that commonly reach the columella but seldom extend into the dissepimentarium. Minor septa absent or poorly developed. Columella seemingly simple to complex. Dissepimentarium composed of 1 to 3 rows of mostly large inflated dissepiments. Tabulae complete, conical, and spaced about 0.5 mm apart. Ratio of tabularium width to corallite diameter about 0.6. Mode of increase unknown.

Description of holotype.—See Zhizhina (*in* Bul'vanker and others, 1960).

Discussion.—At first glance, the transverse section of this species suggests *Stelechophyllum*, but the tabulae are clearly of the *Acrocyathus* type, and the axial structures in some corallites appear to be complex.

Occurrence.—Lower Carboniferous, middle or upper Viséan. Zone $C_1^{\gamma}f$, Donetz Basin, U.S.S.R.

Acrocyathus cystosus (Zhizhina in Bul'vanker and others)

Eolithostrotionella cystosa Zhizhina in Bul'vanker and others, 1960, p. 250, pl. 61, figs. 1a, b.

Diagnosis.—Cerioid *Acrocyathus* with corallite diameter 20 to 30 mm and 28 to 38 major septa that may or may not extend to the columella and seldom extend into the dissepimentarium. Minor septa poorly developed. Columella seemingly simple to complex. Dissepimentarium composed of as many as 5 rows of dissepiments of varying sizes. Tabulae complete, conical, and spaced about 0.5 mm apart. Ratio of tabularium width to corallite diameter about 0.4 to 0.5. Mode of increase unknown.

Description of holotype.—See Zhizhina (*in* Bul'vanker and others, 1960).

Discussion.—This species is distinguished by its broad dissepimentarium.

Occurrence.—Lower Carboniferous, lower to upper Viséan. Zones $C_1^{\gamma}b$ to $C_1^{\gamma}f$, Donetz Basin, U.S.S.R.

Acrocyathus lissitzini (Zhizhina in Bul'vanker and others)

Eolithostrotionella lissitzini Zhizhina in Bul'vanker and others, 1960, p. 252, pl. 61, figs. 3a, b.

Diagnosis.—Cerioid *Acrocyathus* with corallite diameter 15 to 20 mm and 18 to 25 major septa that approach the columella but seldom reach it and seldom extend into the dissepimentarium. Minor septa absent. Columella seemingly simple to complex. Dissepimentarium composed of 1 to 3 rows of dissepiments of varying sizes. Tabulae complete, conical, and spaced about 1 mm apart. Ratio of tabularium width to corallite diameter about 0.4 to 0.5. Mode of increase unknown.

Description of holotype.—See Zhizhina (*in* Bul'vanker and others, 1960).

Occurrence.—Lower Carboniferous, middle or upper Viséan. Zone $C_1^{\gamma}f$, Donetz Basin, U.S.S.R.

Acrocyathus hsujiulingi (Yoh)

Lithostrotionella hsujiulingi Yoh, 1961, p. 8, 16, pl. 13, figs. 1a–c.

Diagnosis.—Cerioid *Acrocyathus* with corallite diameter averaging 6 mm and about 16 major septa that approach the columella but seldom reach it and do not extend into the dissepimentarium. Minor septa well developed. Columella composed of a thickened axial plate joined to the counter septum, septal lamellae, and concentric traces of tabulae in transverse section. Dissepimentarium composed of a single row of dissepiments of varying sizes. Tabulae complete, conical, and spaced about 0.5 mm apart. Ratio of tabularium width to corallite diameter about 0.5. Mode of increase seemingly peripheral.

Description of holotype.—See Yoh (1961).

Discussion.—This species differs from the other Chinese species, *A.? unicus*, in having fewer major septa, fewer rows of dissepiments, and a somewhat more complex columella.

Occurrence.—Lower Carboniferous(?), Kwangsi Province, China.

Acrocyathus? unicus (Yabe and Hayasaka)

Lithostrotion (Lithostrotionella) unicum Yabe and Hayasaka, 1915, p. 133; 1920, p. 11, pl. 9, figs. 12a, b.

Lithostrotionella unica Yabe and Hayasaka. Wu in Yü and others, 1963, p. 86, pl. 24, figs. 7a, b.

Lithostrotionella unicum Yabe and Hayasaka. Minato and Kato, 1974, p. 72, pl. 15, fig. 1.

Diagnosis.—Cerioid *Acrocyathus*? with corallite diameter averaging 7 mm and about 22 to 26 major septa that approach the columella but seldom reach it and seldom extend into the dissepimentarium. Minor septa well developed. Columella seemingly a simple axial plate augmented by a few axial tabellae and septal lamellae. Dissepimentarium composed of 1 to 3 rows of large inflated dissepiments. Tabulae complete, conical, and spaced 6 to 7 in 2 mm. Ratio of tabularium width to corallite diameter about 0.5. Mode of increase unknown.

Description of holotype.—See Yabe and Hayasaka (1915, 1920) and Minato and Kato (1974).

Discussion.—This species, the type of *Lithostrotionella*, is referred to *Acrocyathus* with query because of uncertainty concerning the morphology of the type specimen (see previous discussion on page 4).

Occurrence.—Carboniferous(?), Yun-nan Province, China.

Acrocyathus? shimeri (Crickmay)

Lithostrotion pennsylvanicum Shimer, 1926, p. 27 [part].

Lonsdaleia shimeri Crickmay, 1955, 1961, p. 13, pl. 1, figs. 9, 10.

Lithostrotionella shimeri (Crickmay). Nelson, 1960, p. 114, pl. 21, figs. 9–15, pl. 22, figs. 1–3; 1961, pl. 14, figs. 3–5, pl. 16, figs. 8, 9, pl. 17, fig. 5, pl. 18, figs. 4, 5; Bamber, 1961, p. 137, pl. 10, figs. 4a–d, pl. 11, figs. 1a, d–j, 2a–d; Armstrong, 1962, p. 39, pl. 3, figs. 13–15, text-fig. 19.

Lithostrotionella pennsylvanica (Shimer). Armstrong, 1970a, p. 31, pl. 9, figs. 1–3.

Diagnosis.—Cerioid *Acrocyathus*? with corallite diameter 7 to 13 mm and 17 to 30 major septa that commonly extend across the tabularium to the columella and seldom extend into the tabularium. Minor septa ordinarily well developed. Columella complex, composed of an axial plate, septal lamellae, and the upturned edges of tabulae. Dissepimentarium composed of a single row of inflated dissepiments. Tabulae complete, essentially horizontal, but deflected upward at columella, and spaced about 0.75 mm apart. Ratio of tabularium width to corallite diameter about 0.4 to 0.5. Increase is peripheral.

Description of holotype.—See Nelson (1960).

Discussion.—This species is distinguished by its nearly horizontal tabulae, which approach the morphology of *Petalaxis*. It differs from the species of *Petalaxis* by its complex columella.

Occurrence.—Lower Carboniferous, middle and upper Viséan. Mount Head Formation, Alberta and British Columbia, Canada; Peratrovich Formation, Alaska, U.S.A.; Black Prince Limestone, Arizona, U.S.A.

Acrocyathus? grechovkae (Degtyarev)

Eolithostrotionella grechovkae Degtyarev, 1973, p. 193, pl. 1, fig. 2, pl. 2, figs. 1a, b.

Diagnosis.—Cerioid *Acrocyathus*? with corallite diameter 10 to 12 mm and 18 to 24 major septa that approach the columella but seldom reach it and seldom extend into the dissepimentarium. Minor septa absent. Columella ordinarily a simple thickened axial plate surrounded by intersections of upturned tabulae in transverse section and occasionally abutted by a few septal lamellae. Dissepimentarium composed of 2 to 3 rows of large inflated dissepiments. Tabulae complete, nearly horizontal at the periphery, but deflected upward at the columella, and spaced about 0.5 mm apart. Ratio of tabularium width to corallite diameter about 0.6. Mode of increase unknown.

Description of holotype.—See Degtyarev (1973).

Discussion.—This species is similar to *A.*? *shimeri* in having nearly horizontal tabulae but differs in having fewer major septa, no minor septa, more rows of dissepiments, and a less complex columella.

Occurrence.—Lower Carboniferous, lower or middle Viséan. Zapadnouralsk Horizon, Ural Mountains, U.S.S.R.

Acrocyathus? zhizhinae (Vasilyuk)

Eolithostrotionella zhizhinae Vasilyuk, 1960, p. 95, pl. 25, figs. 1, 1a.

Diagnosis.—Cerioid-fasciculate *Acrocyathus*? with corallite diameter 13 to 20 mm and 25 to 27 major septa that extend to the columella but do not extend into the dissepimentarium. Minor septa well developed, contratingent. Columella seemingly simple to complex, absent in some corallites. Dissipimentarium composed of 1 to 4 rows of dissepiments of varying sizes. Tabulae complete, flat to conical, and spaced 0.75 to 1 mm apart. Ratio of tabularium width to corallite diameter about 0.5. Mode of increase unknown.

Description of type material.—See Vasilyuk (1960).

Discussion.—The original description and illustrations of this species leave some doubt concerning the structure of the columella and the tabulae. The species is therefore referred to *Acrocyathus* with a query. The long contratingent minor septa are noteworthy.

Occurrence.—Lower Carboniferous, lower to middle Viséan. Zones $C_1^v c$ and $C_1^v d$, Donetz Basin, U.S.S.R.

Acrocyathus spp. indet.

The following taxa are not adequately described and illustrated for specific identification:

Lithostrotionella americana Hayasaka(?). Nelson, 1960, p. 118, pl. 23, fig. 3. Lower Carboniferous, Viséan. Mount Head Formation, Alberta, Canada.

Lithostrotionella shimeri (Crickmay). Nations, 1963, p. 1257, pl. 176, figs. 1, 2. Base of Black Prince Limestone in pebble derived from Escabrosa Limestone, Arizona, U.S.A.

Family PETALAXIDAE Fomichev, 1953

Genus PETALAXIS Milne-Edwards and Haime, 1852

Stylaxis Milne-Edwards and Haime, 1851, p. 452 [part] (not McCoy, 1849, p. 119).

Petalaxis Milne-Edwards and Haime, 1852, p. 204 [part]; Milne-Edwards, 1860, p. 440 [part]; not Barrois, 1882, p. 305; Roemer, 1883, p. 387, 388 [part]; Lindstrom, 1883, p. 12; Stuckenberg, 1888, p. 20 [part]; 1895, p. 74 [part]; Yanishevskiy, 1900, p. 89[?]; Etheridge, 1900, p. 17; Grosch, 1909, p. 5; Yabe and Hayasaka, 1915, p. 94 (32); Bolkhovitinova, 1915, p. 63[?]; Gabounia, 1919, p. 39[?]; not Chi, 1931, p. 28; Dobrolyubova, 1935b, p. 10; Heritsch, 1939, p. 18; not Hill, 1940, p. 165; not Lang, Smith, and Thomas, 1940, p. 97; Kolosvary, 1951, p. 39[?]; Fomichev, 1953, p. 449; not Hill, 1956, p. F 282; Soshkina, Dobrolyubova, and Kabakovich, 1962, p. 339; de Groot, 1963, p. 81; Onoprienko, 1970, p. 3; Fedorowski and Gorianov, 1973, p. 58; not Minato and Kato, 1974, p. 68; Kozyreva, 1974, p. 24 [part]; Sutherland, 1977, p. 185.

Lithostrotion Fleming. Eichwald, 1861, p. 149; Trautschold, 1879, p. 36 [part]; Bassler, 1950, p. 222 [part].

Lithostrotion (*Petalaxis*) Fomichev, 1931, p. 43.

Lithostrotion (*Lithostrotionella*) Merriam, 1942, p. 377 [part]; Bassler, 1950, p. 220, 222, 235, 252; Easton, 1960, p. 578.

Lithostrotionella Yabe and Hayasaka. Chi, 1931, p. 28; Yü, 1933 [1934], p. 102[?]; Dobrolyubova, 1935a, p. 10; 1935b, p. 10, 12; 1936a, p. 28; Hayasaka, 1936, p. 65, 70 [part]; Heritsch, 1937, p. 164; Fomichev, 1939, p. 60; Minato, 1955, p. 99[?]; Yokoyama, 1957, p. 78; Nelson, 1960, p. 114 [part]; Yamagiwa, 1961, p. 102[?]; Bamber, 1961, p. 107 [part]; de Groot, 1963, p. 80 [part]; Wu in Yü

and others, 1963, p. 86[?]; Minato and Kato, 1974, p. 68; Onoprienko, 1976, p. 29 [part].
Lithostrotionella (Hillia) de Groot, 1963, p. 86.
Lonsdaleia McCoy. Dobrolyubova, 1935a, p. 12; 1935b, p. 29.
Cystolonsdaleia Fomichev, 1953, p. 464 [part].
Eastonoides Wilson and Langenheim, 1962, p. 511.

Type species.—*Stylaxis M'coyana* Milne-Edwards and Haime, 1851, p. 453, pl. 12, figs. 5, 5a, equals *Petalaxis M'coyana* Milne-Edwards and Haime, 1852, p. 205, equals *Petalaxis maccoyanus* Milne-Edwards and Haime (by subsequent designation of Roemer, 1883, p. 387, 388). Middle Carboniferous (Moscovian), Moscow Basin, U.S.S.R.

Diagnosis.—Cerioid colonial corals with tabular to hemispherical growth form. Septa of two orders. Major septa thin, ordinarily extending into the tabularium but seldom reaching the columella and ordinarily discontinuous or absent in the dissepimentarium, but species with weakly lonsdaleoid dissepimentarium are known. Minor septa absent to well developed. Columella ordinarily a simple axial plate joined to counter and (or) cardinal septum but composed of axial plate, impersistent vertical axial tabellae, and a few axial lamellae in some species. Tabulae complete and incomplete, essentially horizontal, flat, concave, or convex, turned up at columella in some species. Peripheral clinotabellae may be present. Dissepimentarium ordinarily lonsdaleoid but may be mostly regular in some species. Increase peripheral and intermural.

Discussion.—Milne-Edwards and Haime (1852, p. 204) proposed *Petalaxis* for corals previously described and named *Stylaxis M'coyana* and *Stylaxis portlocki* (Milne Edwards and Haime, 1851, p. 452) because *Stylaxis* had become a junior synonym of *Lithostrotion*, and these two species were distinct. *P. M'coyana*, described and illustrated in 1851, was distinguished by having septa that were interrupted by the dissepiments and did not reach the corallite wall. The type specimen was collected by Verneuil at Kolomna on the Oka River in the Moscow Basin, U.S.S.R., where it is now known that beds of Middle Carboniferous (Moscovian) age are exposed. Subsequently, Hill (1940, p. 167) determined that *P. portlocki*, from the Lower Carboniferous of England, is a *Lithostrotion*. Milne-Edwards (1860, p. 440) diagnosed the genus *Petalaxis* for the first time, basing the diagnosis on the previous description of *P. M'coyana*.

Lang, Smith, and Thomas (1940, p. 97) concluded incorrectly that *Petalaxis* is a replacement name for *Nematophyllum* and that, therefore, *Petalaxis* is a junior synonym of *Lithostrotion*. Hill (1940, p. 167) also attempted to place *Petalaxis* in the synonymy of *Lithostrotion* by selecting *P. portlocki* as type species. However, the foregoing nomenclatural actions were invalidated by Roemer's (1883, p. 387, 388) earlier designation of *P. M'coyana* as the type species of *Petalaxis*.

Although the name *Petalaxis* was used by several earlier Russian authors (Stuckenberg, 1888, 1895; Yanishevskiy, 1900, Bolkhovitinova, 1915; Gabounia, 1919, Fomichev, 1931), there was confusion over the meaning of the name for many years. In the meanwhile, Yabe and Hayasaka (1915) had proposed *Lithostrotionella*, and some authors (for example, Dobrolyubova, 1935a, b, 1936a) used this name in preference to *Petalaxis* for corals with a simple columella and lonsdaleoid dissepiments, regardless of the nature of the tabulae. Fomichev (1953, p. 449–463) sought to clarify the usage of *Petalaxis* by regarding *P. maccoyanus* as the type species and describing some other Middle Carboniferous corals under the name of *Petalaxis*; he noted that forms with horizontal tabulae are characteristic of the Middle Carboniferous in contrast to the tent-shaped tabulae of Early Carboniferous corals.

Kozyreva (1974, p. 24–26) summarized the history of *Petalaxis* and stressed the importance of horizontal tabulae in the definition of the genus. She included in the genus some North American species that actually belong to *Stelechophyllum, Acrocyathus*, and *Thysanophyllum*.

Sutherland (1977) reviewed the *Petalaxis* problem and pointed out that the type specimen has been lost. He based his discussion of the genus on a study of topotypes at the Paleontological Institute in Moscow. Sutherland called attention to the fact that the topotypes have a variable axial structure that is complex in some corallites. He also stressed the horizontal tabulae as a distinguishing feature of *Petalaxis*, which occurs predominantly in the Middle Carboniferous.

Petalaxis is distinguished from *Acrocyathus* and *Stelechophyllum* chiefly by its horizontal tabulae and by its columella. In *Acrocyathus*, the tabulae are conical, without well-defined shoulders, and in *Stelechophyllum*, the tabulae are tent-shaped, with well-defined shoulders and a peripheral zone of more or less horizontal tabellae. In *Petalaxis*, the columella is most commonly a simple, thickened or unthickened axial plate connected to the counter and (or) cardinal septum, but some species have impersistent vertical axial tabellae and rare septal lamellae. In *Acrocyathus*, the columella ranges from a simple axial plate to a complex spiderweb structure composed of axial plate, septal lamellae, and axial tabellae or upturned tabulae. In *Stelechophyllum*, the columella is always a simple axial plate or rod unmodified by axial tabellae or septal lamellae.

Fomichev (1953, p. 464) proposed *Cystolonsdaleia* as a subgenus of *Petalaxis* for corals from the Middle and Upper Carboniferous of the Donetz Basin that have a columella composed of a medial plate, a few septal lamellae, and axial tabellae similar to the Early Carboniferous *Lonsdaleia*. The type species of

Cystolonsdaleia is *C. lutugini* Fomichev from the Moscovian of the Donetz Basin. Fomichev also included *Lonsdaleia portlocki* (Stuckenberg) of Dobrolyubova (1935a, b) and *Lonsdaleia ivanovi* Dobrolyubova (1935a, b) from the Moscovian of the Moscow Basin and indicated that species attributed to *Stylidophyllum* from the Permian of China by Yoh and Huang (1932) and Huang (1932) might belong to the new subgenus. The Permian species were later reassigned to genera of the Family Waagenophyllidae by Minato and Kato (1965).

Petalaxis maccoyanus, the type species of *Petalaxis*, has an impersistently developed complex axial structure with the same morphologic elements as the axial structure of most of the Moscovian species assigned to *Cystolonsdaleia* by Fomichev. It seems impractical to separate these species generically from *P. maccoyanus*. The type species of *Cystolonsdaleia, C. lutugini*, differs from the other Moscovian species by having a complex spiderweb columella with inner zone of tabellae distinct from an outer zone of regular concave tabulae. Accordingly, *Cystolonsdaleia* is retained as a separate genus for this complex species, whereas the other species are placed in *Petalaxis*.

De Groot (1964, p. 86) proposed *Hillia* as a subgenus of *Lithostrotionella* for corals from the Bashkirian of Spain that differ from *Lithostrotion* by having major septa that fall short of the columella, horizontal tabulae, and a columella connected to the cardinal septum; they differ from true *Lithostrotionella* by having a poorly developed lonsdaleoid dissepimentarium.

In other corals that have a columella arising from a single septum, that septum is the counter septum wherever the septa can be identified. De Groot gave no evidence for her conclusion that the septum in *Hillia* is the cardinal septum, and her illustrations of species assigned to *Hillia* show no basis for that conclusion. The columella appears to be the same as that seen in many species of *Petalaxis*. Moreover, the name *Hillia* is preoccupied by *Hillia* Grote (1883) and *Hillia* Mallock (1929), according to Cotton (1974, p. 13), and a replacement name has not been proposed. In my opinion, the reasons for separating *Hillia* de Groot from *Petalaxis* are insufficient, and I am reassigning the species of *Hillia* to *Petalaxis*, recognizing them only as a species group within that genus.

Eastonoides was proposed by Wilson and Langenheim (1962, p. 511) for a Permian coral that has a columella composed of an axial plate connected to the counter septum augmented by rare axial tabellae, slightly sloping tabulae, and a vertically discontinuous lonsdaleoid dissepimentarium. *Lonsdaleia ivanovi* Dobrolyubova was included as the only other known species referred to *Eastonoides*. The essential features of this genus are so similar to the type species of *Petalaxis* that I regard *Eastonoides* as a junior synonym of *Petalaxis*, which includes four other Permian species.

Species of *Petalaxis* are distinguished on differences in mature corallite diameter, number of major septa at maturity, development of minor septa, complexity and development of the columella, major septal extensions into the tabularium, major septal extensions into the dissepimentarium, shape and completeness of the tabulae, spacing of the tabulae, number of rows of dissepiments, size and shape of the dissepiments, and the ratio of tabularium width to corallite diameter.

The species of *Petalaxis* may be arranged in five species groups:

1. *P. simplex* group, including *simplex, wyomingensis, tabulatus, bailliei*, and *tschucoticus*. This group comprises simple forms having mostly complete tabulae turned up at the columella and a simple columella; these forms occur in the Lower Carboniferous (Viséan) and lowest Middle Carboniferous (Namurian).
2. *P. flexuosus* group, including *flexuosus, donbassicus, mokomokensis, exiguus, brokawi, monocyclicus, sexangulus, taishakuensis, immanis, belinskiensis, major, fomichevi,* and *grootae*. This group comprises forms having a simple columella and a narrow dissepimentarium (large ratio of tabularium width to corallite diameter); these forms occur in the Middle Carboniferous (Bashkirian and Moscovian) and Permian.
3. *P. wagneri* group, including *wagneri, perapertuensis, radians, intermedius, santaemariae, cantabricus, orboensis*, and *occidentalis*. This group comprises forms having a simple columella and a weakly lonsdaleoid dissepimentarium; these forms occur in the Middle Carboniferous (Bashkirian and Moscovian) and Permian.
4. *P. vesiculosus* group, including *vesiculosus, lisitschanskensis, exilis, confertus, persubtilis, korkhovae, mirus,* and *evidens*. This group comprises forms having a simple columella and a narrow dissepimentarium (small ratio of tabularium width to corallite diameter); these forms occur in the Middle Carboniferous (Bashkirian and Moscovian).
5. *P. maccoyanus* group, including *maccoyanus, stylaxis, mohikanus, celadensis, elyensis, dobrolyubovae, donetsensis,* and *ivanovi*. This group comprises forms having a complex columella; these forms occur in the Middle Carboniferous (Moscovian) and Permian.

Occurrence.—Lower Carboniferous (Viséan), Middle Carboniferous (Namurian, Bashkirian, and Moscovian), and Permian. U.S.S.R., U.S.A., Canada, Spain, Japan, China(?), Spitzbergen(?).

Petalaxis simplex species group

Petalaxis simplex (Hayasaka)

Plate 18, figures 1–3

Lithostrotionella simplex Hayasaka, 1936, p. 70, pl. 14, figs. 4a, b; Bamber, 1961, p. 155, pl. 12, figs. 2a–c.

Lithostrotion [*Lithostrotionella*] *simplex* (Hayasaka). Bassler, 1950, p. 220.

Material studied.—USNM 120249 (holotype).

Description of holotype.—The specimen is a fragment of a corallum of indeterminate shape in limestone matrix. It was more than 9 cm in diameter and more than 4 cm in height.

Corallites are polygonal, have straight, slightly beaded, double-layered walls as much as 0.3 mm thick, and range from 6 to 9 mm in diameter at maturity. Except for the counter septum, the major septa are short, do not extend to the columella, and seldom extend into the dissepimentarium. There are 16 to 18 major septa at maturity. Minor septa are absent or poorly developed. The columella is a simple thin axial plate that may or may not be connected to the counter septum. Tabulae are ordinarily complete and essentially horizontal; some are turned up at the columella to produce concentric traces in the transverse sections of some corallites. Tabulae are irregularly spaced 0.5 to 1 mm apart. The dissepimentarium is strongly lonsdaleoid and consists of a single row of large inflated dissepiments. There are ordinarily about 2 dissepiments in 2 mm. The ratio of the tabularium width to the corallite diameter is about 0.6 to 0.7. The mode of increase is indeterminate. Septal microstructure is fibronormal.

Discussion.—Comparison with *P. wyomingensis* is made under the discussion of that species.

Occurrence.—Lower Carboniferous, upper Viséan. Little Flat Formation, Utah, U.S.A.

Petalaxis wyomingensis, n. sp.

Plate 18, figures 4, 5

Lithostrotionella simplex Hayasaka, 1936, p. 70 [part].

Material studied.—USNM 120675 (holotype).

Description of holotype.—The specimen is a fragment of a corallum of indeterminate shape in limestone matrix. It was more than 7 cm in diameter and more than 4 cm in height.

Corallites are polygonal, have sinuous, beaded, double-layered walls as much as 0.6 mm thick, and range from 7 to 9 mm in diameter at maturity. The major septa ordinarily extend to the columella but seldom extend into the dissepimentarium. There are 17 to 18 major septa at maturity. Minor septa are absent. The columella is a simple thickened axial plate ordinarily connected to the counter septum. It is as much as 0.7 mm in short diameter and 1 mm in long diameter. Tabulae are complete or incomplete, essentially horizontal, turned up at the columella, and irregularly spaced 0.25 to 0.5 mm apart. The dissepimentarium is strongly lonsdaleoid and consists of 1 to 3 rows of inflated dissepiments of varying sizes. Ordinarily, there are 1 to 3 dissepiments in 2 mm. The ratio of tabularium width to the corallite diameter is about 0.5 to 0.6. The mode of increase is indeterminate. Septal microstructure is fibronormal.

Discussion.—The holotype of this species was a paratype of *Lithostrotionella simplex* Hayasaka. *P. wyomingensis* is similar to *P. simplex* (Hayasaka) but differs in having longer major septa, a thickened columella, thicker corallite walls, more rows of dissepiments, a smaller ratio of tabularium width to corallite diameter, and more tabulae.

Occurrence.—Middle Carboniferous, Namurian. "Wells" Formation, Wyoming, U.S.A.

Petalaxis tabulatus (Hayasaka)

Plate 19, figures 5–7

Lithostrotionella tabulata Hayasaka, 1936, p. 69, pl. 17, fig. 2.

Lithostrotion [*Lithostrotionella*] *tabulatum* (Hayasaka). Bassler, 1950, p. 220.

Material studied.—USNM 120246 (holotype), USNM 216197 (paratypes).

Description of holotype.—The specimen is a fragment of a corallum of indeterminate shape. It was more than 12 cm in diameter and 14 cm in height.

Corallites are polygonal, have straight, beaded, and denticulate double-layered walls as much as 0.4 mm thick, and range from 8 to 10 mm in diameter at maturity. The major septa ordinarily extend to the columella and into the dissepimentarium. There are 16 to 18 major septa at maturity. Minor septa are ordinarily well developed. The columella is a simple, serrated, thickened axial plate connected to one or more major septa. Tabulae are mostly complete, essentially horizontal, commonly turned up at the columella, and irregularly spaced 0.25 to 0.5 mm apart. The dissepimentarium is composed of 1 to 2 rows of inflated dissepiments of varying sizes. There are 2 to 4 dissepiments in 2 mm. The ratio of tabularium width to corallite diameter is about 0.6 to 0.7. The mode of increase is peripheral. Septal microstructure is obscure, seemingly amorphous.

Discussion.—The transverse section of this species looks like that of a *Stelechophyllum*. It is placed in *Petalaxis* because of its horizontal tabulae. The species differs from *P. wyomingensis* in having a serrated, less thickened columella, to which more major septa are attached, thinner corallite walls, a larger ratio of tabularium width to corallite diameter, more extensions of the major septa into the tabularium, and well-developed minor septa.

Occurrence.— Lower Carboniferous, upper Viséan. Aspen Range Formation, Idaho, U.S.A.

Petalaxis bailliei (Nelson)

Lithostrotionella bailliei Nelson, 1960, p. 114, pl. 21, figs. 7, 8; 1962, pl. 14, figs. 1, 2.
Lithostrotionella cf. *bailliei* Nelson. Bamber, 1961, p. 126, pl. 10, figs. 1a–g.

Diagnosis.—*Petalaxis* with corallites 5 to 6 mm in diameter and 17 to 18 major septa that ordinarily extend to the columella but seldom extend into the dissepimentarium. Minor septa ordinarily well developed. Columella a simple thickened axial rod or plate formed by extension of the counter septum. Dissepimentarium composed of a single row of large inflated dissepiments. Tabulae ordinarily complete, essentially horizontal, and irregularly spaced 3 in 1 mm. Ratio of tabularium width to corallite diameter about 0.5. Mode of increase unknown.

Description of holotype.—See Nelson (1960).

Discussion.—This species is distinguished from *P. wyomingensis* and *P. tabulatus* by its smaller corallite diameter.

Occurrence.—Lower Carboniferous, Viséan. Mount Head Formation, Alberta, Canada, and Prophet Formation, British Columbia, Canada (E. W. Bamber, written commun., 1980).

Petalaxis tschucoticus (Onoprienko)

Lithostrotionella tschucotica Onoprienko, 1976, p. 30, pl. 10, fig. 6, pl. 11, figs. 1, 2.

Diagnosis.—*Petalaxis* with corallite diameter 5 to 7 mm and 15 to 17 major septa that ordinarily extend to the columella but seldom extend into the dissepimentarium. Minor septa poorly developed. Columella a simple axial plate connected to cardinal and counter septa. Dissepimentarium composed of a single row of large inflated dissepiments. Tabulae ordinarily complete, horizontal, commonly turned up at columella, regularly spaced 0.3 to 0.5 mm apart. Ratio of tabularium width to corallite diameter about 0.5 to 0.6. Mode of increase unknown.

Description of type material.—See Onoprienko (1976).

Discussion.—This species differs from *P. bailliei* by having fewer major septa, a less robust columella, and weaker minor septa.

Occurrence.—Lower Carboniferous, Namurian. Yunon Suite, West Chukotka, U.S.S.R.

Petalaxis flexuosus species group

Petalaxis flexuosus (Trautschold)

Lithostrotion flexuosum Trautschold, 1879, p. 37, pl. 5, figs. 7a, b.
Lithostrotionella flexuosa (Trautschold). Dobrolyubova, 1935a, p. 11, pl. 3, figs. 1, 2; 1935b, p. 18, pl. 3, figs. 1, 2.
?*Lithostrotionella flexuosa* (Trautschold). Heritsch, 1939, p. 30, pl. 13, fig. 5, pl. 19, fig. 5.
?*Lithostrotion* [*Lithostrotionella*] *flexuosum* Trautschold. Bassler, 1950, p. 235.

Diagnosis.—*Petalaxis* with corallite diameter 5 to 7 mm and 14 to 17 major septa that approach the columella but seldom reach it and commonly extend into the dissepimentarium. Minor septa well developed. Columella a simple thickened axial plate ordinarily connected to the counter septum and to the cardinal septum in some corallites. Dissepimentarium composed of 1 to 2 rows of generally small inflated dissepiments of varying sizes. Tabulae complete and incomplete, horizontal to inclined, flat, concave or convex, irregularly spaced 0.25 to 1 mm apart. Ratio of tabularium width to corallite diameter 0.6 to 0.7. Mode of increase unknown.

Description of type material.—See Trautschold (1879). The diagnosis is taken largely from Dobrolyubova's (1935b) descriptions and illustrations of topotypes.

Discussion.—*Petalaxis flexuosus* differs from *P. stylaxis* by lacking a complex columella and by having better development of the minor septa, more extensions of the major septa into the dissepimentarium, and generally smaller dissepiments.

Fomichev (1953, p. 453) and Kozyreva (1974, p. 25) placed *P. flexuosus* in the synonymy of *P. maccoyanus* Milne-Edwards and Haime because of general similarity in morphology. I regard these two species as distinct because *P. flexuosus* does not seem to have axial tabellae like *P. maccoyanus*. However, Sutherland (1977, p. 187) pointed out that the complexity of the axial structure is a variable feature in topotypes of *P. maccoyanus*; hence, Dobrolyubova's (1935b) description may be based on simple corallites in a variable colony.

Heritsch's (1939) specimen is referred questionably to the species because no longitudinal section is available.

Occurrence.—Middle Carboniferous, Moscovian. Myachkovo Horizon (C_2^4), Moscow Basin, U.S.S.R. Kings Bay, Spitzbergen(?).

Petalaxis donbassicus (Fomichev)

Lithostrotionella donbassica Fomichev, 1939, p. 60, pl. 9, figs. 4a, b.
Lithostrotion [*Lithostrotionella*] *donbassica* (Fomichev). Bassler, 1950, p. 222.

Diagnosis.—*Petalaxis* with corallite diameter 5 to 7 mm and 14 to 17 major septa that approach the columella but seldom reach it and commonly extend into the dissepimentarium. Minor septa well developed. Columella a strongly thickened axial plate ordinarily connected to the counter septum. Dissepimentarium composed of 1 to 2 rows of inflated dissepiments of varying sizes. Tabulae ordinarily complete, horizontal, irregularly spaced 0.25 to 0.5 mm apart. Ratio of tabularium width to corallite diameter 0.5 to 0.6. Mode of increase unknown.

Description of type material.—See Fomichev (1939).

Discussion.—This species is very similar to *Petalaxis flexuosus*, from which it differs in having better develop-

ment of the minor septa, a thicker columella, a wider dissepimentarium (smaller ratio of tabularium width to corallite diameter), and more complete tabulae.

Occurrence.—Middle Carboniferous, Moscovian. Svita C_2^6 (L_5), Donetz Basin, U.S.S.R.

Petalaxis mokomokensis (Easton)

Lithostrotion [*Lithostrotionella*] *mokomokensis* Easton, 1960, p. 578, text-figs. 9, 10.

Diagnosis.—*Petalaxis* with corallite diameter about 7 mm and 15 major septa that ordinarily are short and do not extend to the columella or into the dissepimentarium. Minor septa poorly developed. Columella a thin axial plate connected to the counter septum. Dissepimentarium composed of 1 to 2 rows of large inflated dissepiments. Tabulae complete and incomplete, essentially horizontal, mostly concave, irregularly spaced 0.25 to 0.75 mm apart. Ratio of tabularium width to corallite diameter about 0.7. Mode of increase unknown.

Description of type material.—See Easton (1960).

Discussion.—This species is distinguished from Middle Carboniferous species from the Soviet Union by its thinner columella and more generally concave tabulae.

Occurrence.—Permian. Arcturus Formation, Nevada, U.S.A.

Petalaxis exiguus n. sp.

Plate 19, figures 1–4

Lithostrotionella girtyi Hayasaka, 1936, p. 65 [part].

Lithostrotion [*Lithostrotionella*] *girtyi* (Hayasaka). Bassler, 1950, p. 220 [part].

Material studied.—USNM 162002B (holotype) and USNM 162002A (paratype).

Description of holotype.—The specimen is a small complete silicified corallum 3.5 cm in diameter and 2 cm in height.

Corallites are polygonal, have straight to rounded, beaded, sinuous, double-layered walls as much as 0.4 mm thick, and range from 10 to 12 mm in diameter at maturity. Except for the counter and cardinal septa, the major septa extend about halfway to the columella and are present in the dissepimentarium only as crests. There are 14 to 15 major septa at maturity. Minor septa are absent. The columella is a simple thickened axial plate, commonly connected to both counter and cardinal septa. Tabulae are complete or incomplete, essentially horizontal, concave to convex, and irregularly spaced 0.5 to 1 mm apart. The dissepimentarium is strongly lonsdaleoid and consists of 1 to 2 rows of mostly large inflated dissepiments. The ratio of tabularium width to corallite diameter is about 0.6. Increase is peripheral. Septal microstructure is fibronormal.

Discussion.—The holotype and paratype of this new species were paratypes of *Lithostrotionella girtyi* Hayasaka. The two type specimens are so small that they may actually represent immature coralla, although no larger coralla were found at the type locality. The description of the holotype serves as a diagnosis for the species, because the paratype is essentially identical with the holotype.

Petalaxis exiguus is distinguished from *P. mokomokensis*, another Permian form, by its diminutive corallum, thickened columella, larger corallite diameter, and smaller ratio of tabularium width to corallite diameter.

Occurrence.—Permian. McCloud Limestone, California, U.S.A.

Petalaxis brokawi (Wilson and Langenheim)

Lithostrotionella sp. Langenheim and others, 1960, p. 151.

Lithostrotionella brokawi Wilson and Langenheim, 1962, p. 512, pl. 88, figs. 7, 8.

Diagnosis.—*Petalaxis* with corallite diameter 4 to 5 mm and 10 to 15 major septa that ordinarily are short and do not extend to the columella and seldom extend into the dissepimentarium. Minor septa ordinarily well developed. Columella a simple thickened axial plate ordinarily connected to the counter septum. Dissepimentarium composed of 1 to 2 rows of mostly large inflated dissepiments. Tabulae mostly complete, inclined slightly toward columella, and irregularly spaced 0.25 to 0.5 mm apart. Ratio of tabularium width to corallite diameter about 0.5. Mode of increase unknown.

Description of type specimens.—See Wilson and Langenheim (1962).

Discussion.—*Petalaxis brokawi* is distinguished from *P. mokomokensis* by its smaller corallites, thickened columella, well-developed minor septa, and smaller ratio of tabularium width to corallite diameter.

Occurrence.—Lower Permian. Ely Limestone, Nevada, U.S.A.

Petalaxis monocyclicus (de Groot)

Lithostrotionella monocyclica de Groot, 1963, p. 85, pl. 17, figs. 1a–c.

Diagnosis.—*Petalaxis* with corallite diameter 5 to 8 mm and 20 to 24 major septa that ordinarily approach the columella but do not reach it and seldom extend into the dissepimentarium. Minor septa absent. Columella a simple thin axial plate connected to the counter septum and to the cardinal septum in some corallites. Dissepimentarium composed of 1 to 3 rows of elongate dissepiments of varying sizes. Tabulae complete, essentially horizontal, concave, turned up at the columella, and irregularly spaced 0.25 to 1 mm apart. Ratio of tabularium width to corallite diameter about 0.4 to 0.5. Mode of increase peripheral.

Description of holotype.—See de Groot (1964 [1963]).

Discussion.—This species differs from the Middle Carboniferous and Permian species diagnosed on previous pages in this report by having tabulae that are regularly

concave and turned up at the columella. It also has more major septa.

Occurrence.—Middle Carboniferous, Bashkirian. Santa Maria Limestone, Palencia, Spain.

Petalaxis sexangulus (de Groot)

Lithostrotionella sexangulus de Groot, 1963, p. 84, pl. 16, figs. 3a–c, 4a, b.

Diagnosis.—*Petalaxis* with corallite diameter 3 to 4 mm and 13 to 15 major septa that ordinarily extend about halfway to the columella and seldom extend into the dissepimentarium. Minor septa poorly developed. Columella a simple slightly thickened axial plate connected to the counter septum and to the cardinal septum in some corallites. Dissepimentarium composed of a single row of small dissepiments. Tabulae mostly complete, essentially horizontal, but commonly nearly tent-shaped, turned up at the columella, and irregularly spaced 0.25 to 1 mm apart. Ratio of tabularium width to corallite diameter about 0.8. Mode of increase unknown.

Description of type material.—See de Groot (1964 [1963]).

Discussion.—This species is distinguished from other members of the *P. flexuosus* species group by its very large ratio of tabularium width to corallite diameter and its tabulae that are commonly nearly tent-shaped and turned up at the columella.

Occurrence.—Middle Carboniferous, Moscovian. Palencia, Spain.

Petalaxis taishakuensis (Yokoyama)

Lithostrotionella taishakuensis Yokoyama, 1957, p. 78, pl. 10, figs. 1–4.

Diagnosis.—*Petalaxis* with corallite diameter 3 to 4 mm and 13 to 15 major septa that ordinarily are short and do not extend to the columella and seldom extend into the dissepimentarium. Minor septa well developed. Columella a simple axial plate connected to the counter septum and joined by 2 or 3 other major septa. Dissepimentarium composed of 1 to 2 rows of inflated dissepiments of varying sizes. Tabulae complete and incomplete, essentially horizontal, and irregularly spaced 0.25 to 1 mm apart. Ratio of tabularium width to corallite diameter about 0.6 to 0.7. Mode of increase unknown.

Description of holotype.—See Yokoyama (1957).

Discussion.—This species is distinguished from *P. sexangulus* by having its columella joined by several major septa, by having stronger major septa, by its tabulae not being turned up at the columella, by its smaller ratio of tabularium width to corallite diameter, and by having more rows of dissepiments.

Occurrence.—Middle Carboniferous. Dangyokei Formation, Hiroshima, Japan.

Petalaxis immanis Kozyreva

Petalaxis immanis Kozyreva, 1974, p. 30, pl. 2, figs. 4a–c, 5a, b.

Diagnosis.—*Petalaxis* with corallite diameter 8 to 18 mm and 17 to 18 major septa that ordinarily approach the columella but do not reach it and seldom extend into the dissepimentarium. Minor septa absent or poorly developed. Columella a simple, strongly thickened axial plate connected to counter septum. Dissepimentarium composed of 2 rows of small inflated dissepiments. Tabulae complete, essentially horizontal, turned up at columella, and irregularly spaced 0.25 to 0.5 mm apart. Ratio of tabularium width to corallite diameter about 0.5 to 0.6. Mode of increase unknown.

Description of type material.—See Kozyreva (1974).

Discussion.—This species is distinguished from all other members of the *P. flexuosus* species group by its very large corallites and its strongly thickened columella.

Occurrence.—Middle Carboniferous, Bashkirian. Horizon b_1-b_2, Voronezh anteclise, U.S.S.R.

Petalaxis belinskiensis Fomichev

Petalaxis mccoyana var. *belinskiensis* Fomichev, 1953, p. 457, pl. 31, figs. 3a, b.

Diagnosis.—*Petalaxis* with corallite diameter 7 to 12 mm and 16 to 24 major septa that approach the columella but seldom reach it and commonly extend into the dissepimentarium. Minor septa well developed. Columella a simple thickened axial plate ordinarily connected to the counter septum. Dissepimentarium composed of 1 to 3 rows of inflated dissepiments of varying sizes. Tabulae mostly complete, essentially horizontal, and spaced 0.25 to 0.5 mm apart. Ratio of tabularium width to corallite diameter about 0.4 to 0.5. Mode of increase unknown.

Description of type material.—See Fomichev (1953).

Discussion.—This species is distinguished from *P. donbassicus* by having larger corallites, more major septa, and a broader dissepimentarium. It lacks the complex columella that characterizes *P. mccoyana*.

Occurrence.—Middle Carboniferous, Moscovian. L_5 Limestone, Donetz Basin, U.S.S.R.

Petalaxis major (de Groot)

Lithostrotionella maccoyana forma *major* de Groot, 1963, p. 83, pl. 16, figs. 2a, b.

Diagnosis.—*Petalaxis* with corallite diameter 5 to 9 mm and 17 to 22 major septa that closely approach the columella but seldom reach it and that commonly extend into the dissepimentarium. Minor septa well developed. Columella a simple axial plate, seldom dilated, connected to the counter septum. A few septal lamellae present in some corallites but no axial tabellae. Dissepimentarium composed of 1 to 3 rows of inflated

dissepiments of varying sizes. Tabulae mostly incomplete, horizontal, concave, and irregularly spaced 0.25 to 0.5 mm apart. Ratio of tabularium width to corallite diameter about 0.6. Increase peripheral.

Description of holotype.—See de Groot (1964 [1963]). The holotype is RGM 112726.

Discussion.—This species differs from *P. mccoyanus* by lacking a complex columella and by its larger corallite diameter and more numerous major septa. It differs from *P. vesiculosus* by having longer major septa, more major septa, by the presence of septal lamellae, and by having more rows of dissepiments.

Occurrence.—Middle Carboniferous, Moscovian. Vañes Formation, Palencia, Spain.

Petalaxis fomichevi n. sp.

Petalaxis maccoyana Milne-Edwards and Haime. Fomichev, 1953, p. 453, pl. 31, figs. 1a–d, 2a–d.

Diagnosis.—*Petalaxis* with corallite diameter 5 to 8 mm and 13 to 22 major septa that extend about half way to the columella and commonly extend into the dissepimentarium. Minor septa well developed. Columella a simple thickened axial plate ordinarily connected to the counter septum and to the cardinal septum in some corallites. Dissepimentarium composed of 1 to 3 rows of inflated dissepiments of varying sizes. Tabulae complete and incomplete, flat to convex, horizontal, and spaced 0.25 to 0.5 mm apart. Ratio of tabularium width to corallite diameter about 0.5 to 0.7. Mode of increase unknown.

Description of type material.—See Fomichev (1953). The holotype is here designated specimen number 57 of Fomichev (1953, p. 456).

Discussion.—This species differs from *P. maccoyanus* by lacking a complex columella and other morphological details. It is distinguished from *P. flexuosus* by having more major septa, more regular tabulae, and more rows of dissepiments.

Occurrence.—Middle Carboniferous, Moscovian. L_5 Limestone, Donetz Basin, U.S.S.R.

Petalaxis grootae, n. sp.

Lithostrotionella maccoyana (Edwards and Haime). De Groot, 1963, p. 82, pl. 16, fig. 1a, b.

Diagnosis.—*Petalaxis* with corallite diameter 4 to 6 mm and 14 to 16 major septa that approach the columella but seldom reach it and seldom extend into the dissepimentarium. Minor septa well developed. Columella a simple axial plate, curved in some corallites, and ordinarily connected to the counter septum. Dissepimentarium composed of 1 to 3 rows of inflated dissepiments of varying sizes. Tabulae complete and incomplete, essentially horizontal, flat, concave or convex, and spaced 0.25 to 0.75 mm apart. Ratio of tabularium width to corallite diameter about 0.6 to 0.7. Mode of increase unknown.

Description of type material.—See de Groot (1964 [1963], p. 83). The holotype is here designated RGM 112721.

Discussion.—This species differs from *P. maccoyanus* by lacking a complex columella. It is distinguished from *P. flexuosus* by having longer major septa, a thinner, commonly curved columella, more rows of dissepiments, and more regularly spaced tabulae.

Occurrence.—Middle Carboniferous, Moscovian. Vañes Formation and Cotarraso Limestone, Palencia, Spain.

Petalaxis wagneri species group

Petalaxis wagneri (de Groot)

Lithostrotionella (Hillia) wagneri de Groot, 1963, p. 88, pl. 18, figs. 1–3.

Diagnosis.—*Petalaxis* with corallite diameter 3 to 4.5 mm and 14 to 16 major septa that closely approach the columella but seldom reach it and extend into the dissepimentarium, ordinarily being attached to the corallite wall. Minor septa ordinarily well developed. Columella a simple axial plate connected to counter or cardinal septum. Dissepimentarium weakly lonsdaleoid, composed of a single row of small inflated dissepiments. Tabulae complete or incomplete, essentially horizontal, mostly concave, and spaced 0.5 to 1 mm apart. Ratio of tabularium width to corallite diameter about 0.7 to 0.8. Increase peripheral.

Description of type material.—See de Groot (1964 [1963]).

Discussion.—This species is similar to *P. maccoyanus* but has smaller corallites, fewer major septa, a weakly lonsdaleoid dissepimentarium, and a simple columella.

Occurrence.—Middle Carboniferous, Bashkirian. Perapertú Formation, Palencia, Spain.

Petalaxis perapertuensis (de Groot)

Lithostrotionella (Hillia) perapertuensis de Groot, 1963, p. 89, pl. 19, figs. 1a-c, 2a-d.

Diagnosis.—*Petalaxis* with corallite diameter 3.5 to 4.5 mm and 14 to 19 major septa that closely approach the columella but seldom reach it and ordinarily extend across the dissepimentarium to the corallite wall. Minor septa ordinarily well developed. Corallite walls strongly dilated. Columella a simple thickened axial plate connected to counter or cardinal septum. Dissepimentarium weakly lonsdaleoid, composed of 1 to 2 rows of small inflated dissepiments. Tabulae incomplete, essentially horizontal, mostly concave, and spaced 0.25 to 0.5 mm apart. Ratio of tabularium width to corallite diameter 0.6 to 0.8. Increase peripheral.

Description of type material.—See de Groot (1964 [1963]).

Discussion.—This species differs from *P. wagneri* by having more major septa, more tabulae, and strongly dilated corallite walls.

Occurrence.—Middle Carboniferous, Bashkirian. Perapertú Formation, Palencia, Spain.

Petalaxis radians (de Groot)

Lithostrotionella (Hillia) radians de Groot, 1963, p. 89, pl. 20, figs. 1a–c.

Diagnosis.—*Petalaxis* with corallite diameter 7 to 9 mm and 15 to 18 major septa that closely approach the columella but seldom reach it and extend into the dissepimentarium, ordinarily being attached to the corallite wall. Minor septa ordinarily well developed. Columella a simple axial plate connected to the counter or cardinal septum. Dissepimentarium weakly lonsdaleoid, composed of 1 to 3 rows of inflated dissepiments of varying sizes. Tabulae incomplete, horizontal, mostly convex, and irregularly spaced 0.25 to 1 mm apart. Ratio of tabularium width to corallite diameter about 0.5 to 0.6. Mode of increase unknown.

Description of type material.—See de Groot (1964 [1963]).

Discussion.—This species differs from *P. wagneri* by having larger corallites, more rows of dissepiments, and less regular tabulae.

Occurrence.—Middle Carboniferous, Bashkirian. Perapertú Formation, Palencia, Spain.

Petalaxis intermedius (de Groot)

Lithostrotionella (Hillia) intermedia de Groot, 1963, p. 90, pl. 20, figs. 2a, b, 3.

Diagnosis.—*Petalaxis* with corallite diameter 5 to 7 mm and 16 to 19 major septa that closely approach the columella but seldom reach it and extend into the dissepimentarium, commonly being attached to the corallite wall. Minor septa well developed. Columella a simple axial plate connected to counter or cardinal septum. Dissepimentarium weakly lonsdaleoid, composed of 1 to 4 rows of mostly small inflated dissepiments. Tabulae mostly incomplete, flat, concave or convex, horizontal, and irregularly spaced 0.25 to 0.75 mm apart. Ratio of tabularium width to corallite diameter about 0.7 to 0.8. Increase peripheral.

Description of type material.—See de Groot (1964 [1963]).

Discussion.—This species differs from *P. wagneri* by having larger corallites, more major septa, and more tabulae.

Occurrence.—Middle Carboniferous, Bashkirian. Perapertú Formation, Palencia, Spain.

Petalaxis santaemariae (de Groot)

Lithostrotionella (Hillia) santaemariae de Groot, 1963, p. 91, pl. 21, figs. 1a–e.

Diagnosis.—*Petalaxis* with corallite diameter 3.5 to 8 mm and 16 to 19 major septa that closely approach the columella but seldom reach it and extend into the dissepimentarium, ordinarily attached to the corallite wall. Minor septa poorly developed. Corallite walls strongly dilated. Columella a simple thickened axial plate connected to counter or cardinal septum. Dissepimentarium weakly lonsdaleoid, composed of a single row of small inflated dissepiments. Tabulae mostly complete, horizontal, mostly concave, and irregularly spaced 0.25 to 1 mm apart. A peripheral zone of clinotabellae may be present. Ratio of tabularium width to corallite diameter about 0.8. Increase peripheral.

Description of holotype.—See de Groot (1964 [1963]).

Discussion.—This species differs from *P. perapertuensis* by having larger corallites, poorly developed minor septa, and fewer tabulae.

Occurrence.—Middle Carboniferous, Bashkirian. Santa Maria Limestone, Palencia, Spain.

Petalaxis cantabricus (de Groot)

Lithostrotionella (Hillia) cantabrica de Groot, 1963, p. 92, pl. 22, figs. 1–4.

Diagnosis.—*Petalaxis* with corallite diameter 4 to 8 mm and 19 to 28 major septa that closely approach the columella but seldom reach it and extend into the dissepimentarium, ordinarily being attached to the corallite wall. Minor septa well developed. Corallite wall strongly dilated and denticulate. Columella a simple commonly thickened axial plate connected to counter or cardinal septum. Dissepimentarium weakly lonsdaleoid, composed of 1 to 3 rows of small inflated dissepiments. Tabulae mostly complete, horizontal, concave, and spaced 0.25 to 1 mm apart. A peripheral zone of clinotabellae may be present. Ratio of tabularium width to corallite diameter about 0.6 to 0.7. Increase peripheral.

Description of type material.—See de Groot (1964 [1963]).

Discussion.—This species is distinguished from all others in the *P. wagneri* species group by having more major septa.

Occurrence.—Middle Carboniferous, Bashkirian to Moscovian(?). Santa Maria Limestone, Perapertú Formation, and Celada Limestone, Palencia, Spain.

Petalaxis orboensis (de Groot)

Lithostrotionella orboensis de Groot, 1963, p. 85, pl. 17, figs. 2a–d.

Diagnosis.—*Petalaxis* with corallite diameter 4.5 to 8 mm and 16 to 21 major septa that closely approach the columella but seldom reach it and extend into the dissepimentarium, commonly being attached to the corallite wall. Minor septa well developed. Columella a simple axial plate connected to counter or cardinal septum;

columella absent or discontinuous in some corallites. Dissepimentarium weakly lonsdaleoid, composed of 1 to 3 rows of inflated dissepiments of varying sizes. Tabulae complete and incomplete, generally horizontal but turned up at columella, and spaced 0.25 to 0.5 mm apart. Ratio of tabularium width to corallite diameter about 0.7. Mode of increase unknown.

Description of type material.—See de Groot (1964 [1963]).

Discussion.—This species is distinguished from others in the *P. wagneri* group by having tabulae that are turned up at the columella and by having the columella absent or discontinuous in some corallites.

Occurrence.—Middle Carboniferous, Moscovian. Orbo Limestone, Palencia, Spain.

Petalaxis occidentalis (Merriam)

Plate 20, figures 1, 2

Lithostrotion (Lithostrotionella) occidentalis Merriam, 1942, p. 377, pl. 56, figs. 2, 4, 7, 8, 11.

Lithostrotion [Lithostrotionella] occidentale Merriam. Bassler, 1950, p. 252.

Diagnosis.—*Petalaxis* with corallite diameter 4.5 to 6.5 mm and 16 to 19 major septa that closely approach the columella but seldom reach it and extend into the dissepimentarium, commonly being attached to the corallite wall. Minor septa well developed. Corallite wall dilated and denticulate. Columella a simple thickened axial plate connected to the counter or cardinal septum. Dissepimentarium weakly lonsdaleoid, composed of 1 to 2 rows of small inflated dissepiments Tabularium consists of a peripheral zone of clinotabellae and a periaxial zone of mostly complete, horizontal, flat or concave tabulae spaced 0.25 to 0.75 mm apart. Ratio of tabularium width to corallite diameter about 0.6. Mode of increase unknown.

Description of holotype.—See Merriam (1942). The holotype is USNM 143440; new thin sections of this specimen are illustrated herein for clarification of morphologic details.

Discussion.—This species differs from *P. perapertuensis* by having larger corallites, a thicker columella, and well-developed clinotabellae.

Occurrence.— Permian. Coyote Butte Formation, Oregon, U.S.A.

Petalaxis vesiculosus species group

Petalaxis vesiculosus (Dobrolyubova)

Lithostrotionella vesiculosa Dobrolyubova, 1935a, p. 11, pl. 2, figs. 3, 4; 1935b, p. 19, pl. 2, figs. 3, 4.

Lithostrotion [Lithostrotionella] vesiculosa Dobrolyubova. Bassler, 1950, p. 222.

Diagnosis.—*Petalaxis* with corallite diameter 6 to 12 mm and 10 to 14 major septa that may or may not extend to the columella and seldom extend into the dissepimentarium. Minor septa ordinarily well developed. Columella a simple thickened axial plate ordinarily connected to the counter and cardinal septa. Dissepimentarium composed of 2 to 6 rows of inflated dissepiments of varying sizes. Tabulae complete or incomplete, horizontal, concave or convex, and irregularly spaced 0.25 to 1 mm apart. Ratio of tabularium width to corallite diameter about 0.3 to 0.4. Mode of increase peripheral.

Description of holotype.—See Dobrolyubova (1935b).

Discussion.—This species is distinguished from all species of the *P. flexuosus* and *P. wagneri* groups by its broader dissepimentarium.

Occurrence.—Middle Carboniferous, Moscovian. Myachkovo Horizon (C_2^4), Moscow Basin, U.S.S.R.

Petalaxis lisitschanskensis Fomichev

Petalaxis vesiculosa (Dobrolyubova) var. *lisitschanskensis* Fomichev, 1953, p. 462, pl. 32, figs. 3a, b.

Diagnosis.—*Petalaxis* with corallite diameter 12 to 15 mm and 16 to 21 major septa that approach the columella and may or may not reach it and do not extend into the dissepimentarium. Minor septa ordinarily well developed. Columella a simple thickened axial plate ordinarily connected to the counter septum. Dissepimentarium composed of 1 to 5 rows of inflated dissepiments of variable size. Tabulae complete or incomplete, horizontal, concave or convex, and irregularly spaced 0.25 to 0.75 mm apart. Ratio of tabularium width to corallite diameter about 0.4. Mode of increase unknown.

Description of holotype.—See Fomichev (1953).

Discussion.—This species is distinguished from *P. vesiculosus* by having larger corallites, more major septa, and generally fewer rows of dissepiments.

Occurrence.—Middle Carboniferous, Moscovian. L_4 and L_5 Limestones, Donetz Basin, U.S.S.R.

Petalaxis exilis Kozyreva

Petalaxis exilis Kozyreva, 1974, p. 26, pl. 1, figs. 1a–d.

Diagnosis.—*Petalaxis* with corallite diameter 5 to 11 mm and 10 to 14 major septa that ordinarily are short and do not extend to the columella or into the dissepimentarium. Minor septa absent. Columella a simple thickened axial plate ordinarily connected to the counter septum and to the cardinal septum in some corallites. Dissepimentarium composed of 1 to 3 rows of mostly large inflated dissepiments. Tabulae complete, horizontal or slightly elevated toward columella, and irregularly spaced 0.5 to 1.25 mm apart. Ratio of tabularium width to corallite diameter about 0.4. Increase probably peripheral.

Description of holotype.—See Kozyreva (1974).

Discussion.—This species is distinguished from *P. vesiculosus* by having fewer septa that extend to the col-

umella, by lacking minor septa, by having fewer rows of dissepiments, and by having fewer tabulae.

Occurrence.—Middle Carboniferous, Bashkirian. Horizon b_4, Voronezh anteclise, U.S.S.R.

Petalaxis confertus Kozyreva

Petalaxis confertus Kozyreva, 1974, p. 27, pl. 1, figs. 2a, b, 3a, b.

Diagnosis.—*Petalaxis* with corallite diameter 8 to 12 mm and 19 to 20 major septa that commonly approach the columella but do not extend into the dissepimentarium. Minor septa absent. Columella a simple thickened axial plate connected to the counter septum. Dissepimentarium composed of 1 to 3 rows of inflated dissepiments of varying sizes. Tabulae mostly incomplete, varying in attitude, and irregularly spaced 0.25 to 1 mm apart. Ratio of tabularium width to corallite diameter about 0.4 to 0.5. Mode of increase unknown.

Description of type material.—See Kozyreva (1974).

Discussion.—This species is distinguished from *P. exilis* by having more major septa, longer major septa, and by its incomplete tabulae.

Occurrence.—Middle Carboniferous, Bashkirian. Voronezh anteclise, U.S.S.R.

Petalaxis persubtilis Kozyreva

Petalaxis persubtilis Kozyreva, 1974, p. 27, pl. 1, figs. 4a–c, 5, 6.

Diagnosis.—*Petalaxis* with corallite diameter 9 to 15 mm and 15 to 17 major septa that commonly approach the columella and may or may not extend into the dissepimentarium. Minor septa absent or variably developed. Columella absent or weakly developed as a simple axial plate connected to the counter septum. Dissepimentarium composed of 2 to 4 rows of large inflated dissepiments. Tabulae complete, horizontal, commonly weakly turned up at columella, and irregularly spaced 0.25 to 1 mm apart. Ratio of tabularium width to corallite diameter 0.3 to 0.4. Increase peripheral.

Description of type material.—See Kozyreva (1974).

Discussion.—This species is distinguished from *P. confertus* by having larger corallites, more major septa, more rows of dissepiments, and a smaller ratio of tabularium width to corallite diameter.

Occurrence.—Middle Carboniferous, Bashkirian. Horizon b_1, Voronezh anteclise, U.S.S.R.

Petalaxis korkhovae Kozyreva

Petalaxis korkhovae Kozyreva, 1974, p. 28, pl. 1, figs. 7a–c.

Diagnosis.—*Petalaxis* with corallite diameter 9 to 15 mm and 16 to 18 major septa that ordinarily extend about halfway to the columella but seldom extend into the dissepimentarium. Minor septa absent or poorly developed. Columella a simple thickened axial plate connected to the counter septum. Dissepimentarium composed of 3 to 4 rows of inflated dissepiments of varying sizes. Tabulae complete, horizontal, mostly flat, and irregularly spaced 0.25 to 1 mm apart. Ratio of tabularium width to corallite diameter 0.3 to 0.4. Increase peripheral.

Description of type material.—See Kozyreva (1974).

Discussion.—This species is distinguished from *P. persubtilis* by having a stronger columella, shorter major septa, and flatter tabulae.

Occurrence.—Middle Carboniferous, Bashkirian. Horizon b_1, Voronezh anteclise, U.S.S.R.

Petalaxis mirus Kozyreva

Petalaxis mirus Kozyreva, 1974, p. 29, pl. 2, figs. 1a–c.

Diagnosis.—*Petalaxis* with corallite diameter 7 to 15 mm and 16 to 18 major septa that ordinarily extend about halfway to the columella but seldom extend into the dissepimentarium. Minor septa absent or very poorly developed. Columella a simple thickened axial plate connected to the counter septum in most corallites but absent in some. Dissepimentarium consists of 1 to 3 rows of large elongate dissepiments. Tabulae complete, horizontal, and spaced about 1 mm apart. Ratio of tabularium width to corallite diameter about 0.3 to 0.4 Increase peripheral and intermural.

Description of type material.—See Kozyreva (1974).

Discussion.—This species is distinguished by its polymorphic coralla, which include the morphologies of *Petalaxis, Sciophyllum,* and *Thysanophyllum.*

Occurrence.—Middle Carboniferous, Bashkirian. Horizon b_4, Voronezh anteclise, U.S.S.R.

Petalaxis evidens Kozyreva

Petalaxis evidens Kozyreva, 1974, p. 30, pl. 2, figs. 2a, b, 3.

Diagnosis.—*Petalaxis* with corallite diameter 8 to 16 mm and 18 to 22 major septa that extend about two-thirds of the way to the columella but seldom extend into the dissepimentarium. Minor septa absent or very poorly developed. Columella a simple thickened axial plate connected to the counter septum. Dissepimentarium consists of 1 to 3 rows of large inflated dissepiments. Tabulae complete and incomplete, horizontal, concave, turned up at the columella, and irregularly spaced 0.25 to 1 mm apart. Ratio of tabularium width to corallite diameter about 0.3 to 0.4. Mode of increase unknown.

Description of type material.—See Kozyreva (1974).

Discussion.—This species is distinguished from *P. korkhovae* by having more major septa, longer major septa, and by having its tabulae turned up at the columella.

Occurrence. Middle Carboniferous, Bashkirian. Horizon b_4, Voronezh anteclise, U.S.S.R.

Petalaxis maccoyanus species group

Petalaxis maccoyanus Milne-Edwards and Haime

Stylaxis M'coyana Milne-Edwards and Haime, 1851, p. 453, pl. 12, figs. 5, 5a.

Petalaxis M'coyana Milne-Edwards and Haime, 1852, p. 205; Milne-Edwards, 1860, p. 440; Roemer, 1883, p. 387.

Lithostrotion Portlocki Milne-Edwards and Haime. Eichwald, 1861, p. 149, 150.

Lithostrotion Mac-Coyanum Milne-Edwards and Haime. Eichwald, 1861, p. 150.

Lithostrotion maccoyanum (Milne-Edwards and Haime). Bassler, 1950, p. 222.

Petalaxis mccoyana Milne-Edwards and Haime. Fedorowski and Gorianov, 1973, p. 58, pl. 12, figs. 4a, b, text-figs. 20a, b; Sutherland, 1977, p. 185, figs. 1–7.

Not *Petalaxis maccoyana* Milne-Edwards and Haime. Fomichev, 1953, p. 453, pl. 31, figs. 1a–d, 2a–d.

Not *Lithostrotionella maccoyana* (Edwards and Haime). de Groot, 1963, p. 82, pl. 16, figs. 1a, b.

Diagnosis.—*Petalaxis* with maximum corallite diameter 5.4 to 7.8 mm and 13 to 18 major septa that approach the columella but seldom reach it and seldom extend into the dissepimentarium. Minor septa poorly developed. Columella a thickened axial plate connected to the counter septum augmented in some corallites by vertical axial tabellae and rare, poorly developed septal lamellae. Dissepimentarium composed of 1 to 2 rows of small inflated dissepiments Tabulae mostly incomplete, essentially horizontal, flat, concave, or convex, and irregularly spaced 0.5 to 1 mm apart. Ratio of tabularium width to corallite diameter about 0.6. Increase peripheral.

Description of type material.—See Milne-Edwards and Haime (1851). According to Sutherland (1977, p. 185), the holotype and paratype are lost and a neotype may have to be designated from a topotype lot in the collections of the Paleontological Institute of the Academy of Sciences of the USSR in Moscow. Pending further work by Sutherland, the diagnosis is based largely on descriptions and illustrations of topotypes published by Fedorowski and Gorianov (1973) and Sutherland (1977).

Discussion.—This species, the type of *Petalaxis*, has a narrow dissepimentarium like species of the *P. flexuosus* group but is distinguished by its variable columella, which ranges from a simple thickened axial plate to a complex structure made up of axial plate, vertical tabellae, and rare septal lamellae. Specimens of similar general morphology but lacking a complex axial structure were referred to the species by Fomichev (1953) and de Groot (1964) but are here excluded from the species. The only described material included in the species is from the Moscow Basin.

Occurrence.—Middle Carboniferous, Moscovian. Myachkovo Horizon, Moscow Basin, U.S.S.R.

Petalaxis stylaxis (Trautschold)

Lithostrotion stylaxis Trautschold, 1879, p. 36, pl. 5, figs. 6a–c.

Petalaxis stylaxis Stuckenberg, 1888, p. 21, pl. 3, figs. 17–21.

?*Petalaxis stylaxis* Trautschold. Bolkhovitinova, 1915, p. 63, pl. 5, fig. 1.

Lithostrotionella stylaxis (Trautschold). Dobrolyubova, 1935a, p. 10, pl. 1, figs. 1–5, pl. 2, figs. 1, 2, 5; pl. 13, figs. 1–3; 1935b, p. 14, pl. 1, figs. 1–5, pl. 2, figs. 1, 2, 5, pl. 13, figs. 1–3; Fomichev, 1939, p. 60, pl. 9, figs. 6a, b; not Wu and Zhao, 1974, p. 271, pl. 137, figs. 5, 6.

?*Lithostrotionella stylaxis* (Trautschold). Heritsch, 1937, p. 164, figs. 1–4; 1939, p. 29, pl. 18, fig. 7, pl. 21, figs. 17, 18.

?*Lithostrotion* [*Lithostrotionella*] *stylaxis* (Trautschold). Bassler, 1950, p. 235.

Diagnosis.—*Petalaxis* with corallite diameter 3.5 to 9 mm and 11 to 18 major septa that approach the columella but seldom reach it and seldom extend into the dissepimentarium. Minor septa absent to well developed. Columella ranging from a simple axial plate ordinarily connected to the counter septum to a complex structure in which the axial plate is augmented by impersistent vertical axial tabellae and rare septal lamellae. Dissepimentarium composed of 1 to 3 rows of inflated dissepiments of varying sizes. Tabulae complete and incomplete, horizontal, flat, concave or convex, and irregularly spaced 0.25 to 2 mm apart. Ratio of tabularium width to corallite diameter 0.4 to 0.7. Mode of increase unknown.

Description of type material.—See Trautschold (1879). The diagnosis is taken largely from Dobrolyubova's (1935b) descriptions and illustrations of topotypes.

Discussion.—Dobrolyubova (1935a, b) recognized three morphological variants in her study of topotypes: *Lithostrotionella stylaxis, L. stylaxis* var. 1, and *L. stylaxis* var. 2. These were treated like separate species in a morphological series. The three morphotypes were collected from the same horizon at different geographic locations, all in the Moscow Basin. Pending further study, I have included all three morphotypes in the concept of *Petalaxis stylaxis.*

Bolkhovitinova's (1915) specimen is included here with a question because of inadequate description and illustration. Heritsch's (1937, 1939) specimens are referred questionably to the species because no longitudinal sections are available.

Petalaxis stylaxis differs from *P. maccoyanus* by having slightly larger corallites, an unthickened columella, and some well-developed minor septa.

Occurrence.—Middle Carboniferous, Moscovian. Myachkovo Horizon (C_2^4), Moscow Basin, U.S.S.R. Corakalk, Kings Bay, Spitzbergen(?). Arabian Desert(?).

Petalaxis mohikanus (Fomichev)

Lithostrotionella mohikana Fomichev, 1939, p. 60, pl. 9, figs. 5a, b.

Petalaxis mohikana Fomichev, 1953, p. 459, pl. 32, figs. 1a, b, 2a, b, pl. 33, fig. 1.

Diagnosis.—*Petalaxis* with corallite diameter 6 to 10 mm and 13 to 18 major septa that closely approach the columella and commonly extend into the dissepimentarium. Minor septa well developed. Columella ordinarily a simple axial plate but augmented by rare short septal lamellae and a few vertical axial tabellae in some corallites. Dissepimentarium composed of 1 to 3 rows of mostly large inflated dissepiments. Tabulae complete and incomplete, essentially horizontal, commonly turned up at columella, and spaced 0.25 to 0.5 mm apart. Ratio of tabularium width to corallite diameter about 0.4 to 0.5. Mode of increase unknown.

Description of type material.—See Fomichev (1953).

Discussion.—This species differs from *P. maccoyanus* by having larger corallites, more extensions of the major septa into the dissepimentarium, well-developed minor septa, and more tabulae.

Occurrence.—Middle Carboniferous, Moscovian. M_3 Limestone, Donetz Basin, U.S.S.R.

Petalaxis celadensis (de Groot)

Lithostrotionella celadensis de Groot, 1963, p. 82, pl. 15, figs. 2a–d.

Diagnosis.—*Petalaxis* with corallite diameter 3.5 to 6 mm and 12 to 16 major septa that extend about halfway to the columella but seldom extend into the dissepimentarium. Minor septa absent or poorly developed. Columella ranging from a simple axial plate connected to the counter septum to a complex structure composed of an axial plate, vertical axial tabellae, and a few septal lamellae. Dissepimentarium composed of 1 to 2 rows of large inflated dissepiments. Tabulae mostly incomplete, flat to concave, horizontal, and irregularly spaced 0.25 to 0.75 mm apart. Ratio of tabularium width to corallite diameter about 0.6. Mode of increase unknown.

Description of holotype.—See de Groot (1964 [1963]).

Discussion.—This species differs from *P. maccoyanus* by having smaller corallites, fewer and shorter major septa, weaker minor septa, and more tabulae.

Occurrence.—Middle Carboniferous, Moscovian. Celada Limestone, Palencia, Spain.

Petalaxis elyensis (Wilson and Langenheim)

Eastonoides elyensis Wilson and Langenheim, 1962, p. 512, pl. 88, figs. 4–6.

Diagnosis.—*Petalaxis* with corallite diameter 4 to 5 mm and 10 to 15 major septa that extend about halfway to the columella. Major septa are attached to the corallite wall except where impersistent lonsdaleoid dissepiments are present. Minor septa poorly developed, contratingent. Columella a thickened axial plate connected to the counter septum and augmented by rare impersistent vertical axial tabellae and very rare septal lamellae. Dissepimentarium consists of a single row of impersistent inflated dissepiments. Tabulae mostly complete, generally flat, locally sagging or domed, and spaced 0.5 to 1 mm apart. Tabularium width equals corallite diameter, except where dissepiments are developed. Mode of increase unknown.

Description of type material.—See Wilson and Langenheim (1962).

Discussion.—This species is distinguished from most other species of *Petalaxis* by having an impersistent lonsdaleoid dissepimentarium and impersistent axial tabellae. *P. elyensis* is the type species of *Eastonoides* Wilson and Langenheim, which was proposed to include the type species and *Lonsdaleia ivanovi* Dobrolyubova, which Fomichev (1953, p. 464) included in *Cystolonsdaleia*. These species have the general morphology of *P. maccoyanus*, the type species of *Petalaxis*, which also has impersistent axial tabellae. Thus, *Eastonoides* is regarded as a junior synonym of *Petalaxis*, and *P. elyensis* is included in the *P. maccoyanus* species group.

Occurrence.—Lower Permian. Ely Limestone, Nevada, U.S.A.

Petalaxis dobrolyubovae n. sp.

Not *Stylaxis portlocki* Milne-Edwards and Haime, 1851, p. 453.

Not *Petalaxis portlocki* Milne-Edwards and Haime, 1852, p. 204, pl. 38, figs. 44, 4a; Haime, 1860, p. 441.

Petalaxis portlocki Edwards and Haime. Stuckenberg, 1888, p. 22, pl. 2, figs. 44–49.

Lonsdaleia portlocki (Stuckenberg). Dobrolyubova, 1935a, p. 12, pl. 9, figs 1–4, not pl. 10, figs. 1, 2; 1935b, p. 29, pl. 9, figs. 1–4, not pl. 10, figs. 1, 2.

Not *Cystolonsdaleia portlocki* (Dobrolyubova). Fomichev, 1953, p. 467, pl. 32, figs. 4a–v.

Not *Lonsdaleia portlocki* (Stuckenberg) *densiconus* de Groot, 1963, p. 79, pl. 15, fig. 1.

Diagnosis.—*Petalaxis* with corallite diameter 5 to 11 mm and 11 to 17 major septa that extend halfway to or closely approach the columella but seldom reach it and commonly extend into the dissepimentarium. Minor septa absent to well developed. Columella ranging from a simple axial plate connected to the counter septum to a complex structure composed of axial plate, vertical axial tabellae, and rare septal lamellae augmented by stereoplasm in some corallites to produce a netlike structure in transverse section. Dissepimentarium composed of 1 to 2 rows of inflated dissepiments of varying sizes. Tabulae mostly incomplete, flat, concave, or convex, horizontal, and irregularly spaced 0.25 to 1 mm apart. Ratio of tabularium width to corallite diameter about 0.6 to 0.7. Mode of increase unknown.

Description of type material.—See Dobrolyubova (1935b). The holotype is the specimen illustrated by Dobrolyubova (1936b) as her plate 9, figures 1 and 2.

Discussion.—Dobrolyubova's illustrations suggest that more than one species may be present in the type lot. I exclude the specimen figured as her plate 10, figures 1 and 2, because it seems much more complex

than the other two specimens illustrated. The remaining figured specimens are notably different from one another but are retained in the species concept pending further work on the type material.

Cystolonsdaleia portlocki (Dobrolyubova) Fomichev does not belong here and is described below as a new species. *Lonsdaleia portlocki* (Stuckenberg) *densiconus* de Groot is a separate species assigned to *Cystolonsdaleia* Fomichev.

P. dobrolyubovae differs from *P. maccoyanus* by having larger corallites, more abundant complex columellae, and more extensions of the major septa into the dissepimentarium.

Occurrence.—Middle Carboniferous, Moscovian. Myachkovo Horizon, Moscow Basin, U.S.S.R.

Petalaxis donetsensis n. sp.

Cystolonsdaleia portlocki (Dobrolyubova). Fomichev, 1953, p. 467, pl. 32, figs. 4a–v.

Diagnosis.—*Petalaxis* with corallite diameter 8 to 10 mm and 13 to 16 major septa that approach the columella but do not ordinarily reach it and seldom extend into the dissepimentarium. Minor septa absent or poorly developed. Columella ranging from a simple axial plate connected to the counter septum to a more complex structure composed of axial plate and impersistent vertical axial tabellae. Dissepimentarium composed of 2 to 4 rows of inflated dissepiments of varying sizes. Tabulae mostly incomplete, mostly concave, horizontal, and irregularly spaced 0.25 to 1 mm apart. Ratio of tabularium width to corallite diameter about 0.3 to 0.6. Mode of increase unknown.

Description of holotype.—See Fomichev (1953). The holotype is specimen number 36 of Fomichev.

Discussion.—This species differs from *P. dobrolyubovae* by having more rows of dissepiments, weaker minor septa, a smaller ratio of tabularium width to corallite diameter, and by its less abundant complex columellae.

Occurrence.—Middle Carboniferous, Moscovian. N_1 Limestone, Donetz Basin, U.S.S.R.

Petalaxis ivanovi (Dobrolyubova)

Lonsdaleia ivanovi Dobrolyubova, 1935a, p. 12, pl. 11, figs. 1, 2; 1935b, p. 31, pl. 11, figs. 1, 2.

Diagnosis.—*Petalaxis* with corallite diameter 6 to 6.5 mm and 13 to 14 major septa that closely approach the columella but seldom reach it. Major septa are attached to the corallite wall, except where impersistent lonsdaleoid dissepiments are present. Minor septa well developed. Columella ranging from a simple axial plate to a complex structure consisting of axial plate, vertical axial tabellae, and a few septal lamellae commonly reinforced by stereoplasm to form a thick rod or netlike structure in transverse section. Dissepimentarium impersistent, composed of a single row of dissepiments of varying sizes where present. Tabulae mostly incomplete, horizontal, flat, concave, or convex, and irregularly spaced 0.25 to 1 mm apart. Tabularium width equals corallite diameter except where dissepiments are present. Mode of increase unknown.

Description of holotype.—See Dobrolyubova (1935b).

Discussion.—This species differs from *P. elyensis* by having larger corallites, stronger minor septa, and a better developed complex columella.

Occurrence.—Middle Carboniferous, Moscovian. Myachkovo Horizon, Moscow Basin, U.S.S.R.

Petalaxis? spp. indet.

The following taxa are referred questionably to *Petalaxis* and are not diagnosed because of insufficient illustration or description of morphological details:

Lithostrotionella tingi Chi, 1931, p. 28, pl. 4, figs. 6a, b; Wu in Yü and others, 1963, p. 86, pl. 24, figs. 6a, b. Middle Carboniferous, Moscovian. Laokunchai Limestone, Kueichou, China.

Lithostrotionella aff. *stylaxis* Trautschold. Dobrolyubova, 1936b, p. 127, figs. 55, 56. Middle Carboniferous, Moscovian. Ural Mountains, U.S.S.R.

Lithostrotionella sp. indet. Yamagiwa, 1961, p. 102, pl. 5, figs. 1–3. Lower Permian. Atetsu Limestone, Okayana, Japan.

Lithostrotionella kitakamiensis Minato, 1955, p. 88, pl. 4, figs. 2, 7, 8, 10, pl. 34, figs. 2, 3. Middle Carboniferous, Bashkirian. Nagaiwa Series, Iwate, Japan.

Lithostrotionella spiniformis Yü, 1933 [1934], p. 102, pl. 21, figs. 2a, b; Wu in Yü and others, 1963, p. 87, pl. 24, figs. 5a, b. Lower Carboniferous, Viséan. Shangssu Limestone, Kueichou, China.

Petalaxis timanicus Stuckenberg. Heritsch, 1939, p. 18, pl. 2, fig. 8, pl. 3, fig. 1, pl. 15, figs. 2, 3, pl. 21, figs. 8–16. Carboniferous or Permian. Cora Limestone, Spitzbergen.

Petalaxis timanicus Stuckenberg. Kolosvary, 1951, p. 39, pl. 9, figs. 5–7. Permian, Hungary.

Petalaxis maccoyana var. *multiseptata* Fomichev, 1953, p. 458, pl. 31, fig. 4. Middle Carboniferous, Moscovian. L_5 Limestone, Donetz Basin, U.S.S.R.

Petalaxis maccoyana forma *orlovkensis* Fomichev, 1953, p. 456. Middle Carboniferous, Moscovian. L_5 and L_6 Limestone, Donetz Basin, U.S.S.R.

Family LONSDALEIIDAE Chapman, 1893

Genus THYSANOPHYLLUM Nicholson and Thomson, 1876

Thysanophyllum Nicholson and Thomson, 1876, p. 150; Hill, 1940, p. 160.

Type species.-Thysanophyllum orientale Nicholson and Thomson, 1876, p. 150. Lower Carboniferous, Scotland.

Discussion.–*Thysanophyllum* is distinguished by its cerioid corallum having corallites with a lonsdaleoid dissepimentarium and lacking an axial structure or having a weak impersistent axial plate. The genus is probably polyphyletic like other colonial rugose corals without a persistent axial structure, corals such as *Diphyphyllum* and *Pseudodorlodotia.*

Thysanophyllum astraeiforme (Warren)

Diphyphyllum astraeiformis Warren, 1927, p. 44, pl. 3, figs. 2, 3.
Lithostrotionella astraeiformis (Warren). Kelly, 1942, p. 352; Bamber, 1961, p. 152, pl. 12, figs. 1a, b; Nelson, 1961, pl. 18, figs. 1–3.
Lithostrotionella (Thysanophyllum) astraeiformis (Warren). Nelson, 1960, p. 115, pl. 22, figs. 7–10.
Thysanophyllum astraeiforme (Warren). Bamber, 1966, p. 23, pl. 4, figs. 3a–b, 4a–c; Armstrong, 1970a, p. 37, pl. 11, figs. 5–8; 1970b, p. 28, pl. 9, figs. 1–6, text-fig. 33.

Description of lectotype.–See Bamber (1966).

Discussion.–This species is rather common in western Canada and Alaska, where it ranges from Mamet Zone 13 into 16i; it is most common in Mamet Zones 14 and 15. These occurrences are of middle and late Viséan age. The structure of the columella, where present, suggests relationship to *Acrocyathus.*

Genus LONSDALEIA McCoy, 1849

Lonsdaleia McCoy, 1849, p. 11; Smith, 1916, p. 218; Hill, 1940, p. 151; Sando, 1975, p. C20.

Type species.–*Erismatolithus Madreporites (duplicatus)* Martin, 1809, equals *Lonsdaleia duplicata* (Martin). Lower Carboniferous, England.

Diagnosis.–See Cotton (1973, p. 117).

Discussion.–The genus is subdivided into two subgenera on the basis of growth form: *Lonsdaleia (Lonsdaleia)*, phaceloid, and *Lonsdaleia (Actinocyathus)*, cerioid.

Subgenus ACTINOCYATHUS d'Orbigny, 1849

Actinocyathus d'Orbigny, 1849a, p. 12.
Stylidophyllum de Fromentel, 1861, p. 316.
?*Protolonsdalia* Lisitsyn, 1925, p. 68.
?*Sublonsdalia* Lisitsyn, 1925, p. 68.
?*Protolonsdaleia* Lang, Smith, and Thomas, 1940, p. 106.
?*Sublonsdaleia* Lang, Smith, and Thomas, 1940, p. 128

Type species.–*Cyathophyllum crenulare* Phillips, 1836, equals *Erismatolithus Madreporites (floriformis)* Martin, 1809, equals *Lonsdaleia floriformis* (Martin). Lower Carboniferous, England.

Diagnosis.–Cerioid *Lonsdaleia.*

Discussion.–See Sando (1975, p. C20) for discussion of the type species and synonymic placement of *Stylidophyllum. Protolonsdalia* (nomen vanum *Protolonsdaleia*) and *Sublonsdalia* (nomen vanum *Sublonsdaleia*) are both inadequately founded on type material that has been lost (N. P. Vasilyuk, oral commun., 1975); they may be junior synonyms of *Actinocyathus*, but neotypes need to be described before a final decision can be made.

Lonsdaleia (Actinocyathus) berthiaumi (Merriam)

Plate 20, figures 3, 4

Lithostrotion (Lithostrotionella) berthiaumi Merriam, 1942, p. 378, pl. 56, figs. 9, 10; Bassler, 1950, p. 252.

Description of holotype.–See Merriam (1942).

Discussion.–*Lonsdaleia (Actinocyathus)* was previously represented in North America by a single species, *L. (A.) stelcki* Nelson (1960, p. 119, pl. 23, figs. 6–10), as determined by Sando (1975, p. C21). Nelson's species is restricted to the upper Viséan and lower Namurian (Mamet Zones 16s, 17, and 18). Examination of the holotype (USNM 132988) and a topotype (USNM 132989) of Merriam's species reveals that it is very similar to Nelson's species but differs in having fewer tabulae. New thin sections of Merriam's holotype (USNM 132988) are figured herein to provide a better basis for interpreting this specimen.

Merriam (1942, p. 379) stated that the type material of *L. berthiaumi* is from the Permian Coyote Butte Formation of Oregon, a stratigraphic level that is inconsistent with other North American occurrences of the genus to which it is now assigned. According to E. C. Wilson (written commun., 1979), exposures in the type area are poor, geologic structure is complex, and beds in the area range from Devonian to Permian. I conclude that the specimens are probably from beds of Carboniferous (late Viséan or early Namurian) age.

Lonsdaleia (Actinocyathus) peratrovichensis (Armstrong)

Lithostrotionella peratrovichensis Armstrong, 1970a, p. 35, pl. 12, figs. 8–11.

Description of holotype.–See Armstrong (1970a).

Discussion.–Examination of the holotype (USNM 160493) of *L. peratrovichensis* reveals a morphology consistent with *Lonsdaleia (Actinocyathus)*. The species differs from the widely distributed *L. (A.) stelcki* (Nelson) by its smaller corallite diameter, thicker corallite walls, fewer dissepiments, and tabulae of varying form, some of which are inclined upward toward the columella.

The presence of *L. (A.) peratrovichensis* in beds of late Viséan age and the nature of its tabulae suggest that it is ancestral to *L. (A.) stelcki.*

Family DURHAMINIDAE Minato and Kato, 1965

Genus KLEOPATRINA McCutcheon and Wilson, 1963

Ptolemaia McCutcheon and Wilson, 1961, p. 1020 (not Osborn, 1908, p. 267).
Kleopatrina McCutcheon and Wilson, 1963, p. 299; Minato and Kato, 1965, p. 67 (replacement name for *Ptolemaia* McCutcheon and Wilson).

Type species.—*Ptolemaia ftatateeta* McCutcheon and Wilson, 1961, p. 1025, pl. 123, figs. 1–6. Lower Permian, Nevada.

Diagnosis.—See Minato and Kato (1965).

Discussion.—This genus is found predominantly in Permian strata, although Bamber and Macqueen (1979, p. 11) reported *Kleopatrina* (*Porfierevella*) from beds of Moscovian Age in British Columbia. The two species questionably referred here (see below) are the first possible representatives from the Upper Carboniferous.

Subgenus KLEOPATRINA McCutcheon and Wilson, 1963

Type species.—As for genus *Kleopatrina.*

Diagnosis.—See Minato and Kato (1965).

Kleopatrina (Kleopatrina)? dilatata (Easton)

Lithostrotion [Lithostrotionella] dilatata Easton, 1960, p. 578, text-figs. 7, 8.

Description of holotype.—See Easton (1960).

Discussion.—Judging from Easton's description and illustrations, the type material of this species has most of the essential features of *Kleopatrina* (*Kleopatrina*). However, the types do not seem to have a complex axial structure, which casts doubt on the taxonomic placement. The type material needs to be reinvestigated.

Occurrence.—Permian. Arcturus and Rib Hill Formations, Nevada, U.S.A.

Kleopatrina (Kleopatrina)? uralica (Dobrolyubova)

Lithostrotionella uralica Dobrolyubova, 1936a, p. 28, pl. 13, figs. 33-35.

Description of type material.—See Dobrolyubova (1936a).

Discussion.—Dobrolyubova's description and illustrations of this species suggest that it may be an early representative of *Kleopatrina* (*Kleopatrina*). This species occurs in beds of Late Carboniferous age, whereas all other known representatives of the subgenus are from the Permian. The type material needs to be reinvestigated.

Kleopatrina (Kleopatrina)? wahooenis (Armstrong)

Lithostrotionella wahooenis Armstrong, 1972b, p. 14, pl. 5, fig. 1, pl. 6, figs. 1–5, pl. 7, figs. 1–3.

Description of holotype and paratypes.—See Armstrong (1972b).

Discussion.—Armstrong's holotype and paratypes have the essential morphological characters of *Kleopatrina* (*Kleopatrina*). Differences between these specimens and the holotype of *K.* (*K.*) *ftatateeta* seem to be of specific rank only. However, Armstrong's species is from beds that are much older than those in which other known species of the subgenus are found. The occurrence is Middle Pennsylvanian (Atokan) Mamet Zone 21, which equates with high Bashkirian or low Moscovian of the U.S.S.R. Because of possible homeomorphism with the Permian forms, the placement of this species in *Kleopatrina* (*Kleopatrina*) is made with question.

UNDETERMINED LITHOSTROTIONELLOID CORALS

The following taxa are not identified generically because of inadequate specimens or inadequate illustrations and descriptions:

Lithostrotionella americana Hayasaka, 1936, p. 62 (Paratypes, USNM 174371 and 174373). Permian. McCloud Limestone, California, U.S.A.

Lithostrotionella flexuosa (Trautschold). Heritsch, 1940, p. 72, pl. 2, figs. 1, 2. Upper Carboniferous, Yugoslavia.

Petalaxis grandis Heritsch, 1939, p. 27, pl. 2, figs. 4, 5, pl. 19, fig. 11. Carboniferous or Permian, Spitzbergen.

Petalaxis? inconfertus Lonsdale. Yanishevskiy, 1900, p. 89. Carboniferous, Ural Mountains, U.S.S.R.

Petalaxis indigae Stuckenberg, 1895, p. 76, pl. 19, fig. 7. Upper Carboniferous, Timan, U.S.S.R.

Lithostrotionella kuechouensis Yü, [1933] 1934, p. 101, pl. 21, figs. 1a, b; Wu in Yü and others, 1963, p. 87, pl. 25, figs. 1a, b. Lower Carboniferous, Viséan. Shangssu Limestone, Kueichou, China.

Petalaxis kunthi Stuckenberg, 1888, p. 23; 1895, p. 78, pl. 12, fig. 7; Heritsch, 1939, p. 25, pl. 11, fig. 1, pl. 13, figs. 3, 7, pl. 19, fig. 4. Upper Carboniferous, Moscow Basin and Ural Mountains, U.S.S.R. Carboniferous or Permian, Spitzbergen.

Petalaxis sibiricus Gabounia, 1919, p. 39, pl. 2, fig. 2, pl. 3, fig. 1; Fomichev, 1931, p. 44, 72, pl. 1, figs. 2a–e; 1955, p. 303, pl. 80, figs. 5, 6. Lower Carboniferous, Kuznetsk Basin, U.S.S.R.

Lithostrotionella stylaxis (Trautschold). Rukhin, 1938, p. 40, pl. 5, figs. 7–9. Lower Carboniferous, Siranka River basin, U.S.S.R.

Lithostrotionella stylaxis (Trautschold). Wu and Zhao, 1974, p. 271, pl. 137, figs. 5, 6. Middle Carboniferous, Wei-Ling Group, Kueichou, China.

Petalaxis timanicus Stuckenberg, 1895, p. 76, pl. 12, fig. 5. Upper Carboniferous, Ural Mountains and Timan, U.S.S.R.

Lithostrotionella tingi Chi. Yü, Lin and Fan, 1962, p. 24, pl. 4, figs. 3a, b. Middle Carboniferous, Sinkiang, China.

Styllophyllum tolmachevi Rukhin, 1938, p. 41, pl. 5, figs. 10, 11. Lower Carboniferous, Omulevka River, U.S.S.R.

Petalaxis uchtensis Stuckenberg, 1895, p. 77, pl. 12, fig. 2, pl. 16,fig. 4. Upper Carboniferous, Timan, U.S.S.R.

Lithostrotionella cf. *spiniformis* Yü. Wu, 1964, p. 35, 79, pl. 4, figs. 7, 8. Lower Carboniferous, Viséan. Hunan, China.

Lithostrotionella sp. B. Lo and Chao, 1962, p. 184, pl. 22, fig. 6. Lower Carboniferous, Viséan. Ching-hai, China.

Lithostrotionella sp. *Kolosvary*, 1951, p. 38, pl. 10, figs. 4–9,pl. 18, figs. 1–3. Carboniferous or Permian, Hungary.

Lithostrotionella sp. Dobrolyubova, 1936a, p. 29, pl. 13, figs. 36, 37. Upper Carboniferous, Ural Mountains, U.S.S.R.

Lithostrotionella sp. undet. Minato, 1955, p. 87, pl. 1, fig. 3, pl. 34, fig. 11, pl. 37, fig. 9. Lower Carboniferous, Iwate, Japan.

Lithostrotionella? sp. Ross and Ross, 1963, p. 418, pl. 49, figs. 1, 2, 4, 10. Upper Carboniferous, Virgilian. Gaptank Formation, Texas, U.S.A.

ADDITIONAL TAXA

While the manuscript was being processed for publication, several additional studies of lithostrotionelloid corals described under the names of *Hillia, Lithostrotionella, Petalaxis, Stelechophyllum,* and *Thysanophyllum* came to my attention. Translations of the descriptions of these taxa that are in Chinese and Russian papers were not available at the time, preventing a complete evaluation of them. Moreover, taxa in the Chinese papers are poorly illustrated. These additional taxa are listed below, by publication.

Fan, Y. N., 1978, *in* Southwest China Geological Institute, [Paleontological atlas of southwestern China, Sichuan Province]: v. 2, 684 p., 191 pls. (In Chinese.) See p. 182–184.
Lithostrotionella maccoyana (Edwards and Haime)
L. sexangula de Groot
L. mui (Lo)
L. fugimotoi (Igo)
L. orboensis de Groot
L. orboensis regularis Fan, n.subsp.
L. pinguis Fan, n. sp.
L. awenggouensis Fan, n. sp.
L. vesiculosa vesiculosa Fan, n. subsp.
?*L.* sp.
Stelechophyllum ascendens ascendens (Tolmachev)
S. ascendens simplex Drobolyubova

Gorskiy, I. I., 1978, Korally Srednego Karbona zapadnogo sklona Urala [The Middle Carboniferous corals of the western slope of the Urals]: Akademiya Nauk SSSR, Otdelenie Geologii, Geofiziki, i Geokhimi, Izdatelstvo "Nauka," 223 p., 23 pls., 43 figs. See p. 150–152.
Lithostrotionella stylaxis (Trautschold) subsp. *uralica* Gorskiy, n. subsp.
L. flexuosa (Trautschold)

Guo, Z. C., 1976, *in* Northeastern Geological Institute and Geological Bureau of Inner Mongolia, [Paleontological atlas of northern China, part of Inner Mongolia]: v. 1, 502 p., 232 pls. (In Chinese.) See p. 86.
Lithostrotionella ivanovi Dobrolyubova
L. banffense (Warren)

Wang, H. D., 1978, *in* Stratigraphic-Paleontological Working Team of Guizhou Province, [Paleontological atlas of southwestern China, Guizhou Province]: v. 2, 638 p., 165 pls. (In Chinese.) See p. 133–140.
Lithostrotionella kueichouensis Yü
L. kuechouensis magna Wang, n. subsp.
L. baijinensis Wang, n. sp.
L. multivesiculata Wang, n. sp.
L. spiniformis Yü
L. changshunensis Wang, n. sp.
L. stylaxis (Trautschold)
L. tingi Chi
L. dushanensis Wang, n. sp.
L. elegantula (Wu and Zhao)
L. jiaruoensis Wang, n. sp.
Hillia perapertuensis de Groot
H. minor (Wu and Zhao)

Wilson, E. C., 1982, Wolfcampian rugose and tabulate corals (Coelenterata: Anthozoa) from the Lower Permian McCloud Limestone of northern California: Los Angeles County Natural History Museum Contributions in Science no. 337, 90 p., 48 figs. See p. 65–73.
Petalaxis allisonae Wilson, n. sp.
P. besti Wilson, n. sp.
P. kennedyi Wilson, n. sp.
P. pecki Wilson, n. sp.
P. sutherlandi Wilson, n. sp.

Xu, 1977, *in* Central Southern Geological Institute and Geological Bureaus of Henan, Hubei, Hunan, Guangdong, and Guangxi Provinces, [Paleontological atlas of central southern China]: v. 2, 856 p., 253 pls. (In Chinese.) See p. 202–203.
Lithostrotionella hsujiulingi Yoh
L. micra Kelly
L. maccoyana (Edwards and Haime)
Thysanophyllum ascendens ascendens (Tolmachev)
T. ascendens simplex (Dobrolyubova)

Yü, C. C., Lin, I. T., Huang, C. H., and Tsai, T. S., 1978, [Early Carboniferous stratigraphy and corals of eastern Xinjiang]: Chinese Academy of Geological Sciences, Editorial Committee of Professional Papers of Stratigraphy and Paleontology, Profes-

sional Papers of Stratigraphy and Paleontology No. 5, p. 1–70, 10 figs., 16 pls. (In Chinese with English summary.) See p. 29, 38–40. Peking, Geological Publishing House)
Lithostrotionella shimeri (Crickmay)
L. pennsylvanica (Shimer)
L. crassus n. sp.

REGISTER OF USGS LOCALITIES FOR HAYASAKA (1936) TYPE SPECIMENS OF *LITHOSTROTIONELLA* SPECIES

83–PC: Newman Limestone, St Louis Limestone Member. West side of Roundstone Creek, 300 ft (100 m) above creek, about 0.5 mi (0.8 km) south of site of town of Langford near intersection of Roundstone Creek and Renfro Creek, southeast quarter of Wildie quadrangle, Rockcastle County, Ky. Collected by F. B. Weeks, June 29, 1896. See Gualtieri (1968) for geologic map.

104–PC: Lodgepole Limestone (Zone C_1 of Sando and others, 1969).Sec. 12, T. 11 S., R. 44 E., Montpelier quadrangle, Bear Lake County, Idaho. Collected by G. R. Mansfield, June 12, 1911. This collection is composed of two lots, one that has a fauna from the upper part of the Lodgepole Limestone and another that contains *Faberophyllum* and is from the Aspen Range Formation.

346C–PC: Boulders of residual chert derived from Tuscumbia Limestone (St. Louis Limestone equivalent) at unconformity at top of Tuscumbia Limestone. Along pike about 0.5 mi (0.8 km) southwest of Cherokee, probably in SE¼ sec. 34 or SW¼ sec. 35, T. 3 S., R. 14 W., Cherokee quadrangle, Colbert County, Ala. Collected by P. V. Roundy, 1911. See Butts (1926) for geologic map of the area. See McCalley (1896, p. 152–153, 158) and Butts (1926, p. 175) for description of the geology.

490–PC: Float from Lodgepole Limestone (Zone C_1 of Sando and others, 1969). Old Laketown Canyon, near center of sec. 32, T. 13 N., R. 6 E., Randolph quadrangle, Rich County, Utah. Collected by G. B. Richardson, 1912. See Richardson (1941) for geologic map and Sando and others (1959) for discussion of geology.

498–PC: St. Louis Limestone, at base. Outskirts of Maeystown, probably in bed of Maeystown Creek about 1 mi (1.6 km) southeast of Maeystown in SW¼ sec. 1, T. 4 S., R. 11 W., Selma quadrangle, Monroe County, Ill. Collected by G. H. Girty, September 8, 1912.

499–PC: St. Louis Limestone, basal beds just above cephalopod bed. Ravine in river bluff about 1 mi (1.6 km) southeast of Maeystown, probably in SE¼ sec. 1 or NE¼ sec. 12, T. 4 S., R. 11 W., Selma quadrangle, Monroe County, Ill. Collected by Weller and Girty, September 8, 1912.

643–PC: St. Louis Limestone(?). On Tebo Creek about 1.5 mi (2.4 km) east of Leesville, Leesville quadrangle, Henry County, Mo.(?). Collected by W. P. Jenney, 1891.

Original locality data indicate that the stratigraphic unit was probably the Cherokee limestone or Seneca chert of Jenney (1894), which Jenney thought to be of Warsaw or St. Louis age. According to Wilmarth (1938, p. 415), subsequent authors regarded the Cherokee limestone as Boone Formation and the Seneca chert as the Grand Falls Chert Member of the Boone. According to Wilson (1922, p. 180), most of Henry County is underlain by the Cherokee Shale of Pennsylvanian age, but the Burlington and Keokuk Limestones are exposed beneath the Cherokee in the valley of Tebo Creek.

Hayasaka's specimen attributed to this locality is surely a St. Louis Limestone form. Thus, the locality data may be erroneous or the specimen may be a residual fragment derived from the St. Louis Limestone during post-St. Louis, pre-Cherokee erosion. There are no other specimens in the collection.

932A–PC: Float from St. Louis Limestone. In cut of St. Louis and San Francisco Railroad in NE¼ SE¼ or SE¼ NE¼ sec. 10, T. 4 N., R. 5 E., Kirkwood quadrangle, St. Louis County, Mo. Collected by G. H. Girty, August 8, 1904. See Fenneman (1911, pl. 1) for geologic map of the area.

970–PC: Alapah Limestone(?). 141st meridian, easterly spur from ridge between headwaters forks of Incog Creek, about 2 mi (3.2 km) northwest from station 966, Table Mountain quadrangle, northeastern Alaska. Collected by A. G. Maddren, July 1, 1912.

1148–PC: Float from St. Louis Limestone. 3 mi (4.8 km) west of Tennessee, Ill., in NW¼ SW¼ sec. 19, T. 5 N., R. 4 W., Colchester quadrangle, McDonough County, Ill. Collected by Henry Hinds, November 22, 1912. See Hinds (1919) for geologic map.

1211B–PC: Oolite in lower part of St. Louis Limestone. Mosher quarry (Ste. Genevieve Lime and Quarry Company) at Macy (Mosher Station) about 2 mi (3.2 km) southwest of Ste. Genevieve on Illinois Southern Railroad in T. 38 N., R. 9 E., Weingarten quadrangle, Ste. Genevieve County, Mo. Collected by E. O. Ulrich, November 2, 1903. See Weller and St. Clair (1928) for geologic map of the area.

1439–PC: Lodgepole Limestone, Woodhurst Member (Zone C_1 of Sando and others, 1969). In low saddle on west slope of hill (altitude 8,172 ft (2,490 m)) west of Georgetown Canyon, NW¼ sec. 34, T. 10 S., R. 44 E., Slug Creek quadrangle, Bear Lake County, Idaho. Collected by G. H. Girty, November 11, 1914. This locality was mapped as Madison Limestone by Mansfield (1927, pl. 6). Megafossils associated with the coral specimen are all compatible with a Zone C_1 determination.

1476–PC: Aspen Formation (Mamet foraminifer Zone 14). SW¼ sec. 8, T. 5 S., R. 43 E., at altitude 6,650 ft (2,015 m) in point projecting north from ridge south of Grays Lake, Lanes Creek quadrangle, Caribou County, Idaho. Collected by E. L. Jones and G. H. Girty, November 5, 1914. This locality was mapped as Brazer Limestone by Mansfield (1927, pl. 4). The file card by Girty indicates "near top" of the Brazer, but this locality is in a fault block, so the position is doubtful. Microfossils in the collection indicate Mamet Zone 14, and megafossils indicate Zone E of Sando and others (1969).

2013B–PC: Greenbrier Limestone, Hillsdale Member, near base. In cut of Norfolk and Western Railroad along Indian Creek 1.5 mi (2.4 km) northeast of Cedar Bluff, Tazewell quadrangle (30-minute) and Pounding Mill quadrangle (15-minute), Tazewell County, Va. Collected by G. H. Girty, June 17, 1920. See Campbell (1897) for geologic map of the area.

2020–PC: Greenbrier Limestone, Hillsdale Member, at base. Forks of road 0.5 mi (2.4 km) southeast of Shrader, Tazewell quadrangle (30-minute), Tazewell County, Va. Collected by Harnsberger, September 1916. See Campbell (1897) for geologic map of the area.

2020A–PC: Greenbrier Limestone, Hillsdale Member, about 25 ft (7.5 m) above base. Same geographic location as 2020–PC. See Girty (1923, p. 470) for faunal list and description of the locality.

2222A–PC: St. Louis Limestone, 0.75 mi (1.2 km) northeast of Hicks, probably in NE¼ sec. 19, T. 11 S., R. 8 E., Equality quadrangle, Hardin County, Ill. Collected by Charles Butts, 1916. See Weller (1920, pl. 1) for geologic map of the area.

2222C–PC: Same as 2222A–PC.

2226–PC: St. Louis Limestone. 0.75 mi (1.2 km) north of Big Creek School, probably in SE¼ sec. 21, T. 11 S., R. 8 E., Equality quadrangle, Hardin County, Ill. Collected by Charles Butts, 1916. See Weller (1920, pl. 1) for geologic map of the area.

2333–PC: St. Louis Limestone. Near top of divide near Allen Springs, 8 to 10 mi (12.8 to 16 km) northwest of Scottsville, Allen Springs

quadrangle, Allen County, Ky. Collected by E. W. Shaw, 1917. See Moore (1963) for geologic map of the area.

3024-PC: Little Flat Formation (Mamet foraminifer Zone 14). NW¼ sec. 13, T. 7 S., R. 40 E., altitude 6,650 ft (2,015 m), Henry quadrangle, Caribou County, Idaho. Collected by P. V. Roundy, June 29, 1916. This locality is mapped as Brazer Limestone by Mansfield (1927, pl. 3). Megafossils in the collection indicate Zone E of Sando and others (1969), and microfossils are Mamet Zone 14.

3159-PC: Newman Limestone, at base. 1.5 (2.4 km) mi northeast of Cleveland, Carbo quadrangle (7 1/2-minute), Russell County, Va. Collected by Charles Butts, March 1912. See Campbell (1899) for geologic map of the area.

3282-PC: Hillsdale Member of Greenbrier Limestone, lower 50–75 ft (15-23 m). In low hills and flats of the "little levels" within 1 mi (1.6 km) west and southwest of Mill Point, Marlintown quadrangle (15-minute), Pocahontas County, W. Va. Collected by W. A. Price and G. H. Girty, September 23, 1920. See Price (1929) for geologic map of the area and Girty (1923, p. 456) for faunal list and description of the locality. The collection contains corals, bryozoans, and brachiopods listed by Girty.

3283-PC: Hillsdale Member of Greenbrier Limestone, lower 70 ft (21.2 m). Limestone ledges at Mill Point in small hill (altitude 2,260–2,330 ft, 685–706 m) just north of residence of Mr. Wallace, east of Stamping Creek and north of highway from Mill Point to Buckeye, Marlinton quadrangle (15-minute), Pocahontas County, W. Va. Collected by W. A. Price and G. H. Girty, September 22, 1920. See 3282-PC for further information on this locality.

3290-PC: Lodgepole Limestone, Woodhurst Member (Zone C_1 of Sando and others, 1969). Near Lime Spur, probably in sec. 17, 18, 19, or 20, T. 1 N., R. 2 W., Jefferson Island quadrangle, Jefferson or Madison County, Mont. Collected by D. C. Bard. See Chelini (1965, fig. 5) for geologic map of the area. Collection contains megafossils that indicate Zone C_1 of Sando and others (1969) and algae that indicate Mamet Zones 7–8.

3747C-PC: Peratrovich Formation, limestone and chert member (upper Meramecian). South shore of Shelikof Island at entrance to Soda Bay, about on parallel 55°15′, southeastern Alaska. Collected by G. H. Girty, June 9, 1918. See Armstrong (1970a, p. 29–31) for discussion.

3760-PC: Peratrovich Formation, limestone and chert member (upper Meramecian). West end of south shore of Madre de Dios Island, southeastern Alaska. Collected by G. H. Girty, June 18, 1918. See Armstrong (1970a) for discussion.

3856-PC (green label): McCloud Limestone (Lower Permian). Crest of Limestone ridge 0.5 mi (0.8 km) north of James ranch in NE ¼ sec. 22, T. 33 N., R. 4 W., Redding quadrangle, Shasta County, Calif. Collected by J. S. Diller, July 5, 1902. The occurrence of *Heterocaninia? gabbi* (Meek) and *Omphalotrochus whitneyi* (Meek) in the collection confirm the McCloud assignment.

3858-PC (green label): McCloud Limestone (Lower Permian). 1 mi (1.6 km) northwest of Lillienthal, probably in NE ¼ sec. 27, T. 33 N., R. 4 W., Redding quadrangle, Shasta County, Calif. Collected by Stanton and Richardson, July 8, 1902. The locality was mapped as McCloud Limestone by Diller (1906). The only other fossil in the collection is *Heritschioides*? sp. The locality number was erroneously given as 3859 by Hayasaka (1936, p. 64).

3864-PC: Float from Lodgepole Limestone, Woodhurst Member (Zone C_1 of Sando and others, 1969). Unknown canyon on south side of Little Rocky Mountains, Phillips County(?), Mont. See Knechtel (1959, pl. 52) for geologic map of the area.

The stratigraphic level assigned to this locality is the only one in which corals of this kind occur in the Little Rocky Mountains. The canyon in which the specimen was found was said to be the one containing the powerline to Zortman, but on recent maps of the area, I can find no powerline shown in any of the canyons on the south side of the Little Rocky Mountains.

3890-PC (green label): McCloud Limestone (Lower Permian). Summit of Gray Rock Ridge northwest of road above Black Diamond mine, probably in NE¼ sec. 5, T. 33 N., R. 4 W., Redding quadrangle, Shasta County, Calif. Collected by Storrs and Washburne. See Diller (1906) for geologic map of the locality. Brachiopods in the collection indicate a Permian age. The locality number was erroneously given as 3896 by Hayasaka (1936, p. 64).

3946-PC (green label): Probably from St. Louis Limestone of the Mississippi Valley region. The specimen was said to come from the Santa Anna Mountains, Orange County, Calif., which is an area of post-Paleozoic rocks. It is a museum specimen attributed to Dr. Steven Bowen of Los Angeles, Calif. The specimen has all the characteristics of corals that are abundant in the St. Louis Limestone of the Mississippi Valley region. The locality number was erroneously given as 3446 by Hayasaka (1936, p. 61).

4801H-PC (green label): Little Flat Formation (Member B of Brazer Limestone of Mullens and Izett, 1964). Probably in sec. 30, T. 10 N., R. 2 E., Paradise quadrangle, Cache County, Utah. Collected by E. M. Kindle, August 12, 1907.

This specimen was erroneously attributed by Hayasaka (1936, p. 66) to USGS Mesozoic loc. 4801H, which is from the Monte de Oro Formation (Upper Jurassic), "western portion of the Oroville plant beds, north side of Feather River, 3 to 4 mi above Oroville, California." Foraminifera in the specimen are Mamet Zones 13–15 (probably 14) and are Western United States species.

5892-PC: Madison Limestone (Zone C_1 of Sando and others, 1969). Ridge west of Holiday Park, probably in sec. 26, 34, or 35, T. 1 N., R. 8 E., Coalville quadrangle, Summit County, Utah. The collection contains megafossils that indicate Zone C_1 of Sando and others (1969).

5893-PC: Little Flat Formation (Member B of the Brazer Limestone of Mullens and Izett, 1964). Probably in sec. 5 or 6, T. 9 N., R. 2 E., Paradise Canyon, Paradise quadrangle, Cache County, Utah. Collected by E. Finch. The collection contains *Faberophyllum* sp. (Zone F of Sando and others, 1969) and foraminifers of Mamet Zone 14.

5894-PC: Float probably from lower part of the Mission Canyon Limestone (Zone C_2 of Sando and others, 1969). Crest of ridge east of Old Baldy at altitude of about 9,000 ft (2,727 m), probably in sec. 26 or 27, T. 7 S., R. 3 W., Varney quadrangle, Madison County, Mont. Collected by R. W. Richards. See Hadley (1969) for geologic map of the area.

7130B-PC: Cobble in river wash derived probably from the Alapah Limestone. Along Hulahula River, Mount Michelson quadrangle, northeastern Alaska. Collected by E. de K. Leffingwell, February 1908.

7452-PC (green label): "Wells" Formation (this may actually be a Mississippian unit related to the Humbug Formation). South end of Cokeville Butte, just west of phosphate mine 1.5 mi (2.4 km) northeast of Cokeville, probably in NW¼ sec. 4, T. 24 N., R. 119 W., Cokeville quadrangle, Lincoln County, Wyo. Collected by G. H. Girty, July 22, 1909. Foraminifers in the specimen are Mamet Zones 18–20.

LOCALITY DATA FOR USNM SPECIMENS NOT HAYASAKA TYPES

USNM No.	Stratigraphic unit	Locality
	Acrocyathus floriformis floriformis	
13669	St. Louis Limestone _____	Mt. Pleasant Iowa
71646	St. Louis Limestone _____ [equivalent].	Rainbow Mountain, Ala.
216206	St. Louis Limestone _____	Livingston, Tenn.
	Acrocyathus floriformis hemisphaericus	
8211	St. Louis Limestone _____	Monroe County, Ind.
98102	St. Louis Limestone _____ [equivalent].	1.25 mi (2 km) north of Cleveland, Va.

LOCALITY DATA FOR USNM SPECIMENS NOT HAYASAKA TYPES—Continued

USNM No.	Stratigraphic unit	Locality
	***Acrocyathus floriformis* subspecies undet.**	
756	St. Louis Limestone	St. Francisville, Mo.
3779	Lower Carboniferous	Sugar Creek, Iowa
15526	do	Near Prairie du Rocher, Ill.
17071	do	Clear Springs, Harrison County, Ind.
17848	St. Louis Limestone	Kentucky
37466	do	St. Louis, Mo.
39654	do	Elizabethtown, Ky.
42695	do	Eddyville, Ky.
42766	do	Clarksville, Tenn.
135092	do	Monroe County, Ind.
135094	do	Weaver's Branch of Des Moines River, near St. Francisville, Clark County, Mo.
135096	do	Livingston, Tenn.
135097	do	Do.
135172	do	Do.
135173	do	Hillside north of South Fork of Holston River, 5 mi (8 km) north of Kingsport, Tenn.
135174	Mississippian	Millpoint, Pocahontas County, W. Va.
135177	St. Louis Limestone	Iowa
135179	do	Horse and Muddy Creeks, Dade County, Mo.
135300	Mississippian	Elgin, Ill
135301	do	Caney Fork River, Dekalb County, Tenn.
135302	St. Louis Limestone	Livingston, Tenn.
136704	do	Do.
166604	Mississippian	Franklin, Ky.
166605	do	Do.
216198	St. Louis Limestone	1 mi (1.6 km) west of Red Hill Post Office, Marshall, County, Ala.
216199	do	River bluff 1 mi (1.6 km) south of Maeystown, Ill.
216200	do	Do.
216202	do	Rock Creek, Hancock County, Ill.
216203	Mississippian	Bloomington, Ind.
216204	do	Slick Rock Creek, Barren County, Ky.
216205	St. Louis Limestone	2 mi (3.2 km) west of Ste. Genevieve, Mo.
216207	do	Livingston, Tenn.
216208	do	Do.
216210	Mississippian	Near Forbuss, Fentress County, Tenn.
216211	do	About 1 mi (1.6 km) east of Little Crab, Standingstone quadrangle, Tennessee
216212	Greenbrier Limestone	0.5 mi (0.8 km) southeast of Shrader, Pounding Mill quadrangle, Virginia
216214	do	Millpoint, Pocahontas County, W. Va.
	Acrocyathus proliferus	
841	St. Louis Limestone	Hardin County, Ill.
4587	Mississippian	Gallatin County, Ill.
37469	St. Louis Limestone	Marion, Ky.
37470	Mississippian	Saginaw Bay, Mich.
37471	do	Belleview, Mich.
39655	St. Louis Limestone	Elizabethtown, Ky.
42667	do	Eddyville, Ky.
42705	do	Do.
42714	do	Clarksville, Tenn.

LOCALITY DATA FOR USNM SPECIMENS NOT HAYASAKA TYPES—Continued

USNM No.	Stratigraphic unit	Locality
	***Acrocyathus proliferus*—Continued**	
42845	do	Scott County, Ill.
49941	do	Clarksville, Tenn.
49942	do	Eddyville, Ky.
52681	Mississippian	Hardin County, Ky.
60306	St. Louis Limestone	Eddyville, Ky.
71647	St. Louis Limestone [equivalent].	Blount Springs, Bount County, Ala.
135085	Hillsdale Member of the Greenbrier Limestone.	Opposite Bishop High School on Virginia Highway 16, Tazewell County, Va.
135087	St. Louis Limestone	1 mi (1.6 km) east of Rockwell, Ky.
135091	St. Louis Limestone [equivalent].	2.5 mi (4 km) southeast of Bandy, Pounding Mill quadrangle, Virginia
135095	St. Louis Limestone	Eddyville, Ky.
135098	do	St. Francisville, Mo.
135168	do	0.75 mi (1.2 km) east of Columbia, Ill.
135176	do	Eddyville, Ky.
216201	do	Maeystown, Ill.
216207	do	Livingston, Tenn.
216209	do	do.
216213	Greenbrier Limestone	Right river cut, 1 mi. (1.6 km) northeast of Cedar Bluff, Va.
239233	St. Louis Limestone	2 mi (3.2 km) northeast of Mills Springs, Ky.

REFERENCES CITED

Allen, A. T., Jr., and Lester, J. G., 1954, Contributions to the paleontology of northwest Georgia: Georgia Geological Survey Bulletin 62, 166 p., 42 pls.

Armstrong, A. K., 1962, Stratigraphy and paleontology of the Mississippian System in southwestern New Mexico and adjacent southeastern Arizona: New Mexico Bureau of Mines and Mineral Resources Memoir 8, 99 p., 12 pls., 41 figs.

———1970a, Mississippian rugose corals, Peratrovich Formation, west coast, Prince of Wales Island, southeastern Alaska: U.S. Geological Survey Professional Paper 534, 44 p., 13 pls., 30 figs.

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

———1972a, Biostratigraphy of Mississippian lithostrotionoid corals, Lisburne Group, arctic Alaska: U.S. Geological Survey Professional Paper 743-A, 28 p., 9 pls., 25 figs.

———1972b, Pennsylvanian carbonates, paleoecology, and rugose colonial corals, north flank, eastern Brooks Range, arctic Alaska: U.S. Geological Survey Professional Paper 747, 21 p., 8 pls., 16 figs.

Bamber, E. W., 1961, Mississippian corals from northeastern British Columbia, Canada: Princeton, N.J., Princeton University, Ph.D. thesis, 199 p., 14 pls., 1 fig.

———1966, Type lithostrotionid corals from the Mississippian of western Canada: Canada Geological Survey Bulletin 135, 28 p., 4 pls.

Bamber, E. W., and Macqueen, R. W., 1979, Upper Carboniferous and Permian stratigraphy of the Monkman Pass and southern Pine Pass areas, northeastern British Columbia: Canada Geological Survey Bulletin 301, 27 p., 40 figs.

Barrois, Charles, 1882, Récherches sur les terrains anciens des Asturies et de la Galice: Société Géologique du Nord Mémoire, v. 2, no. 1, 630 p., 20 pls.

Bassler, R. S., 1950, Faunal lists and descriptions of Paleozoic corals: Geological Society of America Memoir 44, 315 p., 20 pls.

Bolkhovitinova, M. A., 1915, O Kamennougol'nykh korallakh i mshannakh Moskovskoi gubernii [On Carboniferous corals and Bryozoa of Moscow province]: Obshchestvo Lyubitelei Estestvoznaniya Antropologii i Etnografii, Moscow, Geologicheskoe Otdelenie Zapiski, v. 3, p. 61-81, pls. 5, 6.

Boule, Marcellin, and others, 1906, 1907, Types du Prodrome de paléontologie stratigraphique universelle: Annales de Paléontologie, v. 1, pl. 6 (1906); v. 2, p. 89–96, pls. 7, 8 (1907).

———1923, Types du Prodrome de paléontologie stratigraphique universelle d'Alcide d'Orbigny: Paris, v. 1, 203 p., 21 figs., 34 pls.

Bowsher, A. L., 1961, The stratigraphic occurrence of some Lower Mississippian corals from New Mexico and Missouri: Journal of Paleontology, v. 35, no. 5, p. 955–962, pls. 109, 110, 3 figs.

Brindle, J. E., 1960, Mississippian megafaunas in southeastern Saskatchewan: Saskatchewan Department of Mineral Resources Report 45, 107 p., 29 pls., 4 figs.

Bul'vanker, E. Z., Vasilyuk, N. P., Zheltongova, V. A., Zhizhina, M. S., Nikolaeva, T. V., Spasskiy, N. Ya., and Shchukina, V. Ya., 1960, Novye predstaviteli chetyrekhluchevykh korallov SSSR [New representatives of tetraradiate corals in the USSR], *in* Markovskiy, B. P., ed., Novye vidy drevnikh rasteniy i bespozvonochnykh SSSR [New species of ancient plants and invertebrates from USSR]: Moscow, Vsesoyuznyy Nauchno-Issledovatel'skiy Geologicheskiy Institut (VSEGEI), p. 220–254, pls. 44–61.

Butts, Charles, 1917, Descriptions and correlation of theMississippian formations of western Kentucky: Frankfort, Ky., Kentucky Geological Survey, 119 p.

———1926, Geology of Alabama—The Paleozoic rocks: Alabama Geological Survey Special Report 14, p. 41–230, pls. 3–76.

———1941, Geology of the Appalachian Valley in Virginia—Pt. 2, Fossil plates and descriptions: Virginia Geological Survey Bulletin 52, pt. 2, 271 p., 135 pls.

Campbell, M. R., 1897, Description of the Tazewell quadrangle [Va.-W. Va.]: U.S. Geological Survey Geologic Atlas, Folio 44, 6 p., maps.

———1899, Description of the Bristol quadrangle [Va.-Tenn.]: U.S. Geological Survey Geologic Atlas, Folio 59, 8 p., maps.

Carlson, K. J., 1964, Corals of the Gilmore City Limestone (Mississippian) of Iowa: Journal of Paleontology, v. 38, no. 4, p. 662–666, pls. 109, 110.

Castelnau, Francis de, 1843, Essai sur le système Silurien de l'Amérique septentrionale: Paris, 56 p., 27 pls.

Chapman, E. J., 1893, On the corals and coralliform types of Palaeozoic strata: Royal Society of Canada Proceedings and Transactions, v. 10, sec. 4, p. 39–48.

Chelini, J. M., 1965, Limestone, dolomite, and travertine in Montana: Montana Bureau of Mines and Geology Bulletin 44, 53 p., 15 figs.

Chi, Y. S., 1931, Weiningian (Middle Carboniferous) corals of China: Palaeontologica Sinica, ser. B., v. 12, no. 5, 70 p., 5 pls.

Cotton, Geoffrey, 1973, The rugose coral genera: Amsterdam, Elsevier, 358 p.

———1974, The rugose coral genera, Supplement 1: Kidderminster, England, privately published, 35 p.

Crickmay, C. H., 1955, The Minnewanka section of the Mississippian [Alberta]: Calgary, Alberta, Imperial Oil, Ltd., 14 p., 2 pls., 3 charts. (Reprinted with emendations, 1961.)

Davis, D. E., 1956, A taxonomic study of the Mississippian corals of central Utah: Brigham Young University Research Studies, Geology Series, v. 3, no. 5, 49 p., 4 pls., 3 figs.

Degtyarev, D.D., 1973, Novyye vidy korallov Zapadnoural'skogo (uglenoskogo) gorizonta Urala [New species of corals from the Zapadnouralsk (coral-bearing) horizon of the Urals]: Akademiya Nauk SSSR, Uralskiy Nauchnyi Tsentr, Instituta Geologii i Geokhimii Trudy, v. 82, p. 191–205, 5 pls.

Diller, J. S., 1906, Description of the Redding quadrangle [Calif.]: U.S. Geological Survey Geologic Atlas, Folio 138, 14 p., maps.

Dobrolyubova, T. A., 1935a, Opredelitel' kolonial'nykh korallov Rugosa Srednego Karbona Podmoskovnogo Basseina [Determinant of Middle Carboniferous colonial Rugosa corals of the Moscow Basin]: Moscow, Vsesoyuznyy Nauchno-Issledovatel'skiy Institut Mineral'nogo Syriya, 14 p.

———1935b, Kolonial'nye korally Rugosa Srednego Karbona Podmoskovnogo basseina [Rugosa colonial corals in the Middle Carboniferous of the Moscow basin]: Vsesoyuznyy Nauchno-Issledovatel'skiy Institut Mineral'nogo Syriya Trudy, no. 81, 46 p., 14 pls. (English summary.)

———1936a, Korally Verkhnego Karbona zapadnogo sklona srednego Urala i ikh stratigraficheskoe znachenie [Corals of the Upper Carboniferous of the western slope of the middle Urals and their stratigraphic importance]: Vsesoyuznyy Nauchno-Issledovatel'skiy Institut Mineral'nogo Syriya Trudy, no. 103, 68 p., 37 pls. (English summary.)

———1936b, Korally Rugosa srednego i verkhnego Karbona i nizhney permi Severnogo Urala [Rugosa corals of the middle and upper Carboniferous and Lower Permian of the north Urals]: Akademiya Nauk SSSR, Polyarnaya Komissiya Trudy, no. 28, p. 77–158, 81 figs. (English summary.)

———1952, Formoobrazovanie u Nizhnekammenougol'nykh korallov *Lithostrotion* i *Lonsdaleia* v svete Michurinskogo ucheniya [Morphologic development of the lower Carboniferous corals *Lithostrotion* and *Lonsdaleia* in view of the Michurin school]: Akademiya Nauk SSSR, Izvestiya, Seriya Biologicheskaya, no. 6, p. 95–110, 8 figs.

Dobrolyubova, T. A., and Kabakovich, N. V., 1962, Tip Coelenterata. Kishechnopolostnye [Phylum Coelenterata], *in* Khalfin, L. L., ed., Biostratigrafiya Paleozoya Sayano-Altaiskoy gornoy oblasti, Tom 3, Verkhniy Paleozoy [Paleozoic biostratigraphy of the Sayano-Altai mountainous region, v. 3, Upper Paleozoic]: Sibirskii Nauchno-Issledovatel'skiy Institut Geologii, Geofiziki, i Mineral'nogo Syriya (SNIIGGIMS), Trudy, no. 21, p. 115–124, pls. C–3 to C–5.

———1966, Chetyrekhluchevye korally Nizhnego Karbona Kuznetskoy kotloviny [Tetracorals from the lower Carboniferous of the Kuznetsk basin], *in* Dobrolyubova, T. A., Kabakovich, N. V., and Sayutina, T. A., Korally Niznego Karbona Kuznetskoy kotloviny [Corals from the lower Carboniferous of the Kuznetsk basin]: Akademiya Nauk SSSR, Paleontologicheskiy Institut Trudy, v. 111, p. 5–198, pls. 1–36, figs. 1–16.

Easton, W. H., 1944, Corals from the Chouteau and related formations of the Mississippi Valley region: Illinois State Geological Survey Report of Investigations 97, 93 p., 17 pls.

———1958, Mississippian corals from northwestern Sonora, Mexico, *in* Easton, W. H., and others, Mississippian fauna in northwestern Sonora, Mexico: Smithsonian Miscellaneous Collections, v. 119, no. 3, p. 1-40, 2 pls., 3 figs.

———1960, Permian corals from Nevada and California: Journal of Paleontology, v. 34, no. 3, p. 570–583, 18 figs.

———1963, Additional comments on species of *Lithostrotionella*: Journal of Paleontology, v. 37, no. 1, p. 297–298.

———1973, On the tetracorals *Acrocyathus* and *Lithostrotionella* and their septal morphology: Journal of Paleontology, v. 47, no. 1, p. 121–135, 1 pl.

Easton, W. H., and Gutschick, R. C., 1953, Corals from the Redwall Limestone (Mississippian) of Arizona: Southern California Academy of Science Bulletin, v. 52, pt. 1, p. 1–27, 3 pls., 2 figs.

Eichwald, Eduard von, 1861, Paleontologiya Rossii. Drevniy period: St. Petersburg, 520 p.

Etheridge, Robert, Jr., 1900, Corals from the Coral Limestone of Lion Creek, Stanwell, near Rockhampton: Queensland Geological Survey Bulletin 12, p. 5–24, pls. 1, 2.

Fedorowski, J., and Gorianov, V. B., 1973, Redescription of tetracorals described by E. Eichwald in "Palaeontology of Russia": Acta Palaeontologica Polonica, v. 18, no. 1, p. 3–70, 13 pls., 20 figs.

Fenneman, N. M., 1911, Geology and mineral resources of the St. Louis quadrangle, Missouri-Illinois: U.S. Geological Survey Bulletin 438, 73 p., 6 pls., 1 fig.

Fischer von Waldheim, Gotthelf, 1830, Oryctographie du gouvernement du Moscou: Moscow, A. Semen, 202 p., 62 pls. (2d ed., 1837).

Flügel, H. W., 1970, Bibliographie der paläozoischen Anthozoa (Rugosa, Heterocorallia, Tabulata, Heliolitida, Trachypsammiacea). Pt. 2, Index zur Bibliographie: Vienna, Österreichische Akademie der Wissenschaften, 323 p.

Fomichev, V. D., 1931, Novye dannye o Nizhne-Kammenougol'nykh korallakh Kuznetskogo basseina [New data on Lower Carboniferous corals of the Kuznetsk basin]: Russia, Geologo-Razvedochnoe Ob'edeneniya Trudy, no. 49, 80 p., 2 pls.

———1939, Tip Kishechnopolosnye Coelenterata [Phylum Coelenterata], *in* Gorskiy, I. I., Atlas rukovodyashchikh form iskopaemoy fauny SSSR, tom 5, Sredniy i Verkhniy otdely Kamennougol'noy Sistemy [Atlas of the leading forms of the fossil faunas of the USSR, v. 5, Middle and upper Carboniferous]: Tsentral'nyy Nauchno-Issledovatel'skiy Geologo-Razvedochnyy Institut (TSNIGRI), p. 50–64, pls. 6–11, figs. 10–12.

———1953, Korally Rugosa i stratigrafiya sredni- i verkhnekamennougolnykh i permskikh otlozhenii Donetskogo basseina [Rugose corals and stratigraphy of middle and upper Carboniferous and Permian deposits of Donetz basin]: Moscow, Vsesoyuznyy Nauchno-Issledovatel'skiy Geologicheskiy Institut (VSEGEI) Trudy, 622 p. (incl. pls., under separate cover, and geol. map).

———1955, Tip Coelenterata. Kishechnopolostnye [Phylum Coelenterata], *in* Khalfin, L. L., ed., Atlas rukovodyashchikh form iskopaemykh fauny i flory zapadnoy Sibiri [Atlas of the leading forms of fossil fauna and flora from western Siberia]: Zapadno-Sibiriskoe Geologicheskoe Upravlenie-Tomsky Politekhnicheskiy Institut, Moscow, Gosudarstvennoe Nauchno-Tekhnicheskoe Izdatel'stvo Literatur po Geologi i Okhvane Nedr, v. 1, p. 298–305, pls. 79, 80.

Fromentel, Édouard de, 1861, Introduction à l'étude des polypiers fossiles***: Paris, F. Savy, 357 p.

Gabounia, K. E., 1919, Materialy k izucheniyu fauny korallov iz Nizhne-kamennougel'nykh otlozheniy okolo derevin Royki po r. Tomi [Contribution to the study of the coral fauna from the Lower Carboniferous deposits around the village of Royka on the Tom River]: Russia, Geologicheskii Komitet, Zapadno-Sibirskoe Otdelenie Izvestiya, v. 1, no. 3, 48 p., 4 pls.

Garwood, E. J., 1912, The lower Carboniferous succession in the North-west of England: Geological Society of London Quarterly Journal, v. 68, p. 449–572, pls. 44–56.

Girty, G. H., 1923, Observations on the faunas of the Greenbrier limestone and adjacent rocks: West Virginia Geological Survey, Tucker County [Report], p. 450–488.

Gorskiy, I. I., 1935, Nekotorye Coelenterata iz nizhnekamennougol'nykh otlozheniy Novoi Zemli [Some Coelenterata from the lower Carboniferous beds of Novaya Zemlya]: Leningrad, Vsesoyuznyy Arkticheskii Institut Trudy, v. 28, 128 p., 12 pls., 27 figs. (English summary.)

———1938, Kammenougol'nye korally Novoi Zemli [Carboniferous corals from Novaya Zemlya], *in* Nalivkin, D. V., ed., Paleontologiya Sovetskoy Arktiki [Paleontology of the Soviet Arctic]: Leningrad, Vsesoyuznyy Arkticheskii Institut Trudy, v. 93, pt. 2, 221 p., 16 pls., 82 figs. (English summary.)

Groot, G. E. de, 1964, Rugose corals from the Carboniferous of northern Palencia (Spain): Leidse Geologische Mededalingen, v. 29, p. 1–123, pls. 1–26, figs. 1–39. (Preprint 1963.)

Grosch, Paul, 1909, Phylogenetische Korallenstudien (Die Axophylliden): Deutsche Geologische Gesellschaft Zeitschrift, v. 61, no. 1, p. 1–34, pl. 1, 11 figs.

Grote, A. R., 1883, Introduction to a study of North American Noctuidae: American Philosophical Society Proceedings, v. 21, p. 134–176.

Gualtieri, J. L., 1968, Geologic map of the Wildie quadrangle, Garrard and Rockcastle Counties, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ–684, scale 1:24,000.

Hadley, J. B., 1969, Geologic map of the Varney quadrangle, Madison County, Montana: U.S. Geological Survey Geologic Quadrangle Map GQ–814, scale 1:62,500.

Hall, James, and Whitney, J. D., 1858, Report on the geological survey of the State of Iowa, v. 1, pt. 2, Paleontology: [Albany, N.Y.], p. 473–724.

Hayasaka, Ichirô, 1936, On some North American species of *Lithostrotionella*: Taihoku Imperial University Memoir, v. 13, no. 5, Geology, no. 12, p. 47–73, 7 pls.

Heritsch, Franz, 1937, *Lithostrotionella stylaxis* Trautschold aus der arabischen Wüste: Naturwissenschaftlicher Verein für Steiermark, Mitteilungen, v. 74, p. 164–165, 1 fig.

———1939, Die Korallen des Jungpaläozoikums von Spitzbergen: Arkiv für Zoologie, v 31A, heft 3, no. 16, 138 p., 21 pls.

———1940, Korallen aus dem Karbon von Jugoslavien: Yugoslavia Service Géologique Royaume Bulletin, v. 8, p. 69–78, pl. 2.

Hill, Dorothy, 1938, A monograph on the Carboniferous rugose corals of Scotland, pt. 1: London, Palaeontographical Society, p. 1–78.

———1940, A monograph on the Carboniferous rugose corals of Scotland, pt. 3: London, Palaeontographical Society, p. 115–204, pls. 6–11.

———1956, Rugosa, *in* Moore, R. C., ed., Treatise on invertebrate paleontology, pt. F., Coelenterata: New York and Lawrence, Kans., Geological Society of America and University of Kansas Press, p. F233–F324.

Hinds, Henry, 1919, Description of the Colchester and Macomb quadrangles, Illinois: U.S. Geological Survey Geologic Atlas, Folio 208, 14 p., 14 figs., 4 maps.

Holtedahl, Olaf, 1913, Zur Kenntnis der Karbonablagerungen des westlichen Spitzbergens. II. Allgemeine stratigraphische und tecktonische Beobachtungen: Norske Videnskaps-Akademi Skrifter, Matematisk-naturvidenskapelig Klasse, 1912, no. 23, 91 p., 11 pls., 25 figs.

Huang, T. K., 1932, Permian corals of southern China: Palaeontologia Sinica, ser. B., v. 8, fasc. 2, 163 p.

Ivanovskiy, A. B., 1967, Etyudy o Rannekamennougol'nykh Rugozakh [Studies of Early Carboniferous Rugosa]: Moscow, Akademiya Nauk SSSR, Sibirskoye Otdeleniye, Institut Geologii i Geofiziki, 92 p., 22 pls., 22 figs.

———1975, Rugozy [Rugosa]: Moscow, Izdatel'stvo "Nauka", 121 p.

Jenney, W. P., 1894, The lead and zinc deposits of the Mississippi Valley: American Institute of Mining Engineers Transactions, v. 22, p. 171–225, 621–646.

Jones, O. A., 1929, On the coral genera *Endophyllum* Edwards and Haime and *Spongophyllum* Edwards and Haime: Geological Magazine, v. 66, no. 776, p. 84–91.

Kato, Makoto, 1963, Fine skeletal structures in Rugosa: Hokkaido University Faculty of Science Journal, ser. 4, v. 11, no. 4, p. 571-630, 3 pls., 19 figs.

———1966, Note on some Carboniferous coral genera: *Clisaxophyllum, Clisiophyllum (Neoclisiophyllum), Zaphrentoides,*

Stylidophyllum, and *Actinocyathus*: Japanese Journal of Geology and Geography, v. 37, nos. 2-4, p. 93-104.

Kelly, W. A., 1942, Lithostrotiontidae in the Rocky Mountains: Journal of Paleontology, v. 16, no. 3, p. 351-361, pls. 50, 51, 1 fig.

Keyes, C. R., 1894, Paleontology of Missouri, Pt. 1: Missouri Geological Survey, v. 4, 271 p., 32 pls.

Knechtel, M. M., 1959, Stratigraphy of the Little Rocky Mountains and encircling foothills, Montana: U.S. Geological Survey Bulletin 1072-N, p. 723-752, pl. 52, 53, figs. 32, 33.

Kolosváry, Gabor, 1951, Magyarország permokarbon koralljai [Permo-Carboniferous corals of Hungary]: Földtani Közlöny, v. 81, nos. 1-3, 4-6, p. 4-52, 171-185, pls. 1-19, 6 figs. (English summary.)

Koninck, L. G. de, 1872, Nouvelles recherches sur les animaux fossiles du terrain Carbonifère de la Belgique ***: Brussels, F. Hayez, 178 p.

Kozyreva, T. A., 1974, Novye korally roda *Petalaxis* (Rugosa) iz Bashkirskogo yarusa Voronezhskoy anteklizy [New corals of the genus *Petalaxis* (Rugosa) from the Bashkirian stage of the Voronezh anteclise]: Paleontologicheskiy Zhurnal, 1974, no. 3, p. 23-31, 2 pls.

Lambe, L. M., 1899, On some species of Canadian Paleozoic corals: Ottawa Naturalist, v. 12, p. 217-226, 237-258.

———1901, A revision of the genera and species of Canadian Palaeozoic corals; the Madreporaria Aporosa and the Madreporaria Rugosa: Canada Geological Survey, Contributions to Canadian Palaeontology, v. 4, pt. 2, p. 97-197.

Lang, W. D., Smith, Stanley, and Thomas, H. D., 1940, Index of Palaeozoic coral genera: London, British Museum, 231 p.

Langenheim, R. L., Jr., and others, 1960, Preliminary report on the geology of the Ely No. 3 quadrangle, White Pine County, Nevada, *in* Boettcher, J. W., and Sloan, W. W., eds., Guidebook to the geology of east central Nevada–Intermountain Association of Petroleum Geologists, 11th Annual Field Conference, 1960: Salt Lake City, Utah Geological and Mineralogical Survey, p. 148-156.

Lecompte, Marius, 1952, Madréporaires paléozoiques, *in* Pivetau, Jean, Traité de paléontologie, tome 1: Paris, Masson, p. 419-538, 75 figs.

Lindström, Gustaf, 1884, Index to the generic names applied to the corals of the Palaeozoic formations: Svenska Vetenskaps-Akademiens Handlingar, Bihang, v. 8 (1883-1884), no. 9, 14 p. [1883].

Lisitsyn, K. I., 1925, Podrazdeleniya Nizhnego Karbona i ikh korallavo-brakhiopodovaya fauna [Subdivisions of the Lower Carboniferous and their coral-brachiopod fauna]: Donskoi Politekhnicheskii Institut Izvestiya, v. 9, p. 54-68, 2 pls.

Lo, C. T., and Chao, C. M., 1962, [Lower Carboniferous tetracorals of the Chilien-shan (Tsinghai) district], *in* [Geology of Chilien-shan Mountains]: Peking, v. 4, no. 3, p. 111-199, pls. 1-30. (In Chinese.)

Mallock, J. R., 1929, Notes on Australian Diptera XX: Linnean Society of New South Wales Proceedings, v. 54, p. 283-343.

Mansfield, G. R., 1927, Geography, geology, and mineral resources of part of southeastern Idaho: U.S. Geological Survey Professional Paper 152, 409 p., 46 figs., 63 pls.

Martin, William, 1809, Petrificata derbiensia; or Figures and descriptions of petrifactions collected in Derbyshire: Wigan, D. Lyon, 102 p., 52 pls.

McCalley, Henry, 1896, Report on the valley regions of Alabama (Paleozoic strata). Part 1, on the Tennessee Valley region: Montgomery, Ala., Alabama Geological Survey, 436 p., 9 pls.

McCoy, Frederick, 1849, On some new genera and species of Palaeozoic corals and Foraminifera: Annals and Magazine of Natural History, 2d ser., v. 3, p. 1-20, 119-136.

McCutcheon, V. A., and Wilson, E. C., 1961, *Ptolemaia*, a new colonial coral from the Lower Permian of eastern Nevada and western Russia: Journal of Paleontology, v. 35, no. 5, p. 1020-1028, 1 pl., 3 figs.

———1963, *Kleopatrina*, new name for *Ptolemaia* McCutcheon and Wilson: Journal of Paleontology, v. 37, no. 1, p. 299.

McLaren, D. J., and Sutherland, P. K., 1949, *Lithostrotion* from northeast British Columbia and its bearing on the genomorph concept: Journal of Paleontology, v. 23, no. 6, p. 625-634, pl. 103, 4 figs.

Meek, F. B., 1864, Description of the Carboniferous fossils: California Geological Survey, Palaeontology, v. 1, sec. 1, p. 1-16, pls. 1, 2.

Merriam, C. W., 1942, Carboniferous and Permian corals from central Oregon: Journal of Paleontology, v. 16, no. 3, p. 372-381, pls. 54-57.

Milne-Edwards, H. M., 1860, Histoire naturelle des coralliaires, ou polypes proprement dits, V. 3: Paris, Roret, 560 p.

Milne-Edwards, H. M., and Haime, Jules, 1850, 1852, A monograph of the British fossil corals, Pts. 1 and 3: London, Palaeontographical Society, Pt. 1, p. 1-71, pls. 1-11; Pt. 3, p. 147-210, pls. 31-46.

———[1851?] Monographie des polypiers fossiles des terrains palaeozoiques: Paris, Gide et J. Baudry, 502 p., 14 pls. (Muséum d'Histoire Naturelle [Paris], Archives, v. 5.)

Minato, Masao, 1955, Japanese Carboniferous and Permian corals: Hokkaido University, Faculty of Science Journal, ser. 4, Geology and Mineralogy, v. 9, no. 2, 202 p., 43 pls., 24 figs. (Also pub. as: Hokkaido University, Faculty of Science, Dept. of Geology and Mineralogy Contribution 540.)

Minato, Masao, and Kato, Makoto, 1965, Durhaminidae (tetracoral): Hokkaido University, Faculty of Science Journal, ser. 4, Geology and Mineralogy, v. 13, no. 1, p. 13-86, pls. 1-5, figs. 1-24.

———1974, Upper Carboniferous corals from the Nagaiwa Series, southern Kitakami Mountains, N. E. Japan: Hokkaido University, Faculty of Science Journal, ser. 4, Geology and Mineralogy, v. 16, nos. 2-3, p. 43-119, 16 pls., 7 figs.

Moore, S. L., 1963, Geology of the Allen Springs quadrangle, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-285, scale 1:24,000.

Morse, W. C., 1930, Paleozoic rocks: Mississippi Geological Survey Bulletin 23, 212 p.

Mullens, T. E., and Izett, G. A., 1964, Geology of the Paradise quadrangle, Cache County, Utah: U.S. Geological Survey Bulletin 1181-S, 32 p., 1 pl., 1 fig.

Nations, J. D., 1963, Evidence for a Morrowan age for the Black Prince Limestone of southeastern Arizona: Journal of Paleontology, v. 37, no. 6, p. 1252-1264, pls. 175-177, 5 figs.

Nelson, S. J., 1960, Mississippian lithostrotionid zones of the southern Canadian Rocky Mountains: Journal of Paleontology, v. 34, no. 1, p. 107-126, pls. 21-25, 3 figs.

———1961, Reference fossils of Canada–Pt. 2, Mississippian faunas of western Canada: Geological Association of Canada Special Paper 2, 39 p., 29 pls., 7 figs.

———1962, *Lithostrotionella jasperensis* and synonyms: Journal of Paleontology, v. 36, no. 1, p. 170-171.

Nicholson, H. A., and Thomson, J., 1876, Descriptions of some new or imperfectly understood forms of Palaeozoic corals [abs.]: Royal Society of Edinburgh Proceedings 1875-1876, v. 9, no. 95, p. 149-150.

Onoprienko, Yu. I., 1970, K voprosu ob obshcheme roda *Lithostrotionella* Yabe et Hayasaka, 1915 [On the scope of the genus *Lithostrotionella* Yabe and Hayasaka, 1915]: Severo-vostochnoe Geologicheskoe Upravlenie (Magadan), Informatsionnoe Soobshchenie, no. 5, p. 3-6.

———1976, Rannekamennougol'nye kolonial'nye rugozy severo-vostoka SSSR [Early Carboniferous colonial Rugosa from the northeast U.S.S.R], *in* Petrashevskaya, V., ed., Morfologiya i systematika iskapaemykh bespozvonochnykh Dal'nego vostoka: Akademiya Nauk SSSR, Dal'nevostochnyy Nauchnyy Tsentr, Biologo-pochvennyy Institut Trudy, v. 42, no. 145, p. 5-34.

Orbigny, A. D., d', 1849a, Note sur des polypiers fossiles: Paris, Victor Masson, 12 p.

———1849b–1852, Prodrome de paléontologie stratigraphique universelle des animaux mollusques & rayonnés, faisant suite au Cours élémentaire de paléontologie et de géologie stratigraphiques: Paris, V. Masson, 3 v.

Osborn, H. F., 1908, New fossil mammals from the Fayûm Oligocene, Egypt: American Museum of Natural History Bulletin, v. 24, article 16, p. 265–272.

Owen, D. D., 1852, Report of a geological survey of Wisconsin, Iowa, and Minnesota, and incidentally of a portion of Nebraska Territory made under instructions from the United States Treasury Department: Philadelphia, 638 p., 15 pls.

Owen, Richard, 1862, Report of a geological reconnaissance of Indiana made during the years 1859 and 1860 under the direction of the late David Dale Owen, M.D.: Indianapolis, 368 p.

Parks, J. M., 1951, Corals from the Brazer Formation (Mississippian) of northern Utah: Journal of Paleontology, v. 25, no. 2, p. 171–186, pls. 29–33, 3 figs.

Phillips, John, 1836, Illustrations of the geology of Yorkshire; or, A description of the strata and organic remains accompanied by a geological map, sections, and diagrams, and figures of the fossils. Pt. 2, The mountain limestone district: London, J. Murray, 253 p.

Price, P. H., 1929, Pocahontas County: West Virginia Geological Survey, County Reports, 531 p., 71 pls., 21 figs., 2 maps.

Pyzh'anov, I. V., 1964, Novy rod chetyrekhluchevykh korallov iz srednekamennougol'nykh otlozheniy Darvaza [New genus of tetracorals from Middle Carboniferous beds of Darvaz]: Tadzhik SSR, Upravlenie Geologii i Okhrany Nedr, Trudy, Paleontologiya i Stratigrafiya, no. 1, p. 169–174.

Reuss, A. E., 1854, Beiträge zur Charakteristik der Kreideschichten in den Ostalpen, besonders im Gosauthale und am Wolfgangsee: Kaiserliche Akademie der Wissenschaften, Mathematisch-Naturwissenschaftliche Klasse, Denkshrift, v. 7, 156 p., 31 pls.

Richardson, G. B., 1941, Geology and mineral resources of the Randolph quadrangle, Utah-Wyoming: U.S. Geological Survey Bulletin 923, 55 p., 8 pls., 2 figs.

Roemer, Ferdinand, 1883, Lethaea geognostica. Theil 1. [Lethaea Palaeozoica]: Stuttgart, E. Schweizerbart, v. 1, pt. 2, p. 113–544.

Rominger, C. L., 1876, Paleontology–Fossil corals: Michigan, Geological Survey, v. 3, pt. 2, 161 p.

Ross, J. P., and Ross, C. A., 1963, Late Paleozoic rugose corals, Glass Mountains, Texas: Journal of Paleontology, v. 37, no. 2, p. 409–420, pls. 48–50, 2 figs.

Rukhin, L. B., 1938, Nizhnepaleozoyskie korally i stromatoporoidei verkhney chasti basseina r. Kolymy [Lower Paleozoic corals and stromatoporoids of the upper part of the Kolyma river basin]: Moscow, Gostrest Dal'stroy, Materialy po Kolymsko-Indigirskogo Kraya, Ser. 2, Geologii i Geomorfologii, no. 10, 119 p., 28 pls. (English summary.)

Sando, W. J., 1963, New species of colonial rugose corals from the Mississippian of northern Arizona: Journal of Paleontology, v. 37, no. 5, p. 1074–1079, 1 fig., pls. 145, 146.

———1969, Corals, Chap. 6 of McKee, E. D., and Gutschick, R. C., History of the Redwall Limestone of northern Arizona: Geological Society of America Memoir 114, p. 257–344, pls. 29–40, figs. 52–75.

———1975, Coelenterata of the Amsden Formation (Mississippian and Pennsylvanian) of Wyoming: U.S. Geological Survey Professional Paper 848-C, 31 p., 10 pls., 6 figs.

———1976, Revision of the Carboniferous genus *Aulina* Smith (Coelenterata, Anthozoa): U.S. Geological Survey Journal of Research, v. 4, no. 4, p. 421–435, 6 figs.

Sando, W. J., Bamber, E. W., and Armstrong, A. K., 1975, Endemism and similarity indices; clues to the zoogeography of North American Mississippian corals: Geology, v. 3, no. 11, p. 661–664, 8 figs.

———1977, The zoogeography of North American Mississippian corals, *in* Second International Symposium on Corals and Fossil Coral Reefs, Paris, 1975: [France], Bureau de Recherches Géologiques et Minières Mémoire 89, p. 175–184, 9 figs.

Sando, W. J., Dutro, J. T., Jr., and Gere, W. C., 1959, Brazer dolomite (Mississippian), Randolph quadrangle, northeast Utah: American Association of Petroleum Geologists Bulletin, v. 43, no. 12, p. 2741–2769, 5 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. Geological Survey Professional Paper 613-E, 29 p., 7 figs.

Sanford, W. G., 1939, A review of the families of tetracorals: American Journal of Science, v. 237, no. 5, p. 295–323; no. 6, p. 401–423, 16 figs.

Schmidt, H., 1929, Tierische Leitfossilien des Karbon, *in* Gurich, G., Leitfossilien: Berlin, v. 6, 107 p., 23 pls.

Shimer, H. W., 1926, Upper Paleozoic faunas of the Lake Minnewanka section, near Banff, Alberta: Canada Geological Survey Bulletin 42, p. 1–84, pls. 1–8, fig. 1.

Smith, Stanley, 1916, The genus *Lonsdaleia* and *Dibunophyllum rugosum* (McCoy): Geological Society of London Quarterly Journal, no. 282, v. 71, pt. 2, p. 218–272.

Smith, Stanley, and Yü, C. C., 1943, A revision of the coral genus *Aulina* Smith and descriptions of new species from Britain and China: Geological Society of London Quarterly Journal, no. 393–394, v. 99, pts. 1–2, p. 37–61.

Solov'eva, V. V., 1963, O mikrostruckture skeletnykh elementov nekotorykh Srednekamennougol'nykh rugoz podmoskov'ya [Microstructure of skeletal elements in certain Middle Carboniferous Rugosa from the Moscow area]: Paleontologicheskiy Zhurnal, 1963, no. 3, p. 113–116, 6 figs.

Soshkina, E. D., Dobrolyubova, T. A., and Kabakovich, N. V., 1962, Podklass Tetracoralla [Subclass Tetracoralla], *in* Orlov, Yu. A., ed., Osnovy paleontologii [Fundamentals of paleontology]: Akademiya Nauk SSSR, Ministerstvo Geologii i Okhrany Nedr SSSR, Ministerstvo Vysshego Obrazovaniya SSSR, v. 2, p. 286–356, 23 pls., 108 figs. (English translation published by Israel Program for Scientific Translations, 1971.)

Soshkina, E. D., Dobrolyubova, T. A., and Porfir'ev, G., 1941, Permskie Rugosa Evropeyskoy chasti SSSR [Permian Rugosa of the European part of the USSR], *in* Likharev, B. K., ed., Paleontologiya SSSR [Paleontology of the USSR], v. 5, pt. 3, no. 1: Akademiya Nauk SSSR, Paleontologicheskiy Institut, 304 p., 63 pls., 44 figs. (English summary.)

Stensaas, L. J., and Langenheim, R. L., Jr., 1960, Rugose corals from the Lower Mississippian Joana limestone of Nevada: Journal of Paleontology, v. 34, no. 1, p. 179–188, 10 figs.

Stuckenberg, A. A., 1888, Korally i mshanki verkhnego yarusa srednerusskogo Kamennougol'nogo izvestnyaka [Corals and Bryozoa from the upper part of the Middlerussian Carboniferous Limestone]: Russia Geologicheskiy Komitet Trudy, v. 5 (1888–1890), no. 4, 54 p., 4 pls. (German summary.)

———1895, Korally i mshanki Kamennougol'nykh otlozheniy Urala i Timana [Corals and Bryozoa from the Carboniferous deposits of the Urals and Timan]: Russia Geologicheskiy Komitet Trudy, v. 10 (1890–1895), no. 3, 244 p., 24 pls.

Sutherland, P. K., 1958, Carboniferous stratigraphy and rugose coral faunas of northeastern British Columbia: Canada Geological Survey Memoir 295, 177 p.

———1977, Analysis of the Middle Carboniferous rugose coral genus *Petalaxis* and its stratigraphic significance, *in* Second International Symposium on Corals and Fossil Coral Reefs, Paris, 1975:

[France] Bureau de Recherches Géologiques et Minières Mémoire 89, p. 185–189, 1 pl.

Tolmachev, I. P., 1924–1931, Nizhnekamennougol'naya fauna Kuznetskogo uglenosnogo basseina [Lower Carboniferous fauna of the Kuznetsk coal basin]: Russia, Geologicheskiy Komitet, Materialy po obschchei i prikladnoy geologii, no. 25, 2 v.: pt. 1, p. 1–320, 12 pls., 10 figs. (1924); pt. 2, p. 321–663, 11 pls., 1 fig. (1931).

———1933, New names for two genera of Carboniferous corals: Geological Magazine, v. 70, no. 6, p. 287.

Trautschold, H. A. von, 1879, Die Kalkbrüche von Mjatschkowa, eine Monographie des oberen Bergkalks. Schluss: Société Impériale des Naturalistes de Moscou, Nouveaux Mémoires, v. 14, p. 101–180, pls. 12–18. (Last of 3 pts. Pts. 1 (1874) and 2 (1876) pub. in v. 13.)

Ulrich, E. O., 1905, Geology and general relations, *in* Ulrich, E. O., and Smith, W. S. T., The lead, zinc, and fluorspar deposits of western Kentucky: U.S. Geological Survey Professional Paper 36, pt. 1, p. 7–105, pls. 1–7.

Vasilyuk, N. P., 1960, Nizhnekammenougl'nye korally Donetskogo basseina [Lower Carboniferous corals of the Donets basin]: Akademiya Nauk Ukrainskoy SSR, Institut Geogichnykh Nauk Trudy, Seriya Stratigrafii i Paleontologii, No. 13, 178 p., 42 pls.

———1964, Korally zon $C_1^{v}g$–$C_1^{n}a$ of the Donets basin, *in* Aizenverg, D. E., ed., Materialy k faune verkhnego paleozoya Donbassa [Contributions to the upper Paleozoic fauna of the Donbass]: Akademiya Nauk Ukrainskoy SSR, Institut Geologichnykh Nauk Trudy, Seriya Stratigraffi i Paleontologii, No. 48, p. 60–103, pls. 1–8. (In Ukrainian.)

Vaughan, Arthur, 1905, The palaeontological sequence in the Carboniferous Limestone of the Bristol area: Geological Society of London Quarterly Journal, v. 61, p. 181–305.

———1906, The Carboniferous Limestone Series (Avonian) of the Avon Gorge: Bristol Naturalists' Society Proceedings, ser. 4, v. 1, pt. 2, p. 74–168, pls. 1–16.

Wang, H. C., 1950, A revision of the Zoantharia Rugosa in the light of their minute skeletal structures: Royal Society of London Philosophical Transactions, Ser. B, Biological Science, no. 611, v. 234, p. 175–246, pls. 4–8, figs. 76–79.

Warren, P. S., 1927, Banff area, Alberta: Canada Geological Survey Memoir 153, 94 p., 3 pls., 1 fig.

Weller, J. M., 1931, Mississippian fauna: Kentucky Geological Survey Ser. 6, v. 36, p. 249–290, 12 pls., 1 fig.

Weller, J. M., Grogan, R. M., and Tippie, F. E., 1952, Geology of the fluorspar deposits of Illinois: Illinois State Geological Survey Bulletin 76, 147 p.

Weller, Stuart, 1898, A bibliographic index of North American Carboniferous invertebrates: U.S. Geological Survey Bulletin 153, 653 p.

Weller, Stuart, with collaboration of Butts, Charles, Currier, L. W., and Salisbury, R. D., 1920, The geology of Hardin County: Illinois State Geological Survey Bulletin 41, 416 p., 11 pls., 30 figs.

Weller, Stuart, and St. Clair, Stuart, 1928, Geology of Ste. Genevieve County, Missouri: Missouri Bureau of Geology and Mines, 2d ser., v. 22, 352 p., 5 figs., 25 pls., 2 maps.

White, C. A., 1880a, Contributions to invertebrate paleontology no. 8: Fossils from the Carboniferous rocks of the Interior States: U.S. Geological and Geographical Survey of the Territories (Hayden), Annual Report 12, pt. 1 (1883, advance printing 1880), p. 155–171, pls. 39–42.

———1880b, Fossils of the Indiana rocks: Indiana Department of Statistics and Geology, Annual Report 2, p. 471–522.

———1882, Fossils of the Indiana rocks, no. 2: Indiana Department of Geology and Natural History, Annual Report 11, p. 347–401.

Wilmarth, M. G., 1938, Lexicon of geologic names of the United States (including Alaska): U.S. Geological Survey Bulletin 896, 2v. 2,396 p.

Wilson, E. C., and Langenheim, R. L., Jr., 1962, Rugose and tabulate corals from Permian rocks in the Ely quadrangle, White Pine County, Nevada: Journal of Palentology, v. 36, no. 3, p. 495–520, pls. 86–89, 4 figs.

Wilson, M. E., 1922, The occurrence of oil and gas in Missouri: Missouri Bureau of Geology and Mines, 2d ser., v. 16, 284 p., 11 pls.

Wu, W. S., 1964, [Lower Carboniferous corals in central Hunan]: Academia Sinica, Institute of Geology and Palaeontology, Memoir 3, p. 1–100, pls. 1–16 (In Chinese, English summary.)

Wu, W. S., and Zhao, J. M., 1974, [Carboniferous corals] *in* [Handbook of the stratigraphy and paleontology of southwest China]: Nanking Institute of Geology and Paleontology, Academia Sinica, p. 265–273. (In Chinese.)

Yabe, Hisakatsu, and Hayasaka, Ichirô, 1915, Palaeozoic corals from Japan, Korea, and China: Geological Society of Tokyo Journal, v. 22, p. 55–70, 79–92, 93–109, 127–142.

———1920, Paleontology of southern China: Tokyo, Tokyo Geographical Society, 221 p., 27 pls. (in portfolio).

Yamagiwa, Nobuo, 1961, The Permo-Carboniferous corals from the Atetsu Plateau and the coral faunas of the same age in southwest Japan: Osaka University, Liberal Arts and Education Memoir, Ser. B, Natural Science, no. 10, p. 77–114, 8 pls., 2 figs.

Yanishevskiy, M. E., 1900, Fauna Kamennougol'nogo izvestnyaka vystupayushchego po r. Shartymke na vostochnom sklon Urala [Fauna of the Carboniferous Limestone along the Sartymka River on the west slope of the Urals]: Kazan Universitet, Obshchestvo Estestvoispytatelei Trudy, v. 34, no. 5, p. 1–379, 7 pls. (German summary.)

Yoh, S. S., 1961, On some new tetracorals from the Carboniferous of China: Acta Palaeontologica Sinica, v. 9, no. 1, p. 1–17, pls. 1–3. (In Chinese, English summary.)

Yoh, S. S., and Huang, T. K., 1932, The coral fauna of the Chihsia Limestone of the lower Yangtse Valley: Palaeontologia Sinica, ser. B., v. 8, pt. 1, p. 1–72, pls. 1–10.

Yokoyama, Tsuruo, 1957, Notes on some Carboniferous corals from Taishaku district, Hiroshima prefecture, Japan: Hiroshima University, Journal of Science, Ser. C (Geology), v. 2, no. 1, p. 73–82, pls. 10–12, 2 figs.

Yü, C. C., 1933, Lower Carboniferous corals of China: Palaeontologia Sinica, Ser. B, v. 12, fasc. 3, 211 p., 24 pls. [1934]

———1962, [Revision of some Permo-Carboniferous rugose corals]: [Changchun Geological Academy 10th Anniversary Science Papers], p. 1–11. (In Chinese.)

Yü, C. C., Lin, I. D., and Fan, Y. N., 1962, [The rugose corals of the Permo-Carboniferous Periods in Sinkiang and Chinghai (Tsinghai) Provinces]: [Changchun Geological Academy, 10th Anniversary Science Paper], p. 13–35, pls. 1–4 (In Chinese.)

Yü, C. M., Wu, W. S., Chao, C. M., and Chang, C. C., 1963, [Fossil corals of China]: Peking, 390 p., 98 pls. (In Chinese.)

Zhizhina, M. S., 1956, Semeystvo Lithostrotionidae Grabau, *in* Kiparisova, L. D., Markovskiy, B. P., and Radchenko, G. P., eds., Materialy po paleontologii; novye semeistva i rody [Contributions to paleontology; new families and genera]: Vsesoyuznyy Nauchno-Issledovatel'skiy Geologicheskiy Institut (VSEGEI), Materialy po paleontologii, novaya seriya, no. 12, p. 39–41, pl. 9.

INDEX

[Italic page numbers indicate major references]

PLATES 1-20

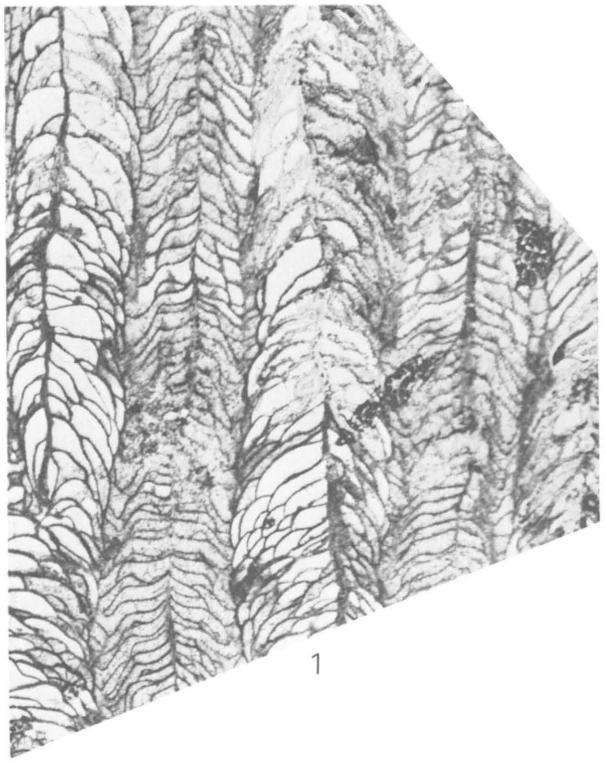
Contact photographs of the plates in this report are available, at cost, from U.S. Geological Survey Library, Federal Center, Denver, Colorado 80225

PLATE 1

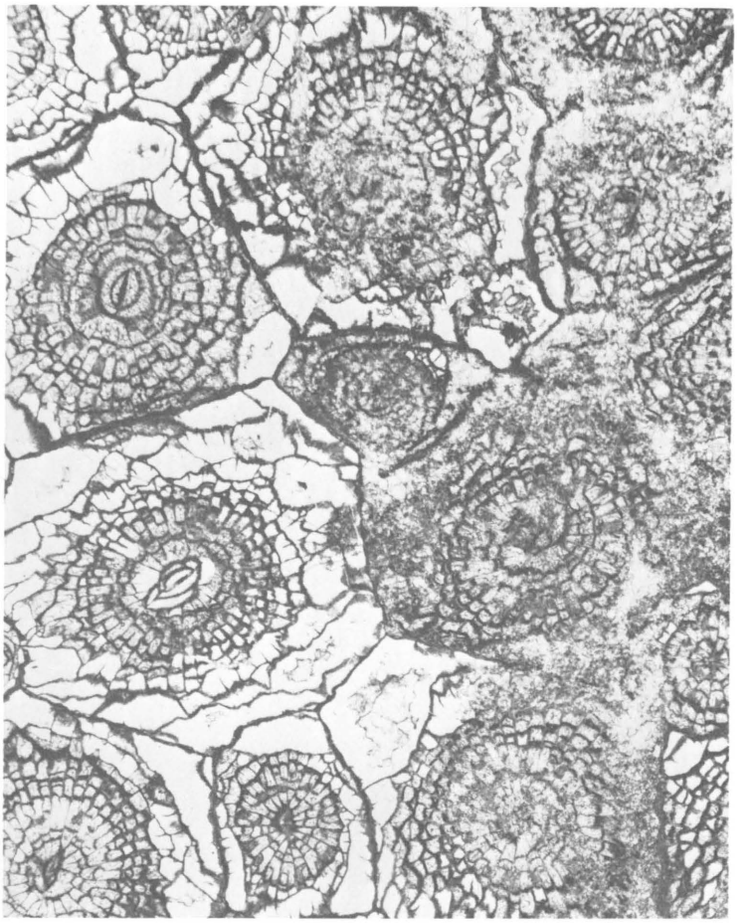
[All figures × 4]

FIGURES 1, 2. *Stelechophyllum microstylum* (White) (p. 11).
USNM 120244 (holotype of *Lithostrotionella multiradiata* Hayasaka). USGS loc. 490–PC, Lodgepole Limestone, Utah.
1. Longitudinal thin section, USNM 120244b.
2. Transverse thin section, USNM 120244a.

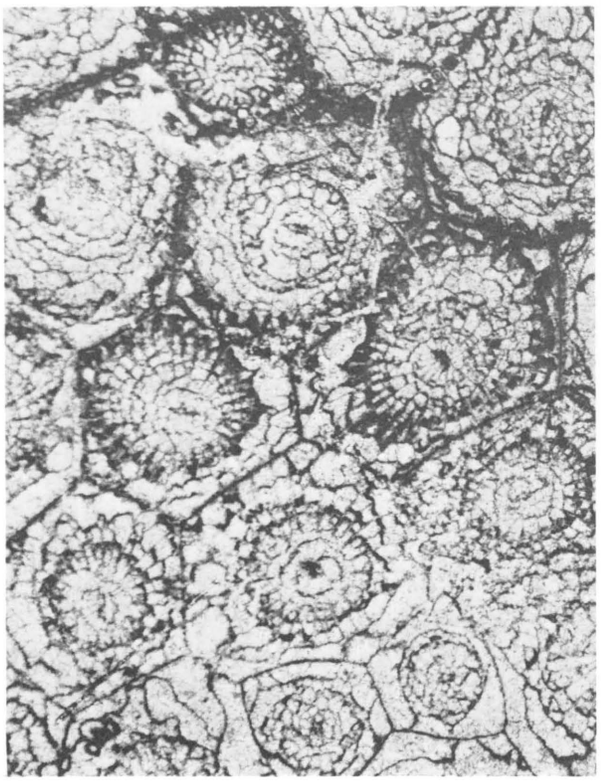
3, 4. *Stelechophyllum microstylum* (White) (p. 11).
USNM 162005 (paratype of *Lithostrotionella multiradiata* Hayasaka). USGS loc. 104–PC, Lodgepole Limestone, Idaho.
3. Transverse thin section, USNM 162005a.
4. Longitudinal thin section, USNM 162005b.



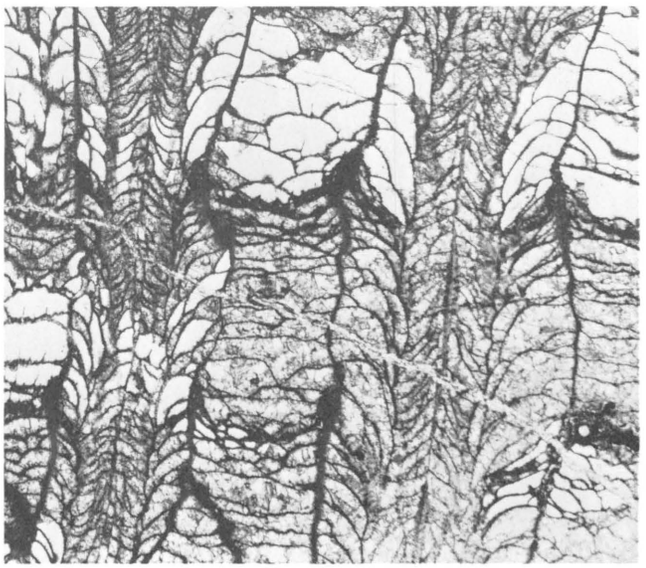
1



2



3



4

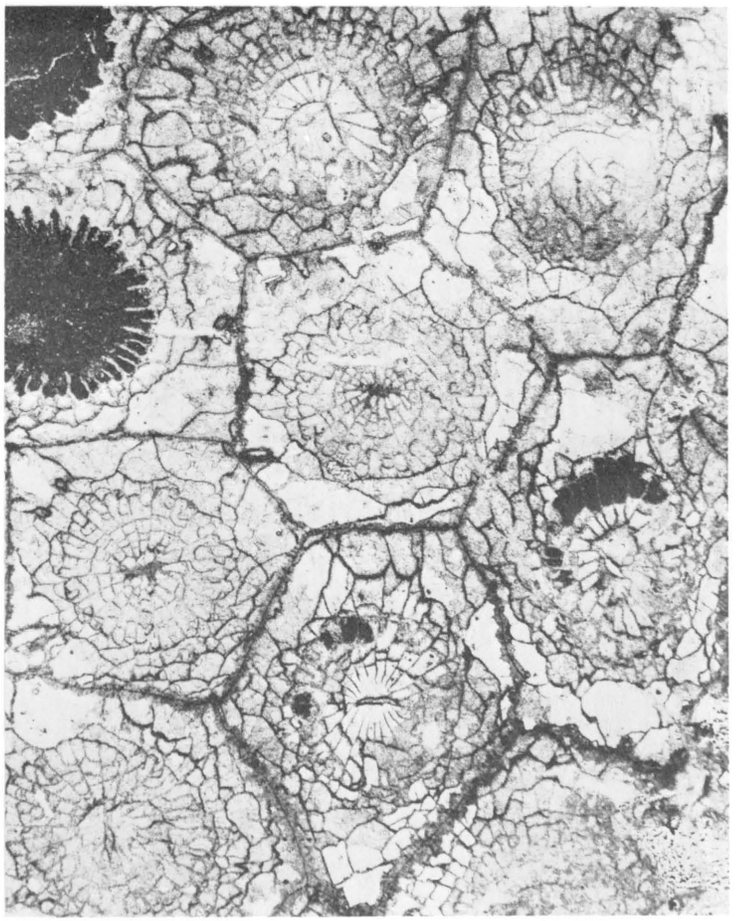
STELECHOPHYLLUM MICROSTYLUM (WHITE)

PLATE 2

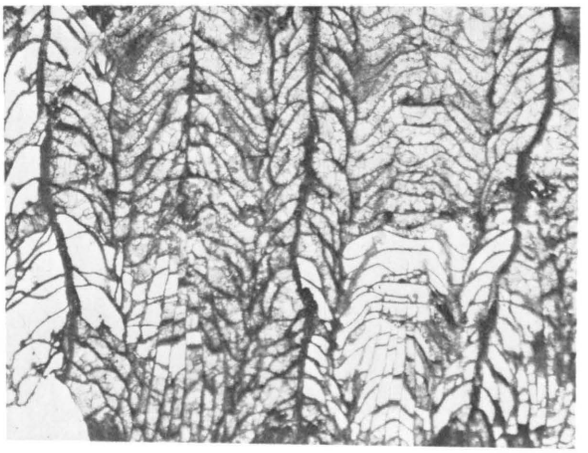
[All figures × 4]

FIGURES 1, 2. *Stelechophyllum microstylum* (White) p. 11).
USNM 161996 (paratype of *Lithostrotionella hemisphaerica* Hayasaka). USGS loc. 1439–PC, Lodgepole Limestone, Idaho.
1. Transverse thin section, USNM 161996a.
2. Longitudinal thin section, USNM 161996b.

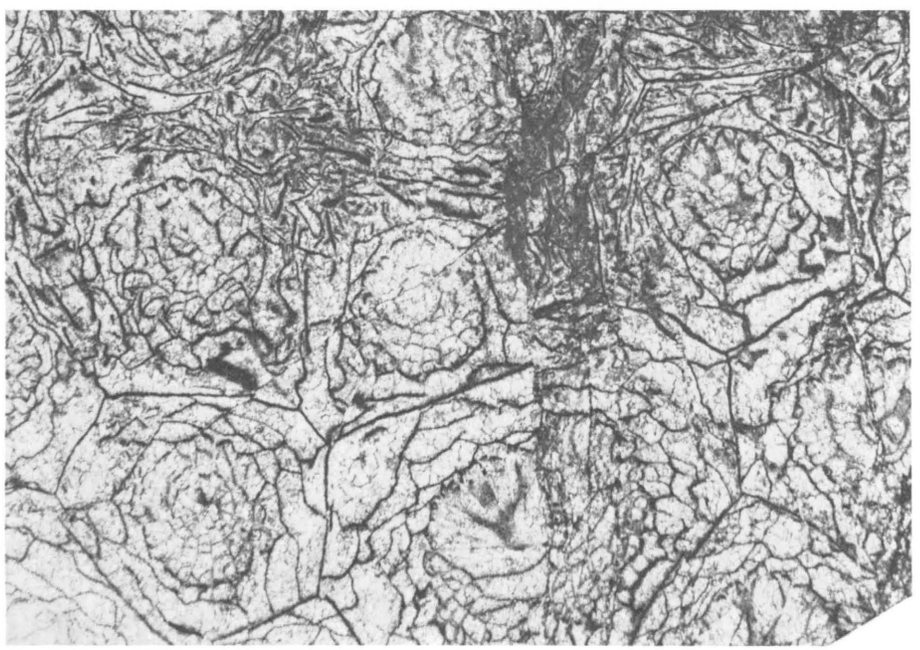
3. 4. *Stelechophyllum microstylum* (White)? (p. 11).
USNM 162003 (paratype of *Lithostrotionella girtyi* Hayasaka). USGS loc. 3864–PC, Lodgepole Limestone, Montana.
3. Transverse thin section, USNM 162003a.
4. Longitudinal thin section, USNM 162003c.



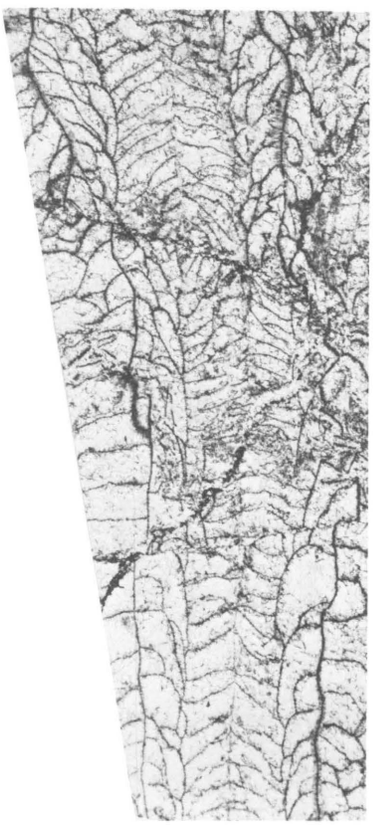
1



2



3



4

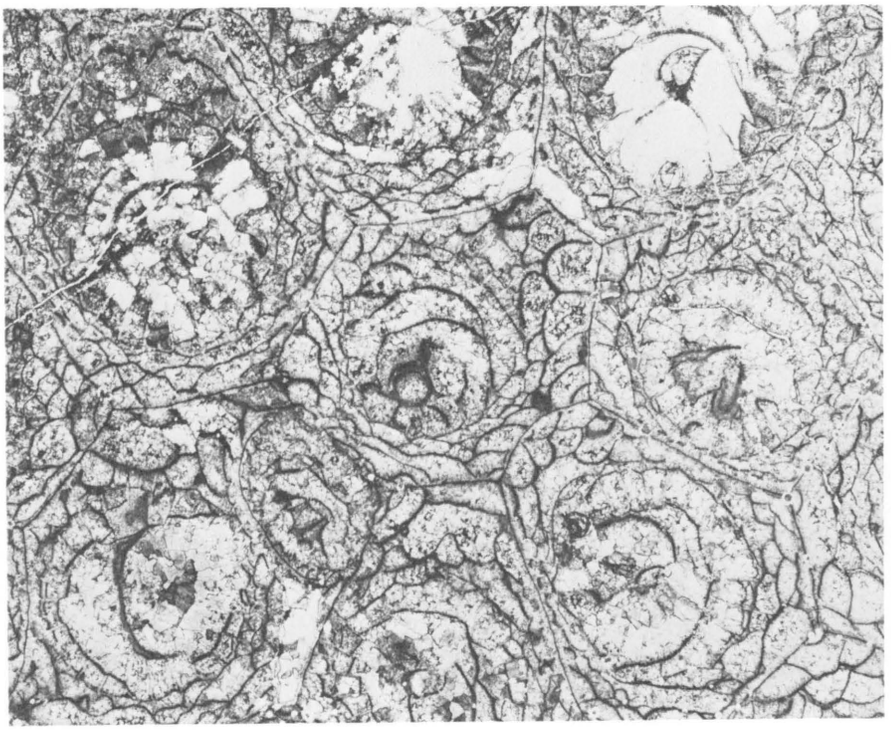
STELECHOPHYLLUM MICROSTYLUM (WHITE)

PLATE 3

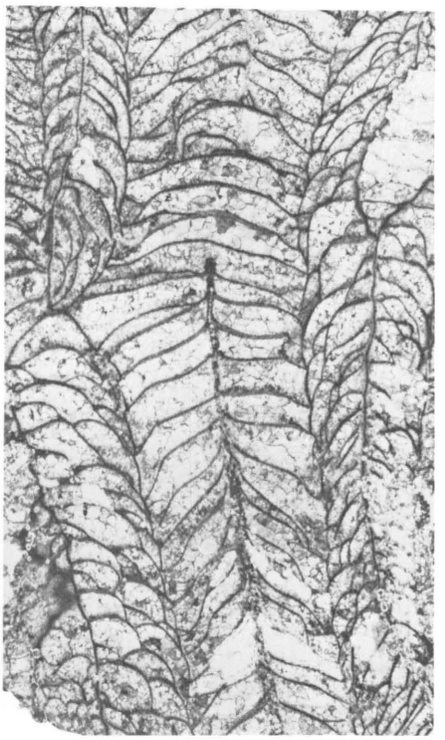
[All figures × 4]

FIGURES 1, 2. *Stelechophyllum banffense* (Warren)? (p. 13).
USNM 174372 (paratype of *Lithostrotionella americana* Hayasaka). USGS Loc. 7130B–PC, Alapah Limestone(?), Alaska.
1. Transverse thin section, USNM 174372a.
2. Longitudinal thin section, USNM 174372b.

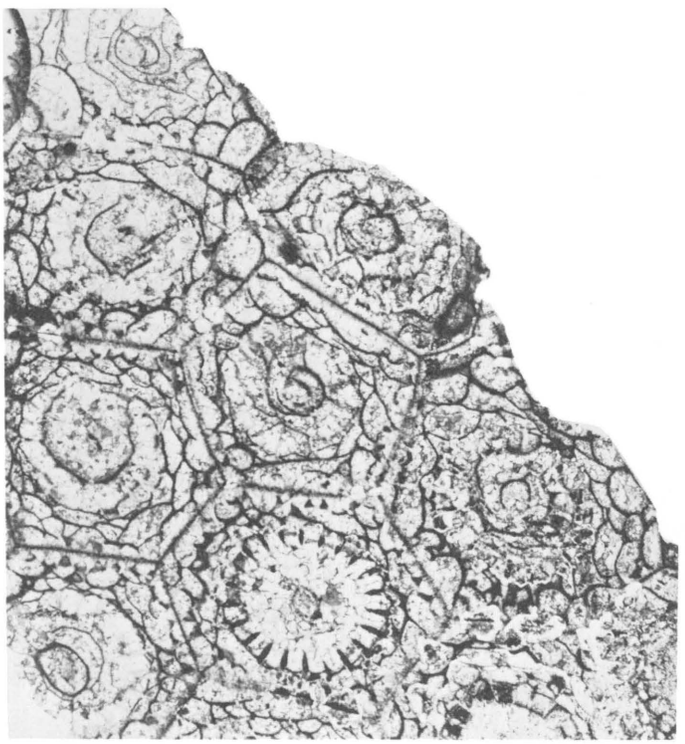
3, 4. *Stelechophyllum banffense* (Warren)? (p. 13).
USNM 174374 (paratype of *Lithostrotionella americana* Hayasaka). USGS Loc. 970–PC, Alapah Limestone(?), Alaska.
3. Transverse thin section, USNM 174374a.
4. Longitudinal thin section, USNM 174374b.



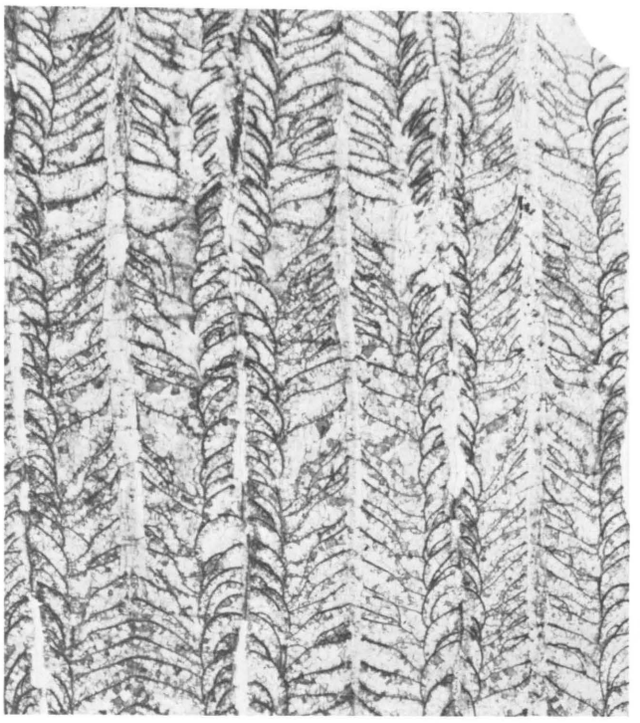
1



2



3



4

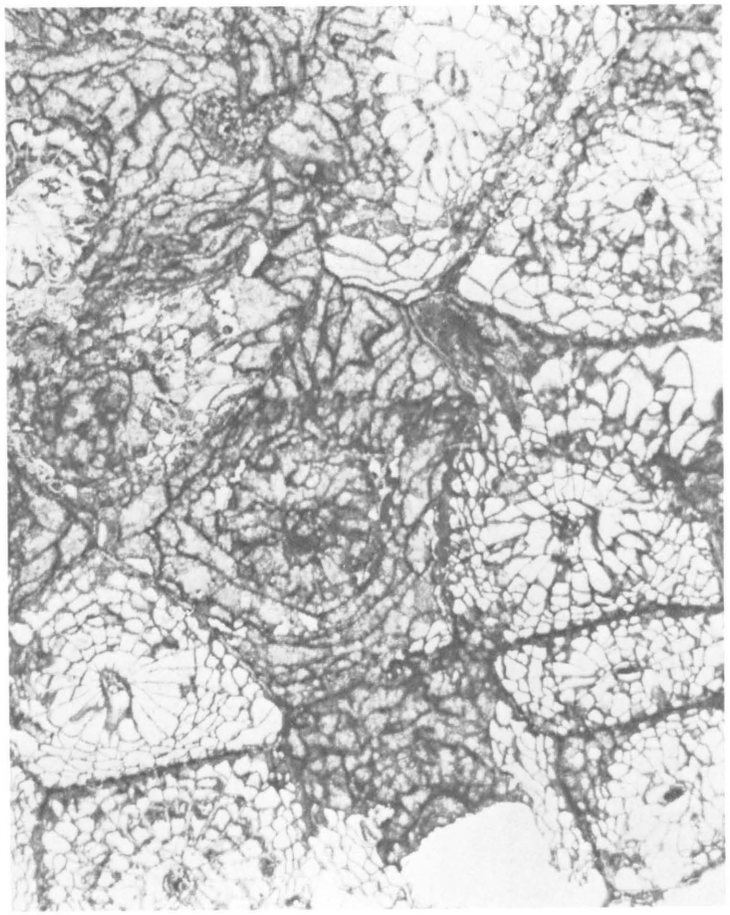
STELECHOPHYLLUM BANFFENSE (WARREN)?

PLATE 4

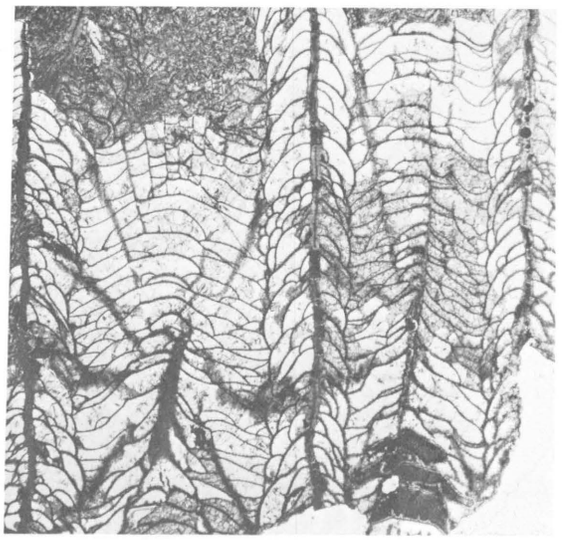
[All figures × 4]

FIGURES 1, 2. *Stelechophyllum banffense* (Warren)? (p. 13).
USNM 174375 (paratype *Lithostrotionella americana* Hayasaka). USGS Loc. 3024-PC, Little Flat Formation, Idaho.
1. Transverse thin section, USNM 174375a.
2. Longitudinal thin section, USNM 174375c.

3, 4. *Stelechophyllum* sp. indet. (p. 15).
USNM 120239 (paratype of *Lithostrotionella hemisphaerica* Hayasaka). USGS Loc. 5892-PC, Madison Limestone, Utah.
3. Longitudinal thin section, USNM 120239c.
4. Transverse thin section, USNM 120239a.

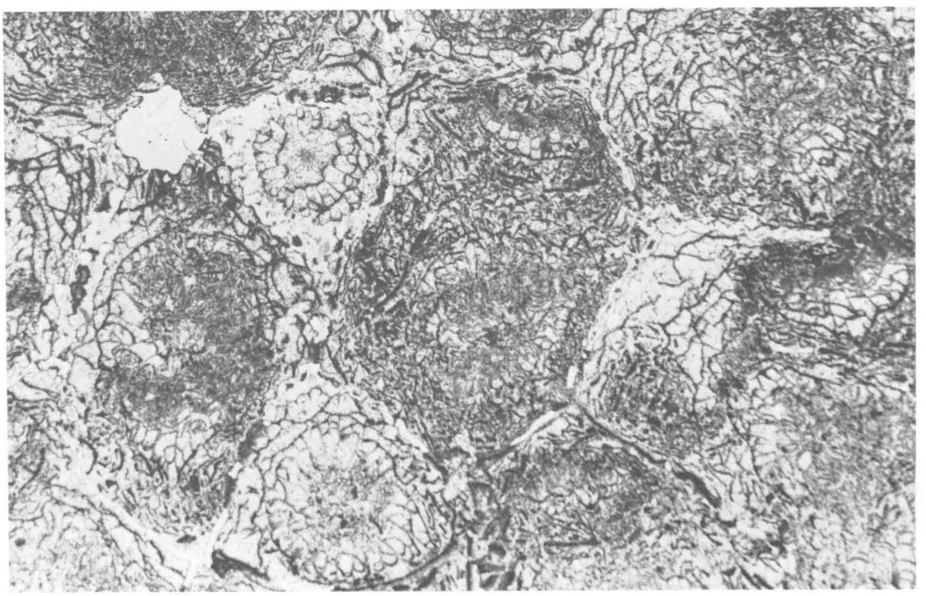


1



2

3



4

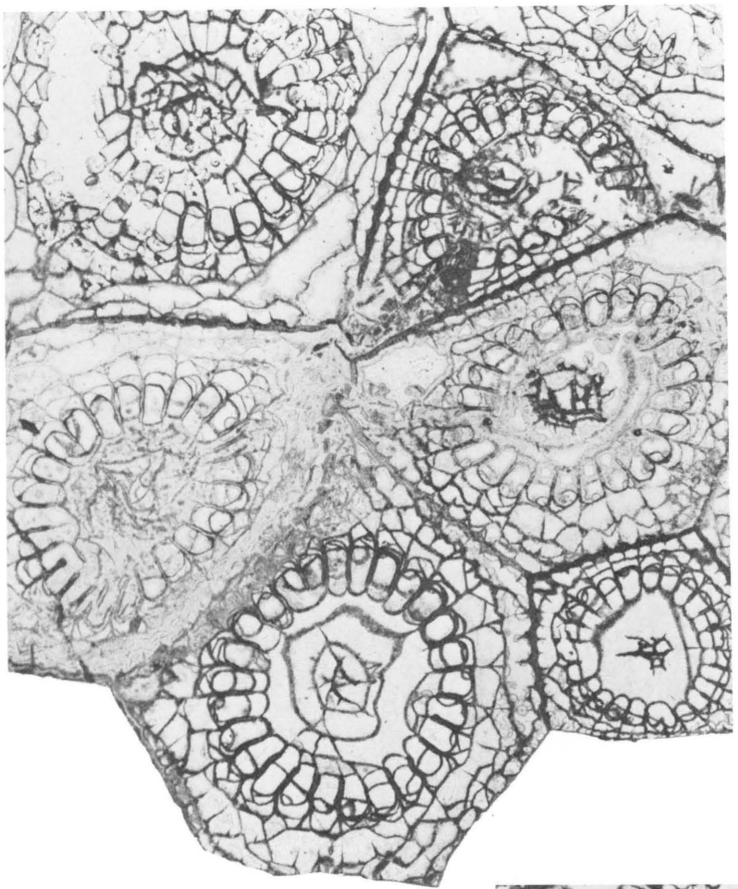
STELECHOPHYLLUM BANFFENSE (WARREN)? AND *STELECHOPHYLLUM* SP. INDET.

PLATE 5

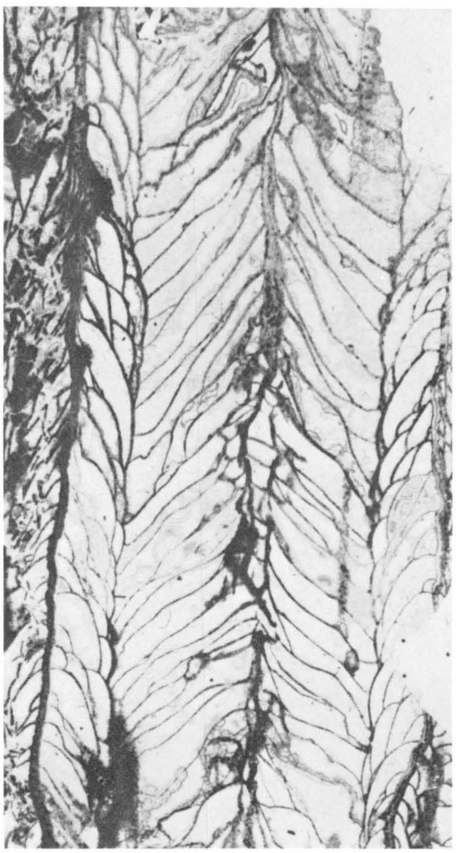
[All figures × 4]

FIGURES 1, 2. *Acrocyathus floriformis floriformis* d'Orbigny (p. 17).
USNM 120240 (holotype of *Lithostrotionella americana* Hayasaka). USGS Loc. 2333–PC, St. Louis Limestone, Kentucky.
1. Transverse thin section, USNM 120240a.
2. Longitudinal thin section, USNM 120240b.

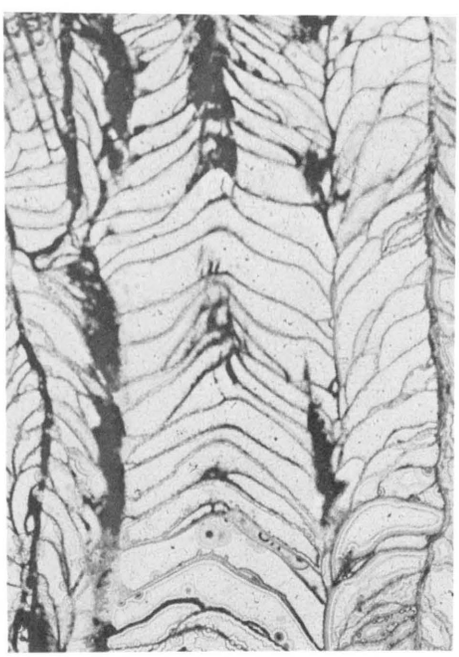
3, 4. *Acrocyathus floriformis floriformis* d'Orbigny (p. 17).
USNM 174376 (paratype of *Lithostrotionella americana* Hayasaka). USGS Loc. 499–PC, St. Louis Limestone, Illinois.
3. Longitudinal thin section (cut slightly off axis of corallite), USNM 174376b.
4. Transverse thin section, USNM 174376a.



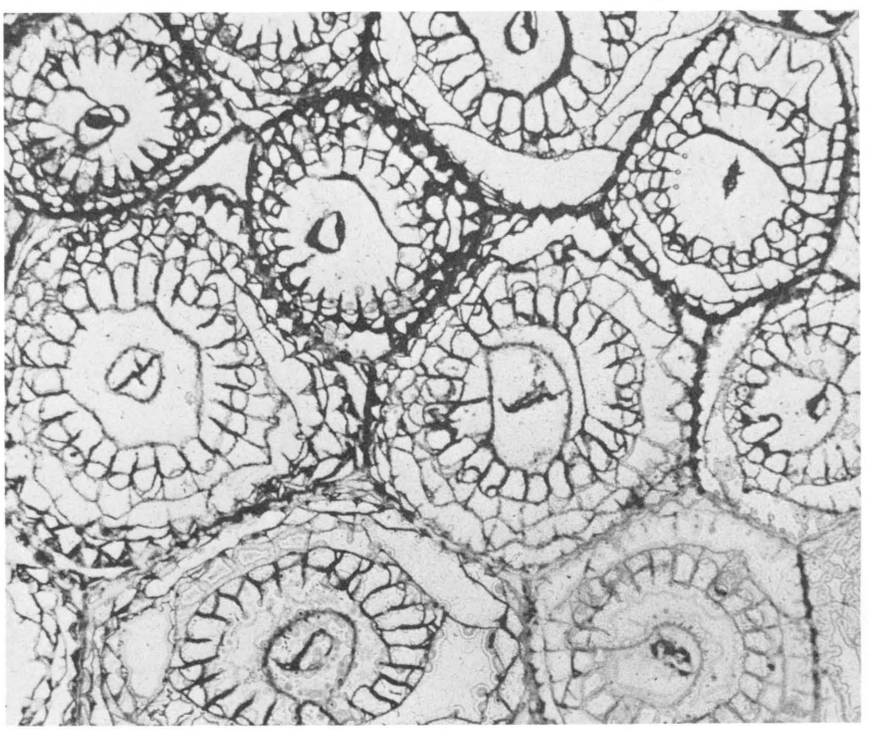
1



2



3



4

ACROCYATHUS FLORIFORMIS FLORIFORMIS D'ORBIGNY

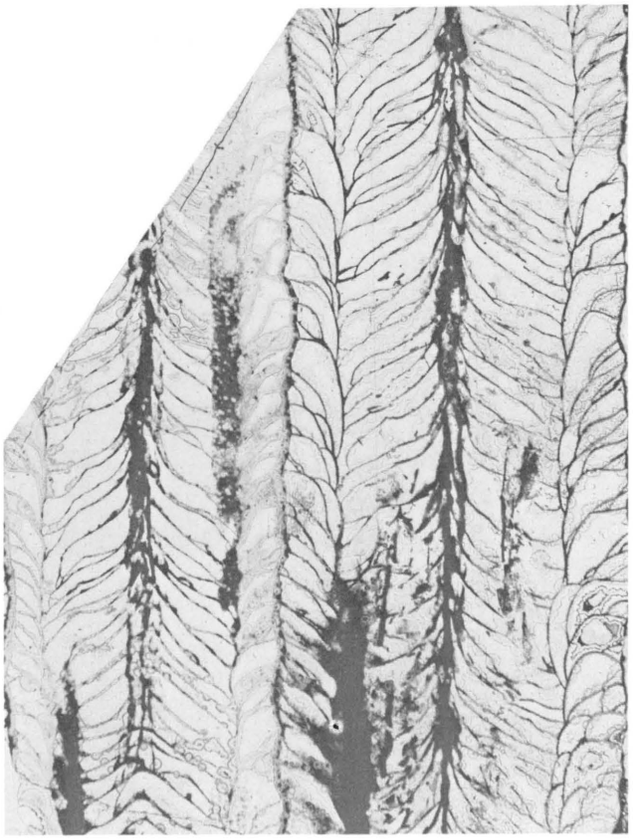
PLATE 6

[All figures × 4]

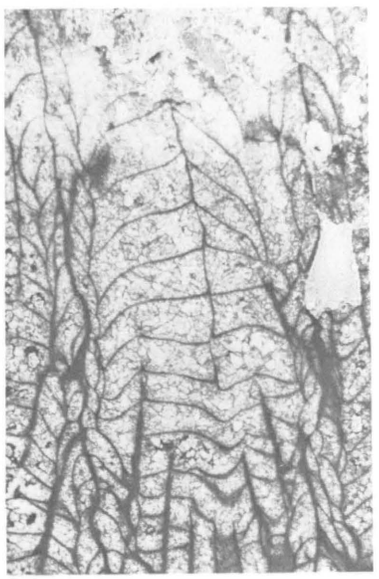
FIGURES 1, 2. *Acrocyathus floriformis floriformis* d'Orbigny? (p. 17).
USNM 162001 (paratype of *Lithostrotionella americana* Hayasaka). USGS Loc. 498–PC, St. Louis Limestone, Illinois.
1. Transverse thin section, USNM 162001a.
2. Longitudinal thin section, USNM 162001b.

3,4. *Acrocyathus floriformis floriformis* d'Orbigny? (p. 17).
USNM 120241 (paratype of *Lithostrotionella americana* Hayasaka). USGS Loc. 1211B–PC, St. Louis Limestone, Missouri. Thysanophylloid variants in a polymorphic corallum.
3. Longitudinal thin section, USNM 120241b.
4. Transverse thin section, USNM 120241a.

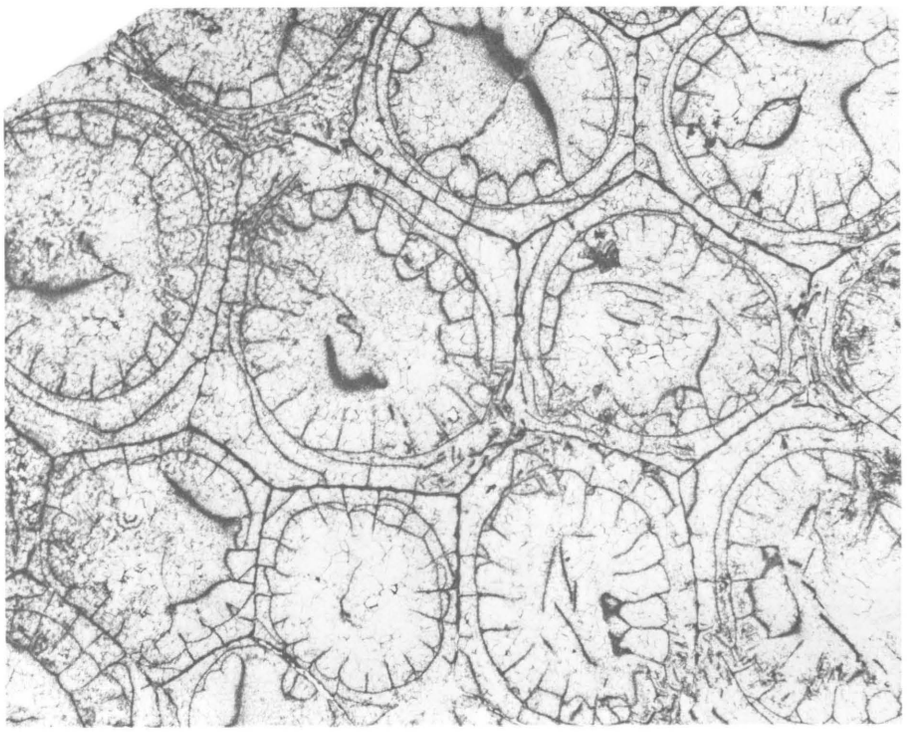
1



2



3



4

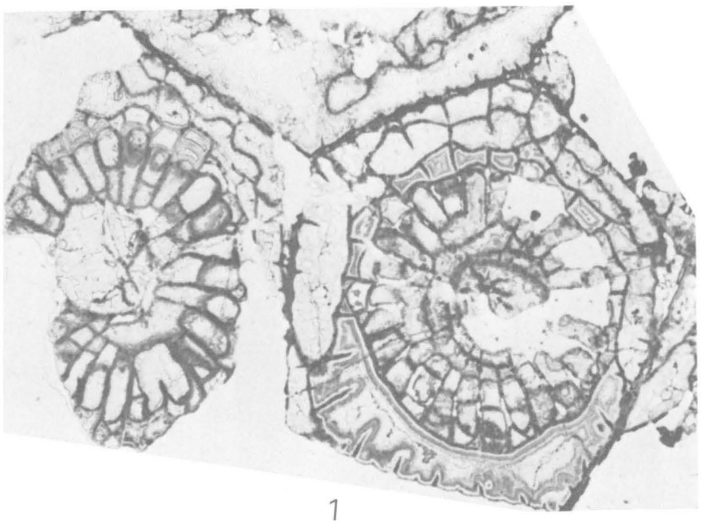
ACROCYATHUS FLORIFORMIS FLORIFORMIS D'ORBIGNY?

PLATE 7

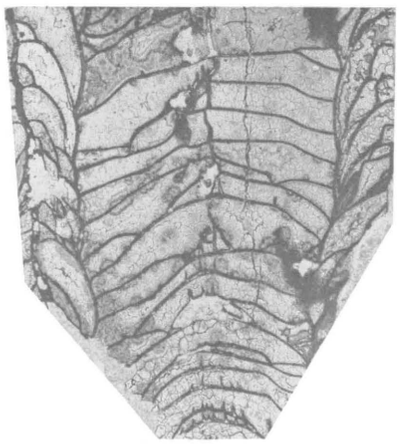
[All figures × 4]

FIGURES 1, 2. *Acrocyathus floriformis floriformis* d'Orbigny? (p. 17).
USNM 174377 (paratype of *Lithostrotionella castelnaui* Hayasaka). USGS 3946-PC (green), unknown locality, probably St. Louis Limestone, Mississippi Valley region.
1. Transverse thin section, USNM 174377a.
2. Longitudinal thin section (cut slightly off axis of corallite), USNM 174377b.

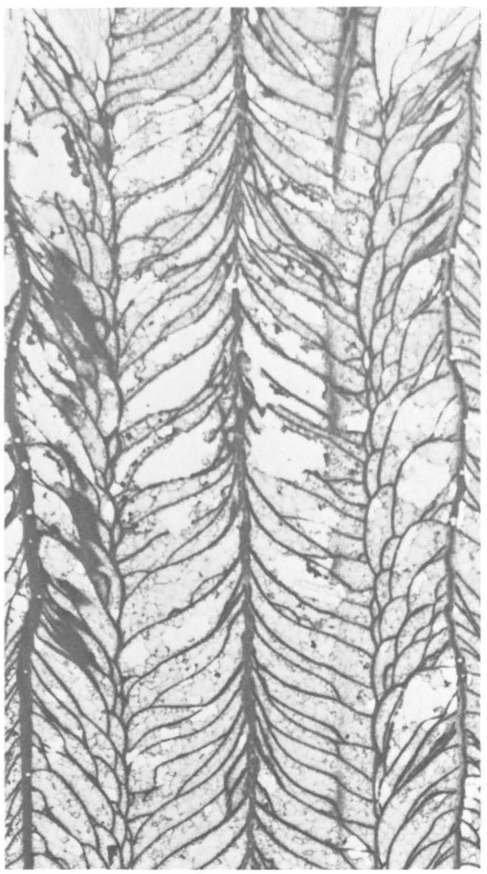
3, 4. *Acrocyathus floriformis floriformis* d'Orbigny (p. 17).
USNM 120235 (holotype of *Lithostrotionella castelnaui* Hayasaka). USGS Loc. 499-PC, St. Louis Limestone, Illinois.
3. Longitudinal thin section, USNM 120235c.
4. Transverse thin section, USNM 120235a.



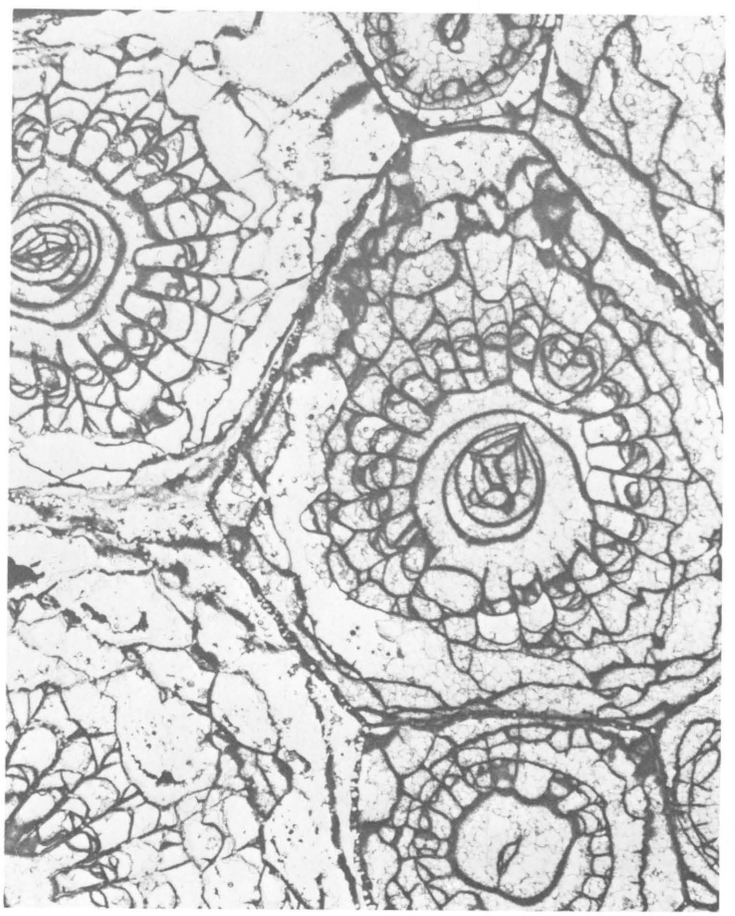
1



2



3



4

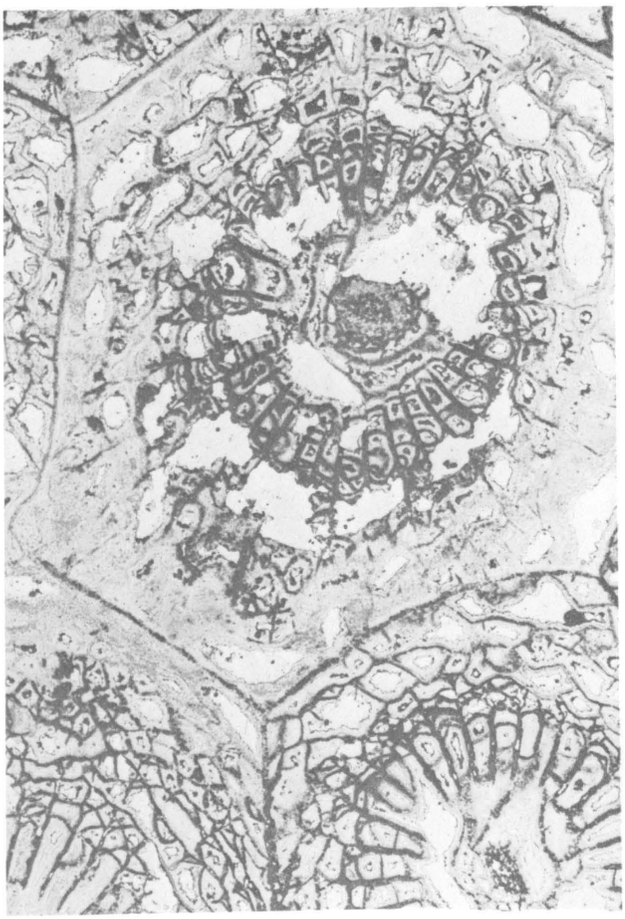
ACROCYATHUS FLORIFORMIS FLORIFORMIS D'ORBIGNY? AND
ACROCYATHUS FLORIFORMIS FLORIFORMIS D'ORBIGNY

PLATE 8

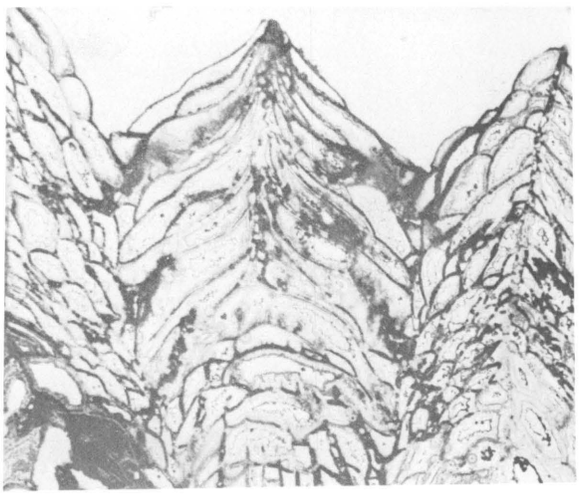
[All figures × 4]

FIGURES 1, 2. *Acrocyathus floriformis floriformis* d'Orbigny (p. 17).
USNM 161991 (paratype of *Lithostrotionella castelnaui* Hayasaka). USGS Loc. 643-PC, St. Louis Limestone(?), Missouri.
1. Transverse thin section, USNM 161991a.
2. Longitudinal thin section, USNM 161991b.

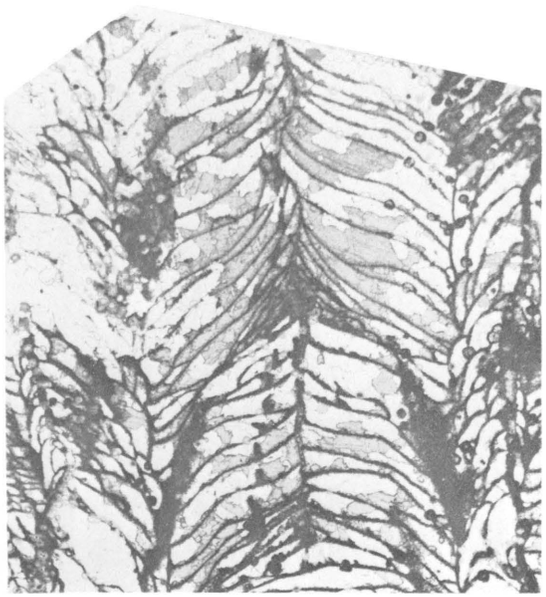
3, 4. *Acrocyathus floriformis floriformis* d'Orbigny (p. 17).
USNM 161990 (paratype of *Lithostrotionella castelnaui* Hayasaka). USGS Loc. 346C-PC, residual chert from Tuscumbia Limestone, Alabama.
3. Longitudinal thin section, USNM 161990b.
4. Transverse thin section, USNM 161990a.



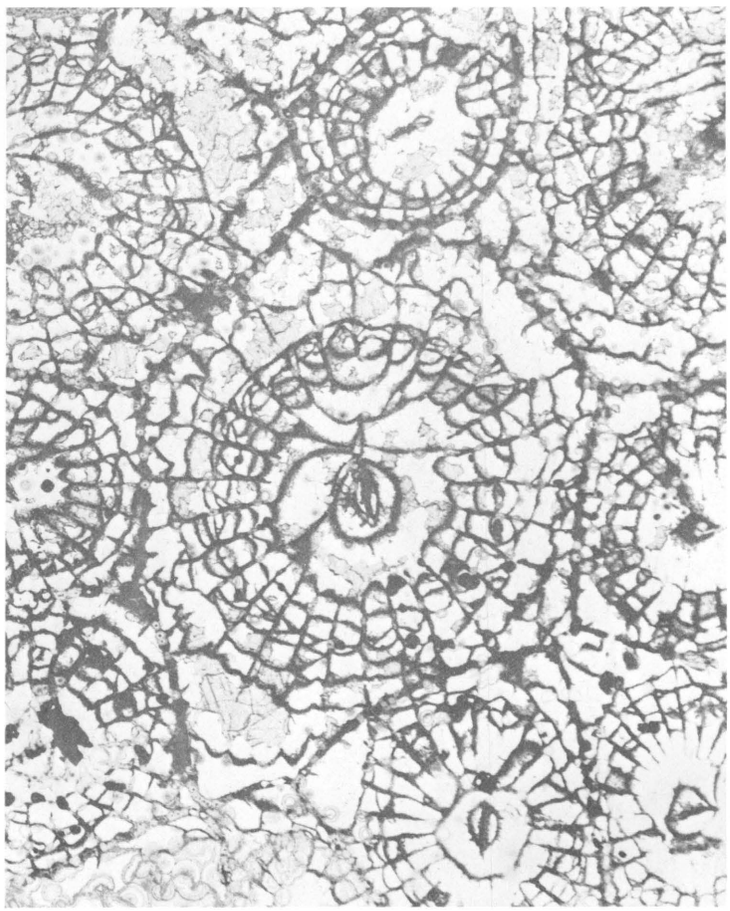
1



2



3



4

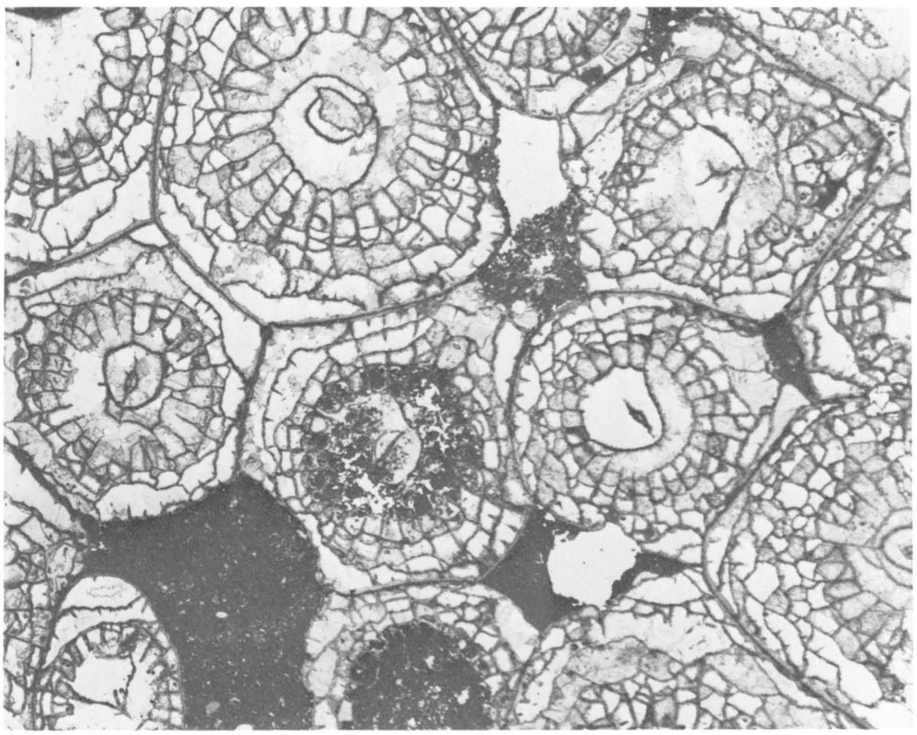
ACROCYATHUS FLORIFORMIS FLORIFORMIS D'ORBIGNY

PLATE 9

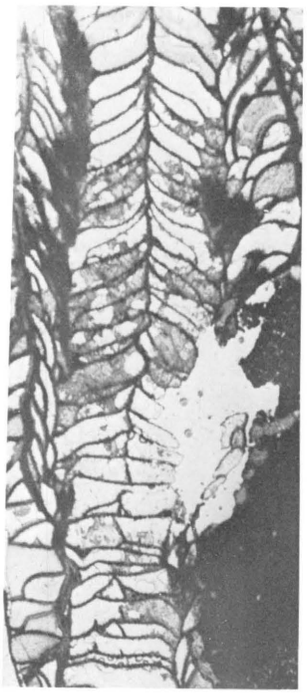
[All figures × 4]

FIGURES 1, 2. *Acrocyathus floriformis floriformis* d'Orbigny (p. 17).
USNM 161994 (paratype of *Lithostrotionella castelnaui* Hayasaka). USGS 2013B–PC, Greenbrier Limestone, Virginia.
1. Transverse thin section, USNM 161994a.
2. Longitudinal thin section, USNM 161994b.

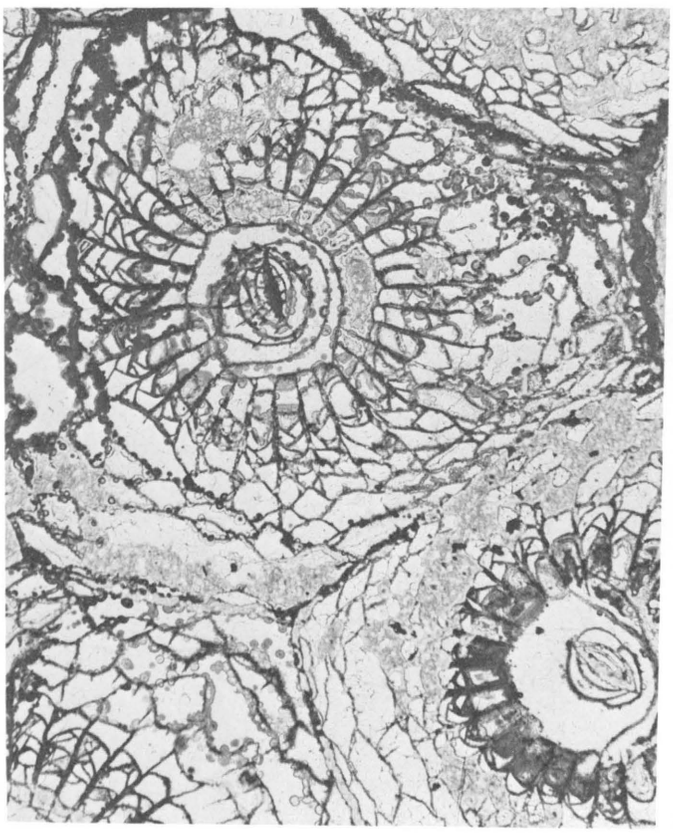
3, 4. *Acrocyathus floriformis floriformis* d'Orbigny (p. 17).
USNM 161989 (paratype of *Lithostrotionella castelnaui* Hayasaka). USGS Loc. 2226–PC, St. Louis Limestone, Illinois.
3. Transverse thin section, USNM 161989a.
4. Longitudinal thin section, USNM 161989c.



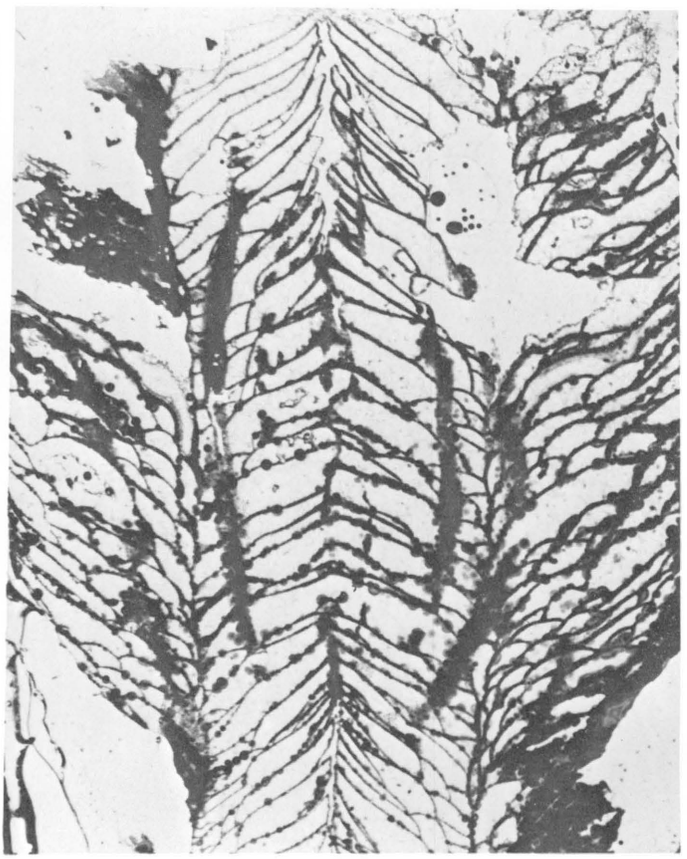
1



2



3



4

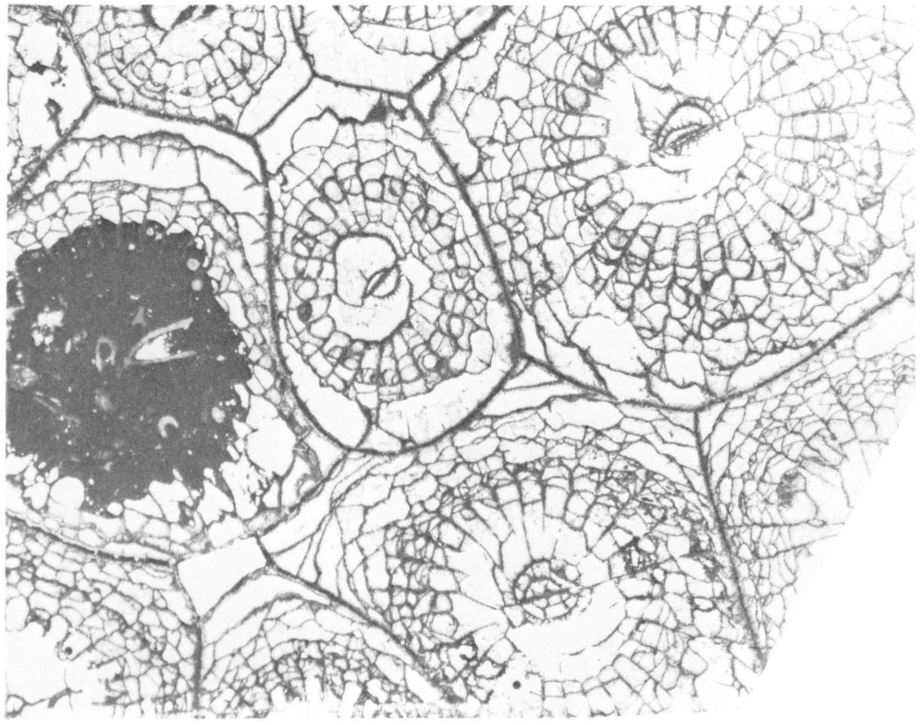
ACROCYATHUS FLORIFORMIS FLORIFORMIS D'ORBIGNY

PLATE 10

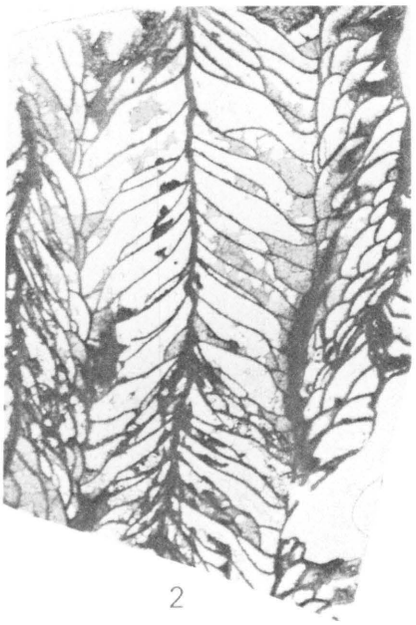
[All figures × 4]

FIGURES 1, 2. *Acrocyathus floriformis floriformis* d'Orbigny (p. 17).
USNM 161997 (paratype of *Lithostrotionella hemisphaerica* Hayasaka). USGS Loc. 2020–PC, Greenbrier Limestone, Virginia.
1. Transverse thin section, USNM 161997a.
2. Longitudinal thin section, USNM 161997b.

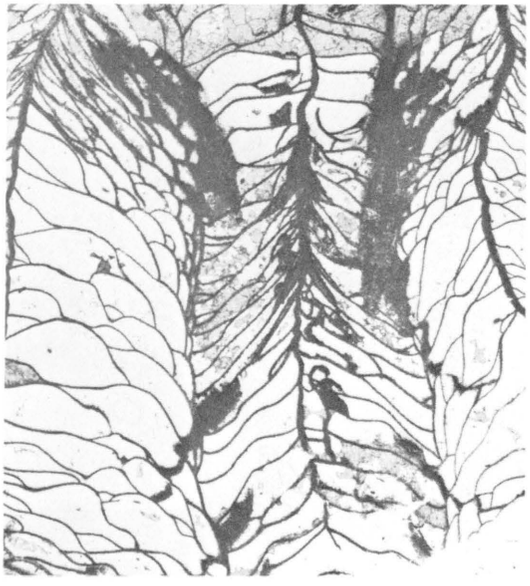
3, 4. *Acrocyathus floriformis floriformis* d'Orbigny (p. 17).
USNM 161993 (paratype of *Lithostrotionella castelnaui* Hayasaka). USGS Loc. 3159–PC, Newman Limestone, Virginia.
3. Longitudinal thin section, USNM 161993b.
4. Transverse thin section, USNM 161993a.



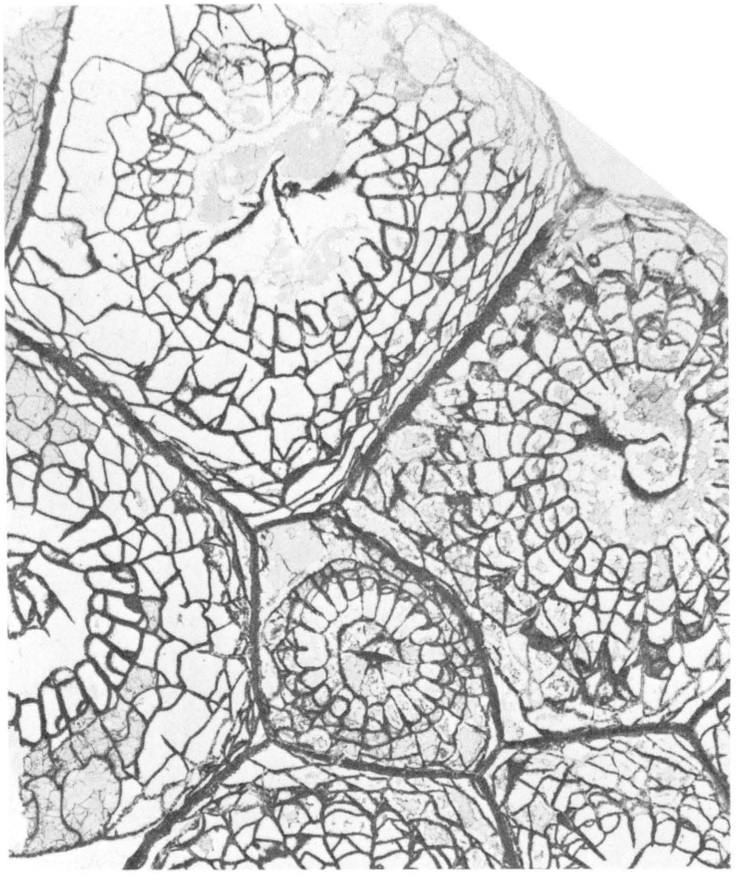
1



2



3



4

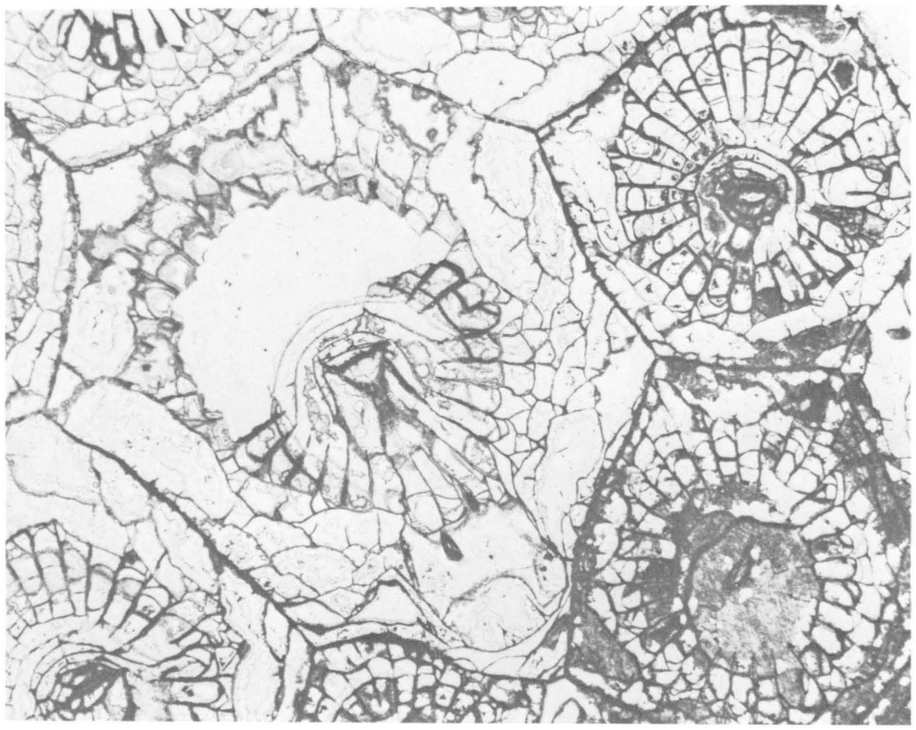
ACROCYATHUS FLORIFORMIS FLORIFORMIS D'ORBIGNY

PLATE 11

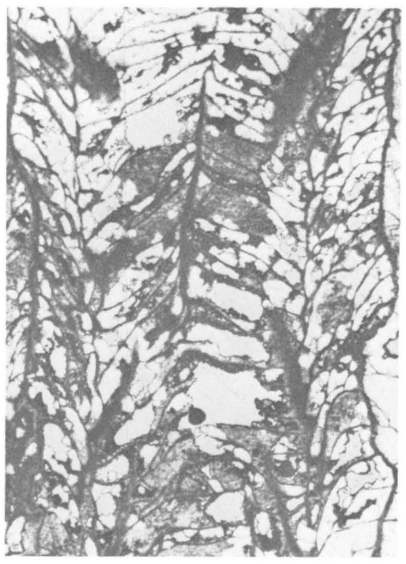
[All figures × 4]

FIGURES 1, 2. *Acrocyathus floriformis floriformus* d'Orbigny (p. 17).
USNM 161995 (paratype of *Lithostrotionella hemisphaerica* Hayasaka). USGS Loc. 83-PC, Newman Limestone, Kentucky.
1. Transverse thin section, USNM 161995a.
2. Longitudinal thin section, USNM 161995b.

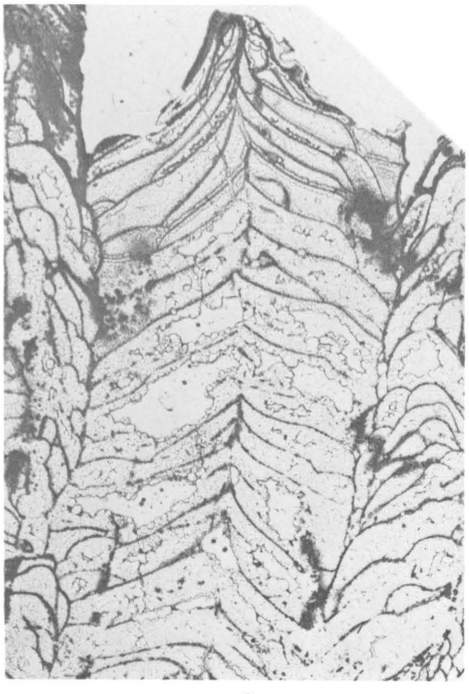
3, 4. *Acrocyathus floriformis floriformis* d'Orbigny (p. 17).
USNM 120238 (paratype of *Lithostrotionella hemisphaerica* Hayasaka). USGS Loc. 3283-PC, Hillsdale Member of Greenbrier Limestone, West Virginia.
3. Longitudinal thin section, USNM 120238d.
4. Transverse thin section, USNM 120238b.



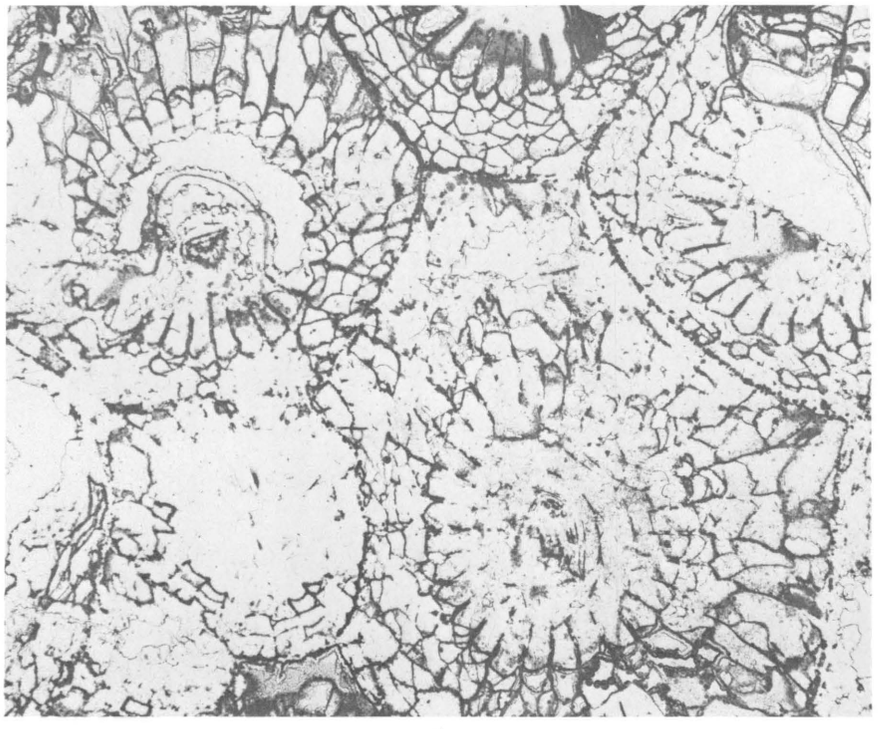
1



2



3



4

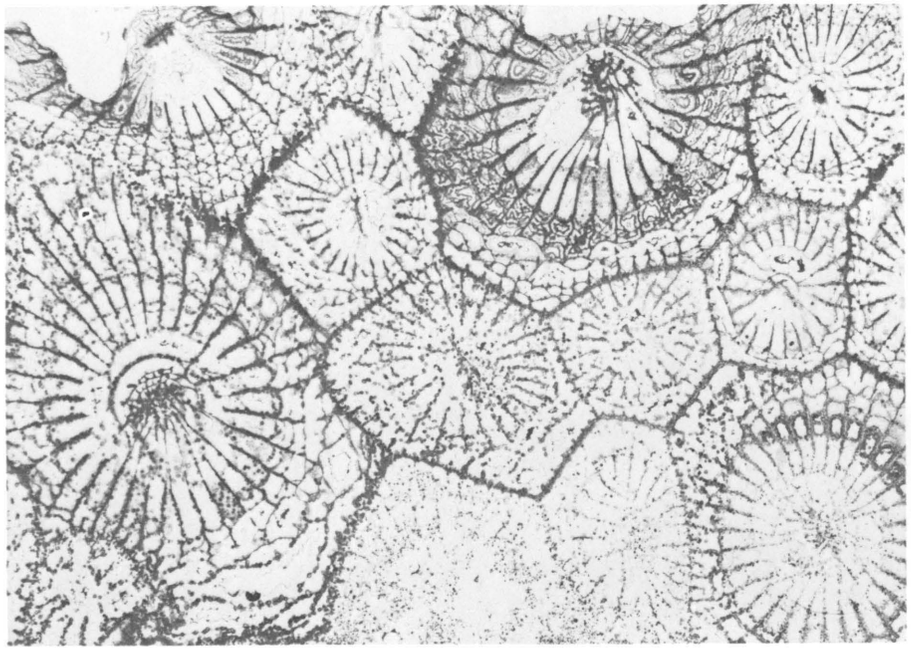
ACROCYATHUS FLORIFORMIS FLORIFORMIS D'ORBIGNY

PLATE 12

[All figures × 4]

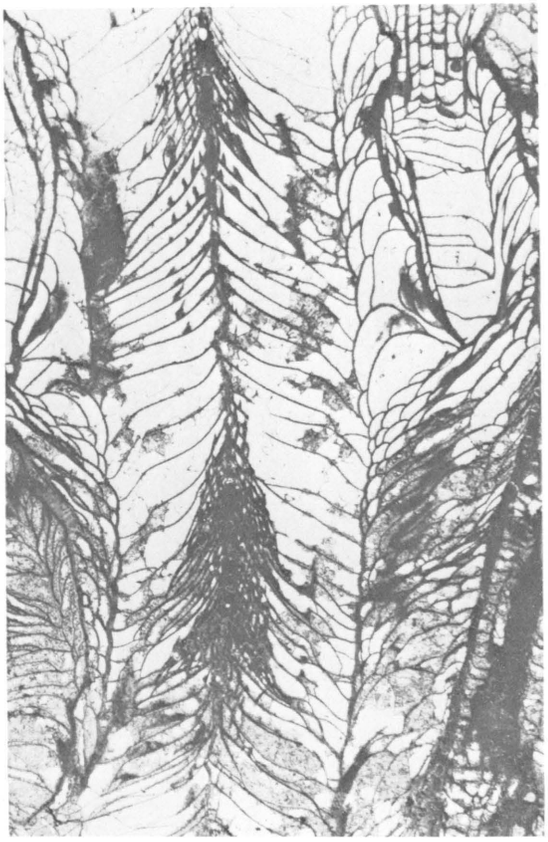
FIGURES 1, 2. *Acrocyathus floriformis hemisphaericus* (Hayasaka) (p. 19).
Holotype, USNM 120237. USGS Loc. 1148–PC, St. Louis Limestone, Illinois.
1. Transverse thin section, USNM 120237a.
2. Longitudinal thin section, USNM 120237c.

3, 4. *Acrocyathus floriformis hemisphaericus* (Hayasaka) (p. 19).
Paratype, USNM 161998. USGS Loc. 932A–PC, St. Louis Limestone, Missouri.
3. Longitudinal thin section, USNM 161998b.
4. Transverse thin section, USNM 161998a.

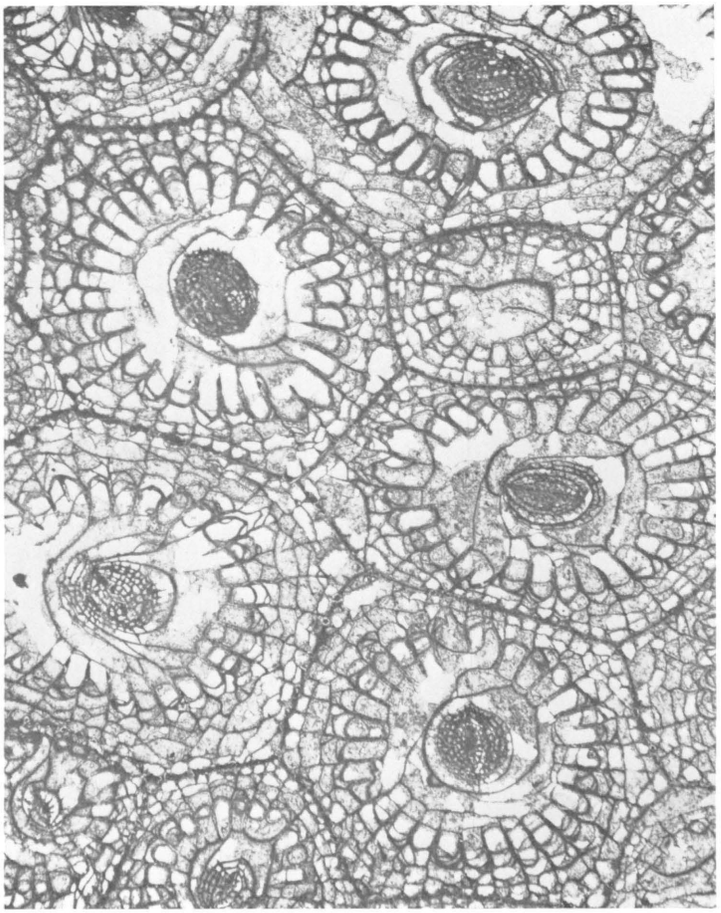


1

2



3



4

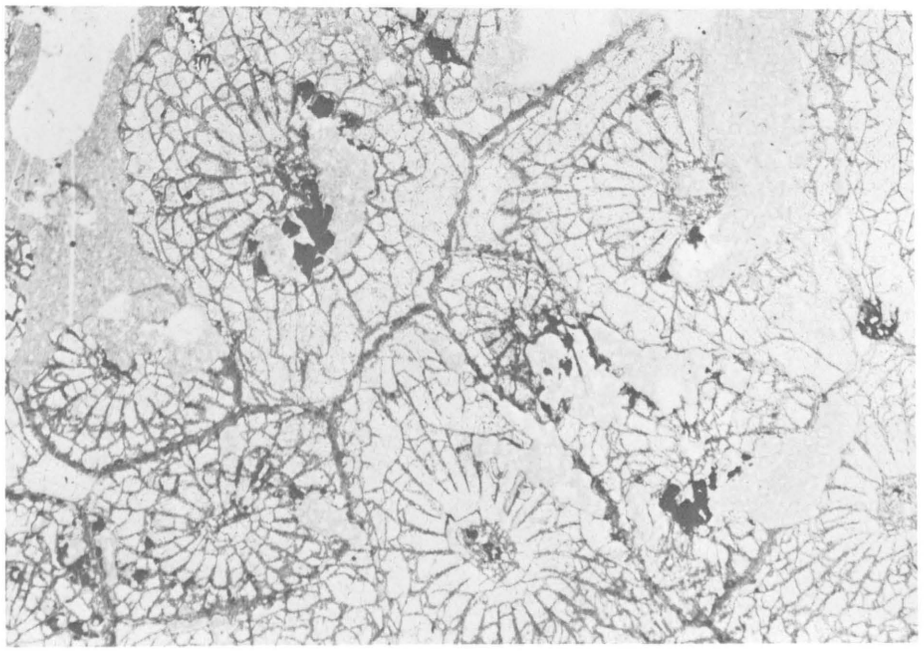
ACROCYATHUS FLORIFORMIS HEMISPHAERICUS (HAYASAKA)

PLATE 13

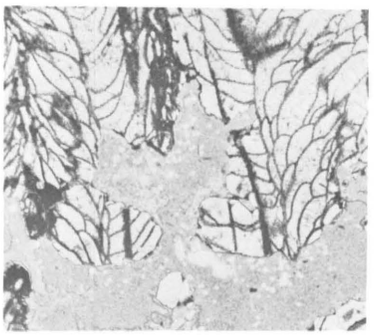
[All figures × 4]

FIGURES 1, 2. *Acrocyathus floriformis hemisphaericus* (Hayasaka) (p. 19).
Paratype, USNM 161999. USGS Loc. 2222A–PC, St. Louis Limestone, Illinois.
1. Transverse thin section, USNM 161999a.
2, 3. Longitudinal thin section, USNM 161999b.

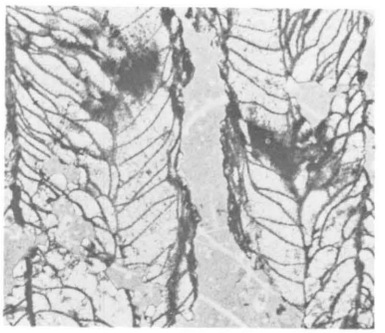
4–6. *Acrocyathus floriformis hemisphaericus* (Hayasaka)? (p. 19).
Paratype, USNM 162000. USGS Loc. 2222C–PC, St. Louis Limestone, Illinois.
4, 5. Longitudinal thin section, USNM 162000b.
6. Transverse thin section, USNM 162000a.



1

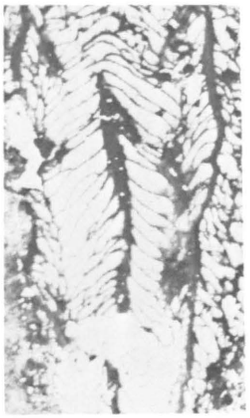


2

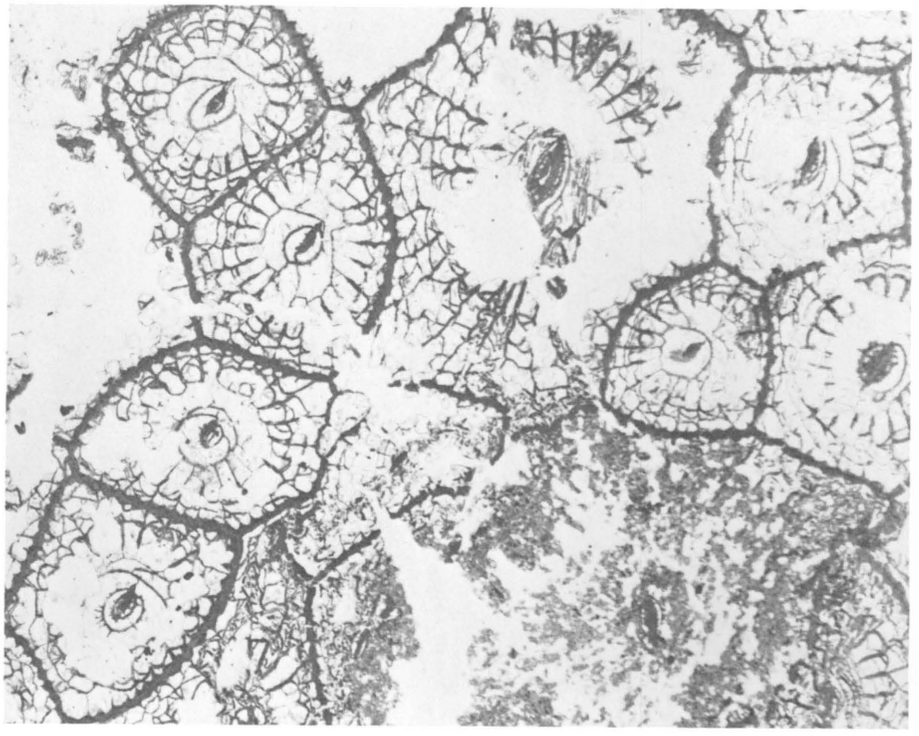


3

4



5



6

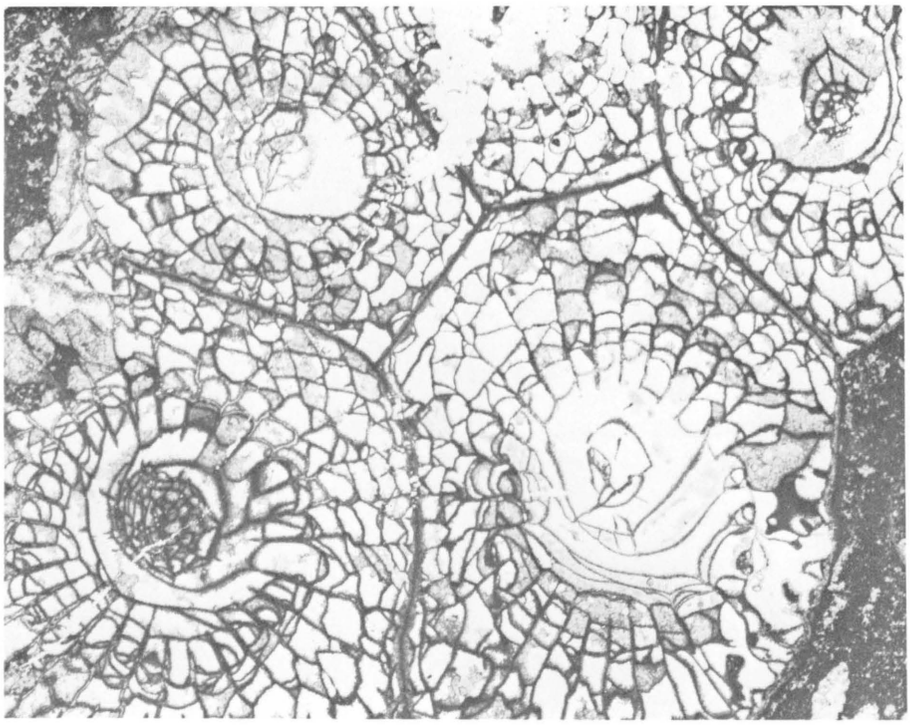
ACROCYATHUS FLORIFORMIS HEMISPHAERICUS (HAYASAKA) AND
ACROCYATHUS FLORIFORMIS HEMISPHAERICUS (HAYASAKA)?

PLATE 14

[All figures × 4]

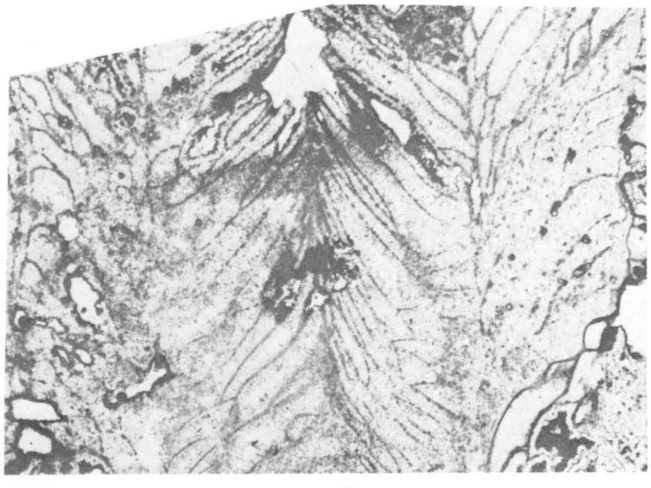
FIGURES 1, 2. *Acrocyathus floriformis hemisphaericus* (Hayasaka) (p. 19).
USNM 161992 (paratype of *Lithostrotionella castelnaui* Hayasaka). USGS Loc. 2020A–PC, Greenbrier Limestone, Virginia.
1. Transverse thin section, USNM 161992a.
2. Longitudinal thin section, USNM 161992b.

3, 4. *Acrocyathus floriformis hemisphaericus* (Hayasaka) (p. 19).
USNM 120236 (paratype of *Lithostrotionella castelnaui* Hayasaka). USGS Loc. 3282–PC, Hillsdale Member of Greenbrier Limestone, West Virginia.
3. Longitudinal thin section, USNM 120236b.
4. Transverse thin section, USNM 120236a.

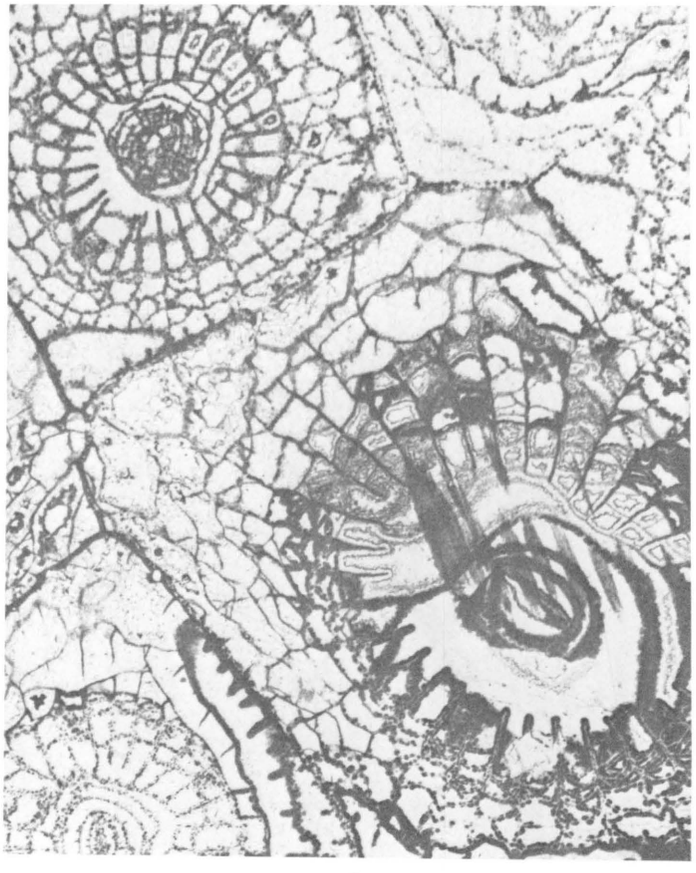


1

2



3

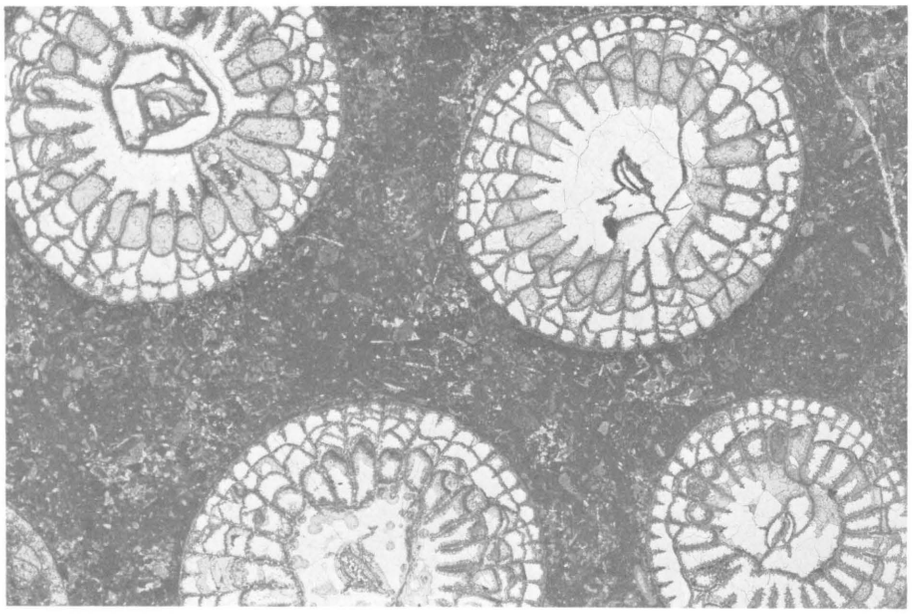


4

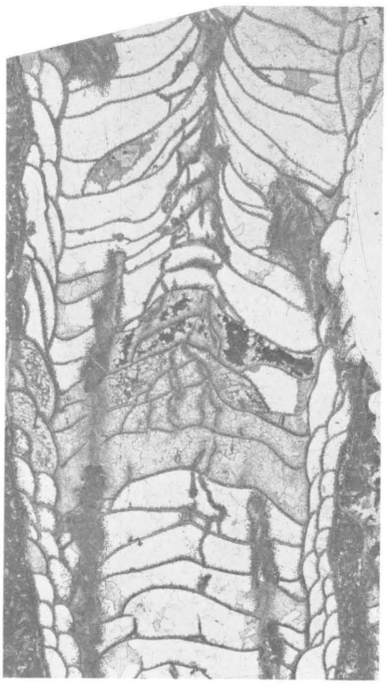
ACROCYATHUS FLORIFORMIS HEMISPHAERICUS (HAYASAKA)

PLATE 15

FIGURES 1–3. *Acrocyathus proliferus* (Hall) (p. 20).
Neotype, USNM 841. St. Louis Limestone, Illinois.
1. Transverse thin section, × 4, USNM 841a.
2. Longitudinal thin section, × 4, USNM 841b.
3. Side view of corallum, × 1.



1



2

3

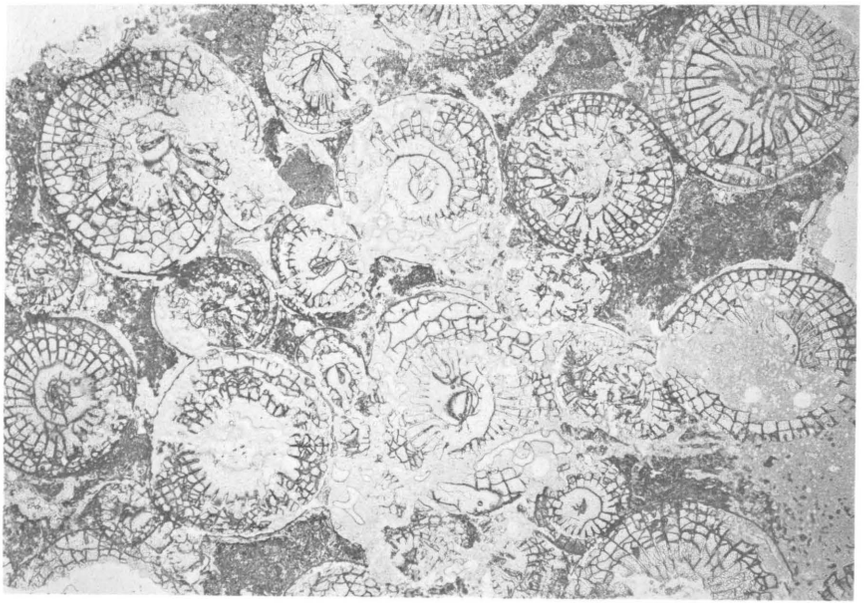
ACROCYATHUS PROLIFERUS (HALL)

PLATE 16

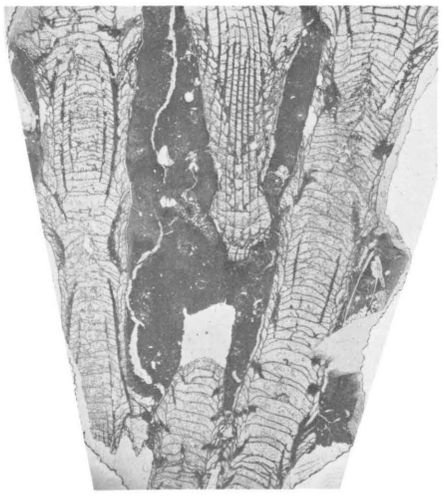
FIGURES 1. *Acrocyathus proliferus* (Hall) (p. 20).
USNM 216207. St. Louis Limestone, Tennessee.
Transverse thin section, × 2, USNM 216207a, showing crowding of corallites by profuse budding.

2. *Acrocyathus floriformis floriformis* d'Orbigny (p. 17).
USNM 161994. Greenbrier Limestone, Virginia.
Transverse thin section, × 2, USNM 161994a, showing cylindrical tendency of some corallites in a predominantly cerioid corallum.

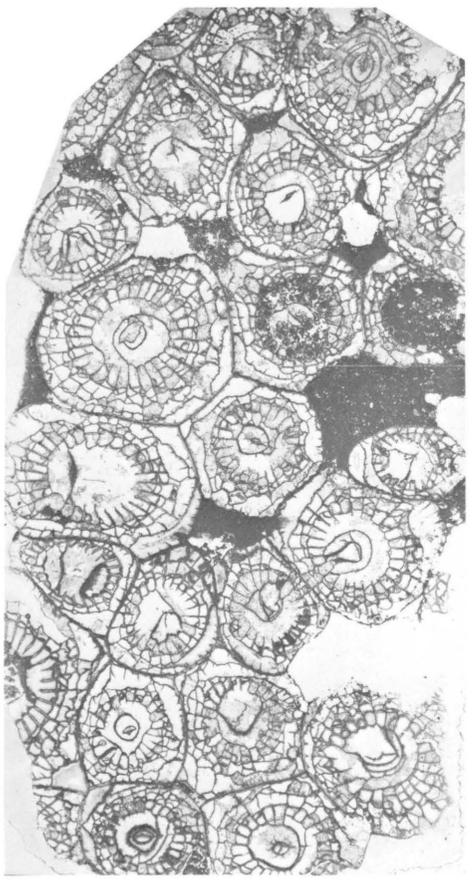
3, 4. *Acrocyathus proliferus* (Hall) (p. 20).
USNM 216209. St. Louis Limestone, Tennessee.
3. Longitudinal thin section, × 1, USNM 216209b showing cylindrical corallites in a predominantly fasciculate corallum.
4. Transverse thin section, × 2, USNM 216209a showing prismatic tendency in crowded corallites in a predominantly fasciculate corallum.



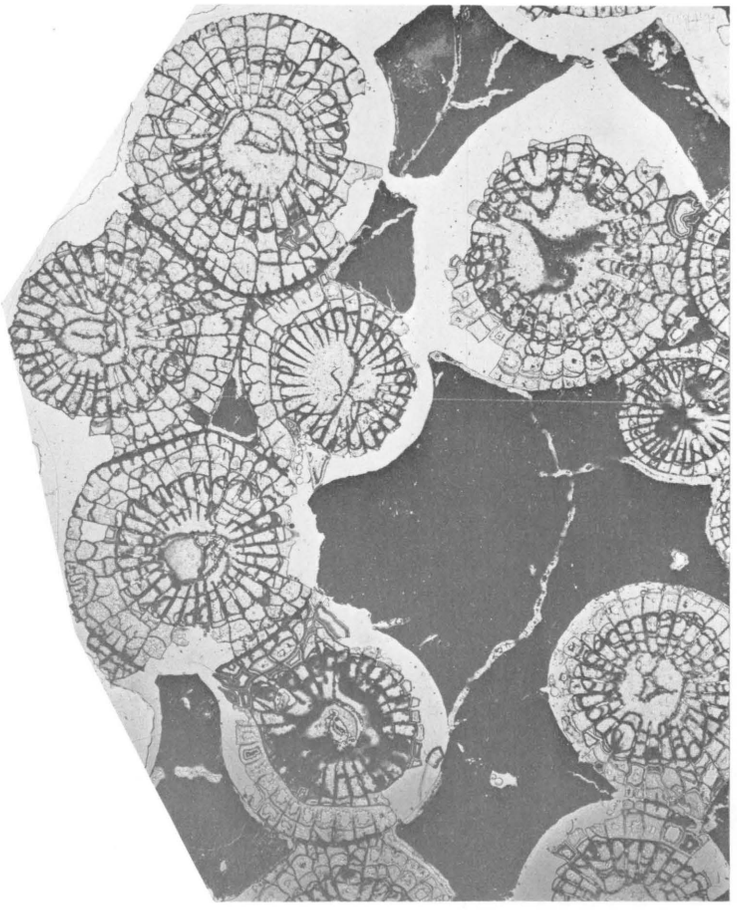
1



3



2



4

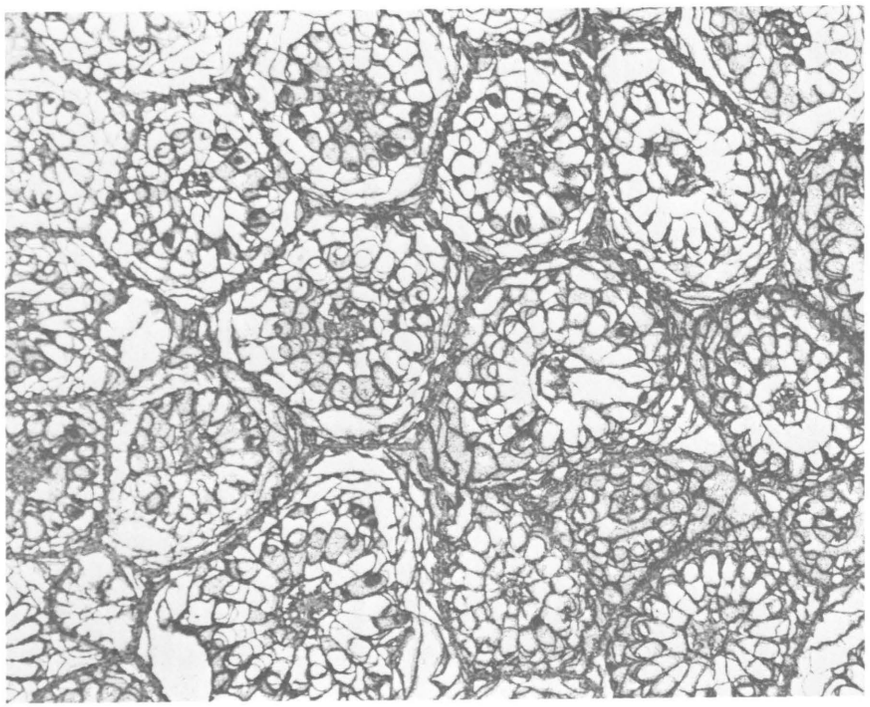
ACROCYATHUS PROLIFERUS (HALL) AND *ACROCYATHUS FLORIFORMIS FLORIFORMIS* D'ORBIGNY

PLATE 17

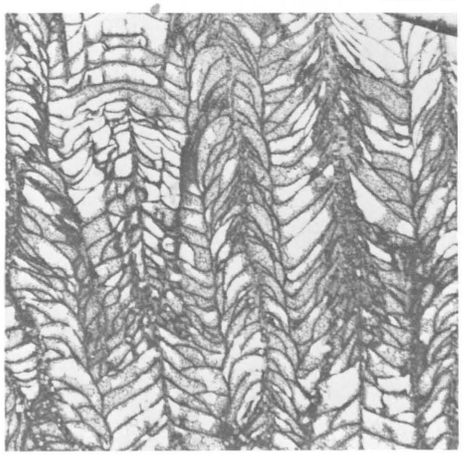
[All figures × 4]

FIGURES 1, 2. *Acrocyathus pilatus* n. sp. (p. 19).
Holotype, USNM 162004 (paratype of *Lithostrotionella girtyi* Hayasaka). USGS Loc. 499–PC, St. Louis Limestone, Illinois.
1. Transverse thin section, USNM 162004a.
2. Longitudinal thin section, USNM 162004b.

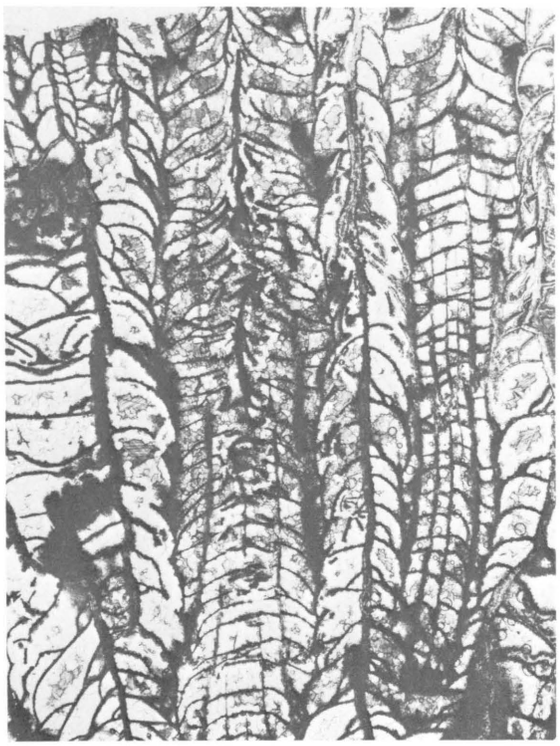
3, 4. *Acrocyathus girtyi* (Hayasaka) (p. 21).
Holotype, USNM 120243. USGS Loc. 4801H–PC (green), Little Flat Formation, Utah.
3. Longitudinal thin section, USNM 120243b.
4. Transverse thin section, USNM 120243a.



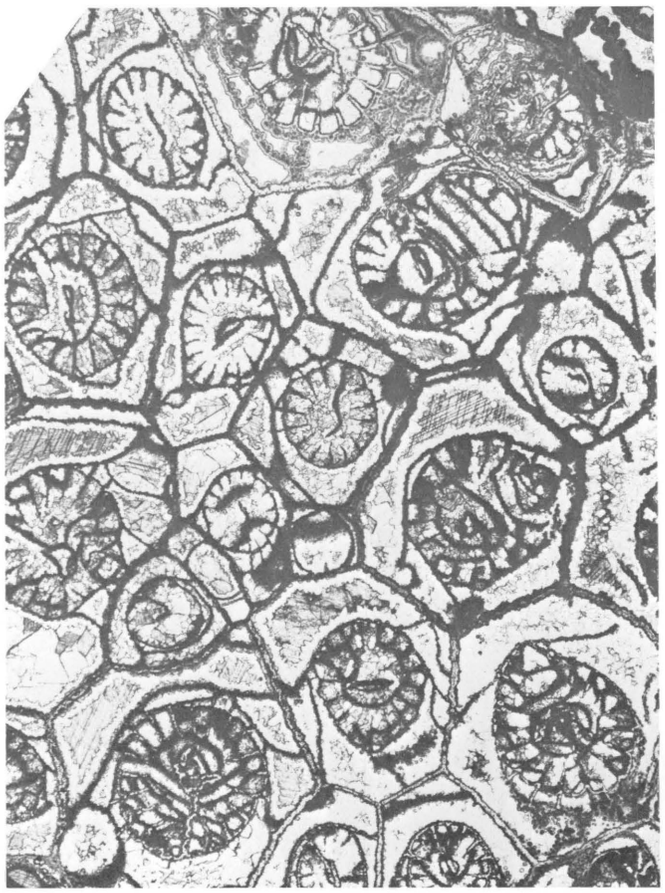
1



2



3



4

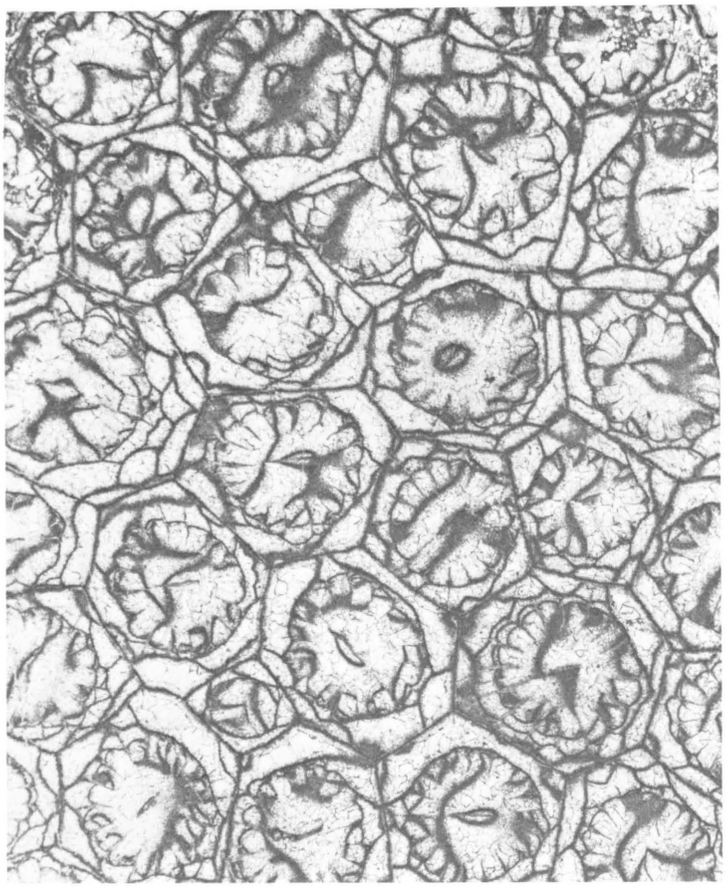
ACROCYATHUS PILATUS N. SP. AND *ACROCYATHUS GIRTYI* (HAYASAKA)

PLATE 18

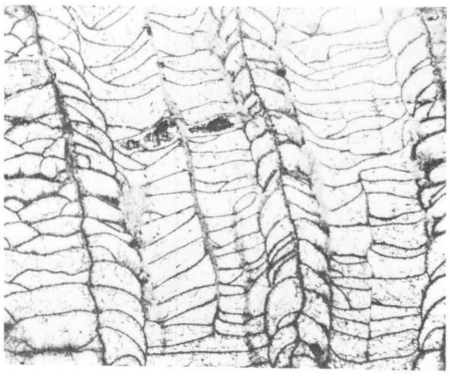
[All figures × 4]

FIGURES 1–3. *Petalaxis simplex* (Hayasaka) (p. 26).
Holotype, USNM 120249. USGS 5893-PC, Little Flat Formation, Utah.
1. Transverse thin section, USNM 120249a.
2, 3. Longitudinal thin section, USNM 120249b.

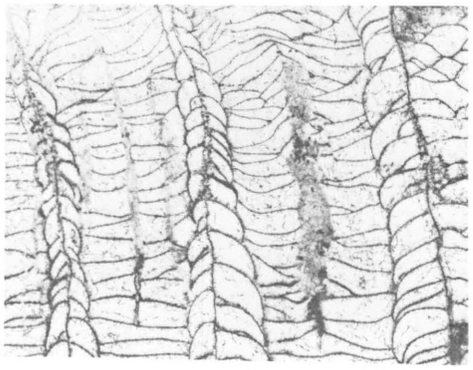
4, 5. *Petalaxis wyomingensis* n. sp. (p. 26).
Holotype, USNM 120675 (paratype of *Lithostrotionella simplex* Hayasaka). USGS 7452-PC (green), "Wells" Formation), Wyoming.
4. Longitudinal thin section, USNM 120675b.
5. Transverse thin section, USNM 120675c.



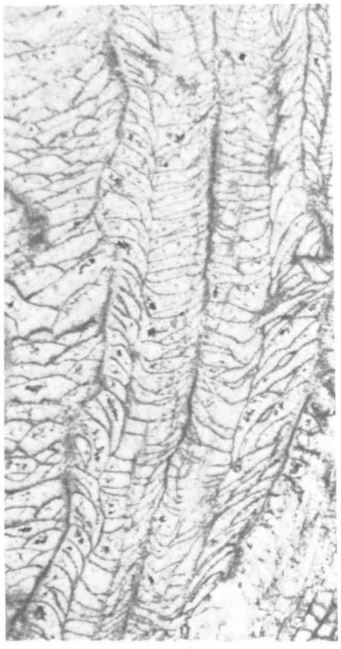
1



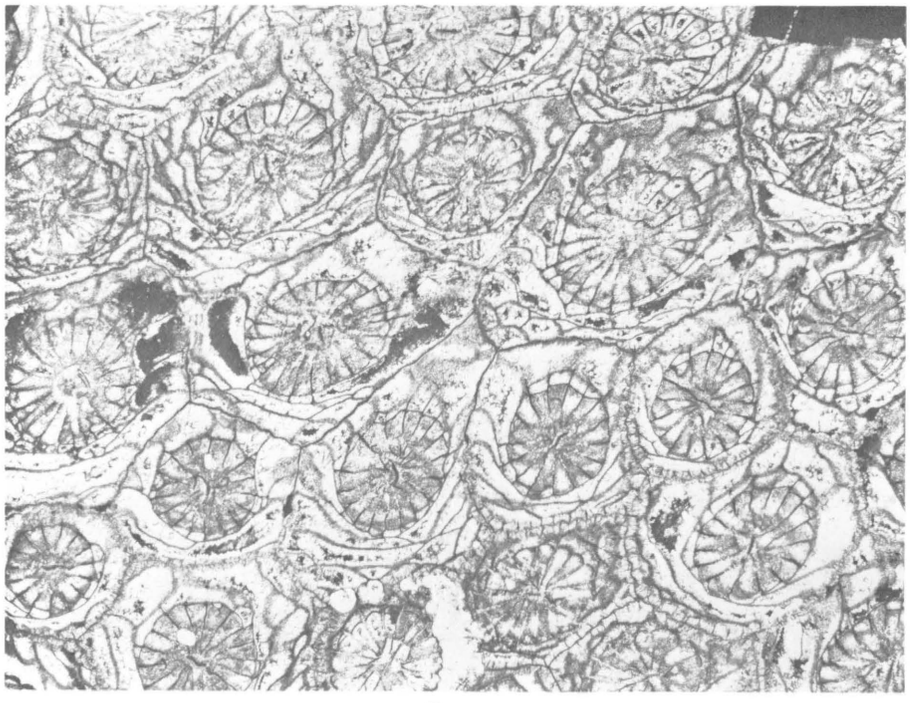
2



3



4



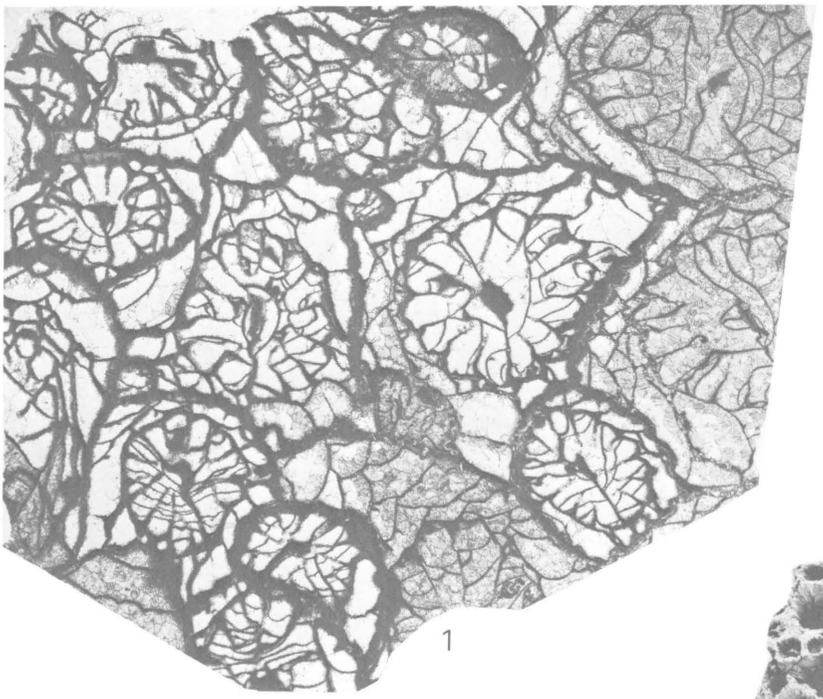
5

PETALAXIS SIMPLEX (HAYASAKA) AND *PETALAXIS WYOMINGENSIS* N. SP.

PLATE 19

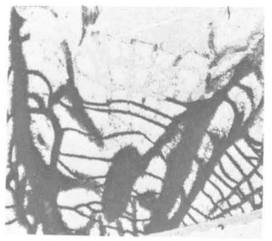
FIGURES 1–4. *Petalaxis exiguus* n. sp. (p. 28).
Holotype, USNM 162002B (paratype of *Lithostrotionella girtyi* Hayasaka). USGS Loc. 3856–PC (green), McCloud Limestone, California.
1. Transverse thin section, × 4, USNM 162002Ba.
2, 3. Longitudinal thin section, × 4, USNM 162002Bb.
4. Oblique view of corallum, × 1.

5–7. *Petalaxis tabulatus* (Hayasaka) (p. 26).
Holotype, USNM 120246. USGS Loc. 1476–PC, Aspen Range Formation, Idaho.
5. Longitudinal thin section, × 4, USNM 120246b.
6. Longitudinal thin section, × 4, USNM 120246c.
7. Transverse thin section, × 4, USNM 120246a.



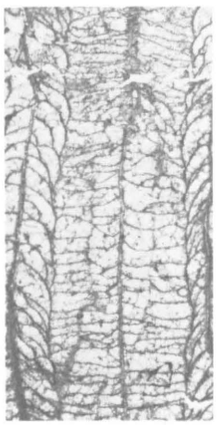
1

2

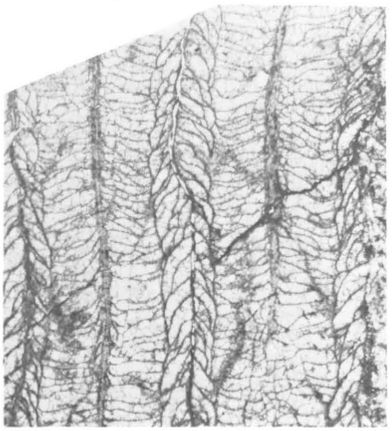


3

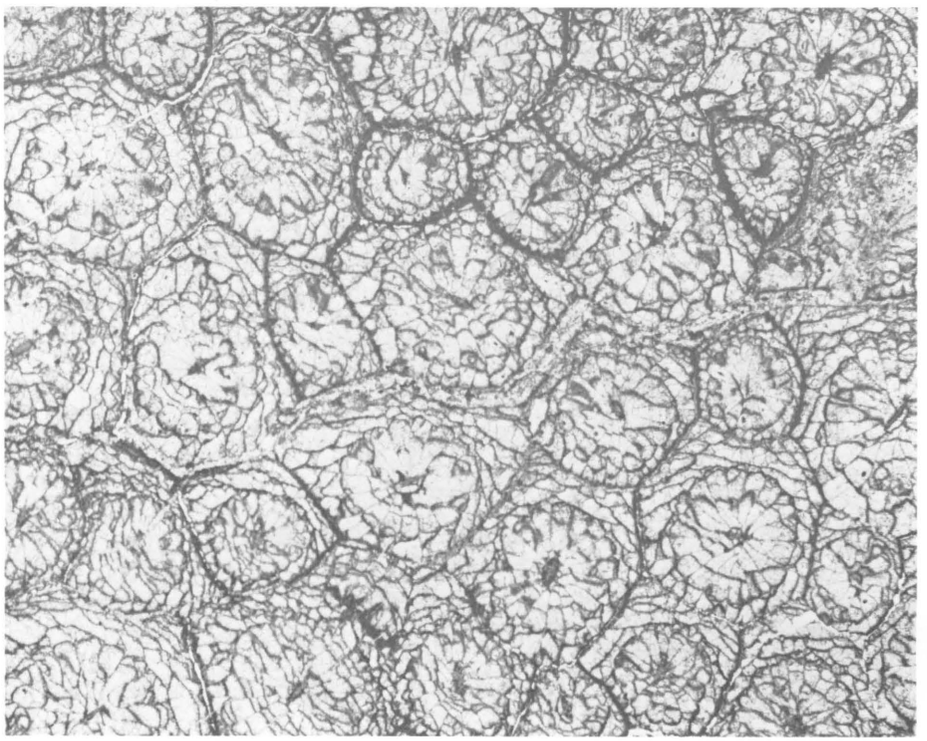
4



5



6



7

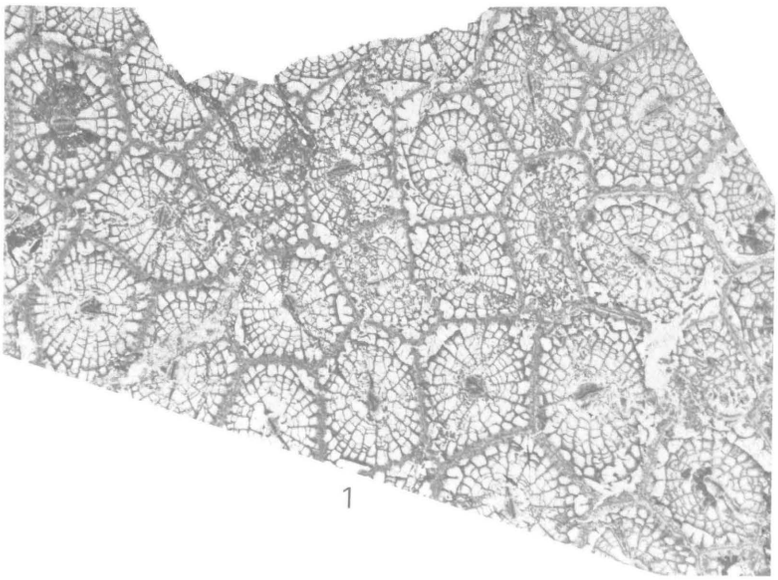
PETALAXIS EXIGUUS N. SP. AND *PETALAXIS TABULATUS* (HAYASAKA)

PLATE 20

[All figures × 4]

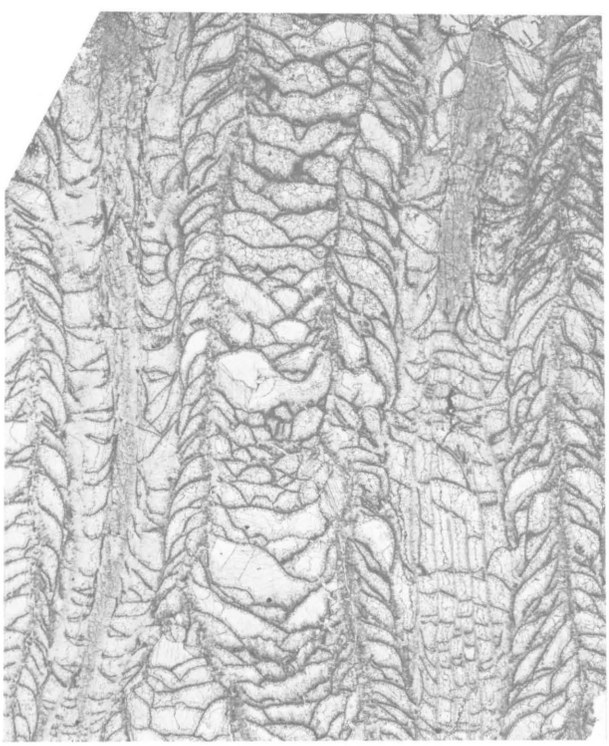
FIGURES 1, 2. *Petalaxis occidentalis* (Merriam) (p. 32).
Holotype, USNM 143440. Coyote Butte Formation, Oregon.
1. Transverse thin section, USNM 143440c.
2. Longitudinal thin section, USNM 143440e.

3, 4. *Lonsdaleia (Actinocyathus) berthiaumi* (Merriam) (p. 37).
Holotype, USNM 132988. Unknown formation, Oregon.
3. Longitudinal thin section, USNM 132988d.
4. Transverse thin section, USNM 132988c.

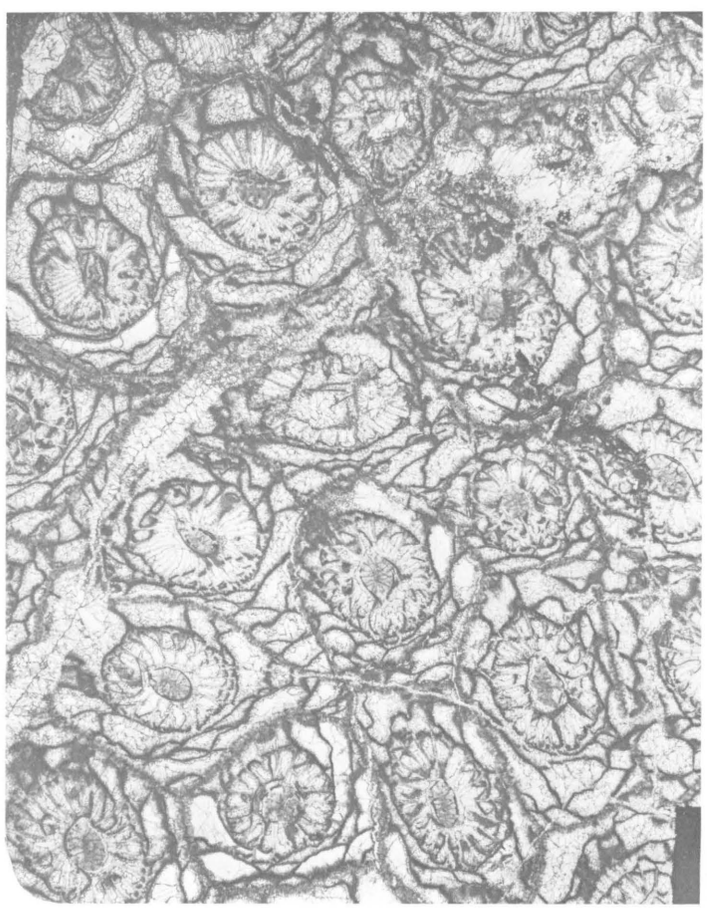


1

2



3



4

PETALAXIS OCCIDENTALIS (MERRIAM) AND *LONSDALEIA (ACTINOCYATHUS) BERTHIAUMI* (MERRIAM)